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Richard H.M. Goossens *Editor*

Advances in Social & Occupational Ergonomics

Proceedings of the AHFE 2016 International Conference on Social and Occupational Ergonomics, July 27–31, 2016, Walt Disney World®, Florida, USA

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Advances in Human Factors and Ergonomics 2016

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7th International Conference on Applied Human Factors and Ergonomics

Proceedings of the AHFE 2016 International Conference on Social and Occupational Ergonomics, July 27–31, 2016, Walt Disney World®, Florida, USA

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Preface

This book provides an exploration on how ergonomics can contribute to the solution of important societal and engineering challenges. Advances in Social and Organizational Factors discusses the optimization of sociotechnical systems, including their organizational structures, policies, and processes. It includes coverage of communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, organizational culture, virtual organizations, telework, and quality management.

This book provides research on urban infrastructures and how to shape urban spaces, including stadiums and museums. It covers warning systems in cars, voice-based interfaces, and the positive effects on manufacturing processes available from health informatics and management systems. Several chapters examine the role human factors can play in counterterrorism efforts and in interpreting deceptive behaviors. They provide suggestions on how to improve enterprise resource planning systems and stress the importance of lifelong learning, personalized learning, and work–life balance. This book also highlights the issues with special populations, detailing how to design and adapt products and work situations for these groups. In addition to exploring the challenges faced by optimizing sociotechnical systems, this book underlines themes that play a role in all the challenges and how they are linked to each other. It concludes with an exploration of emotional ergonomics and the important positive effects of making people happy and healthy. With chapter authors from around the globe, this book supplies a broad look at current challenges and possible solutions. This book contains a total of six parts that covers the following topics.

Part I: Macroergonomic Systems
Part II: Social and Occupational Innovation
Part III: Modeling and Systems in Occupational Ergonomics
Part IV: Job Satisfaction, Workload and Musculoskeletal Disorders
Part V: Accidents and Safety
Part VI: Social and Organizational Factors in Industry

The organizers would like to thank all the authors for their contributions. Each of the chapters was either reviewed by the members of the editorial board or germinated by them. For these, our sincere thanks and appreciation go to the members of the board listed below.

We hope this book will contribute to the knowledge in the field of social and organizational Ergonomics and that readers find the contributions in this book interesting and helpful.

Delft, The Netherlands
July 2016

Richard H.M. Goossens

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Part I
Macroergonomic Systems

The Usage of Simulation Technology for Macroergonomic Industrial Systems Improvement

Leszek Pacholski and Pawel Pawlewski

Abstract The paper presents progress and results of the project, which was performed for the particular macroergonomic system. The goal of the project is the analysis of the buses' production process capability after the assembly hall expansion. The project includes the reengineering of the macroergonomic industrial system model for the new work organization, visualization and verification. Furthermore, the evaluation of workstations and configuration of human working teams, which supports particular workstations were described. The performed activities enabled describing imperfections of created concept as well as for proposing some improvements. On the one hand, this allowed for the human working teams to accept the manufacturing enterprises' identity and on the other hand for minimizing the costs of assembly process.

Keyword Macroergonomics · Simulation technology · Reengineering

1 Introduction

There are many various reasons for the improvement of industrial manufacturing systems. One group of reasons is connected with market, economy, finance and technology factors. The other group represents a wide range of macroergonomic conditions, i.e. factors resulting from the connection between the human factor and technical devices, material and organization work environment, necessity of the human working teams enterprises' identity. In practice both groups of prerequisites combine into one characteristic. The contemporary theories describing the functioning of manufacturing system introduce new elements, which may have impact on activity of such systems, so that the range of interest becomes wider. They also

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focus more on problems connected with the human factor. Thus, we observe a growth of the rank of macroergonomic prerequisites in theoretical deliberations, as well as in practical solutions concerning functioning of industrial organizations. A system approach, which dominates in scientific and practical descriptions of different aspects of economic activity, also affects the character of connections between elements of functioning of particular enterprises.

Macrogonomics is a science, which studies a multi-objective manufacturing system, which organizational structure and relations directly depend from external environment of defined system [1, 2, 3].

A macroergonomic system is defined as a human-centric oriented socio-technical system. Authors of this elaboration present an opinion that industrial systems improvement obviously concerns systems as defined above. Macroergonomic, human-centric and process approach should certainly guarantee fulfilling goals of the technological and human factors improvement of an already existing multi-objective manufacturing system [4, 5].

Macroergonomics is directly connected with management, organization of economic development and entrepreneurship, thus, it is searching modern reserves of productivity. According to the theory of the Kondratieff's cycles [4], the biggest reserves may be connected with the human factor in the area of [4]. The "imperative of demand" concerning ecology, strictly connected with problems of the human factor in technology, is another feature of determined cycle. Thus, so-called basic innovations of the fifth Kondratieff's cycle are the first ones, which are focused on the macroergonomic activities, not on technological and economical effects. We might predict that macroergonomics would be a stimulus of the improvement in many engineering projects for nearest years to come. It would probably also include economic growth. Realization of defined direction in enterprises might be supported by a following sequence of activities connected with the industrial systems improvement:

- identifying macroergonomic prerequisites of the manufacturing systems improvement,
- making managers and engineers realize the role of about mentioned prerequisites,
- elaborating rules of implementation of premises in processes of manufacturing systems improvement,
- accustoming and assessing the macroergonomic industrial systems improvement.

2 Peculiarity and Prerequisites of Macroergonomic Industrial Systems Improvement

Manufacturing systems improvement was mainly concerning the exchange of old machines, equipment and tools for better, newer ones, which could provide higher efficiency, lower costs, better quality of products or replacing old, expensive, toxic materials by new ones. After the dynamic development of scientific work organization and (later) ergonomics—it has changed. Manufacturing systems improvement also could mean changes of methods of production and work organization (it could concern the human factor) or upgrading equipment of rooms and work—stations. Hence, motives were still based on technological and economical aspects.

Along with the development of ergonomics, the role of this science in economic practice has also increase. It led to a new tendency of implementing ergonomic improvement instead of performing punctual corrections. Ergonomics introduces new conditions and methods of work in a form of a complete system, which is based on diagnostic research analysis concerning ergonomics as a general problem. Its goal is to obtain by the people working in the system the proper level of welfare and to make the system efficient.

So, along with the concept of macroergonomics, the range of manufacturing systems improvement is growing and at present it should include changes directed on upgrading all relations between particular elements of the system and relations between parts of the system and its environment (social, economic, ecologic, etc.).

Manufacturing systems improvement as renewal is a specific phenomenon. It includes aspects of reconstructing, bringing back elements and situations to their proper, positive state (which are degenerated, damaged or physically used) and creating new elements replacing old ones or realizing additional functions. Such process is often realized throughout redesigning, i.e. implementing small construction, technology, material and organization changes, which do not interfere main structures, functioning of the process or device [6]. However, redesigning an element might sometimes mean a radical change (reengineering), with use of new technological inventions or new conceptions of realization. Whereas all macroergonomic system improvement activities should be realized based on diagnosis and analysis, so that all noticed errors could be eliminated and all positive observation could be developed.

Unlike designing new systems, improvement concerns manufacturing system, which are already in use. It enables observing all sorts of reactions inside and between different work—stations, but also relations with the direct environment (material environment of work, supportive services) and with the external environment (natural environment, changing situations on the market). A practical assessment of the macroergonomic situation can empower an accurate reconstruction of network of relations. It might cause composite changes of the system, which would significantly increase values of different aspects of its functioning, instead of transforming individual man—machine systems or adjusting particular parameters.

Another important and difficult problem is how to implement manufacturing systems improvement into practice. In a situation, when the company is functioning, there is almost no possibility to stop the production process for the time of implementation of changes in the equipment or in work organization. So, the idea to use planned breaks for renovations or inspections and realize changes partially seem to be rather logic. Some activities might be realized without disturbing the continuity of the work process on particular work—stations of the system [7]. Therefore, there are some trials of preparing schedules for realizing composite manufacturing systems improvement activities in reference to the macroergonomic aspect [7].

The method of implementing the manufacturing systems improvement should also recognize questions of design, organizational preparation, selection of contractors and realizing teams from the structure of the company. The company should also prepare a monitoring system for controlling most important parameters of system's functioning in its long term activity, i.e. how does the system work in periods of cyclically repeating technical, organizational and ergonomic improvement.

There are many reasons for taking a decision of macroergonomic manufacturing systems improvement. Market prerequisites are connected with market demands, trials of reaching new markets, demands of clients. They direct improvement activities on effects linked with the product, its characteristics, with the supply, etc. Economical prerequisites prefer renewal, which significantly lower costs of the production or general functioning of the enterprise. Technological prerequisites focus on exchanging technologies, purchasing new machines and devices or their improvement throughout exchanging fragments of their construction. Their goal is to obtain better competitive position, which is also connected with market and economical aspects.

Macroergonomic prerequisites might be also called "humanization" aspects. They are focused on man's well-being, including the operator—producer but also the employee of supporting and servicing departments, receiver/customer of the product, or even the inhabitant of the area exposed to the hazard of environmental (ecological) influence of the company [8]. Therefore, macroergonomic premises of modernization might have form of:

- unfavorable conditions of work, which have been noticed many times by employees, their managers, external audits, National Labor Inspectorate, industrial healthcare,
- necessity of meeting demands of various standards and certificates,
- aspiration of upgrading the functioning of organization structures,
- incorrect human relations,
- lack of the enterprise identity in the human working team.
- hazard, which the system represents to its environment (natural environment and population living in it),
- aspiration for obtaining certificates (quality, security, industrial safety, environment) for the management system.

Examples presented above illustrate, that macroergonomic prerequisites might cause improvement activities within technological, organization or psychological and social aspects. Hence, usually all enumerated premises are combined. Even though, one reason might be dominant and clearly articulated by the management, it automatically creates a necessity (or need) of taking other prerequisites under consideration.

The group of first three prerequisites (technological, organization or psychological and social) usually appears as one package of reasons, even though they might appear in various configurations of hierarchy. Unfortunately, macroergonomics premises are still rarely dominant reasons of modernization. Usually the opinion of their necessity must be reinforced by other reasons, which are often more important to the managers. This is why it is so important to explain and persuade managers and general boards of enterprises, that macroergonomic prerequisites should be deciding in their choice of term and form of manufacturing systems improvement. Practical implementation of ergonomics of the first and second generation has met identical difficulties. Its criterions and ways of thinking were difficult to accept by designers, creators of procedures for machine, devices, work—stations, rooms and other creations of man in a manufacturing system.

However, we mustn't forget that macroergonomic premises, just like other ones, depend on financial abilities and state of their feasibility. Therefore, they must be also examined with regard to economical and technologic criterions. Similar, the assessment of efficiency of modernization implementing should also include economic efficiency and reached technological development.

In conclusion, authors state that in most favorable situations macroergonomic prerequisites would be dominant for decision about realizing technological, economical or marketing improvement of the company.

3 Progress and Results of the Project

3.1 Reasons, Aims and Method of the Macroergonomic System Improvement

The case study concerns the industrial system improvement in a bus production plant. In recent years the number of contracts won by the company has been steadily growing and their products have been conquering the European market. The assembly line must be more efficient, because imperfections of the current work organization are becoming a problem for the company employees and directly affect financial results of the company. The current work organization does not allow to take full advantage of manufacturing force and it is impossible to realize the necessary number of procurements.

Due to the increasing number of orders and the diversity of bus types, and also low level of the so-called the enterprise identity of human working teams, the assembly system, which has been applied, so far does no longer meet the new requirements. Therefore, the improvement of the assembly process is necessary. The factory employees have a radical idea for changing the macroergonomic system of the assembly process. Their idea is to make a transformation from one assembly line to three parallel assembly lines. As a result, such an improvement can be considered as the reengineering of the assembly process [9].

The main goals, which the enterprise wants to achieve, are the elimination of "bottle necks", the increase in the production system efficiency and the increased the level of the so-called the human working teams enterprise identity. In the macroergonomic industrial system project the company staff designed the arrangement of workstations in the new production hall and the work organization of work-teams, which perform various operations for many different types of buses. Then the simulation model was made to verify the described improvement concept. The scope of the mentioned verification includes:

- building a simulation model, which presents the new assembly line in the factory, taking into account the arrangement of workstations and work-teams in the new production hall, as well as the transport between workstations,
- presenting work organization of work-teams and division of individual workers' actions (who belongs to a particular work-team and performs operations on buses in a particular workstation) in order to determine the best allocation of tasks and the optimum size of individual work-teams,
- determining the effect of assembly interferences on the work of particular work-teams and the efficiency of the whole macroergonomic production system,
- defining the efficiency of the designed assembly lines and proposing changes of the created conception aimed at the ergonomic improvement and the human working teams' enterprise identity.

Another problem, which we needed to check simultaneously, was the question of verifying the efficiency of the designed system of workstations, especially when the factory produces such types of buses which are the most work-loaded for employees.

In the course of research and creation of the simulation model there were a lot of difficulties. They were mostly related with the need to understand the specific employees' vision of the company's identity, as well as with the visualization and verification of the new work improvement and the appropriate use of data about operations in the simulation model. After the selection of data, separate lists of operations for each work-team were created. These lists determined, among other things, sequences and execution times of operations for different types of buses. The lists of operations were organized in a such way that operations were carried out in accordance with the technological route (used in the factory) and the actual state of affairs in the production system. A big challenge was to present the work organization of various work-teams in individual workstations.

The model was created with use of LogABS technology [10] and FlexSim Simulation Software.

The presented method is based on mixing DES (Discrete Event Simulation) and ABS (Agent Based Simulation) approach where DES was used to model the main process—material flow (buses) and ABS was used to model assembling operations of teams of workers.

3.2 The Problem of the Balanced Production Line

From formal point of view the problem described in this paper refers to balancing the production line. It is a technique applied in industrial systems which uses production lines or group technologies by elaborate objective systems [11]. It depends on assigning work to workstations, which are connected in a series, while we should focus on minimizing the number of workstations and reduce the total idle time for all workstations for a given level of production [12]. In theory, when all workstations have the same amount of work which must be done, the production line is perfectly balanced. However, in reality, most of production lines are unbalanced, because the actual amount of work done by individual workstations is different.

The problem of proper balance of production lines is one of the most common issues raised by engineers—production ergonomists. It is a multi-step decision-making process, which is related to the allocation of a specific permissible group of operations to workstations on an assembly line, at particular discrete points in time called the assembly cycles.

Due to the criterion of optimization, the problem concerns two types of tasks: minimizing the quantity of assembly positions with a constant cycle, or minimizing the duration of the production cycle with a constant quantity of workstations. According to the classical method of balancing the production line for a set cycle time, tasks should be assigned to workstations in such a way so that the time losses (idle time of machines) are as short as possible [13]. The balance problem is related to a much wider group of production lines. However, taking the constraints into account, the solution in each case is supposed to minimize the idleness of workstations.

The applied methods can be classified into two groups [14]:

- exact methods, discrete linear programming, dynamic programming, division and restrictions,
- heuristic methods, serialization and division algorithms, approximation methods (one and many heuristics, relapse, limited time to obtain an optimal solution).

In the industrial environment, the most commonly used solutions are the very simple ones. Employees create graphs on boards, in the form of magnetic panels or sheets (the size of a sheet is proportional to the time it takes to perform an individual activity), which show Gantt charts. In this case, Excel Spreadsheets are the most commonly used IT support. Usually, such solutions are sufficient to organize work in one workstation for several work-teams.

However, simple solutions like, for example, magnetic boards with Gantt charts cannot solve complex problems and take into account uncertain execution times of operations which are extremely important in this case (usually execution times are changeable, they oscillates around particular values). It is also necessary to take into account the distance crossed by workers during the passing between several workstations—it is an important factor in case of the assembly of large objects such as buses.

3.3 The Simulation Tools Use and the Project Results

Considering issues listed above, we decided to use simulation technology for modeling work organization of work-teams. The available simulation software allows building complex models [15] in a relatively easy way. Moreover, many simulation programs offers tools, which support the preparation of schedules.

The most commonly used software is DES (Discrete Event System). DES has been the main way for the process simulation of manufacturing and logistics for about four decades. This is adequate for problems that consist of queuing simulations and a variability is represented through stochastic distributions [16]. This approach is applicable in simulating the manufacturing and supply chain processes. DES models are characterized by a process oriented approach (they focus on modeling the system in detail, not the entities) [17]. They are based on a top-down modeling approach and have one thread of control (centralized). They contain passive entities (i.e. something is done to the entities while they move through the system) and intelligence (e.g. decision making) is modeled as part of the system. In DES, queues are the crucial element; a flow of entities through a system is defined; macro behavior is modeled and input distributions are often based on collected/measured (objective) data.

In case of assembling operations we think that the process approach is insufficient. Workers are task executers. It means that they have the list of tasks to do. The worker decides what he will do next based on this list. So we think about worker as an agent. To do it we use approach based on ABS (Agent Based Systems). ABS modeling seems to be useful for modeling operators and forklifts, which have their own "intelligence", where the intelligence means the ability to complete changeable task lists (in our case—the picking list). In this case, an operator must have the ability to receive and send messages to the adoption of a task list, and to send a message about the execution or termination of the implementation of the task list. In the literature this approach is also referred to as Task Driven [15].

Authors of this paper based on their research proposed to mix DES and ABS approaches.

The defined task is to visualize and verify the work organization so that we can design precise arrangement of workstations and work-teams. The aim of the analysis performed with the simulation model is to confirm or reject the designed organization of the production process and identify imperfections of the created conception. These activities will help the company to improve the project before it is put into practice and also avoid time-consuming and expensive verification or solving problems which may appear.

The main change is a transition from a single assembly line to three parallel assembly lines, which work with a delay, but their work is synchronized. This is a complex problem because it is necessary to describe each phase of the process, which involves complete of more than 2700 operations for many types of buses by over 200 workers, who work in 20 workstations.

The workstations are supported by many work-teams, which have different names, different sizes and various lists of operations which must be performed in consecutive cycles of work. Buses pass through several workstations within the same assembly line. In the consecutive workstations buses are operated by other work-teams. Employees from several work-teams perform operations on buses in a sequence and time defined by global tables. Therefore, it is possible to carry out activities in accordance to the technological route and the work reality in the factory. Each work-team consists of a specified number of employees and is assigned a list of operations and workstations, which is necessary for the work.

Typically simulation tools use a process driven approach where the flow of the parts between processes cause the demands on resources, i.e. a part moves to a machine and demands a resource to complete the operation. Whilst this methodology is fine for some applications it does not allow for situations where the resources have tasks to complete which are not flow related. In these situations a task driven approach ensures that jobs can be undertaken in a realistic manner, e.g. an operator (mobile resource) has the job of performing a set of inspections of idle equipment when not otherwise engaged in process work. The task based approach allows for the creation of activities for an operator (mobile resource) which are totally independent of any processing activities and allows him to become engaged in a set of tasks which may require him to travel, acquire tools and remain “busy” for a period of time. Furthermore, using a task driven approach, resources can incorporate their own ‘intelligence’ to decide what jobs to do and when.

Many discrete events simulation programs available on market offer these possibilities. For the performed projected we prepared the solution in environment of FlexSim. This program offers the task sequence mechanism to model mobile resources. The modeler has possibilities to prepare the list of tasks for execution using special functions. The set of tasks includes following activities: travel, load, unload, break, utilize. FlexSim offers the special object called dispatcher to manage the set of operators. We extended this concept. We define agents based on task executers from FlexSim—we add intelligence it means that our agent (extended FlexSim task executer object) can make decision and he prepares based on order for him, his own list of tasks to do with possibilities to change this list. The defined agent has following characteristics according to [18]:

- is identifiable, a discrete individual with set of characteristics and rules governing its behaviors and decision-making capabilities,
- is autonomous and self-directed,
- is situated, living in environment with it interacts with other agents—has protocols for interaction with other agents,
- is goal directed—having goals to achieve,
- is flexible—having the ability to learn and adapt its behaviors based on experiences.

To solve the problem of modeling and simulation work of many work-teams for assembling, we defined two special agents: base agent—contractor and team agent. Contractor is agent build based on task-executers from FlexSim, but his set of skills is extended in comparison with original task-executer from FlexSim. Team agent is the agent which has following rules:

- to prepare the goals for agents from team based on order (main task list),
- to control—it means to select, prepare and activate agents in team,
- to control time.

Orders (list of activities to perform) are built based on an excel file obtained from bus company. The structure of this file is as follow:

- a row in a table—one activity from the location indicated by columns,
- columns contain the name of the activity, number of station, number of zone, time of activity depend on type of bus—if time is 0 it means that this activity is not valid for this type of bus.

The Team Agent prepares the list of tasks based on the set of rows from Order table and sends this list to Contractors. The Team Agent works as an answer to a request from the assembling line. When the bus enters station, the requests are sent to Team Agents which are assigned to this station. Team Agent has to perform the list of all activities in cycle time (150 min) using all Contractors assigned to team.

Described mechanism was implemented in FlexSim. The model includes 20 stations—2 special stations in the beginning of process and 18 stations in three parallel lines. The work of 23 work-teams was modeled. It is possible to change the number of members of work-teams and to define new type of bus. The model enables to perform experiments with following reports:

- work-team conflicts; situation when the work-team finish his work after end of the cycle time,
- list of operations which cannot be performed because the time to the end of cycle is shorter than time of operation,
- list of idle time by work-team at the end of cycle; to evaluate the team work.

4 Conclusions

The paper presents the progress and results of the project performed for the bus company's macroergonomic system. The industrial system improvement project focuses on building the simulation model of work-teams work in final assembling line. The goal of the project is the analysis of the buses' production process capability after the assembly hall expansion. The project includes the reengineering of the macroergonomic industrial system model for the new work organization, visualization and verification. Furthermore, the evaluation of workstations and configuration of human working teams, which supports particular workstations were described.

To build the model we use mixt DES/ABS approach. As base the DES simulation the program FlexSim was used and in this environment we developed our own agent base simulation tool. To do it, we extended standard FlexSim task executers and task sequence mechanism. The model and prepared tools were implemented in bus company to analyze new assembling process. Thanks to it, the company can short the time of making decisions about work-team work organization.

This tool can be used in two levels: design level—when new layout and new organization of works are designed and operational level—where finding the best solution is needed because of absence of workers or sudden disturbances in assembling process.

The paper presents the first built model. The model was accepted by the bus company, so we define the possibilities to extended it by:—skills matrix of workers (team agent assign workers to activity based on skills of workers which are saved in this matrix),—introducing special Contractor Agent Jumpers (workers which can be shared by many work-teams), and—introducing tools which will enable to define optimization task to find the best assigning.

The performed activities enabled describing imperfections of created concept, as well as for proposing some improvements. On the one hand, this allowed the human working teams to accept the manufacturing enterprises' identity and on the other hand for minimizing the costs of assembly process.

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3D Laser Models for the Ergonomic Assessment of the Working Environment

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Abstract The article presents an analysis of the applicability of 3D laser model technology in the ergonomic assessment of the working environment. The results show that in the case of 3D technology, it is especially useful to describe the changes in the working environment and the ways of performing work activities (deviations from the regulations regarding activities specified by the employer). The article also presents algorithms for the use of 3D laser models in many workplaces where one cannot plan the work tasks in detail, since they are flexible and often their course is changed. This applies to work such as that of warehouse workers, maintenance staff or mining work.

Keywords Ergonomic assessment · Human-Systems integration · Systems engineering

1 Introduction

Presently, there is an observable tendency towards computer visualization of an increasing number of aspects of the working environment, relating to not only the spatial parameters of the environment and its facilities, but also the real time visualization of the course of the whole production process including the body position of the worker during subsequent stages of production. The digitalization of various areas of a company, or the creation of a comprehensive network of digital models, methods and tools, which form a cohesive system, gives the opportunity to

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manage data in a comprehensive way, however, it requires the collection of massive amounts of data, such as spatial parameters, as well as programming methods enabling pattern recognition.

Given the growing demand for rapid recognition of hazardous states and the simultaneous documentation of these events for their later or remote analysis, 3D recording has become an indispensable tool in process excellence, which has a kind of side effect of increasing the ergonomic quality of work [1]. The use of 3D imaging methods can be found in the following areas of human activity: security features involving the identification of unique individual characteristics [2, 3], rendering body shapes for medical and rehabilitation purposes [4], reverse engineering [5], surveying, architecture [6], archeology [7], and for the purposes of forensic science, agriculture and forestry [8]. However, its relative applicability in ergonomic engineering to date has been limited to anthropometric measurements [9, 10] and the field of reverse engineering. On the other hand, there has been much development in the simulation capabilities of 3D technology [11], which allows to present reality in a simulated setting, to create simulations and evaluate them based on the simulated virtual reality.

The use of 3D scanning in ergonomics has become particularly important in the search for opportunities to increase the ergonomic quality of work for complex anthropotechnical systems [12], while reducing the time needed for their implementation.

2 Frames of 3D Scanning Technology

Telemetric and advanced scanning methods have significantly facilitated the transfer of the observed reality into virtual reality. This is also the case in 3D laser scanning, which calculates the distance between the measured object and the unit (scanner) emitting and receiving the laser pulses reflected from the object, while determining the spatial coordinates (X, Y, Z) describing the position of the device in space as well as the direction of the laser beam at the time of sending the pulse. Operating on a "point cloud" allows for realistic visuals, a precise measurement of the space transferred to virtual reality as well as a foundation for advanced spatial modeling and reverse engineering [13].

3D laser scanning has many applications, however it is particularly useful in the design of a system taking into consideration an already existing, specified space which imposes certain conditions. Traditional methods, involving the measurement of points of actual dimensions of a select few features (e.g., distance between buildings), are suited for small and simple subjects. Employing these methods for a reconstruction of such a large subject, with multiple installations of a complicated course, irregular shape, with inaccessible spaces, e.g. located high above the floor, is practically impossible and unprofitable, because its measurement and transfer to a CAD program would take a massive amount of time, even with the involvement of a large group of people. In such cases, the ideal solution is to use terrestrial laser scanning technology.

To enhance documentation during 3D scanning, in addition to point clouds, a so-called bubble view is generated. The point cloud, which is assigned RGB colors based on taken photographs and data such as reflectance intensity and thermal scans, allows to recognize phenomena of a varied nature, which could not previously be examined due to their transience. It should be noted that during measurement a laser scanner is able to collect a huge amount of data in a relatively short period of time (up to one million points per second), which means that it will reflect the spatial characteristics of events that are short-term, but static for at least a few minutes (time of scanning depends on the assumed density and precision of scanning).

A major advantage of 3D scanning is its non-contact feature, which enables the measurement of objects without having to set up special platforms, scaffolding or other entries around them, which would not be possible with conventional methods due to the lack of access [14]. Scanners also work independently of a light source—the laser beam itself is light, so measurements can be performed in poorly-lit areas as well as during the night. This provides the ability to perform 24-h measurements [15].

3 Application of 3D Scanning Technology in Safety Engineering and Ergonomics

Laser scanning can be applied in many fields related to safety, where, in view of the massive amount of data and complexity of spaces, it replaces traditional measurement methods. Thanks to laser scanning, it's possible to analyze at-risk industrial facilities with the aim of early hazard detection and conducting in-depth analyses of deformation, strain, changes in position, which can be a source of information on whether to undertake modernization actions. Examples include:

- measurement and analysis of tank deformation or of other facilities at risk for an uncontrolled release of energy;
- measurement and analysis of changes in the shape of lift shafts in mines and mine workings;
- measurement of strain and deflection of steel and reinforced concrete, e.g. tent hall construction, monitoring roof sagging under snow load; monitoring and analysis of building deflection under wind, thermal loads or deformation due to the influence of natural or artificial sources of energy (requires the additional use of a thermal imaging camera to color the point cloud with colors corresponding to temperature);
- comparison of the model created from the point cloud with its theoretical counterpart, also in terms of dynamics and critical states;

- post-disaster analysis, which is particularly important when rescue work or restoration of communication routes will obscure information important to determine the causes and circumstances of the event;
- measurement of the spatial position (geometry) of components of mechanical devices in different states, e.g. vertical and horizontal alignment of devices; monitoring the straightness of crane subgrades;

This can be extremely important in case of design for safety especially in reboost design or design focused on process safety [16]. In addition to the typical uses of 3D scanners in safety engineering, the possibility of modeling the environment responsible for the ergonomics of work or daily life should also be mentioned, in particular:

- the width and height of passageways (travel distances) in work spaces; the distance between devices and workstations—e.g. for the future imaging of phenomena such as noise propagation;
- the distance between racks and stacks of materials, in order to check whether they are suitable for the means of transport and the ability to manipulate them and for the safe handling and piling by employees; angle of material piling in order to determine the possibility of safe passage around the heap or stockpile (in the case of traditional surveying methods there is a risk of burying the employee performing the measurement);
- distances which must be overcome by an employee between workstations or at one station, the slope of the surface on which an employee moves, and features of the terrain that must be overcome (the data can be used to calculate energy expenditures, the possibility of manual handling of materials based on e.g. the slope of the floor, as well as the optimization of work processes);
- site planning taking into account the needs of people with reduced mobility—e.g. by creating alternative barrier-free routes in an urban environment, these scans may also be used by a city's government to determine the areas in which these measures would have the greatest impact on the quality of life of residents with disabilities;
- the surface area of the workplace, the whole space, which can be compared with the existing regulations related to the amount of space per employee, the ratio of window surface area to floor surface area related to the use of daylight for lighting workplaces;

The application of any solution other than 3D scanning will require the use of additional software to identify and classify the specified areas, which in the case of significant variability of processes cannot be performed manually. Some of the applications of 3D method will be also found by complex reengineering of human machines subsystems [17], with the exceptions made in next chapter.

4 Application of 3D Scanning Technology in Ergonomic Assessment

Ergonomic assessment is one of the key phases in the redesign of work organization and work stations. It occurs both during the first and the last phases of the design process and determines the success of the entire procedure since the obtained degree of change is what determines the ergonomic quality of a solution, and thus the long-term user satisfaction. The table presents assessment criteria of workstations, along with areas for the possible application of 3D technology.

It should be noted that the reproduction of moving objects is made difficult because of the coverage area and in most cases it will be ineffective. The propositions presented in Table 1 are related to the use of 3D technology, taking into account currently used devices, however their application requires the development of an operating algorithm, the validity of which seems to be the biggest in the event of a clear superiority of mapping with the use of point clouds in comparison to other methods of recording reality. Examples of such situations are presented in Table 2.

Table 1 Example of ergonomic assessment phases and alternative methods

Ergonomic assessment phase	Traditional method	3D application example
Work area formation assessment	Measurement of individual technical environment parameters, e.g. countertop height and acromial process	Establishing distance ranges between points demarcating areas of impact (grip, reach) and work zones (levers, devices)—however, there still are no capabilities to map anthropometric features in the case of human movement
Communication system suitability assessment	Measurement of individual spatial parameters, eye tracking	Establishing angles of signaling devices (screens) in relation to the position of the head and shoulder girdle—determines the neutral zone during performance of work (which will be difficult in the case of movement of the operator)
Work posture assessment	Observational and classification methods—OWAS, RULA, REBA	Determining the body segments critical for body position and their mutual relationship as well as an evaluation based on objective criteria
Biomechanical load assessment	Biomechanical models based on selected individual characteristics (height, arm length) e.g. Delmia, 3DSSPP	Full spatial mapping of the human body together with the determination of the center of gravity of body segments during static positions

(continued)

Table 1 (continued)

Ergonomic assessment phase	Traditional method	3D application example
Multi-faceted assessment of task groups—team performance	Subjective methods—questionnaires, spaghetti plots, evaluation of selected spatial parameters—e.g. passageway width	Spatial modeling of the movement of objects and people, but because laser scanners mapping human movement, e.g. Velodyne, are a fairly small group of solutions, modeling will take place through the use of dual technology introducing a virtual simulation of movement to the static environment mapped by laser scanning, which will detect collisions and mismatch of the real environment to the intended actions; Virtual verification of existing facilities in terms of group behavior during the evacuation of people and property

Table 2 Areas of application of 3D laser scanning technology and the conditions for its application in ergonomic engineering

Action	Application	Remarks
Spatial record along with detailed mapping of participating facilities	Archiving immediately following accidents (work, transportation or other event), for which the complexity of analysis or consequences of findings exclude a simplified analysis	A record using point clouds in a universal format should give various specialists access to the data necessary for the simulation of the event, which would limit the time needed for data collection and at the same time reduce the downtime resulting from the event (e.g. road accident)
Preparation for modeling the material work environment	Preparation of spatial maps for the modeling of phenomena such as noise, radiation	Visualization of the work environment allows to determine what real objects constitute hazards—e.g. noise at a certain frequency or radiation, the point analysis of which allows to present a spatial analysis of a particular phenomenon, however, technology alone could not capture these phenomena without the use of other measurement tools (e.g. noise phenomenon)

(continued)

Table 2 (continued)

Action	Application	Remarks
Supporting mapping of loads leading to WRMSDs	Analysis of static positions and the ability to map body position during work, particularly in the case of difficult access to the studied workstation (no view of the position in the frontal and sagittal planes)	Positions adopted by the employee while working, along with a depiction of coordinates for each point of reference, independent of the available space and the place of performing scanning (in the case of an ordinary photograph it is not possible to determine the spatial relationships between a human and the work environment—Fig. 1.)

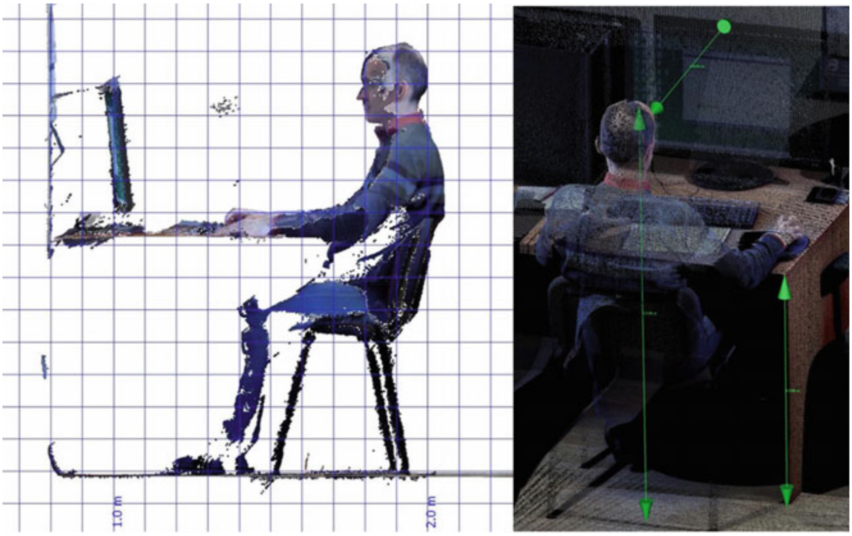

Fig. 1 Example of point cloud for workplace assessment

Due to the rather static image obtained during 3D scanning, along with the high cost of the method, its use is limited to application in documentation, however, it is anticipated that the growing number of lawsuits arising from the loss of health at work will force employers to increase focus on the quality of working conditions, while documenting efforts in this regard. A significant limitation of the method used in dynamic environments is time—e.g. for one workstation this time (for the scanner Z+F IMAGER 5010C) is approx. 3 min 20 s (point density—every 6.3 mm by 10 m), not including photos. Taking pictures takes an additional 3–10 min depending on how long the scanner will collect and grayscale images and whether the photos should be prepared using an additional source of light. For faster scans, which last approximately 1 min less, the lower accuracy and point density may not give sufficient information for analysis.

5 Conclusion

Increasingly advanced means of communication allow to obtain information about the characteristics of reality and to represent it spatially in a computer in a way hitherto unknown. This has brought about a need for increasingly complex computational techniques, which will enable the interpretation of the observed reality. Ergonomic design methods based on an assessment of the current situation, will have to absorb much more data, which in the future may allow to obtain solutions with a much higher level of ergonomic quality. For this purpose, operational methods supporting design decisions will have to be used.

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A Multi-Criterial Hardware Assessment of the Psychophysical Capacity of Workers in the Investigation of Fatigue

Grzegorz Dahlke, Milena Drzewiecka, Marcin Butlewski and Leszek Pacholski

Abstract The article presents a multiple-criteria-based evaluation of the suitability of selected measuring devices for assessing fatigue levels in miners during underground work in a bituminous coal mine. The changing levels of fatigue and decreased psychomotor performance influence worker reliability and susceptibility to accidents. Therefore, monitoring the level of fatigue can be a means of accident prevention. The study allowed to identify the physiological parameters that are relevant in monitoring worker reliability. A multi-criterial compartment establish most reliable fatigue indicators based on before and after work measurements: multi-frequency segmental body composition analysis, reaction time and recognition with Dufour Cross-Shaped Apparatus and analysis of changes in power grip strength.

Keywords Fatigue · Fatigue measurements · Measuring devices in ergonomics

1 Introduction

Work fatigue levels and physical and mental capacity impairment have an impact on worker reliability and accident proneness. Therefore, the monitoring of fatigue levels may offer an opportunity to prevent accidents. Monitoring devices, focused in particular on physiological parameters, have long been used in sports and in observing the drivers of various transportation machinery. A research team of the Poznań University of Technology have been investigating the suitability of such devices in assessing workers involved in various types of mining operations. In their research, the team conducted a number of tests to assess various fatigue symptoms. The tests additionally provide an indication of the workers' failure and error rates. Miners are a unique profession associated with a particularly high risk of

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sustaining durable and significant health damage in the form of occupational diseases and overall physical and mental strain [1, p. 35].

The working environment of a mine features a range of unique factors contributing to miner fatigue. The most common of these are [2, pp. 34–35]:

- the absence of natural daylight,
- discomfort resulting from having to work in confined spaces,
- very humid, dusty and oxygen-poor air contaminated with mining gases,
- continuous drafts (reaching speeds of up to 5 m/s in mining headings, up to 8 m/s in dog headings and up to 12 m/s in shafts and ducts during human transport),
- elevated air pressure due to depths below ground level,
- constantly changing work locations (resulting from the exploration of ever changing heading and mining faces),
- disruptions of rock structure (resulting in rock chunks falling off the rock face),
- water leaks from heading roof and/or condensation on heading roof,
- the inclinations of seams and the headings made in such seams,
- noise and vibrations generated by the machinery used to mine and convey winnings,
- high temperatures,
- heavy traffic confined to a small number of tight headings,
- natural hazards (rock cracking, methane leaks, fires, methane and coal dust explosions, gas and rock outbursts, etc.),
- physical fatigue in workers forced to operate in such conditions.

The findings of the research experiments conducted in coal mines allowed the researchers to verify the suitability of the selected measuring devices for assessing changes in the levels of miner fatigue and propose preventive measures. A list of basic criteria was selected that needed to be satisfied to complete the study. The list extended to the organization of mining work, the acceptability of the criteria by the test subjects and the potential impact of employing the criteria on result accuracy. A priority matrix was used to rank measuring devices in terms of suitability.

2 Measuring Device Descriptions

Miner fatigue symptoms were measured by means of devices which enabled the identification of changes in visual perception and body movements, the parameters associated with body bioimpedance [3], the activation of the balance system and physiological changes. The parameters were assessed by means of the measuring devices shown in Table 1 before and after subject work shifts.

The comparative analysis of the measuring devices was conducted using a priority matrix which helped structure the approach to choosing solutions from among a small number of options. The matrix was used to weight criteria and assess

Table 1 Measuring devices employed in the study

Measuring device	Measured parameters	Measuring experiment
K-03 Dufour Cross-Shaped Apparatus[a]	Minimum reaction time [s] Maximum reaction time [s] Average reaction time [s] Number of adequate reactions Number of erroneous reactions Number of failures to react Button coordinates	Study of changes in reaction times and failure rates of the central and peripheral nervous system as a result of work exposures
DataLog G100 electronic dynamometer[b]	Changes in grip strength over time (measurement of MHT (maximum holding time))	Analysis of changes in muscular tension and upper limb muscle fatigue
TANITA MC-780MA (segmental body composition monitor certified for medical applications)[c]	Body mass; Fat tissue; Bone tissue; Volume of water; Muscle tissue	Analysis of changes in muscular and fat tissues during exertion
Win-Pod pedometer from Medicapteurs[d]	Foot area, maximum foot pressure, average pressure, route length, circumference area, mean square area of rectangle, length over time, route length over envelope, area of closed ellipse on oscyllogram, length over area, mean square velocity, mean deviation X, mean deviation Y, mean velocity X, mean velocity Y	Analysis of balance system stimulation during exposure to working environment
Polar S810i	Heart rate over time	Analysis of heart rate changes over time; measurement of energy expenditure based on heart rate change; analysis of the need to provide restorative and preventive meals to workers (in keeping with legal requirements)
MCR 2001E reaction time measuring device from Psychotronics	Time of individual reactions (simple or complex), mean times, number of adequate, delayed, missed and erroneous reactions	Analysis of time change and correctness for reactions to visual and acoustic stimuli

[a]For detailed device description, see [7]
[b]For detailed device description, see [9]
[c]For detailed device description, see [10–13]
[d]For detailed device description, see [8]

Table 2 The devices analyzed using the priority matrix

Device ID	Name
D1	K-03 Dufour Cross-Shaped Apparatus
D2	DataLog G100 electronic dynamometer
D3	TANITA MC-780MA segmental body composition monitor
D4	Win-Pod pedometer from Medicapteurs
D5	Polar S810i
D6	MCR 2001E reaction time measuring device from Psychotronics

Table 3 Device evaluation criteria

Criterion ID	Criterion description
C1	Ability to assess worker fatigue
C2	Time required to process results
C3	Measurement time per person
C4	Condition of device operation (suitability for rough conditions required)
C5	Impact of subject commitment on study results
C6	Impact of environmental factors or factors not consciously controlled by the subject and investigator on study results

options against the adopted indicators [4, p. 1006; 5, p. 112]. Unique codes, as shown in Table 2, have been assigned to the devices in question.

Based on extensive experience in research on working environments and their impacts on worker fatigue and the preliminary conditions stipulated by miner employers, the team identified key criteria for the selection of research experiment devices. The team relied on its initial experience with mine experiments to verify the device evaluation criteria. The criteria they selected are given in Table 3.

Although one might attempt to assign ranking weights to the individual criteria C1 through C6 (Table 3), such an analysis would be highly subjective, dependent on the individual approach of the assessors and devoid of a methodological structure. The research team found it essential to be able to assess worker fatigue through tests. Without such an option, the use of the measuring devices would be pointless. In any case, there always remained one unknown, i.e. the impact on measurement results of any unidentified factors to which the miners were exposed. The time pressure exerted by the subjects and their employers was an additional challenge faced in the study. The devices that the team were looking for were expected to ensure the ability to conduct duplicable and rapid tests that would also be as independent as possible of the subjects' level of commitment. The mining companies provided the research team with sufficient space to set up test stations in a duplicable manner. The challenge, however, was to isolate the individual devices so as to meet all expectations.

In keeping with the procedure for using the priority matrix, the next step taken was to differentiate the criteria by significance and rank the available devices by such criteria. To that end, the team followed a recommendation proposed by the publication's authors [5, p. 113], where:

- the value 10 means that criterion X is substantially more significant than criterion Y,
- value 5 means that criterion X is more significant than criterion Y,
- value 1 means that criterion X is equally as significant as criterion Y,
- value 1/5 (0.20) means that criterion X is less significant than criterion Y,
- value 1/10 (0.10) means that criterion X is substantially less significant than criterion Y.

The individual elements of the matrix were compared in pairs. The final weights assigned to the criteria are given in Table 4.

Specific devices were then evaluated against the identified criteria. The results are provided in Tables 5, 6, 7, 8, 9 and 10.

Once the criteria have been compiled on the basis of the above data, a summary matrix was drawn up, as shown in Table 11. The higher the value, the more completely is criterion C satisfied by device D. The combined weights were used to rank the devices.

With the help of the priority matrix, the devices were ranked against multiple criteria, as illustrated in Table 12.

Table 4 The weights assigned to the individual criteria

	C1	C2	C3	C4	C5	C6	Sum	Weight
C1	–	10.00	1.00	5.00	0.20	5.00	21.20	0.25
C2	0.10	–	0.10	0.20	0.10	0.20	0.70	0.01
C3	1.00	10.00	–	1.00	1.00	5.00	18.00	0.21
C4	0.20	5.00	1.00	–	1.00	5.00	12.20	0.14
C5	5.00	10.00	1.00	1.00	–	10.00	27.00	0.32
C6	0.20	5.00	0.20	0.20	0.10	–	5.70	0.07
–	–	–	–	–	–	Sum	84.80	1.00

Table 5 Device evaluation against criterion C1

	D1	D2	D3	D4	D5	D6	Sum	Weight
D1	–	5.00	1.00	1.00	0.20	1.00	8.20	0.11
D2	0.20	–	0.20	0.10	0.10	0.20	0.80	0.01
D3	1.00	5.00	–	1.00	0.20	5.00	12.20	0.16
D4	1.00	10.00	1.00	–	0.20	5.00	17.20	0.23
D5	5.00	10.00	5.00	5.00	–	5.00	30.00	0.40
D6	1.00	5.00	0.20	0.20	0.20	–	6.60	0.09
–	–	–	–	–	–	Sum	75.00	1.00

Table 6 Device evaluation against criterion C2

	D1	D2	D3	D4	D5	D6	Sum	Weight
D1	–	0.10	1.00	5.00	5.00	1.00	12.10	0.12
D2	10.00	–	10.00	10.00	5.00	10.00	45.00	0.46
D3	1.00	0.10	–	5.00	0.20	1.00	7.30	0.07
D4	0.20	0.10	0.20	–	0.10	0.20	0.80	0.01
D5	0.20	0.20	5.00	10.00	–	10.00	25.40	0.26
D6	1.00	0.10	1.00	5.00	0.10	–	7.20	0.07
–	–	–	–	–	–	Sum	97.80	1.00

Table 7 Device evaluation against criterion C3

	D1	D2	D3	D4	D5	D6	Sum	Weight
D1	–	0.20	1.00	5.00	10.00	5.00	21.20	0.27
D2	5.00	–	1.00	5.00	10.00	5.00	26.00	0.33
D3	1.00	1.00	–	5.00	5.00	5.00	17.00	0.22
D4	0.20	0.20	0.20	–	5.00	1.00	6.60	0.08
D5	0.10	0.10	0.20	0.20	–	0.20	0.80	0.01
D6	0.20	0.20	0.20	1.00	5.00	–	6.60	0.08
–	–	–	–	–	–	Sum	78.20	1.00

Table 8 Device evaluation against criterion C4

	D1	D2	D3	D4	D5	D6	Sum	Weight
D1	–	0.10	0.20	1.00	0.20	1.00	2.50	0.03
D2	10.00	–	10.00	5.00	5.00	10.00	40.00	0.49
D3	5.00	0.10	–	5.00	1.00	5.00	16.10	0.20
D4	1.00	0.20	0.20	–	0.20	5.00	6.60	0.08
D5	5.00	0.20	1.00	5.00	–	5.00	16.20	0.20
D6	1.00	0.10	0.20	0.20	0.20	–	1.70	0.02
–	–	–	–	–	–	Sum	81.40	1.00

Table 9 Device evaluation against criterion C5

	D1	D2	D3	D4	D5	D6	Sum	Weight
D1	–	10.00	0.20	1.00	10.00	1.00	22.20	0.31
D2	0.10	–	0.10	0.20	1.00	0.20	1.60	0.02
D3	5.00	10.00	–	5.00	5.00	5.00	30.00	0.42
D4	1.00	5.00	0.20	–	5.00	5.00	16.20	0.23
D5	0.10	1.00	0.20	0.20	–	0.20	1.70	0.02
D6	1.00	5.00	0.20	0.20	5.00	–	11.40	0.16
–	–	–	–	–	–	Sum	71.70	1.00

Table 10 Device evaluation against criterion C6

	D1	D2	D3	D4	D5	D6	Sum	Weight
D1	–	0.20	10.00	5.00	10.00	5.00	30.20	0.36
D2	5.00	–	10.00	5.00	10.00	5.00	35.00	0.42
D3	0.10	0.10	–	0.20	1.00	0.20	1.60	0.02
D4	0.20	0.20	5.00	–	5.00	5.00	15.40	0.18
D5	0.20	0.10	1.00	0.20	–	0.20	1.70	0.02
D6	0.20	0.20	5.00	0.20	5.00	–	10.60	0.13
–	–	–	–	–	–	Sum	83.90	1.00

Table 11 Summary matrix

	C1	C2	C3	C4	C5	C6	Sum	Weight
D1	0.0314	0.0011	0.0636	0.0049	0.0727	0.0272	0.2009	0.1913
D2	0.0031	0.0042	0.0780	0.0782	0.0052	0.0315	0.2002	0.1907
D3	0.0467	0.0007	0.0510	0.0315	0.0982	0.0014	0.2295	0.2185
D4	0.0658	0.0001	0.0198	0.0129	0.0530	0.0139	0.1655	0.1576
D5	0.1147	0.0024	0.0024	0.0317	0.0056	0.0015	0.1583	0.1507
D6	0.0252	0.0007	0.0198	0.0033	0.0373	0.0096	0.0959	0.0913
–	–	–	–	–	–	Sum	1.0502	1.0000

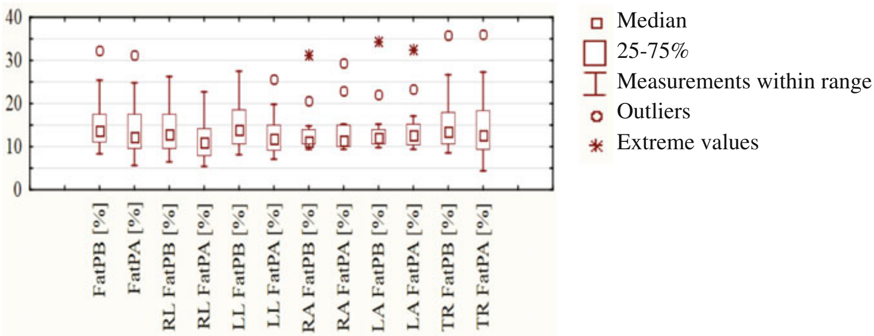
Table 12 Rating of measuring apparatus

Device ID	Name	Rating of measuring apparatus
D1	K-03 Dufour Cross-Shaped Apparatus	2
D2	DataLog G100 electronic dynamometer	3
D3	TANITA MC-780MA segmental body composition monitor	1
D4	Win-Pod pedometer from Medicapteurs	4
D5	Polar S810i	5
D6	MCR 2001E reaction time measuring device from Psychotronics	6

The analysis of the suitability of measuring devices for studies of changes in miner fatigue during work conducted by the research team identified the body composition monitor as the most useful of the available devices (Table 12). The monitor measured the physiological impact of physical loads and environmental and organization factors on worker body impedance. The study did not allow the team to observe the miners at work so as to identify the tasks they performed and the associated internal loads impacting on their bodies [6]. The device ranked second best was the cross device which made it possible to examine the workers' motor-eye coordination. The results obtained for the device were more influenced by the subjects' commitment. However, the imposed test time frame and the workers' constant focus made the study more likely to be objective. The electronic dynamometer (which ranked third) offered the capacity to examine changes in hand grip strength. During the mine experiment, the researchers measured the maximum grip strength as well as the maximum holding time (MHT). Although the measurement itself was very simple, the determination of the MHT depended largely on the subject's commitment. A posturographic assessments conducted by means of a pedometer (which ranked fourth) allowed one to present the effects of stimulating a worker's balance system. One drawback was that the researchers were unable to influence the reliability of the subject's input. The only way to verify such input was to run the test multiple times and assess any discrepancies. However, such an approach would be considerably more time consuming and time is of the essence in mine testing. The Polar 810i heart rate meter, which ranked fifth, provides a continuous record of heart rate fluctuations. The heart rate meter offers highly accurate insights into workload changes. However, it is not approved for underground use and, as such, could not be used during work. The heart rate meter was nevertheless included in the comparative analysis as the fatigue monitoring system prepared by the authors envisions the use of a device that allows one to monitor heart and saturation rates. The study revealed the strengths and weaknesses of heart rate measurement—these will be accounted for in the final solution. Heart rate fluctuations may depend on the physical workload as well as the emotional strain and pathological body conditions. Without a knowledge of the reasons for heart rate changes, it is very difficult to determine its links to fatigue. The lowest place in the ranking was assigned to the reaction time measuring device. While the study results for the device do indeed allow one to assess changes in motor-eye coordination similarly as in the case of the Dufour Cross-Shaped Apparatus, the results of the former are noticeably more influenced by external distortions. The waiting time for light and sound stimuli and the need to remember complex upper and lower limb reactions, make any distractions of the subjects substantially more significant. Neither can one rule out the influence of the subjects' commitment on end results.

3 Results of Experimental Tests

The above test results made it possible to observe changes in the measured parameters. The highest-ranked device, which was the body composition monitor, made it possible to assess fat tissue burning and changes in body water content during miner work. The device helped associate the largest losses in fat content with the lower extremities. This was the result of performing miner tasks while standing up and having to walk a long distance (over 4400 m) to reach the work area. Since much of the work involved the use of a spade and moving objects manually, one can additionally notice fat level reductions in the torso. Not all employees made the same use of the individual segments of their motoric system. Therefore, a slight increase in torso fat tissue was observed in four of them. The device measurements



FatPB [%]-Body fat before work
FatPA [%]-Body fat after work
RL FatPB [%]-Right leg fat before work
RL FatPA [%]-Right leg fat after work
LL FatPB [%]-Left leg fat before work
LL FatPA [%]-Left leg fat after work
RA FatPB [%]-Right arm fat before work
RA FatPA [%]-Right arm fat after work
LA FatPB [%]-Left arm fat before work
LA FatPA [%]-Left arm fat after work
TR FatPB [%]-Trunk fat before work
TR FatPA [%]-Trunk fat after work

Fig. 1 Variability of miners' fat level around the median [10]

were compared with a subjective fatigue assessment on a scale from 1 to 10 (where 1 denotes no fatigue and 10: extreme work-induced exhaustion). Such assessments were made by means of a test questionnaire developed by the authors. The arithmetic mean subjective assessment was 5.08, which corresponds to the expected average. This result was directly proportional to fat tissue loss [7–10] (Fig. 1).

In devising a worker fatigue management system, it is advisable to examine changes in the body composition of the workers. This will help detect health conditions as well as any fatigue levels which require immediate preventive measures.

4 Conclusions

The physiological parameters of workers carrying out hard physical labor need to be monitored to identify periods of excessive fatigue and allow for proper recovery. No devices approved for use in bituminous coal mining are available in Poland that would measure and monitor the heart rate in real-life conditions. The interinstitutional research project involving the Poznań University of Technology, the Wrocław University of Technology and the Poznań University of Medical Sciences is expected to produce tools for monitoring the physiological parameters of miners at work and a system for managing fatigue and increasing work efficiency.

The analyses presented hereinabove have been used to formulate recommendations on the application of measuring devices in ergonomics. The measuring experiments made it possible to select physical and mental parameters that are crucial for monitoring employee reliability. The parameters will be critical in constructing a fatigue management system that may be used in a range of professions in which the performance of work leads to increased metabolism.

This paper has been written as a follow-up to the project entitled: “A fatigue management system for workers employed in underground hard coal mines”. The refinancing contract is SP/K/10/234194/14.

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The Maintenance Management in the Macro-Ergonomics Context

Malgorzata Jasiulewicz-Kaczmarek, Anna Saniuk and Tadeusz Nowicki

Abstract The future factory empowers managers with new capabilities and enables the realization of sophisticated approaches based on the collaboration of devices, network services within the single enterprise and among enterprises. This is a key issue especially for the maintenance. Technical systems are no longer passive, but became active entities that can do self-monitoring, proactively inform third party services about their status or maintenance needs and therefore greatly enhance existing efforts for remote and autonomous maintenance. Influence of the Industry 4.0 approach on working mode is nowadays the issue widely discussed. Does it lead to the insensate production where there is no place for human factor?

Keywords Future factory · Human factors · Maintenance management · Macro-ergonomics

1 Introduction

The future factory empowers managers with new capabilities and enables the realization of sophisticated approaches based on the collaboration of devices, network services within the single enterprise and among enterprises. The integration of

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the Internet into production machines, smart sensors, autonomous transport systems and self-organized production facilities—all increase the complexity of manual workstations and will be accompanied by changing tasks and demands for humans in smart factories. This is a key issue especially for the maintenance. Maintenance system is a set of organizational units and relations between them defined by maintenance processes accordingly to technologies accepted and used. Thus, maintenance system has the characteristics of socio-technical systems [1]. The technical subsystem comprises the devices, tools and techniques needed to transform inputs into outputs in a way which enhances the economic performance of the maintenance. The social system comprises the employees (at all levels) and the knowledge, skills, attitudes, values and needs they bring to the work environment as well as the reward system and authority structures. Analyzing maintenance management system in macro-ergonomic context (property issues, structure and goals are defined using formal rules used for organization as a whole), it is possible to take into consideration not only system elements, but also the fact that work system design should include relations between these elements stressing human factor and its role in maintenance organization.

The goal of the paper is presentation of the maintenance system and its socio-technical aspects, and the challenges maintenance stakeholders are facing as the consequence of the next industrial revolution referred to as Industry 4.0 are the reference point.

2 Macro-Ergonomics

The third generation of ergonomics is macro-ergonomics. It is defined as "a top-down sociotechnical systems approach to the design of work systems, and the carry-through of overall work system design to the design of the human-job, human-machine, and human-software interfaces" [2]. Macro-ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies and processes. Our civilization generates many problems related to human factor that cannot be solved by one branch of expertise, mostly because each branch approaches the problem in a fragmentary way. It is macro-ergonomics which tries to deal with the challenge, as it connects organization and management of work with axiology, sociology, psychology, pedagogy, technical sciences, economics [3]. Examples of relevant macro-ergonomic topics include communication, human resource management, teamwork, participatory work design, community ergonomics, computer-supported cooperative work, virtual organizations and quality management [4].

The concept of socio-technical systems (STS) emphasizes that org-ware and socio-ware are integral parts of a technology [5]. Mumford [6] sees the technology as a "mega-machine". He made two important points about technology: (1) technology is not an external driver of societal transformations, but part of them; (2) configurations combining the social and technical should be considered in order to understand society and technology. Technologists tend to see their environment only in terms of opportunities and constraints for the introduction of their new project But, in fact, the social environment has its own dynamics, and it has already shapes the opportunities for, as well as the ideas about configuration. Therefore, structural aspects of the environment of technologies, and existing systems and sociotechnical landscapes, must be taken into account [5, 7]. STS design methods are an approach to design that consider human, social and organizational factors, as well as technical factors in the design of organizational systems. STS design are intended to ensure that the technical and organizational aspects of a system are considered together. The outcome of applying these methods is a better understanding of how human, social and organizational factors affect the ways that work is done and technical systems are used [8].

This approach is specifically important nowadays, as managers are facing challenges of the fourth industrial revolution.

3 Future Manufacturing and Human Factor

Recently, the emerging technologies (e.g., Internet of Things (IoT), wireless sensor networks, big data, cloud computing, embedded system, and mobile Internet) are being introduced into the manufacturing environment [9]. In the literature on production, the changes are referred to as the next (fourth) industrial revolution. Historically, the first industrial revolution was triggered by the invention of the steam engine and the mechanization of manual work in the 18th century. The second revolution involved the implementation of mass production techniques in the early 20th century, and a third happened when electronic systems and computer technologies started to be used for manufacturing automation. The fourth one is commonly called "Industry 4.0". The term Industry 4.0 was coined and first introduced in 2011 at the Hannover Fair. Industry 4.0 is a high-tech strategy of the German Government, which promotes the computerization of the manufacturing industry [10, 11]. Some of the key aspects addressed by Industry 4.0 are [12]: (1) the IT-enabled mass customization of manufactured products, in which production must adapt to very short batches or even individual needs, (2) the automatic and flexible adaptation of the production chain to changing requirements, (3) the tracking and self-awareness of parts and products and their communication with the machines and with other products, (4) the improved human machine interaction paradigms, including the coexistence with robots or radically new ways to interact and operate in the factory, (5) the optimization of production due to IoT-enabled communication in the Smart Factory, (6) the emergence of radically new types of services and business models contributing to new ways of interaction in the value chain.

The goal of Industry 4.0 is the creation of smart factories which key characteristics will not only be adaptability and resource efficiency but also the integration of diversity and ergonomic aspects into production processes. Smart factories allow individual customer requirements to be met and mean that even one-off items can be manufactured profitably. In Industry 4.0, dynamic business and engineering processes enable last-minute changes to production and deliver the ability to respond flexibly to disruptions and failures on behalf of suppliers. End-to-end transparency is provided over the manufacturing process, facilitating optimized decision-making. Industry 4.0 will also result in new ways of creating value and novel business models.

Industry 4.0 predicts that industrial processes, technological infrastructure and all corresponding business processes, with the help of information and communication technology (ICT), will advance to integrated, ad hoc interconnected and decentralized Cyber-Physical Production Systems (CPPS) with real-time capabilities of self-optimization and adaptability [13, 14]. The elements of a CPPS are able to acquisition and process data, and can self-control certain tasks and interact with humans via interfaces (Fig. 1).

To achieve this vision, it is necessary to capture, analyze and interact with both the real—physical- and the virtual—digital/cyber- production world [12, 16]. The goal of Industry 4.0 is the creation of smart factories which key characteristics will not only be adaptability and resource efficiency but also the integration of diversity and ergonomic/human factor aspects into production processes (Fig. 2).

Ergonomics and human factor has always been important to manufacturing, particularly from the industrial revolution when people and machinery were forced together in large-scale mass-production factory environments and socio-technical problems began to emerge as a result. Although manufacturing engineers and managers have traditionally focused on developing technical systems to replace people, there is now an increasing recognition that even in highly advanced and automated production processes people are still essential for various roles [17].

The integration of the Internet into production machines, robotic collaborative applications, smart sensors, autonomous transport systems and self-organized production facilities—all increase the complexity of manual workstations and will be

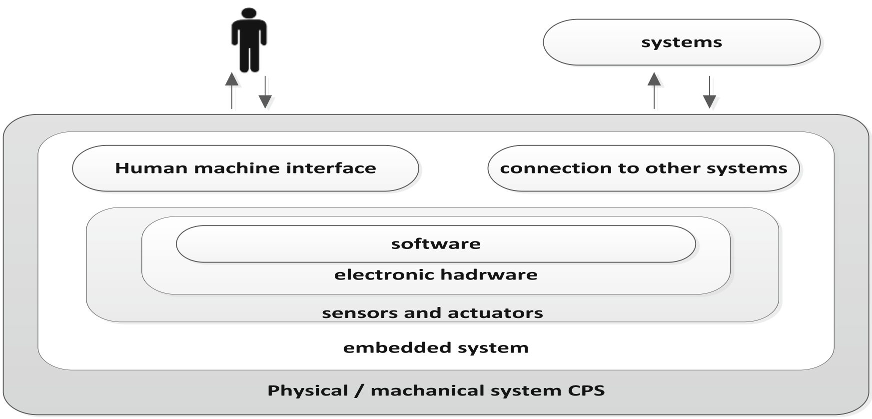

Fig. 1 Interaction between humans and machines in cyber physical systems [15]

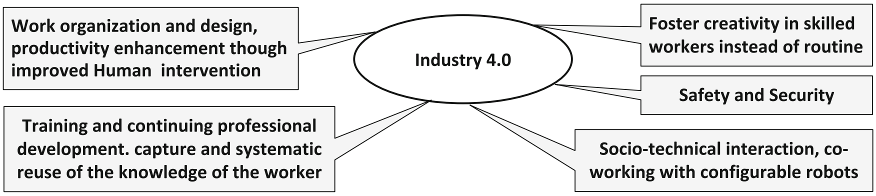

Fig. 2 Industry 4.0—relation with human factors

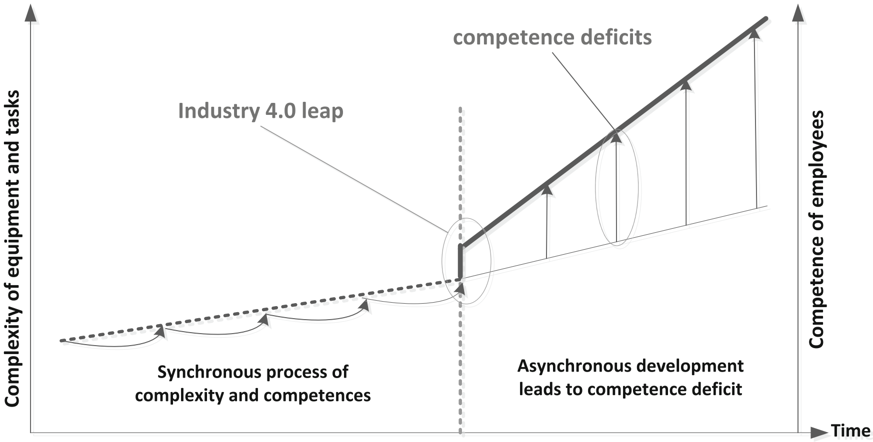

Fig. 3 Increasing complexity of equipment and tasks and competence of employees [18]

accompanied by changing tasks and demands for humans in smart factories (Fig. 3). Companies do realize that the way to a successful Industry 4.0 implementation covers well trained employees, and that refers specifically to employees responsible for planning and engineering, and maintenance of machines, devices and infrastructure. Their tasks and responsibilities will continuously expand and become more complex.

4 Maintenance Management

4.1 Maintenance Objectives

The future factory empowers us with new capabilities and enables the realization of sophisticated approaches based on the collaboration of devices, network services within the single enterprise and among enterprises. This is a key issue especially for the maintenance. Technical systems are no longer passive, but become active entities that can do self-monitoring, proactively inform third party services about their status or maintenance needs and therefore greatly enhance existing efforts for remote and autonomous maintenance.

The main objectives on maintenance management are: ensuring the plant functionality (availability, reliability, product quality etc.); ensuring plant and environmental safety; ensuring cost effectiveness in maintenance [19] and effective use of resources (energy and raw materials). The fulfilment of maintenance management objectives is highly dependent on the proper mix of resources and the development of good communication between all participants. Clearly, the choice of the structural elements of maintenance is not independent from the environment. Factors like the business context, society, legislation, outsourcing market, will be important. Furthermore new manufacturing trends, such as the Industry 4.0 context, will influence the current and future maintenance management enormously. A whole new era for maintenance is expected as communication barriers are bridged and coordination opportunities of maintenance service become more intense. Two factors—technology and people—are the keys to transforming maintenance processes, in the way enabling meeting requirements of the Industry 4.0 approach. Neither, alone, is the driver of transformation. Certainly technology is a key enabler of transformation. But technology is not transformation. Transformation changes the maintenance processes—the way the work is done. Applying technology without social redesign is merely automation. Applying social change without technical reengineering is merely a reorganization effort. Only transformation, the holistic total-systems combination of the technical and social aspects of processes, will produce success.

4.2 Maintenance Technology

A human centered solution for maintenance has to consider all the future technologies that will be involved in the maintenance process. E-maintenance is the base technology. This technology expresses the emerging synthesis of two considerable trends in today's society: the rapid development of information and communication technology (ICT), and the growing importance of maintenance as a key strategy for managing the product life cycle. One of the goals of e-Maintenance is to achieve agility for supporting and maintaining complex technical systems.

Muller et al. [20] define e-Maintenance as: "Maintenance support which includes the resources, services and management necessary to enable proactive decision process execution. This support includes e-technologies (i.e. ICT, Web-based, tether-free, wireless, infotronics technologies) but also, e-maintenance activities (operations or processes) such as e-monitoring, e-diagnosis, e-prognosis, etc." The e-maintenance enables four main different maintenance strategies [20] such as: remote maintenance, predictive maintenance, real-time maintenance and collaborative maintenance.

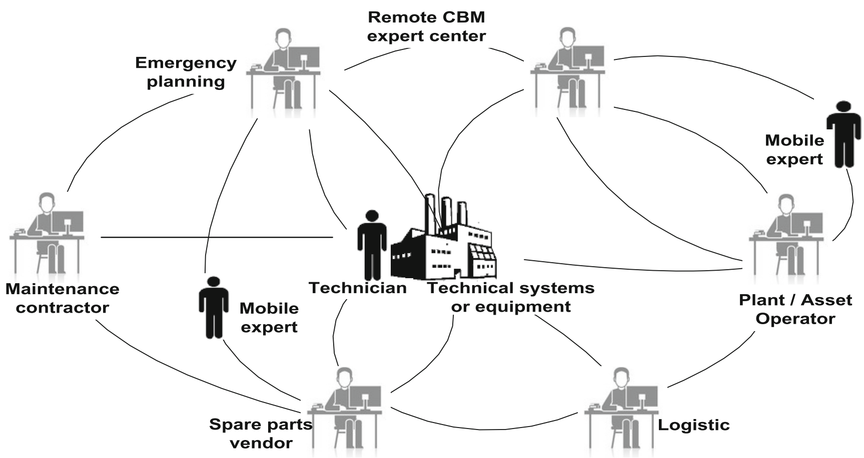

Fig. 4 e-Maintenance environment [21]

e-Maintenance seeks to implement maintenance management, wherein maintenance operations, planning and decisions data and tools to process and act upon them become available anytime, anywhere and to anyone at multiple levels of operation outside and inside factory (Fig. 4).

From internal perspective of a company, all the echelons of factory are consumers of the e-Maintenance solutions. At the strategic level, e-Maintenance deals with making available the IT tools needed to support making decisions about the maintenance policy to be adopted, as well as with defining this policy and assigning its execution to lower hierarchical maintenance layers. In this level interfaces with internal and external stakeholders are needed [22]. At the tactical level, e-Maintenance provides enabling tools and in formation mediation to facilitate the implementation of the maintenance policy selected at the strategic level. It provides seamless interfaces with CMMS data and the central ERP system in order to ensure that the necessary resources, services and management means necessary to the maintenance intervention execution are made available. At the operational level, e-maintenance provides enabling technologies and tools to integrate functions related to monitoring component degradation status and availability state, support personnel decisions with diagnostics and prognostics information, as well as support the estimation of performance indicators [23]. As research developed by [24] suggests, dimensions of e-maintenance technology readiness in manufacturing firms are mainly influenced by technological and organizational determinants involving technological infrastructure and competence, expected benefits and challenges of e-maintenance, and firm size and ownership. In case of e-maintenance technology, adoption strategies should be built around fostering level of employees' technological knowledge and skills and technology infrastructure.

e-Maintenance is the base technology, but there is also IoT, with RFID and WSNs, Semantic Web, and visualization technologies, such as AR. In the coming years, the IoT will be fundamental in improving productivity and efficiency in every industry. The IoT will enhance machinery and equipment management processes by introducing more automation, real-time data analysis and intelligent decision-making. There are several ways the IoT can improve the way machinery and equipment are managed: (1) Greater adoption of Predictive Maintenance—The main reason for applying IoT to manage assets is predictive maintenance. Rather than performing routine calendar-based inspections and component replacement, predictive techniques monitor equipment for pending failures and notify maintenance staff when a part replacement is required. Sensors embedded in equipment check for abnormal conditions and trigger work orders when safe operating limits are breeched. (2) Real-Time data analysis—The IoT takes Machine-to-machine (technologies that allow machines to communicate with each other) to the next level by including a third element: data. The availability of all machine data in one virtual network gives original equipment manufacturers the ability to aggregate and analyze the data to generate better predictive analytic models. (3) Accurate performance metrics—Availability, reliability and other key performance metrics such as mean time between failures (MTBF) and mean time to repair (MTTR) can be calculated automatically by the system and fed to reporting dashboards. This removes the human element in capturing all downtime, ensuring the data is as accurate as possible. (4) Remote assets. The connected assets generating their own work orders in the CMMS with a proposed list of action items and recommended list of spares to complete the job will reduce the mean time to repair. (5) Recommended repair actions. The complete data on failure can be collected, segregated and performer in the real time using cloud technology. Repair options can be taken automatically by the system, and actions can be recommended to the technician. All possible failure data will be used to direct the repair, including system operating conditions at the time of failure, previous repair data from the CMMS, wear patterns and operating data from the equipment. In effect, the technicians will be able to perform their work more efficiently.

The true value of the IoT can only be fully realized when managers take a holistic view of machinery and equipment management. Powerful virtual cloud networks will continually collect, aggregate and model data to then accurately predict failures and put contingencies in place to limit their impact on system availability. The IoT will become fundamental in improving asset reliability and driving cost takeout by delivering real-time, intelligent and actionable data to connected systems or the production and maintenance staff.

However, before companies reach the level of being the IoT data-driven organizations, and "flying maintenance robots in production halls and using drones to make inventories of warehouse stock levels and deliver spare parts, at any time of day or night and in any terrain and weather" [25], are simply routines in the autonomous and smart factories of the future it may take time for company. But, the change is coming, and companies should be prepared for it. Each and every change in technology results in changes in social systems. Hence, preparing people to changes and designing suitable work environment is the challenge practitioners and scientists are facing.

4.3 Maintenance Staff

The introduction of new technology is heavily context dependent, not only because of the learning that has to occur, but also because of the socio-technical linkages and regimes that exist already, and that might be created. The actual trajectory toward such a future depends on the cumulative effect of moves taken now, in the context of the present regimes. Looking at socio-technical systems makes it inevitable to take an analytical view on actors. Their specific interests, tasks, and activities and the technology used to support them are at the center of the socio-technical system.

In this context, ergonomics becomes a fundamental field of study to define and discuss the interaction among workers and other elements of the future factory system in order to improve human well-being and the overall system performance.

There are three factors to have a large influence on the human factor and fundamentally change in a factory of the future:

- tools and technologies—which refer to all kinds of tools and technologies that the maintenance staff uses and by which the maintenance staff is affected [26].
- organization and structure—which includes the organizational setting in which the maintenance staff performs their work.
- working environment—which considers the physical environment that directly affects the maintenance staff because they perform their work within the working environment.

The work performed by the maintenance staff on the shop floor, by maintenance managers in a factory of the future will differ significantly from the situation in today's factories. Consequently, the qualifications and skills of the maintenance staff and maintenance managers, which are required to fulfil the tasks occurring in a factory of the future, will differ as well. The qualifications and skills of future maintenance staff should be divided into two groups: technical and personal qualifications and skills (Q&S), and then classified with their relative importance (must, should and could—"MuShCo" technique [27] (Table 1).

Qualifications and technical skills are the natural requirements as long as the technical departments staff is concerned. However, additionally to technical skills, soft skills such as social and communication skills as well as team working and self-management abilities become very important for the skilled labor, as well. Currently, the typical maintenance worker does not enjoy training in those areas because the job content does usually not necessitate the application of these skills. However, in a factory of the future, there will not only be significantly more teamwork on the shop floor level but also more teamwork and communication in daily business. Due to greater responsibilities and influence of the workers, there evolves a need for self-management and other general management skills [28].

Table 1 Qualifications and skills of future maintenance staff

	Must…	Should…	Could…
Technical Q&S	IT knowledge and abilities	Computer programing	Interdisciplinary/generic knowledge about technologies and organizations
	Data and information processing and analytics	Knowledge about technologies	Awareness for ergonomics
	Specialized knowledge of maintenance	Statistical knowledge	Understanding of legal requirements
	Organizational and processual understanding	Awareness for IT security and data protection	–
	Ability to interact with modern interfaces (human-machine/human-robot)		–
Personal Q&S	Adaptability and ability to change	Focused for improvement	–
	Team working abilities	Mindset for lifelong learning	–
	Social skills	Trust in new technologies	–
	Communication skills	–	–
	Self-management	–	–

5 Summary

Similar to the previous three industrial revolutions, the fourth industrial revolution with its advanced manufacturing and information technologies provokes a change process for the people working in direct and indirect areas of manufacturing. The people will have to be able to adapt to the new technologies and the organizational changes they imply. A central part of this adoption process will be preparation of qualification principles for workers that make them ready for the new area of modern manufacturing and maintenance systems, including greater competences within the area of analysis, abstractive thinking, problem solving and decision making.

It is widely discussed whether Industry 4.0 influences the future working mode. Is it going to bring about de-humanized production processes, work in which there is no place for human factor? Quite contrary. It is human being with its skills who shapes the new mode of cooperation between people and technology available—and not the opposite. Just like in the case of the previous industrial revolutions, also the fourth one is to be initiated and completed with human hands. According to authors' opinion the fourth industrial revolution will result in creating new jobs and workplaces, though they may differ from the present ones. The capabilities required in the next few years are to be completely different from the ones required now, hence future generations will have to increase and change their qualifications constantly, and what is even more important follow the new, changed approach to work and way of thinking.

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Agreement for Safety in the Building Sector as a Good Practice to Improve Safety in the Work Environment

Jozef Fras, Ilona Olsztynska and Sebastian Scholz

Abstract In the field of labor protection system there must be distinguished the Polish legal system, which is the legal scope of work including safety and health as well as the organizational system of state institutions and workplaces. For many years the sector of economy in which there have happened most fatal and serious accidents has been the building sector. A number of factors has impact on this such as the low level of education of workers, the lack of reliable selection of subcontractors and little awareness of the need to comply with health and safety regulations on building sites. However, this situation has begun to change since the founding of the "Agreement for safety in the building sector". This Agreement was established in August 2010 by the largest building companies and its aim was to launch a wide-ranging actions for safety on building sites and reduce the number of accidents at work.

Keywords Work safety · Accidents at building sites · Agreement · Agreement for safety building · Serious accidents · Protection system work · Occupational health and safety (OHS)

1 System of Labor Protection in Poland

In terms of the legal system of labor protection there is a set of organizational units, interrelated subsidiaries and/or cooperating in order to protect workers' rights as defined in the labor law and the law on the basis of which workers perform their

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tasks. In Poland, the system of labor protection includes two ranges: the legal system and the organizational system. The first of these is an integral part of the Polish labor law and informs the current legal standards and their location in the hierarchy of sources of law relating to health and safety. The other is the organizational system of labor protection at the level of the state, the plant and offices participating in the creation and control of occupational health and safety in Poland.

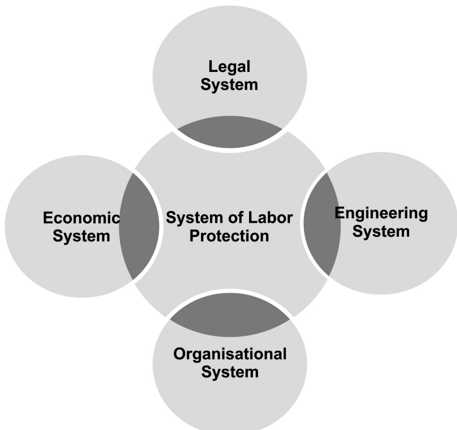
The international law concerning the social rights of workers has identified a group of legislation elements to ensure the safety and health at work. These elements provide a framework to create norms of labor law and the rules of workers' safety and health. In Poland, the general norms of labor law are referred to as the rules of safety and health (OSH). Unlike the norms of international law, health and safety regulations in Poland are the subject of regulations which are the working conditions, while in international law these rules protect the employee.

For years in the field of work safety there were many views on the question what protection labor was. Defining this concept is difficult because it is considered differently by workers and employers as well as by the scientists, philosophers or sociologists. Certainly this is not a clear concept. In economy for many years there was used the definition of labor protection as a set of figures for which they were legal norms and means of research, organizational and technical measures to protect workers' rights and the protection of workers' life and health from factors dangerous and harmful in working environment as well as allowing the workers to optimize operating conditions from the point of view of ergonomics, physiology and psychology of work [1].

In other words, labor protection is a system of legal, economic, organizational and technical elements to ensure workers the safety and health in the work process. Therefore the system must be understood as a set of ordered units for a whole organization (Fig. 1) [2, p. 48].

The organizational system of labor protection in Poland is divided into two levels: national and the factory. The national system constitutes the parliament,

Fig. 1 Determinants' system of labor protection [2, p. 51]



government, ministries and other government offices, state supervisory authorities and controls that have different tasks, and the factory system constitutes the regulations deployed in them.

In the Polish legal system, work safety and workers' rights are guaranteed by the Constitution of the Republic of Poland. This is the supreme act of the Polish law. This Constitution states the right to safe and healthy working conditions, in particular its Articles. 24 and 66 where the State guarantees everyone in Poland working conditions [3]. The act regulating the rights and duties of citizens in this area is the Labor Code. It was established by the Act of 26 June 1974 [4]. This Code includes within its scope safety and health as well as the organizational system of both state organizations and private entities. Basic Code regulations in the field of health and safety are listed in Chap. X of the Code relating to health and safety, in Sect. VII concerning the protection of women and in Sect. IX concerning the protection of young people at work. While Article. 9 of the Labor Code indicates other sources of labor law, especially normative agreement concluded between the social partners, it is the Collective agreements and other arrangements.

The Labor Code over the years has undergone numerous changes, including the implementation of the directives of the European Communities.

The Code acts concern generally applicable law as well as provisions of other areas of law regulating the matter of health and safety. Such regulations are construction law, mining and geological or nuclear law, others.

The group of generally applicable law also includes some technical standards. Technical norms are issued under the Act of 3 April 1993. Normalization [5]. The rule set out in Article. 13 of this act of law is that technical norms are voluntary but they may be mandatory if the relevant ministers introduce an obligation to use them [5].

The employer according to this document is responsible for the implementation and compliance with the rules of work and safety at the plant.

The plant can also be enacted as legislation constituted, which is contained in a multi-employer and company collective bargaining agreements. It is regulated by the Labor Code.

The document regulating matters of health and safety in the workplace is also working rules created on the basis of the Labor Code. These rules include regulations regarding equipment workers in clothing and footwear and personal protective equipment and hygiene, lists of work prohibited in the employment of minors and women. Work regulations are determined by the employer in consultation with trade unions of the organization, or set on their own when there are no trade unions in the plant.

Safety rules are rules on non-legal model of general clauses. This means that they are not legally defined or defined in the regulations, however both the employer and the person in charge of the employees and the employees are obliged to follow them, and the violation or non-compliance of these rules may lead to sanctions provided for in the Labor Code. In theory, the safety rules are considered to be rules of conduct arising from life experience and scientific and technical evidence.

In accordance with national regulations it is the employer to be responsible to ensure safe and healthy working conditions in the workplace [4]. These tasks are performed using specialized services of health and safety at work and a physician responsible for taking care of workers' health. Additionally, in the workplace there is the working committee, which is a consultative and advisory body, responsible for health and safety of workers. In certain workplaces there also operate trade unions and social labor inspectors [6]. They fulfill functions of supervisory and control regarding compliance with the employer's obligation to provide safe and healthy working conditions.

2 Construction Sector to Improve

Despite numerous acts of law and non-legal regulations in economies of each country, including Poland, there are still severe and fatal accidents. In comparison to other European Union' countries the number of fatal accidents in Poland per 1000 employees is located at the middle level and does not change since 2000 (Fig. 2) [7].

In Poland in particular industries, the number of accidents is different. Sectors, for which the index of number of serious and fatal accidents is the highest are: building, mining and manufacturing (Table 1).

Number of fatal accidents is still the highest in the construction industry: 127 in 2008 [8], 118 in 2009 [9], 112 in 2010 [10], 82 in 2012 and 71 in 2013 [11], and in 2014–55 [12].

For comparison, the number of mining fatal accidents is as follows: 31 in 2008, 41 in 2009, 27 in 2012, 18 in 2013 [11] and 25 in 2014 [12].

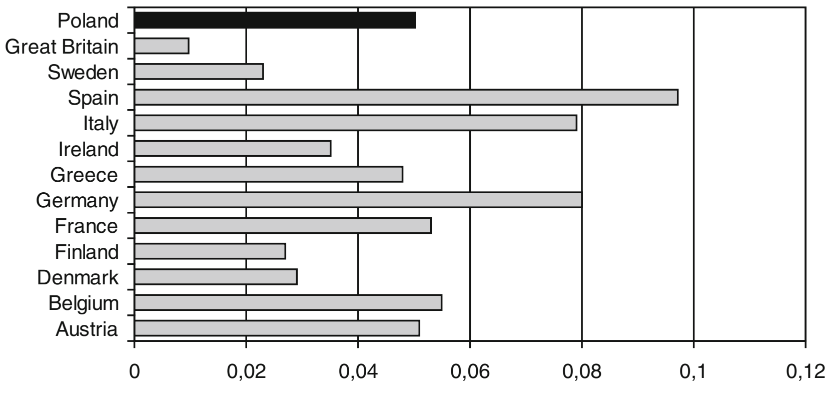


Fig. 2 Indicator of fatalities in accidents at work in selected EU countries and in Poland (2001)—Accident rate per 1000 employees

Table 1 The number of victims of fatal and serious accidents in chosen sections of the Polish economy in 2011 [14] and 2014 [12] (Accident rate per 1000 employees) (Own study based on data from the Central Statistical Office)

Year	2011			2014		
Accidents	Total	Fatal	Serious	Total	Fatal	Serious
Total economy	8.34	0.035	0.06	7.53	0.22	0.04
Mining	16.69	0.166	0.13	13.56	0.147	0.17
Manufacturing	13.70	0.035	0.11	11.70	0.022	0.010
Building	10.39	0.112	0.16	7.91	0.069	0.09

It means that, statistically, the average for the period of 2008–2010 was for construction approx. 120 fatal accidents per year, which means that every 3 days there was killed one man at a construction site.

The main reason for this is the lack of skills of construction workers, non-compliance with safety rules and imperfect security system [13]. The most common accidents are falls from height, falling object hit or being crushed. The most dangerous is work on roofs, scaffolds as well as in deep excavations. Every second there is a victim of the construction whom is the employee with work experience not exceeding three months on site [13].

Because of the importance of the construction industry in the Polish economy, many companies that have been increasingly working on principles of subcontracting and a high level of employment in this sector, have decided that in cooperation with the State Labor Inspection that measures shall be taken to improve the security situation in this area.

Statistical data collected each year by the Central Statistical Office has allowed an analysis of accidents in the construction industry. These analyses and conducted inspections of the State Labor Inspectorate in companies have shown that the most important factors influencing the number of accidents are: low level of education of workers, the lack of reliable selection of subcontractors and little awareness of the need to respect health and safety regulations at the construction site.

3 Agreement for Safety in the Building Sector

The document “Agreement for Safety in the Building Sector” was initiated by the Chief Inspector of Labor, with the support of the Polish Association of Construction Engineers and Technicians. It was the result of the awareness that the actual improvement of safety on Polish construction sites can only be done by conducting comprehensive measures. Currently these activities are also supported by the Trade Union “Builders”, the Polish Association of Construction Industry Employers, Secretariat Building and Wood Industry “Solidarity” and the Polish Board of Civil Engineers. August 26, 2010 on the initiative of the President of the Association of Civil Engineers and Technicians, Victor Piwkowski and the Chief Labor Inspector, Tadeusz Rabbit, six General Contractors—Bilfinger Berger (now Porr Infrastructure), Budimex, Hochtief Poland, Polimex Mostostal, Skanska and Warbud —concluded an agreement for Construction Safety. On September 13, 2010 Mostostal Warszawa joined this agreement. followed by Mota Engil C.E (October 23, 2013) and Erbud and Unibep (February 4, 2015) [13].

Pursuant to this agreement, the company should intend to improve the standards and safety culture in the construction sector in Poland, in order to reduce the number of accidents at work, in particular fatal accidents [13].

To work on the initiatives of the Agreement there was established a working group, composed of the heads of health and safety of all signatories. Also there was established the Steering Committee of this Agreement, which coordinates the work and approve the terms of the working groups and initiates development following this Agreement. In the framework of cooperative work there are set goals to implement the Agreement and defined common areas which tends to result in action. The result of this work was the creation and signing of March 21, 2011 by the presidents of the seven companies of the document named "Standards minimum requirements for subcontractors" in the division on the contractual provisions as well as training and additional qualifications. During the meeting, the current representative of the President of the Polish Republic declared its full support activities for safety in construction. Records of documents are fixing for all signatories to the Agreement and associated subcontractors.

On September 2011, the Agreement was changed and there was introduced an annual presidency which will act as in sequence of each of the signatories. Since October 2011 the chairmanship of the Agreement has been taken over by the Skanska company and a working group started regular work on its projects under this Agreement [13].

3.1 Areas of Action [13]

The main objective of the Agreement is the total elimination of fatal accidents on Polish construction sites. Therefore, it defined five areas of activity, which were then divided into projects developed by working groups under the Agreement. These areas of activity are implemented according to the approved schedule, and the final effect of each project is approved by the Steering Committee of the Agreement.

Qualified Workforce. One of the main reasons for accidents in construction is the lack of experience and skills of workforce. Therefore the replacement of low qualified workers with those professionals having formal education in construction or of certified practical skills is a way to solve this problem. For this purpose, a Certification System, whose purpose is to allow confirmation of professional qualifications by passing the test and getting the certificate. In this way the employee gets a certificate of specific skills gained for example during the previous work, without having to school leaving for many years. This system is in the process of implementation and in future it will be required to have certificates for all employees on site, including subcontractors.

Health and Safety Training. There is lack of knowledge of the correct use of the equipment of individual and collective, as well as carelessness in the approach to the risk that some of the causes of accidents are at construction sites. Health and safety training on equipment and procedures are a way of making employees be aware of the dangers of working. In this area of activities there are identified four types of training, which are standardized and developed for all companies and construction workers. Standardization refers to creation of common principles and guidelines providing training and materials to carry them out. The above mentioned Agreement provides for:

- Information training for employees before starting a work;
- Regular training for employees;
- Workshops for workers—short (15 min) workshops for employees carried out on each site in the field of reminders knowledge of health and safety;
- Training for supervisors—traditional training and e-learning in the field of health and safety.

Subcontractors. Currently in Poland, the amount of work on construction made by subcontractors is up to 70 % of all workforce carrying out the investment. Therefore, the Agreement provides for building awareness of health and safety in companies cooperating with general contractors and assisting them in improving safety standards. The Agreement wants to cooperate with subcontractors for whom life and health of employees is important and who want to participate in improving the standards of health and safety. Activities in this field are formulated by the signatories of the Agreement in the following manner:

- Unification of contracts—aims to introduce common document for all signatories to the Agreement, describing the expectations of general contractors to subcontractors regarding their compliance with the requirements for health and safety;
- Pre-qualification—involves the cooperation with companies that care about the compliance with safety rules and promote safe behavior on construction sites. The purpose of this system will be prequalification assessment of potential subcontractors for compliance with health and safety criteria;
- Introductory meetings—subcontractor starting work on site is familiar with the rules and expectations of the general contractor during the meeting, along with adoption of work to be done.

Risk Management. Identification of emerging risks and development of effective methods in order to eliminate them allows to minimize the number of accidents at construction sites. For this purpose, there have been created documents, which allow subcontractors and supervisors for effective identification of risk and the choice of the appropriate measures for the protection (individual and collective).

- Risk assessment and IBWR—Instructions for the Safe Work Done deal is a document prepared by the subcontractor before contracted work on the construction site. It examines tasks to be performed for the occurrence of risk. In carrying out this analysis subcontractor proposes solutions to eliminate the danger. IBWR as a model is common to all signatories, so it will be easier for subcontractors who work for several general contractors at the same time, and so will be able to expect the same requirements on all construction sites.
- Standards for the work particularly dangerous—Based on the analysis of the accident there is set up a list of works that make the greatest risk to workers. For these works there will be developed common standards including both the use of personal protective equipment and collective and procedural solutions.

Occupational Health and Safety Culture. Building awareness and a culture of occupational health and safety among construction workers as a society, is as important as the development of procedures, protective equipment, etc. Improving safety and protection of life and health is not a luxury, it is the obligation of employers and accountable state institutions]—this is the philosophy of the Agreement. In order to build an occupational health and safety culture area, the Agreement consists of:

- sharing of good and bad experiences—this action is aimed at sharing of good and bad practices by the signatories to promote best practice and to prevent accidents. The project involves the creation of a database containing information which will be available to members of the Agreement and a calendar of the current meeting, on which it will be discussed current issues in the field,
- internal and external communication—implies effective exchange of information between the signatories and the promotion of activities outside the Agreement. The aim is to promote this idea, inter alia, through taking part in conferences and trade fairs, as well as to cooperate with institutions that are interested in promoting the culture of occupational health and safety on construction sites.

Safety Week. In the framework Agreement, for two years, there has been carried the initiative called the "Safety Week". In the framework of this action in Poland, many construction sites signatories to the Agreement conduct various activities to promote the culture of occupational health and safety. The first such initiative, carried out on such a large scale at the same time, took place on May 5–11, 2014. It was an opportunity to reach out to all employees, both own and the majority of subcontractors on the Polish market. The Second Safety Week was organized on May 18–24, 2015. Activities during this period of time were carried out on the construction sites of companies-signatories of the Agreement for Construction Safety (10 largest companies in Poland), too. The organized events were attended by more than 30,000 employees and subcontractors. The project was also actively joined by the State Fire Service, business partners, suppliers and investors. Honorary patronage of Safety Week took Chief of Labor Inspector. Activation measures in the health and safety of employees during this event include: lectures, training in first aid, exercise of the stock of fire, road rescue and storing gases on site. There are also organized exhibits of new solutions and technologies to improve safety. As part of this initiative, some construction sites have been visited by school children and students. The objective of these activities was to learn to cooperate in the area of health and safety.

The Safety Week will also be organized in the future.

4 Improving Work Safety on Construction Sites

The results of the initiative Agreement for the safety in the building sector are visible today. There is a clear decrease in the number of accidents at construction sites since 2010, that is, from the signing of the first signatories of the document establishing this initiative.

Standardization of health and safety requirements and training for all subcontractors are solutions that are successfully implemented and now apply to already 50 % of subcontractors. This allows for easy adaptation of the construction companies to the requirements of the owner of the contract and unifies each equipment companies in the health and safety measures.

For several years, since the establishment of the Agreement, there have been noticeable differences in equipment health and safety and the use of personal protective equipment for workers in the construction sites run by the signatories, in contrast to other companies (non-Agreement). This initiative is national in scope and influences not only the awareness of employees employed by the company signatories of the Agreement, but especially the awareness of subcontractors and their employees, and this deserves the general approbation and should be promoted in other countries.

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A Process-Oriented Design Knowledge Management Method

Biju Yin and Yan Xiong

Abstract Product design process is the information interation process with knowledge-driven. According to the characteristics of design process, a process-oriented design knowledge classify strategy based on cognitive theory, information technology and design theory was established. The three-layer knowledge model was put forward based on knowledge property, knowledge extraction and application with semantic ontology search was discussion, then the immigration, association, synthesis, reasoning of knowledge were realized. Finally, an instance of refrigerator was used to verify the feasibility.

Keywords Knowledge representation · Design process · Knowledge property

1 Introduction

With the emergence of knowledge economy, knowledge has become an important asset for many enterprises in the 21st century. The product design is a knowledge-driven innovative design process, which includes conceptual design, detailed design, engineering analysis and performance evaluation. As the products tend to functional integration and composition, the knowledge involved in the design and the related subjects are more and more, how to organize, storage, acquisition and create knowledge effectively has been the important question that the enterprises face.

The researchers kept exploring on the organization, storage and acquisition of design knowledge, for example the engineering knowledge management project

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WISE in Europe [1], Nonaka et al. [2] established the management and evaluation system of dynamic knowledge assets, Linhuiping [3] put forward the knowledge modeling based on meta-model. However, there are still some problems (1) design knowledge management was usually suitable for the product detailed design process [4]. (2) The traditional knowledge organization kept emphasis on the management of file, engineering data and workflow from the macro level and ignored capturing and storaging design knowledge in the design context. (3) Knowledge is the key factor of creativity, knowledge organization methods should be established from the creativity level.

According to the above discussion, from the definitions of knowledge, design knowledge was classified with the characteristics of different design phases, and then knowledge representation based on knowledge property was put forward in this paper. This knowledge representation and management makes design knowledge flow between the different design phases as the unified form and provides innovative supports for product through the relationship among knowledge.

2 Product Design Knowledge

Data is thought as raw numbers and facts, information as processed data and Davenport and Prusaki define knowledge as 'Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information'. From the natural property, knowledge is dynamic, systematic and incomplete transferability [5, 6]. According to the design process framework or relative context, absorbing, migrating, reorganization or creation knowledge will form the decisions in design process.

Product design is the problem-solving and integration process. From problems identified to detailed design, a lot of different knowledge is applied in the different phases, the knowledge recourses are different including the experiences and communications of designers, knowledge casebase constructed with enterprises knowledge, external patent library, standard library and scientific effect library. From the cognitive theory knowledge, through socialization and explication customers' implicit requirements are transformed to explicit conceptual knowledge; then original knowledge and new knowledge were combined into new product system knowledge prototype (systematic knowledge), this systematic knowledge is stimulated to process knowledge for mass production through internal conversion. Customers' implicit knowledge and engineers' implicit knowledge are intertwined together to optimize and develop new products.

In the design process, the application scopes and methods of design knowledge lie on the familiarity degree of the design context for designers and the abstract level of design objects. According to Cognitive theory, the higher the knowledge's abstract level is, the higher the innovative level is. The upper abstract knowledge expresses the nature of lower specific knowledge concisely, so the upper abstract knowledge has guide meaning for the problems in the problem scope. In the design requirements' analysis phase, knowledge including design methods and inventive principles provide the support for design direction. In the Function solving phase, comprehensive Principles knowledge which fulfill product requirements functions need to be provided, therefore product design are not limited in the specific design knowledge, the innovations will be realized at the higher innovative level. In the detailed design phase or in the structural design phase, the expertise and special knowledge in the different subjects and domains needed to perfect design processes with aid of multidisciplinary optimization. So according to the different supports of product systematic innovative process, this paper classified design knowledge into principles Knowledge, domain knowledge and comprehensive knowledge, these three items combined together constructs product design knowledge model, showed as Fig. 1.

Principle knowledge is design methodology and theories and is the high degree of abstraction of design knowledge, including design methods/principle, Invention principles and scientific effects. It refines design thinkings and defines design specification, such as Design problem representation, requirement analysis, Triz theory, Evolution rules, Axiomatic Design, FBS design method. Domain knowledge is specific knowledge in the different domains, including the fact, definitions, experiments and operations; comprehensive knowledge includes patent knowledge,

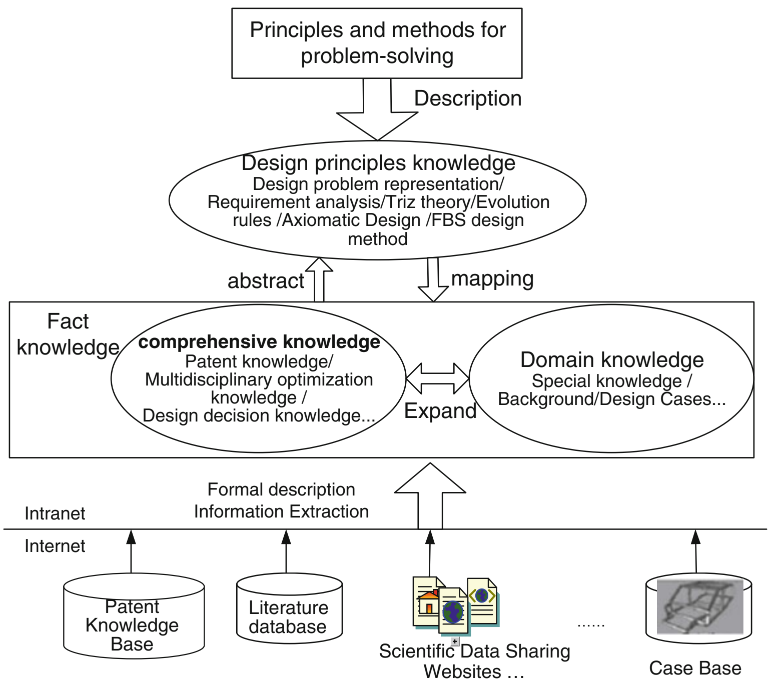

Fig. 1 The classification model of design knowledge

multidisciplinary optimization knowledge, design decision knowledge etc. It is comprehensive experiences used to solving ill-structure problem, and abstract expressions and integrations from explicit knowledge to implicit knowledge. Domain knowledge and comprehensive knowledge are summarized as fact knowledge.

Three classes knowledge that discussed above have closed relations. A design method or principle for problem solving is used in several domain knowledge or comprehensive knowledge. The fact knowledge are applied in several relative problem-solving methods and principles. The processes for design method and principle applied in fact knowledge are mapping processes. The design principle knowledge and design methods abstracted from fact knowledge play guide roles in applying fact knowledge in the design process, and determine the design steps and processes. For example, a set of Axiomatic formal logic system is used to deducted product conceptual development process in Axiomatic design, the relative principles and theories help producing good design examples; the design principles that Embedded in the parameters can be used in specific engineering calculation, solving complicate and structural problems. Knowledge is expanded with abstract degrees to support and simulate design processes and help establish design knowledge base for aided innovative design.

3 Knowledge Modeling Method Based on Knowledge Property

Product design is a complicated process. The premise of realizing knowledge sharing is the uniform knowledge representation and description taken by designers in the organizations. There are 3 basic requirements for knowledge representation model: (1) explicit knowledge and implicit knowledge can be described clearly with knowledge representation; (2) Knowledge representation model can be merged with the researches of design theories and methodology to support designers. (3) Representation model should be developed with advanced compute technology, such as object-oriented technology, distributed multi Agent system model and distributed object model. This paper put forward three layers knowledge representation model based on knowledge property, and then knowledge management and sharing will be realized effectively.

3.1 The Definition of Knowledge Property

Product design processes lie on the supports of design knowledge and experience. With some uncertain degree especially for implicit knowledge, this undescribtion property of knowledge itself was transformed as a set of numerical and language description based on the characteristics of different design phases, through the detailed description or values, the property can be defined. In the problem determination phase, we should standardize customers' expected requirements; in the problem defining/representation phase, function requirements should be structured; and in the strategy formation phase, relative structural designs that realize product functions should be considered. In order to produce the uniform representation and extract key factors in the design process, the representation of design knowledge property are divided into three parts: expected property—extracting customers' requirements, semantic analysis and QFD method were used to Standardize the definition of customers' requirements; functional property—defining and structuring function representation, performed functions and behavior results should be expressed in this phase; such as functional entity; form property—the definition of product structure characteristics, such as products' geometry and material properties.

3.2 *Knowledge Representation Model*

In product knowledge representation model, the design knowledge can be expressed as three levels: physical property, knowledge semantic and knowledge property, that is KM = (PT, KC, KT). The product knowledge representation model based on different design phase is shown as Fig. 2.

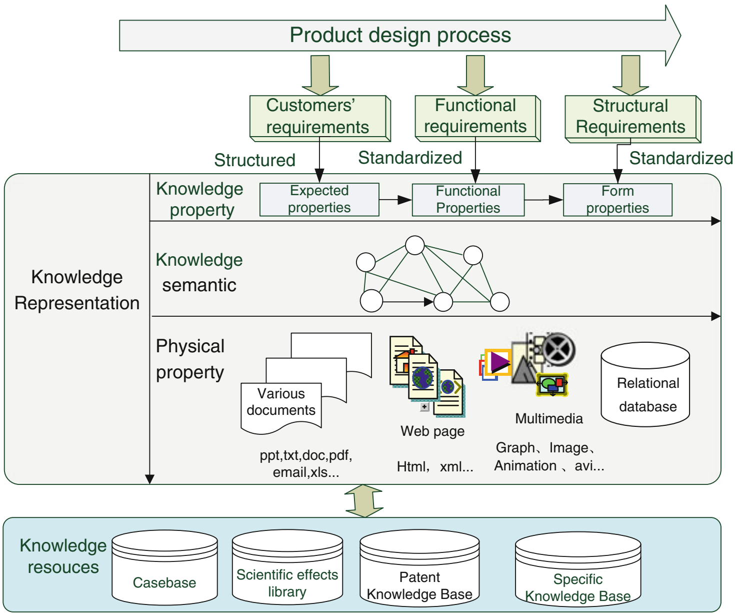

Fig. 2 Product processes Knowledge Representation model

In this model, (1) knowledge property layer: knowledge intrinsic properties are expressed. According to design process, the expected properties, functional properties and form properties are extracted from the abstract layer, and then the product essential characteristics would be got. (2) Knowledge semantic layer: in the design domain designers combine specific operating environment, apply standard semantic forms to describe physical properties, and realize abstract representations of concrete knowledge and analysis of the innovative property knowledge. Describing the knowledge succinctly and summarily then extracting product's semantic index will help to find the similar cases or expressions. (3) Physical property layer: physical property of concrete knowledge structures are expressed, such as documents, graphs, animation and video. The parametric expressions as Mathematical model and symbol formula help designers to get relative knowledge according to the upper layer knowledge semantic and innovative property.

In the representation model discussed above, the contents which reflected in the physical property layer are the channels between knowledge semantic layer and knowledge property layer, design knowledge are described generally and the property are analyzed and extracted further. Through the interactions of explicit and implicit knowledge, knowledge property can be extracted, then the qualitative description will be got, the immigration, combination, association, synthesis, reasoning of knowledge can be realized and the creativity of knowledge will be improved.

4 Knowledge Acquirement Based on the Design Processes

According to the discussion of the classification and representation of knowledge, we can apply unified form to acquire and storage knowledge based on the different phases.

4.1 Customers' Requirements Analysis Phase

In product design, common understandings to the nature and importance of customers' requirements are needed among multi-subjects design teams. In customers' requirements analysis phase, qualitative original customers' requirements can be got through market research and customers' feedback. The key technologies involved are semantic analysis of customers' unstructured natural languages, for example breaking sentences according to semantic analysis, signal words, Syntactic pause. Then the expected properties can be produced. Using expected properties to search knowledge can determine the typy of design tasks: conventional design, innovative design and creative design, then the directions of design are ensured, design strategies or design methods are used. For conventional design the relative knowledge in the physical property layer which have similar semantic environments or conditions can be search directly, then needed knowledge can be got quickly, the knowledge sharing or reuse are realized. For creative design the expected properties are translated as functional properties, design process begins with the definition of functions; for innovation design the expected properties are translated as form properties, then the analysis begins with structural and technological layer.

4.2 Product Function Analysis Phase

The realization of expected properties are based on certain design Principles. In the product principles design phase, principle knowledge, scientific effects or engineering rules are found to support the realization of functions or function entity, then concrete behaviors are constructed with functional principles. The representation based on function entity using semantic graphs was used to express functional properties, shown as Fig. 3. Functional principles can be defined as: Adjective + functional verb + noun, Among them, functional verb + noun is functional entity, and adjective is as the additional Modifier, such as change the hardness.

According to the level characteristics of function granularity, the Top-down Tree hierarchy function affiliations of different products are formed, tree hierarchy functional knowledge maps are got through functional decomposition. The innovative principles and effects are searched according to functional properties, then the agent knowledge body organizes concept searches are established through the membership relations and the correlation of knowledge semantic ontology respectively, the knowledge in the physical property layer. This search mode supports fuzzy Query for designers, and help to improve the innovative level of product design.

4.3 Product Structure Analysis Phase

During the Structure property phase, the structure is the materialize performance of product concept, including geometric and material properties. The structures are restricted by the design principles and Functional requirements. The relations among them are shown as Fig. 4, and then product structural descriptions are got.

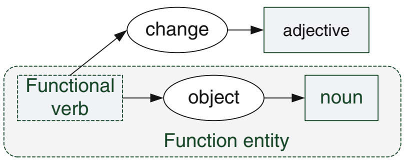

Fig. 3 Functional property representation based on functional entity

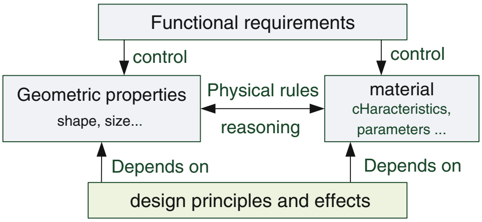

Fig. 4 Structural performance of product concept

According to the representations of structural knowledge, the knowledge was classified, inducted and arranged further, and then the entrance and access of knowledge search are provided to help designers find the required knowledge quickly and accurately.

5 Example

As the Essential electrical appliances in modern family, the main function of Refrigerator is frozen foods. With computer aided product innovative design prototype system, the design idea of refrigerator was got. According to market research, for normal refrigerator Freon is working medium and gas compression are used to refrigerate. The shortcoming of this Refrigeration technology caused customers' requirements: can we find a new method to refrigerate at the room temperature with no pollution and no noise. Through semantic analysis, the expected properties were standardized. After searching the similar cases, the design type can be defined as innovative design, we innovated from function principles. Then standardized the main functional property: reduce the temperature. Using knowledge map to search relative concepts in innovative principles and scientific effects, the principles are phase-change cooling, semiconductor refrigeration, magnetocaloric effect refrigeration… Among them Magnetocaloric effect refrigeration is using a special metal Gadolinium, putting it in Magnetic environment causes the temperature high, removaling it leads the temperature low. According this effect using the Liquid whose freezing point is much lower than pure water as cooling Source, we can make Practical refrigerator with freeze function, the refrigerator knowledge aided Innovative design process are shown as Fig. 5.

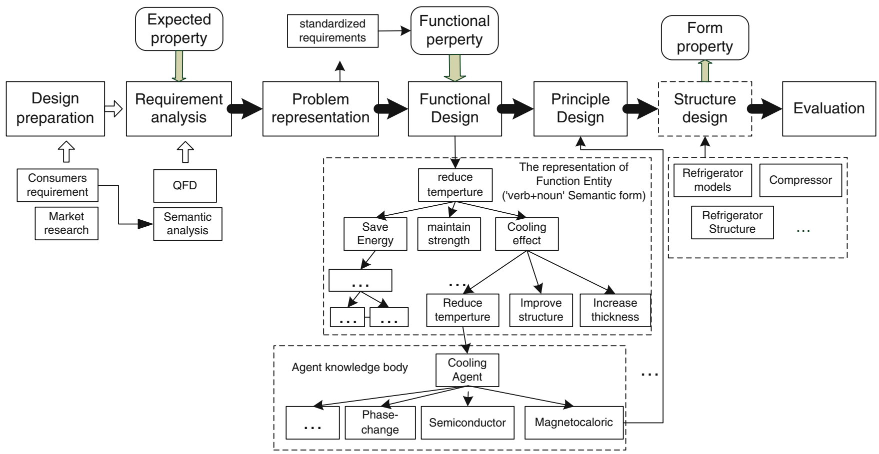

Fig. 5 Refrigerator knowledge aided Innovative design process

6 Conclusion

According to the characteristics of different phases, design knowledge was classified and three layers representation were used to knowledge representation, and knowledge representation, extraction and application combined with design processes were discussed, then the conversion and analysis of explicit and implicit knowledge were realized. This representation helped knowledge integrate and share among design teams, then the development process of new product will be accelerated and new product development circle will be shorten.

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Part II
Social and Occupational Innovation

Caregiver Centered Transfer Aid Designed for Home Care Needs

Kao-Hua Liu and Chien-Hsu Chen

Abstract In this study, an innovative transfer aid is proposed to respond to home care needs of ageing society. The fact that long-term care demanders nowadays prefer to live with their families and friends indirectly results in the gradually increasing number of non-professional caregivers. The incidence of work related injuries of amateur caregivers will be higher than professional nurses. Among all of the nursing activities, patient handling (PH) is the most frequently reported injuries. It is not uncommon to see even the professional nurses getting hurt from transferring patients, not to mention the non-trained caregivers. One of the reasons is that they are not familiar with transfer aids, such as when and how to operate proper aids. Accordingly, the operation of transfer aids for patient handling during home care must be reconsidered and redesigned. Activity theory and Contextual design were adopted in this paper to redesign the caregiver centered transfer aid.

Keywords Home care · Caregiver centered · Transfer aid design

1 Introduction

As ageing society looms, the number of people who need long-term care has grown dramatically recently. Most of them would choose to live with families or friends if they could stay at home or in the community [1], because families and friends offer

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nearly all of the assistance they require [2]. This phenomenon causes an increasing population of both long-term care demanders and caregivers.

Nurses have a higher incidence than most professionals to suffer work related back injuries [3], and among all the nursing activities, patient handling (PH) tends to lead to back pain or musculoskeletal disorder (MSD). Patient transfer to and from bed is performed most frequently in all transfer situations, and injuries derived from it have also been found to be frequently reported [4].

Transferring patients to and from bed requires transfer aids. However, other studies have found that even in hospitals with transfer aids, an unwillingness to use transfer aid [5] exists. The reasons found are that nurses could not understand how to use the equipment, or lack experiences in using it. Also, some nursing personnel did not think the equipment was necessary [6], or that it took too much time using the aid [7]. Alternatively, there was no proper equipment, or the space was limited to accommodate the aid [8].

In most home care situations, caregivers lack professional nursing knowledge. The care demander who need transfer assistance are those who: (1) are dependent, and require more than 50 % of assistance by caregivers; (2) have sufficient upper-extremity strength needed to support their own weight during patient handling; (3) are cooperative and able to follow simple commands [9]. Due to the fact that care demanders rely largely on caretakers in their daily activities, those who provide assistance have to shoulder the burden. Thus, as soon as patient handling is carried out at home, problems could arise. There are times when professional nurses cannot properly transfer care demanders, let alone non-trained caregivers. Once an accident happens, both caretakers and care demanders could be severely injured. Since transfer aids play a critical role in patient handling, improving the aids becomes indispensable. They need to be user-friendly as well as safer.

Thus, in this paper, an innovative caregiver centered transfer aid will be designed to prevent care demanders from secondary injuries during patient handling and ensure the safety of caregivers concurrently.

2 Method

2.1 Patient Handling Process Observation

Participants. Two professional caregivers and a long-term care demander were recruited as participants. One of the professional caregivers is the head nurse of nursing home, and the other is a senior caregiver. They provided specialized nursing knowledge and practical operation instruction about how to assist care demander transfer in bed and to/from bed correctly. The long-term care demander is an elderly with partial self-care ability.

Procedures. The procedures of data collecting mainly follow the contextual inquiry principles [9]. At the beginning, researchers visited a nursing home, and recorded the obstacles that professional nurses encountered while operating patient handling. Then, semi-structured interview with the head nurse of nursing home was used to capture more data in nursing related works, like how to assess what the level of assistance required by a care demander etc. It is helpful for researchers to clarify the conditions of target subjects this study aimed at. She also shared her comprehensive understanding of current long-term care situations, and the risk of caregivers without sufficient nursing knowledge and training. In addition, she also offered researchers educational films to review when needed. After comprehending the standard safe patient handling (SPH), researchers manipulate all of the SPH movements in person to experience the difficulties during SPH process.

Analysis. After the contextual inquiry was finished, a lot of actions and operations data were collected. In order to study the context of patient handling, collected data were analyzed by Activity Theory and Contextual Design. Activity theory was used to understand the mind and the physical activities [10] of the caregivers during patient transfer, as shown in Fig. 1, and contextual design was adopted to list engineering and feature driven models [11], as shown in Fig. 2, about safe patient handling process in order to propose a new caregiver centered transfer process.

2.2 Development of Transfer Aid Design

Formulation of Design Principles. The design principles of the transfer aid are listed in Table 1. According to the analysis by structure of activity theory [12], the standard process of safe patient handling is selected to integrate with the operation process of new transfer aid and lists as one of design principles. The reason is that caregivers are sometimes not familiar with the way of operating transfer aids. Through integrate the existed SPH process with new operation process, the transfer aid is going to be execute more intuitively and correctly.

On the other hand, a problem has been pointed out in the sequence model of contextual design. One of the standard SPH operation nowadays is lifting up the patient a little and pivot onto caregiver to the wheelchair. This movement may still cause harm to caregiver's back. The former study found that workers who (1) worked with 60° trunk flexion or 30° trunk rotation. Or (2) they lift at least 15 times per day with a load of 25 kg or more would have the increased risk of low back pain [13]. Therefore, refine this lifting and rotating movement would lower the incidence of low back pain of caregiver.

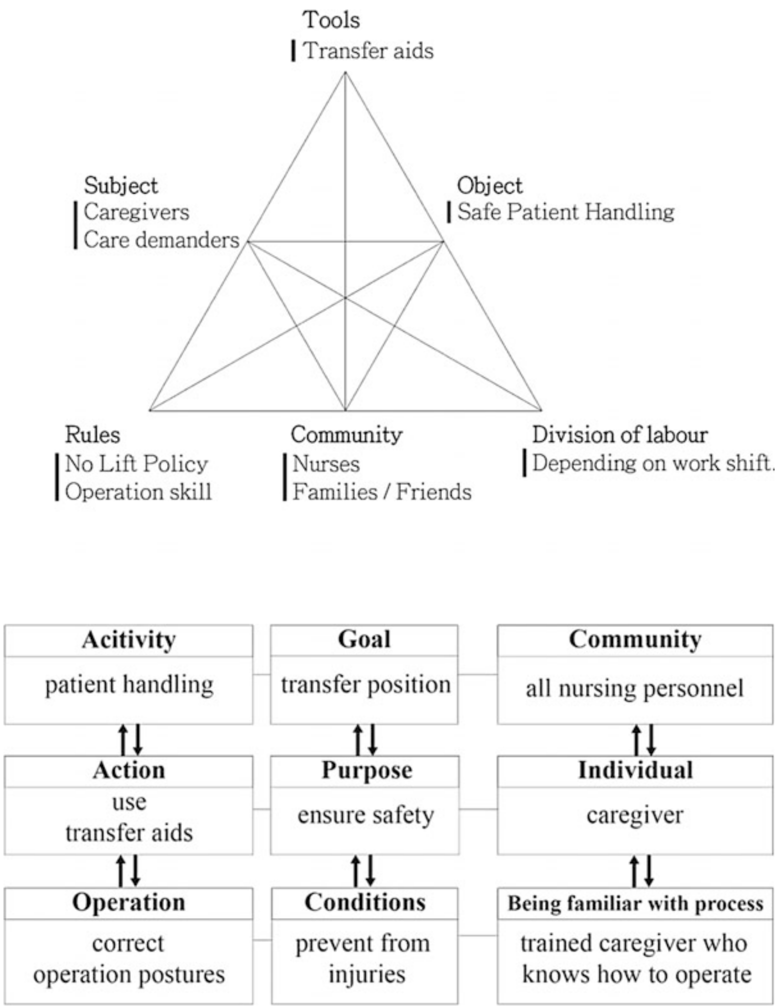

Fig. 1 Activity structure of safe patient handling (SPH)

Besides, why and when does caregiver use wheelchair during home care are rethought. As far as home care needs are concerned, the purpose of transferring to wheelchair is to move to other places such as toilet or car. In the most transfer situations of home care, wheelchair seems like a mediation between A to B. Thus, add mobility function to transfer aid as an alternative of wheelchair will make the

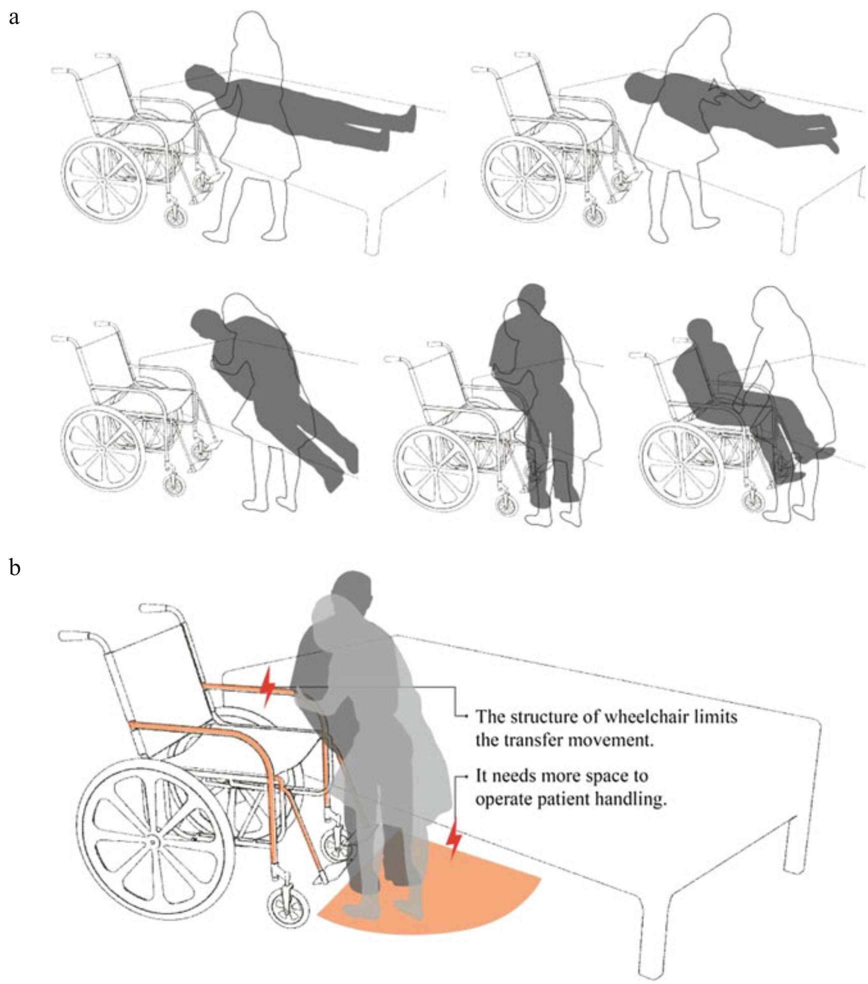

Fig. 2 Work models of SPH. **a** Sequence model. **b** Physical model

Table 1 Principles of transfer aid design established by activity theory and contextual inquiry

Principle	Correspondence problem
• Set the operation sequences according to the standard SPH movements	In order to make the operation more intuitive
• Minimize angle of trunk flexion and rotation	To reduce the incidence of low back pain
• Add mobility function	Make the transfer aid more convenient

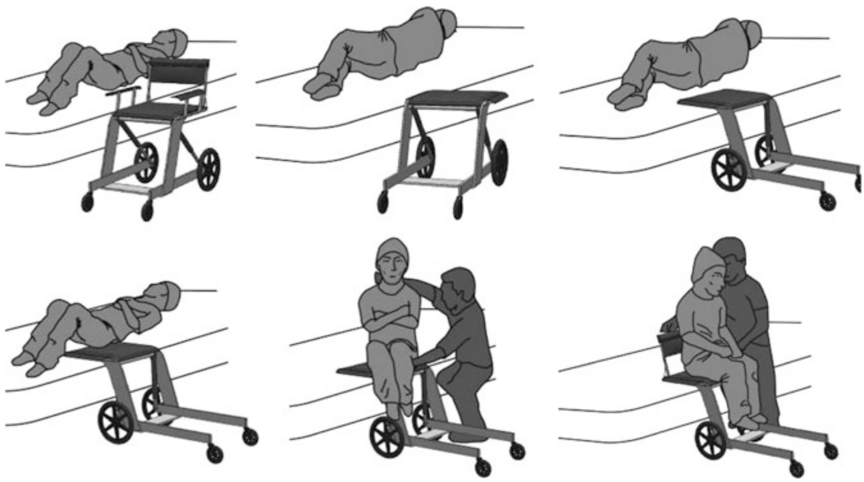

Fig. 3 Operation process of idea generation

patient handling easier, because the caregiver can move the care demander as soon as he/she sit on the transfer aid.

Idea Generation. According to the design principles above, the idea generation of operation process is shown as below: (1) move the transfer aid to the side of bed; (2) have the care demander lied on his/her side with back to the caregiver; (3) slide the seat of transfer aid onto the bed and below buttock of care demander; (4) move care demander to supine position with his/her bottom on the seat; (5) one hand holds his/her shoulder and the other hand holds his/her popliteal, pivot onto the bottom of care demander to sit on the edge of bed; (6) care demander and the seat are slid back the beginning positions of the transfer aid and complete the patient handling process (Fig. 3).

3 Result

A caregiver-centered innovative transfer aid design has been developed in this study. Considering the convenience of home care needs, the mobility function was added. However, it is unsuitable to be used as an outdoor wheelchair because the surface of road is rougher than indoor floor. The challenges of being used as an outdoor mobility aid were not considered in structure design.

a

b

Fig. 4 Detail design of transfer aid **a** a foldable seat back, two foldable handles and two adjustable armrests **b** a movable seat and wheel

The proposed transfer aid has: (1) a foldable seat back, two foldable handles and two adjustable armrests, as shown in Fig. 4a; (2) a movable seat can be slid onto the bed, as shown in Fig. 4b; (3) four wheels are added for better mobility, as shown in Fig. 4b. The complete operation process of this innovative transfer aid is shown in Fig. 5. First, the transfer aid is moved to parallel side of the bed, as shown in Fig. 5a. The armrests are then lowered, and handles and seat back folded up (see Fig. 5b); the seat is unlocked and slid onto the bed (indicated in Fig. 5c). The care demander pivots from supine to sitting at the edge of bed, as shown in Fig. 5d. The care demander along with the seat are slid back the transfer aid, and the armrests, handles, and the seat back are pulled back to their original positions as demonstrated in Fig. 5e.

Two distinct features make this transfer aid stand out from traditional ones: (1) movable chair which accelerates and completes the transferring process from the bed to the seat in one go, and hence reduces the possible risks deriving from trunk flexion and rotation in care providers when lifting and transferring care demanders to and from bed. Furthermore, (2) transfer can be performed in smaller space than before.

Fig. 5 The process of transfer aid: **a** the transfer aid is moved to parallel side of the bed; **b** the armrests are then lowered, and handles and seat back folded up; **c** the seat is unlocked and slid onto the bed; **d** the care demander pivots from supine to sitting at the edge of bed; **e** the care demander along with the seat are slid back the transfer aid, and the armrests, handles, and the seat back are pulled back to their original positions

4 Discussion and Conclusion

In this study, the researchers adopted the comprehensive design methods to realize an innovative caregiver-centered transfer aid design. Since patient handling to and from bed is the most frequently performed patient transfer, reducing the risk factors can fundamentally prevent caregivers from back pain.

A further structure evaluation will be conducted in the future to refine the transfer aid. After practical manipulating this transfer aid, the mobility function was found helpful for enhancing the convenience.

In addition to evaluating the outcome in mechanical aspect, the biomechanical aspect of the transfer aid should also be explored in the further research. Measuring the loading weight and movements of the back of care providers [14] or forces at each operation [15] could provide the precise data to pinpoint the problem more clearly.

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Employment Opportunities for Mature Age People in the Electrical Sector in Lodz Voivodeship in Poland

Aleksandra Polak-Sopińska

Abstract The retirement age reform of 2013 extended the time of mandatory economic activity. Coupled with a difficult situation of mature age people in the job market, it necessitates developing an employment policy for people over 50'. An analysis of employment opportunities for mature age people in various sectors should constitute the basis for its development. It would allow for proper selection and direction of activities supporting employment of mature age people (subsidizing, counseling, trainings etc.). In the pilot study, organizations in Lodz Voivodeship were analyzed. Many sectors were examined, however, due to the constraints on the length of the article, only the results for the electrical job sector are presented and compared with the entirety of the studied organizations. Current employment of people age 50+', demand for mature age employees, actions in the job market for professional activation and employability of people over 50 years of age and adjustment of work conditions of typical occupations in the electrical sector to the needs and capabilities of mature age people were studied in the article. Further, the article provides an answer to the question whether people aged 50 and over are motivated to work and learn. Methodological triangulation was employed in the analysis in order to achieve a comprehensive picture of the phenomenon and to increase the scientific insight of the research results.

Keywords Employee 50+ · Electrical job sector · Age management

1 Introduction

The issue of the aging European population has become the object of discussions both at the level of the European Union as well as at the level of individual member states. The working age population (in Poland as well) is declining while,

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simultaneously, the post-working age population is increasing [1]. For several dozen years, changes in the demographic structure have been observed, the main characteristic of which has been a growing number of older adults. The Central Statistical Office of Poland predicts that in 2035 in Poland the population of the retirement age people will reach 9.62 million whereas at the end of 2011 it was 7.45 million [2]. At the same time, in many European countries the rate of natural increase is negative, which means that employers will have an increasingly difficult time finding young employees in the future. Manpower Inc. experts forecast that in 2030 there will be a shortage of 30 million Europeans fit for work [3]. This decline in workforce poses a considerable risk for the job market and in the foreseeable future may lead to a significant shortage of employees and crisis of the pension system. The problem is the root cause of many new challenges that social policy, economy and medicine are facing. It forces the necessity of a new approach to organization management [4].

Increase in the share of older persons in the population of the European Union demands that attention be paid to this age group. Demographic phenomena make it necessary for Poland to undertake action to increase economic activity of people over 50'. The reform introduced in 2013, which provides for a gradual rise of the retirement age up to 67, may not suffice. Other actions should endeavor to improve work conditions in order to retain older employees at work even after they have reached the retirement age [4]. Unless the mechanisms currently in use are adjusted to the needs and capabilities of aging populations, this process will entail negative consequences.

Changes in the demographic structure of Europe and Poland and their results are also noticeable in Lodz Voivodeship. At the end of 2014, the region's population was 2,504,136 and accounted for 6.5 % of the overall population in Poland. The Voivodeship had the sixth largest population in the country following Masovian, Silesian, Greater Poland, Lesser Poland and Lower Silesian Voivodeships [5].

Evident increase in life expectancy and a declining birth rate results in the aging of the region's population. It also significantly impacts the pressure exerted by the dependent population on the working age population. At the end of 2014, the pre-working age population in Lodz Voivodeship was 422 thousand and accounted for 16.9 % of the general population. The working age population at the end of 2014 was 155 thousand and 61.9 % of the general population of Lodz Voivodeship. At the same time, an increase of the post-working age population to 531 thousand and to 21.2 % was recorded [5]. According to forecasts, the dependency ratio in Lodz Voivodeship calculated as the number of post-working age people to working age people, is expected to grow steadily from 30 in 2010 to reach the value of 51 in 2030 [6].

In Lodz Voivodeship, as well as generally in Poland, low economic activity of older people has been observed. As regards the number of the unemployed people over 50 years of age, Lodz Voivodeship ranks fourth in the country. The increase in the share of the post-working age population in the general population of Lodz Voivodeship has a profound impact on the development of the local social and employment policy. Therefore, the author of the foregoing article decided to analyze employment opportunities for people aged 50 and over in Lodz Voivodeship.

It is reasonable to look for employment opportunities for any job seekers including mature age job seekers in sectors which grow dynamically and are characterized by a large market share and a large average number of employees. In the study, many sectors were researched, however, due to limitations concerning the permitted volume of the article, only the results for one of them are reported and analyzed against the entire group of the examined organizations. The electrical sector has been chosen because it has been growing robustly for a number of years in Poland. Its growth has been spurred by an increase in energy consumption which, according to forecasts, is expected to rise in the next years [7].

At the end of 2013 in Poland, there were 54,766 organizations in the electrical sector 3470 of which in Lodz Voivodeship. They accounted for 1.5 % of all organizations registered in Lodz Voivodeship. Although the percentage is not large, it is worth pointing out that a large number of the electrical sector companies are medium- or large-sized enterprises. Moreover, it is worth bearing in mind that positions related to the electrical trades occur also in organizations not connected with the analyzed sector. Therefore, its importance, despite its small share in the general number of enterprises in Lodz Voivodeship is considered significant. The highly dynamic growth provides many opportunities for employment of new employees. The article attempts to answer the question whether these opportunities include people over 50'.

2 Research Description

2.1 Research Objective and Research Problems

The primary objective of the study was to analyze and evaluate employment opportunities for mature age people in the electrical sector organizations in Lodz Voivodeship. The objective also included a comparison of the results for the sector with the results for the entire group of the Voivodeship organizations (various sectors).

The objective set allowed for the identification of research problems of which the following were singled out:

1. identification of the current employment of people over 50 years of age in the Lodz Voivodeship enterprises and comparison of the statistics with the electrical sector;
2. determination of the demand for labor in Lodz Voivodeship with particular consideration given to the electrical sector;
3. determination of the level of motivation of older adults to work after they have reached their retirement age;

4. determination of the level of motivation to develop their professional qualifications;
5. verification of participation of organizations and employees in project addressed to people over 50 years of age;
6. identification whether the conditions of the physical work environment are suitable for mature age people.

2.2 Research Methods and Techniques

Research data was collected using the following research methods and techniques:

- unstructured interview with a representative of the Voivodeship Labor Office in Lodz concerning actions aimed at professional activation of people 50+;
- structured interview with employers or representatives of the management. 35 organizations in the electrical sector were surveyed (statistical error ca. 19 %) and 227 organizations in various sectors in Lodz Voivodeship (statistical error ca. 6.5 %);
- anonymous survey of employees aged 50 and older. Overall, 347 employees completed the survey of which 95 were employed in the electrical sector;
- secondary data analysis—content of governmental programs and European projects, topics of trainings financed by the European Social Fund addressed to the target group and analysis of official statistical data on employment of people aged 50 and older (Voivodeship Labor Office and County Labor Office);
- checklist—to verify if particular strenuous factors (typical for electrical trades) and/or factors that reduce work capacity of mature age people were present for particular jobs—completed on the basis of [8], unstructured interviews, overt observation of the work process for the jobs and analysis of the documentation concerning e.g. occupational risk assessment.

3 Research Results

3.1 Actual Employment of People Over 50' by Enterprises in Lodz Voivodeship

The results of the analysis of the employment of people over 50 years of age by enterprises in Lodz Voivodeship are presented in Table 1.

Table 1 Research question 1

Do enterprises in Lodz Voivodeship currently employ people over 50' and for what jobs?	
Voivodeship enterprises in general	Electrical sector
62 % of the studied enterprises employ mature age people	74 % of the studied enterprises employ mature age people
Mature age employees are more frequently employed by large and medium size enterprises than by small and micro enterprises. The rate of employment of mature age employees is higher for small and micro enterprises in the electrical sector	
Employment of people over 50' does not depend on their sex. There are sectors where men are more readily employed, and there are other sectors where women are preferred	In the electrical sector it is men aged 50 and older who are preferred (70.7 %) to women (29.3 %). This results from the nature of the job
Most frequently, mature age employees are employed in the positions of laborer (55 % of the mature age employees of the studied enterprises) and administrative-clerical (24 %). Ca. 9 % of the employees age 50+'. The remaining employees are employed in technical-engineering and other positions	Most frequently, mature age employees are employed in the positions of laborer (65 % of the mature age employees of the studied enterprises in the electrical sector) and in managerial positions (15 %), followed by administrative-clerical (13 %) and technical-engineering (7 %)
A majority of the employees over 50 years of age have been employed in their positions for at least 5 years	Many employees have worked in their positions for at least 5 years. In the micro, small and medium-sized organizations ca. 30 % of employees age 50+' have worked for at least 10 years. In large enterprises, 47 % of employees over 50' have been employed 1-5 years, whereas 40 % for at least 5 years

3.2 Demand for Labor of Mature Age Employees in Lodz Voivodeship Enterprises

The decision to employ a new employee by an organization depends primarily on economical factors. A person may be recruited for a newly established position which is required for effective performance of the organization or he/she may take a position of another employee who for various reasons has left the job. Taking on a new employee has to be reasonable. The same applies to hiring mature age people. While investigating the demand for mature age employees in Lodz Voivodeship enterprises, an answer was sought to the second research question (Table 2).

3.3 Work Motivation of Mature Age People

Active aging policies tend to focus primarily on encouraging mature age employees to stay in the job market for as long as possible. The changes introduced to the social security and tax systems are expected to curb the number of financial incentives which lead to earlier retirement. How well-off retirees are going to be

Table 2 Research question 2

Are employers willing to employ mature age persons in the region's enterprises and in the electrical sector? For what positions do they seek to employ people aged 50 and older?	
Voivodeship enterprises in general	Electrical sector
Only 29 % of the studied organizations planned to employ a new employee under an employment contract in 2015	42 % organizations in the electrical sector planned to employ a new employee under an employment contract in 2015
New employees were usually sought by large and medium size employers	
50 % of the large enterprises, 29 % of the medium-sized, 31 % of the small and 26 % of the micro-sized ones planned to employ a new employee	100 % of the large enterprises, 50 % of the medium-sized, 31 % of the small and 25 % of the micro-sized ones planned to employ a new employee
Only 14 % of the organizations responded that they would be willing to accept a mature age person for a vacancy (including 17 % of the large enterprises, 18 % of the medium-sized, 14 % of the small and14 % of the micro-sized ones)	Only 21 % of the organizations in the electrical sector responded that they would be willing to accept a mature age person for a vacancy (among them 33 % of the large enterprises, 50 % of the medium-sized, 17 % of the small and 13 % of the micro-sized)
The employers were the most willing to employ mature age persons in laborer and administrative-clerical positions	Mature age persons were the most likely to be employed in administrative-clerical, technical-engineering and laborer positions
Job advertisements (newspapers, the Internet, County Labor Office) usually do not specify the preferred age of candidates	
Basic services of the employment market are usually addressed to the general population of the unemployed; there are no offers dedicated to people over the age of 50	

depends largely on the age of their retirement. The longer they work, the bigger the pool of funds from which their pension will be paid later. This structure of the social security system is aimed at increasing motivation to work of older people and encouraging them to stay economically active even when they have reached the prescribed retirement age.

The third research question was formulated while examining the willingness and motivation to work of mature age people: Will employees want to continue working when they have reached the retirement age? Conclusions concerning this research question are presented in Table 3.

3.4 Mature Age People Willingness to Develop Their Qualifications

Apart from motivation to work, continual learning and keeping knowledge and competences up to date are also very important. Employee competences are one of the fundamental components determining competitive advantage of the organization. Organizations should take care to effectively manage their own resources, especially human resources, and invest in their development. Employees

Table 3 Research question 3

Will employees want to continue working when they have reached the retirement age?	
Voivodeship enterprises in general	Electrical sector
Nearly half of the respondents (44 %) declared that they did not want to continue working once they have reached the retirement age. It is worth pointing out that a decisive majority of the respondents who declared their wish to work while retired only wanted to do it part-time (40 %). Only 16 % of the respondents expressed their interest in working full-time	40 % of the declared that they did not want to continue working once they have reached the retirement age. Only 20 % of the respondents who declared their wish to work while retired expressed their readiness to work full-time
Usually, it is employees in managerial, laborer and administrative-clerical positions who tend not to want to work beyond the retirement age	Most frequently, it is employees in laborer and administrative-clerical positions who tend not to want to work beyond the retirement age. Managers and technical-engineering employees most often declared their wish to continue working part-time
Employee decisions depends also on the size of the organization. Older employees of large enterprises are the least willing to continue working (68 % of the respondents)	The larger the organization, the fewer employees want to work beyond their retirement age. In large enterprises, 43 % of the mature age respondents want to do so
Men more frequently than women do not want to continue working	Women more frequently than men do not want to continue working
Motivation to work also depends on the employee's educational attainment. The lower the qualifications, the more likely is the employee not to continue working	
The decision of older people to continue their employment is also influenced by the employer's attitude—his/her openness and readiness to cooperate with people over 50 years of age	
Most employers claim that they provide opportunities for employees to continue employment while retired. However, in actual fact, such a situation happens only rarely in large enterprises	

themselves should also continually update their knowledge and competences. The results of the study revealed that few mature age employees of Lodz Voivodeship enterprises took advantage of trainings to change or upgrade their competences. A different situation was observed for the electrical sector where as many as 46 % of the respondents claimed to have participated in three or more trainings within the last 5 years. The remaining conclusions concerning the fourth research question are presented in Table 4.

3.5 Actions of Labor Market Institutions for Professional Activation of People Aged 50 and Over

Increase of employment rates of mature age persons is strongly influenced by national and European policies. Programs supporting economic activity of people

Table 4 Research question 4

Do employees want to advance their qualifications?	
Voivodeship enterprises in general	Electrical sector
60 % of the mature age respondents declared their wish to raise their qualifications	78 % of the mature age respondents declared their wish to advance their qualifications
Willingness to participate in trainings depends on the employee's position. Technical—engineering and managerial positions are more likely to be interested than laborers	Willingness to participate in trainings does not depend on the position. Laborers were equally interested in trainings as the remaining employees
Most frequently, mature age employees of small and medium enterprises were interested in trainings. This may be a consequence of the division of work in these organizations, including the requirement for employees in one position to perform many different tasks. In large enterprises, employees only perform invariable specialized tasks and development of competences consists in mere updating the knowledge they already have	
48 % of the employers claim that they delegate their employees to participate in trainings. Only a few trainings were addressed to people over 50 years of age	53 % of the employers claim to delegate their employees to participate in trainings. The trainings are offered both to young employees as well as employees aged 50 and older
57 % of the mature age respondents have not participated in any form of training except for the mandatory OSH training for the last 5 years. 32 % of the respondents reported to have participated in one or two trainings in the last 5 years. The remaining respondents participated in three or more trainings	Only 22 % of the mature age respondents have not participated in any form of training except for the mandatory OSH training for the last 5 years. 32 % of the respondents reported to have participated in one or two trainings in the last 5 years. The remaining 46 % of the respondents participated in three or more trainings
Training programs usually focus on the development of selected competences. The respondents most frequently mentioned computer and foreign language courses. Additionally, in the electrical sector, the respondents listed professional certification trainings for electrical, electrical power qualifications, and for forklift, excavator and road equipment operators	
Participation in trainings is motivated by the need to learn new skills and willingness to update knowledge	Participation in trainings is primarily motivated by the requirement to advance/update certifications/licenses due to changing legal requirements, by the need to learn new skills or in view of getting a promotion

age 50+' are extremely relevant. Table 5 presents the results of an analysis of actions of labor market institutions undertaken to promote economic activity of people over 50'.

Table 5 Research question 5

<table>
<tr><td colspan="2">Do employers/employees know about (and take advantage of) government and EU programs addressed to people over 50 years of age?</td></tr>
<tr><th>Voivodeship enterprises in general</th><th>Electrical sector</th></tr>
<tr><td colspan="2">Many projects have been carried out, e.g. Solidarność Pokoleń (Solidarity of Generations), within the Human Capital Operational Program, in the implementation of which the voivodeship and county labor offices participate. Actions to encourage economic activity of people over 50 ‘Wspieramy Twoją Aktywność’ (We Support Your Activity), ‘Aktywny Senior’ (Active Senior), Własny Biznes dla 50+ (Start Your Own Business for People Over 50). These actions are concerned with activation of the unemployed, encouraging entrepreneurship by virtue of trainings and financial support for people starting their own businesses, activation and social inclusion of people threatened with social exclusion. The projects provide various forms of support from funds to start a business, bridging financial support, training, internships, psychological and career counseling and job centre services</td></tr>
<tr><td>Most of the trainings offered by the County Labor Office in Lodz (CLO) were certification trainings (for accountants, electricians, forklift operators, MAG(135)-1i TIG(141)-1 welders, etc.) and skill trainings (cash register operator, MS Office, human resources administration, etc.)</td><td>Trainings offered by The County Labor Office in Lodz were concerned with electrical and electrical power certification/examination. Moreover, it seems likely that some of the trainees who have completed trainings for warehouse or forklift operator jobs may as well be employed in the electrical sector</td></tr>
<tr><td colspan="2">Sadly, most of the employers in the voivodeship (67 % of enterprises in general and 62 % of the electrical sector enterprises) have no knowledge that they as well as mature age persons may take part in projects aimed at increasing employability of people aged 50 and older. Only 28 % (16 % for the electrical sector) of the surveyed organizations have participated in such projects. Most of them were small and medium enterprises. Additionally, few of the respondents were able to give the name of the projects. They only tended to remember the activities undertaken</td></tr>
<tr><td>The organizations most often took advantage of training and internship opportunities, socially useful work schemes</td><td>The organizations most frequently took advantage of training and internships for people over 50 years of age</td></tr>
<tr><td colspan="2">The employers negatively evaluated the effectiveness of the projects. They pointed out lack of information on implemented projects and excessively complicated application procedure</td></tr>
<tr><td colspan="2">A majority of the surveyed enterprises do not cooperate with county labor offices</td></tr>
<tr><td>Only 6 % of the mature age employees participated in trainings funded with Labor Fund or the European Social Fund. They were employed in laborer positions as well as in upper-level positions</td><td>Only 5 % of the mature age employees participated in trainings funded with the Labor Fund or the European Social Fund. They were employed in laborer positions as well as in upper-level positions</td></tr>
</table>

3.6 Adjusting Work Conditions to the Needs and Capacities of Mature Age Persons

Human capacity for work changes as the years pass. This is caused by aging which is a sum of physiological changes consisting in the decline of cell, organ and regulatory mechanism functions and deterioration of abilities to adapt to, among others, stress caused by external environmental factors. The stress may vary and therefore, the process of aging occurs at different rates in different persons and hence, the differences among people grow larger as they age.

Significant changes in the functions of the body are already observed at the age of 45. Simultaneously, the frequency of many cardiovascular, respiratory, musculoskeletal diseases as well as hormonal and metabolic disorders increases.

Nevertheless, in spite of the changes in the body of a mature age human being the requirements for the young and the older performing the same job remain the same. This may lead to a situation where the actual workload increases, which entails deterioration of health and acceleration of aging. Workstations in order to be deemed safe and ergonomic should be suitable for a minimum of 90 % of the population of adults and not just for the young and the strongest of them. If this principle were applied, age would cease to be an impediment in any job.

Therefore, it is important to determine how strenuous work is in particular jobs in the electrical sector, which shall allow for a preliminary answer to the question whether a person aged 50 or older may work in such work conditions or not. It is worth adding right at the start, however, that jobs in the electrical sector differ from typical jobs. They are often characterized by non-repetitiveness as regards the type of performed tasks, work place, work conditions, workplace risks and hazards etc. That is the reason why the analysis of job positions was carried out for the most typical occupations in the electrical sector. For each occupation, typical job positions were identified, principal tasks performed by the employee were specified as were the required education and qualifications, work conditions and factors which may adversely affect the health of people aged 50 and older. Only general results of the analysis are presented below for the five most representative for the electrical sector occupations from the top-level to the lowest-level [8]:

1. *Occupation: Electrical Engineer:* Main responsibilities: Control of the process of electric power generation, minimization of its transmission- and usage-related losses, automation of manufacturing processes and measurement of electrical quantities. The wide range of the electrical engineer jobs encompasses different domains of technology and nearly all industry sectors. Adverse factors: Changes in air temperature and humidity; cold or hot microclimate; noise level too high; electromagnetic radiation; too many tasks to be performed in a short time.
2. *Occupation: Electrical technician:* Main responsibilities: Installation of electrical systems and electrical devices and control of their operation are the objectives of the job. Work is performed wherever electric power is used (residential buildings, commercial buildings, industrial facilities, open field). Work conditions depend on the work site. Adverse factors: For electrical technicians who work with machines, the main adverse factor affecting people over 50 is an elevated level of noise and vibrations, awkward body position, occasional physical overload. Working outdoors brings variable temperature and lighting conditions and may require work at height. Variable shift work may also have a negative effect.
3. *Occupation: Electrical mechanic:* Main responsibilities: builds electrical devices used in all technical domains and in the household, e.g. transformers, electric

motors, electric meters, signaling devices, and also performs their repairs and overhauls. Due to a large number and variety of electrical devices, electrical mechanics tend to specialize. Specialist deals with a particular group of devices used in the selected specialization. Adverse factors: Electromagnetic field; hard physical work required for servicing batteries and on the railways (a lot of heavy lifting); when working outdoors, variable weather conditions; exposure to substances hazardous to health, e.g. lead, acid vapors, gases; on the railways, high levels of noise, vibrations, work at height; possible but rare shift work including night shifts, awkward body position.

4. *Occupation: Power plant worker:* Main responsibilities: Ensuring optimal operating parameters of the power plant subcomponents. Parameters are set in the power plant control room; in new or modernized plants these tasks are automated and computer-aided. Many components of the national electric power system require constant control, ongoing maintenance, overhauls and checkpoint performance measurements. Adverse factors: 3-shift work schedule seven days a week, also on holidays, large number of stressors; repair and maintenance work involves working at elevated height under difficult conditions.
5. *Occupation: Electrical apparatus, machine and equipment fitter:* Main responsibilities: manufacture of electrical apparatus and electrical devices, their installation and maintenance of their proper operation, therefore, repair and maintenance activities. Adverse factors: adverse factors are most often present during the installation of electrical apparatus, machines and equipment. They include extremely low or extremely high (ironworks) temperatures, high intensity of noise, dust. It needs to be emphasized that the time spent working under extreme conditions is relatively short when compared to the overall working time; moreover, employees perform their duties during stoppages, overhauls or construction when the intensity of adverse factors is small. Only rarely are the jobs strenuous. vibrations, noise.

4 Conclusions

The analysis of the employment rate of people age 50+' reveals that a decisive majority of the electrical sector enterprises employ mature age people. It is mostly men who are employed both in lower-level and upper-level positions. In the electrical sector in comparison to the enterprises in general, substantially more mature age employees perform managerial roles. Employers appreciate their knowledge and experience, which is indicated by the fact that many employees have worked for the surveyed organizations for several or even several dozen years. Compared to other enterprises, it is the small and micro-sized enterprises in the electrical sector that are more likely to take on mature age workers. The owners of these businesses explained this by the fact that employees are required to have technical knowledge and experience which younger workers tend not to have.

Moreover, they emphasized that by hiring employees age 50' they protected their organizations against unnecessary employee turnover.

Regrettably, high employment costs in Poland are the reason why employers in an attempt to avoid losses related to temporary stoppages, decrease in orders, etc. more and more frequently use the services of temporary work agencies. They would rather hire agency workers than employ workers under an employment contract. Often, they will terminate their employees' agreements and replace them with temporary workers.

This behavior is reflected in the presented statistics. Only 29 % of the surveyed organizations planned to employ new employees under an employment agreement in 2015 including only 50 % of the large enterprises where, as is well-known, there is usually high employee turnover. In the electrical sector, overwhelmingly greater percentage of the enterprises (42 %) planned to employ new employees including all of the surveyed large enterprises. This arises from the fact that the sector is characterized by a dynamic growth. Moreover, as the processes performed at these enterprises are more difficult, the employers less frequently resort to using the services of temporary work agencies.

As regards people age 50+', few organizations (14 %) responded that a person over 50 years of age could become the new employee, with the electrical sector enterprises being slightly more likely to employ older people (21 %). During the survey, the electrical sector employers repeatedly emphasized that they greatly appreciated the knowledge, reliability and loyalty of mature age persons, nevertheless, only 33 % of the large enterprises, 50 % of the medium-sized ones, 17 % of the small ones and 13 % of the micro size organizations would decide to employ a new employee age 50+'. The electrical sector employers explained that mature age persons' health tends to be worse, their efficiency and productivity lower. The large and medium enterprises added that older workers did not respond well to new technologies and work techniques, had bad habits at work and found it difficult to adapt to changes. It may be presumed that updating sector-specific knowledge and development of competences were, in the opinion of the employers, the greatest challenges for employees over 50'.

Were the electrical sector employers to employ a new employee who was 50 or older, they would be mostly likely to do it for an administrative-clerical position followed by technical-engineering position and finally, for a laborer position. This order is exactly reversed compared to the actual current employment of mature age persons in the electrical sector. The discrepancy between additional employment preferences and the actual employment may arise from the strenuousness of work in these positions as perceived by the employers. Work conditions for laborer jobs in the electrical sector frequently do not accommodate the needs and capacities of mature age workers and therefore, whenever an older employee leaves, a younger person is readily taken on to fill the vacancy. Older workers employed in the surveyed organizations have themselves confirmed this claim. In the survey questionnaire, they were asked to indicate the problems/difficulties that they encountered in performing their work tasks. The most frequently given answers were: deteriorating health which negatively influenced their efficiency (56 %), too many tasks to complete within a short time (ca. 42 %—mostly laborers) and difficulty with using the computer (ca. 30 %—mostly managers and administrative-clerical workers). The employees were also asked to indicate those factors which could adversely affect their health. The respondents indicated (in this order): changeable microclimate, night shifts, exposure to chemicals, work at height, too many stressors associated with some of the tasks, great physical load, awkward body position. These factors were most frequently indicated by lower-level employees. Nevertheless, they still believed that they were able to perform most of their duties until retirement because in most cases they work in teams and the more strenuous tasks are delegated to younger workers.

The results of the study have also shown that mature age persons in Lodz Voivodeship both in the enterprises in general and in the electrical sector are not particularly interested in continuing employment once they have reached the retirement age. Most negative answers were given by the mature age employees of the large enterprises followed by the employees in the micro-sized organizations. The enterprises are equally reluctant to employ people of post-working age.

Apart from motivation to work, continual education and advancement of knowledge and competences are of major importance. The study revealed that few mature age employees participated in trainings in order to change or upgrade their qualifications. A different situation was observed for the electrical sector where as many as 46 % of the surveyed mature age employees claimed to have participated in three or more trainings within the last 5 years. Moreover, the employees underscored that trainings are available for both the young and for the older workers.

Increase of employment rates of mature age persons is strongly influenced by the national and European policies. Programs encouraging economic activity of people age 50+' are very relevant. Regrettably, the results of the study indicate that the Voivodeship employers (including the electrical sector) know little about actions to support employability of mature age persons. It is important to remember that whether the support is successful—effective implementation of programs encouraging economic activity—to a large extend depends on employers. The mature age employees were not aware of government and EU programs addressed to them, either.

The analysis of factors which adversely affect health of employees aged 50 and older showed that jobs in the electrical sector do not constitute a group of particularly strenuous ones. Obviously, there are cases when tasks cannot be completed by older persons. What also needs to be emphasized is that the employers who were asked to select factors they considered strenuous for mature age employees, selected fewer factors than the employees did.

The analysis allows for concluding that the electrical sector in Lodz Voivodeship compared to the enterprises in general has a favorable attitude towards employment of mature age persons. Nevertheless, employers should be educated as regards programs encouraging economic activity of mature age people and principles governing adjustment of work conditions, working time etc. to the needs and capacities of employees aged 50 and older.

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A Future Framework of Knowledge-Based Ergonomics Assessment System at Workplace in Automotive Assembly Plant

Fazilah Abdul Aziz, Zakri Ghazalli, Nik Mohd Zuki Nik Mohamed and Amri Isfar

Abstract There are several parameters must be correctly evaluated to guarantee a good level of interaction between worker and working system, in order to avoid safety and health problems. The lack of attention to occupational ergonomics issues may to potential ergonomics risk for which decision makers are ignore when develop new product and process. This paper proposed a novel framework to facilitate the ergonomics knowledge management for occupational risk assessment. It serves two objectives, the first objective is to aid the decision makers predicting ergonomics risk element at early stage of development product and process. The second objective is to develop knowledge-based ergonomics assessment system (KBEAS) in automotive assembly plant. The respondents of the study are about 250 and consist of assembly workers ranging from operator to executive level in automotive component assembly plant. The activities of direct observation, activity analysis, photography, video, survey questionnaire and interviews, are employed to measure the occupational ergonomics risk factors. The outcome of these activities will be used as an input for analytical hierarchy process (AHP) technique to prioritize the occupational ergonomics risk ate workplace. The outcome of this framework could ease decision makers in assessing and prioritizing the ergonomics risk at the early stage of product and process in automotive component manufacturer.

Keywords Occupational ergonomics · Ergonomics risk assessment · Knowledge-Based system · Analytical hierarchy process

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1 Introduction

The purpose of ergonomics assessment in workplace is to minimize and eliminate safety and health issues due to poor interaction between worker and working system. The effective application of ergonomics factors in workplace could create a balance between human operators and job design [1]. The benefits are can enhance the workplace safety, job satisfaction to the employees and also increase their productivity. Now days the principle of occupational ergonomics is well recognize in most automotive assembly plants. But previous researcher commented that the applications have not achieved significant momentum in developing countries [1]. Recent studies have shown positive influences of applying ergonomics rules to workplace including worker, equipment and tools, job task, environmental and organizational [2–7]. Base on this information acknowledge that studies in ergonomics have created data and guidelines for industrial applications. However there is lacking of acceptance and few applications in industry especially in developing countries like Malaysia. Lack of utilization of the ergonomics rules could bring inefficiency to the workplace [1].

Health safety environments and ergonomics are important concepts in today's industries as scientists and researchers have been continuously trying to improve the relations between human and his surrounding atmosphere [8]. Human-oriented management is one of the main characteristics of modern automotive assembly plant systems.

Lately there are various type ergonomics studies have produced to secure human and economic sustainability, including integrating ergonomics into designing sustainable work systems, broad stakeholder participation, link between performance and health goals, process focused to change tools, and general strategies of ergonomics design [9]. There is an urgent need for implementation of ergonomics knowledge in design and decision-making as well as in the use of machines, equipment and production systems and for this in the modern enterprises ergonomics and safety consideration need to be integrated into the design, analysis, and implementation phases of the system [10]. Sharma added that the application of computer-assisted systems in ergonomics is one feasible solution suggested for the effective utilization of ergonomics knowledge for industrial activities.

Normally company is focusing on how to achieve market demand and increase the productivity. Without realize the human factors ergonomics concerns in assembly plant has been ignored. Grote had commented that it is frequently that human factors and ergonomics knowledge does not receive the attention and consideration that it deserves [11]. Numerous industrial accidents have exposed the ineffectiveness of conventional risk evaluation methods as well as negligence of risk factors having major impact on the health and safety of workers and nearby residents [12]. Industrial injuries and accidents occurred due to lack of consistent and complete ergonomics assessment from the beginning of project. Ergonomics so far has had little impact in Malaysia. For most Malaysian managers, ergonomics is not considered to be associated with performance, but rather with occupational health and safety and legislation [13]. The lack of attention to ergonomics issue may lead to potential ergonomics risk for which decision makers are often unaware when develop new product and process. In long term the potential ergonomics risk will interrupt company achievement on productivity and product quality. Knowledge and experience are very important for ergonomic risk assessment. Lack of knowledge about human and technology interaction will give impact on quality and productivity [5]. There is a necessity to consider ergonomic principals at the time of designing industrial workstation to reduce musculoskeletal disorders (MSDs) and prevent injuries to the industrial operators [14]. Based on these scenarios there is need to identify the mechanism of knowledge management in the integration of ergonomics assessment method and prioritizing the risk level for assembly worker's working condition in automotive plant during early product development phase. Therefore the overall aim is to develop a system to better assess and predict the occupational ergonomics risk as relevant to acquisition of ergonomic knowledge in automotive assembly plant.

2 Intelligence Decision Support System Applies in Ergonomics Assessment Process

2.1 Theoretical Approach

Employees in assembly plant must have a comprehensive understanding of the scope of the discipline and be able to apply the ergonomics principles to improve working conditions. In 2000 the International ergonomics association (IEA) has proposed the three broad domains of specialization within ergonomics in order to establish some clear identification of the recognized areas of the discipline [15]. The three broad domains of specialization can be referring to Table 1. Generally, work-related strain (both physical and mental) is being reported more often, and this tends to lead to such things as increased absenteeism, poor motivation or commitment to the job [16]. As shown in Fig. 1 there are five basic elements of occupational ergonomics that need to be addressed in workplace. When analyzing

Table 1 Domain of specialization within ergonomics, by international ergonomics association, 2000

Physical ergonomics	Cognitive ergonomics	Organisational ergonomics
Concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity	Concerned with mental processes, such as perception, memory, reasoning and motor response, as they affect interactions among humans and other elements of a system	Concerned with the optimisation of sociotechnical systems, including their organisational structures, policies and processes

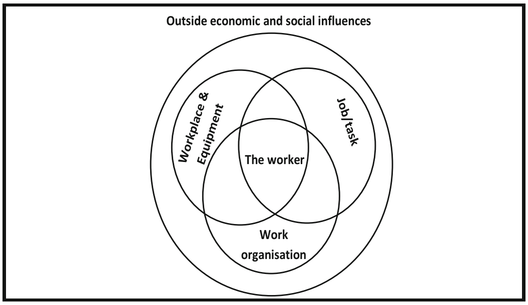

Fig. 1 The relationship between different elements of occupational ergonomics

assembly work and how it can be improved from an ergonomics point of view we need to consider the human element of the workplace, job requirements, work stations and equipment design, working environment, and work organization structure. How these elements interact and allow for a good match between workers and their works is one of the aims of occupational ergonomics assessment in this research study.

2.2 Conceptual Framework

The useful knowledge or data needed for the ergonomics assessment and risk level analysis systems is stored in the knowledge base. The procedures for knowledge acquisition and knowledge management are illustrated in Fig. 2. The framework consists of an industrial assessment and process experience. The knowledge obtained from these sources will be structure so that it can be used by an inference system and can contribute to the solution of a broad range of problems.

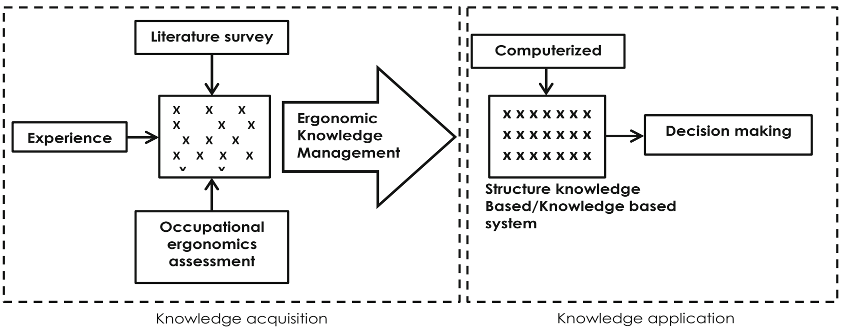

Fig. 2 The conceptual framework of the study

2.3 Occupational Ergonomics in Industry

The main focus of occupational ergonomics is the compatibility of jobs and environments with human factors. It seeks to harmonize the functionalities of the tasks with the capabilities of the humans performing them. Occupational ergonomics knowledge is extensive as it considers not only anthropometrics and biomechanics, but also cognitive issues. For this reason it was decided to limit this research to the occupational ergonomics of automotive assembly process. Several dimensions of ergonomics such as physical, organizational and psychosocial risk factors may be reasons for disorders among assembly operators [8]. Physical risk factors, including repetition, awkward postures, forceful movements and heavy lifting can increase the risk of WRMSDs [3, 4]. Latest studies have shown that psychosocial factors may independently increase the risk of musculoskeletal disorders or the interactive effect between them may cause WRMSDs [3, 17]. According to Falck and Rosenqvist both ergonomics and quality issues can be proactively solved at the same time, which should encourage companies to consider assembly ergonomics more seriously [5]. They added further research needs to be done to find out what physical and cognitive ergonomics factors that contribute the most to assembly errors [5]. Subsequently ergonomics risk cannot be adequately assessed by evaluating each potential risk separately, which is the approach implemented in ergonomics risk assessment, and commonly undertaken by many companies.

2.4 Knowledge-Based System Application in Ergonomics Field

A knowledge-based system (KBS) is a computer program that reasons and uses a knowledge base to solve complex problems. Basically the KBS is based on artificial intelligence (AI) methods and techniques. The importance of the selection and integration of ergonomics methods for the evaluation of working conditions of health care staffs to knowledge based ergonomics is the possibility to reuse the same information resources depending on the purpose and the method of ergonomics analysis [18]. Refer to previous study method the knowledge acquisition was again a combination of a literature survey and the transfer of human knowledge and experience, and lastly the collected knowledge was organized and written in the form of production rules, to be used by the intelligent system [19]. It is different in this study proposed approach which is the ergonomics knowledge will get through by conducting the integrated ergonomics risk assessment in the workplace. We believe that the input data through job task assessment, organization evaluation, and analysis of worker's performance will make the knowledge database containing the elements of risk has reached a sufficient level of completeness risk(or danger) sequences will be taken into consideration. Figure 3 shows the expected data flow,

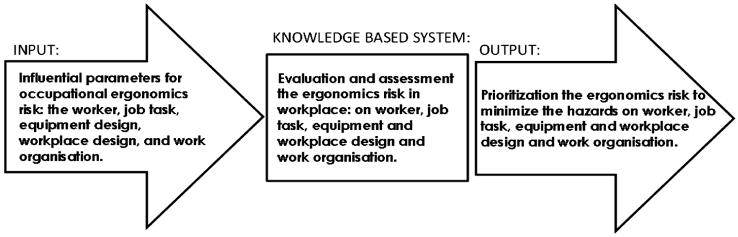

Fig. 3 Basic structure of the intelligent decision support system for occupational ergonomics assessment

where input data are a significant factor for intelligent module performance, the results of which depend on knowledge base content.

2.5 Analytical Hierarchy Process Application in Occupational Risk Management

The Analytic Hierarchy Process (AHP) is a theory of measurement through pair-wise comparisons and relies on the judgements of experts to derive priority scales [20]. AHP method is based on three fundamental principles: decomposition of the structure, comparison of judgments and hierarchical composition (or synthesis) of priorities [13]. Authors informed that the AHP is applicable to decision situations involving subjective expert judgments and uses both qualitative and quantitative data. AHP is flexible and ease to use, and able to provide a measure of the consistency of the decision maker's judgment [21].

3 Gap of Research

3.1 The Occupational Ergonomics Risk Factors

Base on the literature review previous research's mostly focused ergonomics assessment on physical factors and it is lacking on other factors. The latest research related to occupational ergonomics risk assessment can be referring to Table 2. The main purpose of such methodology is to offer a broad vision of overall exposure to occupational ergonomics risk and to rank the risk level for corrective actions purpose.

Table 2 Comparison occupational ergonomics risk assessment in this study versus other studies

Authors/Year	Physical factors	Psychological factors	Organisational factors	Individual factors
Ergonomics assessment of this study	✓	✓	✓	✓
Zare et al. 2015	✓	✓	✓	
Widanarko et al. 2015	✓		✓	✓
Widarnarko et al. 2014	✓		✓	
Oakman et al. 2014	✓		✓	✓
Falck and Rosenqvist 2014	✓			
Falck et al. 2014	✓			
Marvis et al. 2014	✓			
Akbari et al. 2013	✓			
Qutubuddin et al. 2013	✓			
Balakrishna et al. 2013	✓			

3.2 The Application of Knowledge Based System on Occupational Ergonomics Assessment

Although studies have recognized knowledge based system application in the manufacturing industry, research has yet to conduct the prevalence of knowledge-based occupational ergonomics assessment. Table 3 shows several application of knowledge based system on ergonomics field in manufacturing industry. In this paper a novel model of a knowledge based ergonomics assessment system (KBEAS) is proposed to facilitate the employees in automotive assembly plant on ergonomics risk study in early product development phase.

3.3 Analytical Hierarchy Process Technique in Occupational Risk Management

Surprisingly the analytical hierarchy process (AHP) technique has yet been empirically applied on occupational risk management in manufacturing industry and specifically in automotive sector. Thus this study is proposing a flexible approach multi criteria occupational ergonomic risk decision making in automotive assembly plant. Table 4 shows the recent trends of AHP application in occupational risk management.

Table 3 Several application of knowledge based system on ergonomics field in manufacturing industry

Authors/Year	Knowledge based system	Research application	Industry
(Harih 2014)	Intelligent decision support system OSCAR	The system allows a correct determination of tool-handle size and shape according to the target population and provides general ergonomics knowledge	Manufacturing
(Kaljun and Dolšak 2012)	Intelligent system OSCAR	Hand tool ergonomics design	Manufacturing
(Maldonado et al. 2012)	Fuzzy axiomatic design method	New multi attribute axiomatic design methodology for ergonomic compatibility evaluation of Advance Manufacturing Technology (AMT)	Manufacturing
(Kavitha et al. 2012)	Neuro fuzzy system	Generate models of car seat design variables to affective user satisfaction (body contact, sweat and heat generation, shoulder support and child safety)	Manufacturing
(Martin et al. 2012)	Ergonomic monitoring system	Determining the level of lifting and carrying methods that detrimental employee's health through real-time ergonomic analysis of lifts performed by human	Manufacturing

Table 4 Several of AHP applications in occupational ergonomics risk management

Authors year	AHP application	Study area
Kim et al. (2010)	A safety risk assessment methodology considering the risk influence factors of construction sites using expert surveys and the AHP	Construction industry
(Badri et al. 2012)	The proposed approach involves the AHP method for the paired comparison of the OSH risk factors	Manufacturing industry
(Ersoy 2013)	Used AHP to determine the weight of the accident risk and the safety measure taken	Marble quarries
(Aminbakhsh et al. 2013)	Used AHP method for the paired comparison of the risk factors allowing reliable prioritizing of identified risks by inquiring objective judgments	Construction industry
(Rossi et al. 2013)	Used AHP to select the best manuable handling solutions evaluating ergonomics criteria and production performance measures	Manufacturing industry

4 Development Occupational Ergonomics Assessment Framework

4.1 Knowledge Base Ergonomics Assessment Design

Basically this study has three phases of research activities. The research design structure can be referring to Fig. 4. There are five basic elements in occupational ergonomics to be addressed in this study, worker, job/task design, equipment design, and work place design and work organisation. Several methodological approaches in ergonomics such as direct observation, survey, trial tests, experimental measuring of physical and mental workloads can be further applied in assessing the appropriateness and effectiveness of the user-product/system interaction [9]. In order to evaluate the risk, this study will conduct three ergonomics assessment method which are physical environment observation and evaluation, self-report questionnaire respect to physical and psychological risk, and work related musculoskeletal disorders assessment. The analytical hierarchy process method will apply for prioritizing the ergonomics risk level.

4.2 Knowledge Base Ergonomics Assessment Procedure

Previous review research revealed that research areas in ergonomics based on 'methods and techniques' and 'human characteristics' were less dominating than they were in the past [10]. The study method process for development of knowledge based ergonomics assessment system can be referring to Fig. 5.

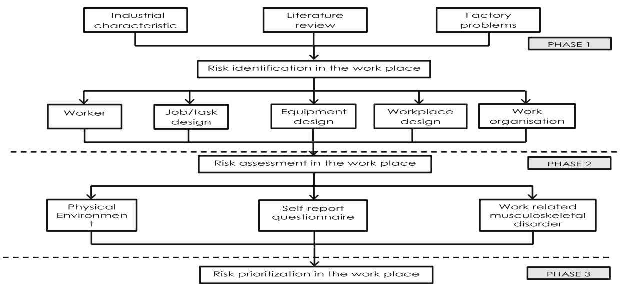

Fig. 4 Research design for KBEAS development

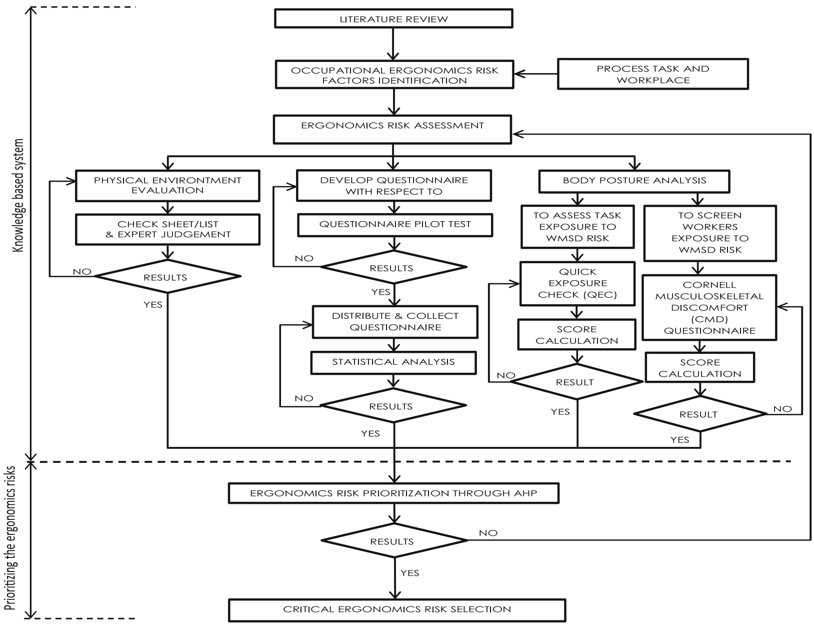

Fig. 5 Methodology for development of knowledge based ergonomics assessment system

4.3 Instruments

About 250 respondent of automotive component manufacturer will be participate in this occupational ergonomics assessment. This study will use survey and interview method simultaneously. The ergonomics risk factors will be identify by using direct observation and survey such as activity analysis, photography, video, survey questionnaire and interviews. Study data will obtain with a design self-report questionnaire, and modified Work Organisation Assessment Questionnaire (WOAQ). The occupational ergonomics assessment data also will collect through interview session base on standard questionnaire which are QEC (Quick Exposure Check) and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and physical environment condition evaluation method. The output of this ergonomics assessment will be prioritize using analytical hierarchy process technique (Refer Fig. 6).

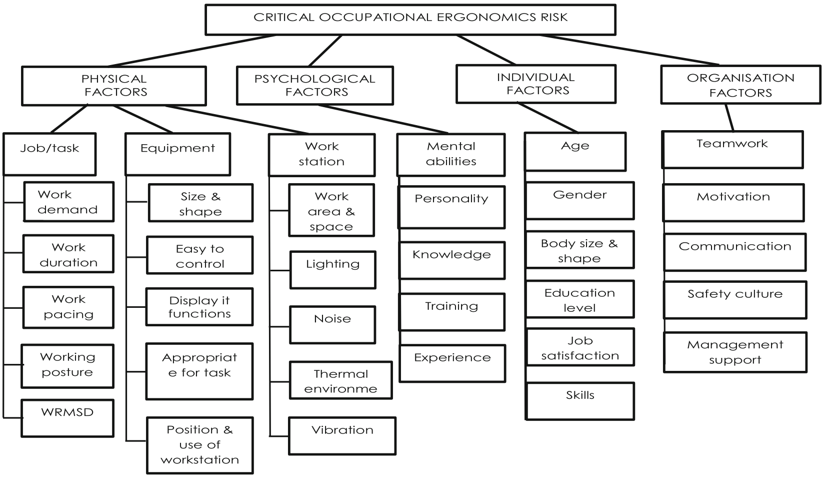

Fig. 6 Proposed Hierarchy structure of occupational ergonomics elements

5 Conclusion

There is need to identify the mechanism of knowledge management in the integration of ergonomics assessment method. Thus this paper proposed a novel framework to facilitate the ergonomics knowledge management for occupational risk assessment. Knowledge based ergonomics assessment system will develop and purpose is to help the decision makers to predict ergonomics risk elements at early stage of product or process development. The main focus of occupational ergonomics is the compatibility of jobs and environments with human factors. The advantages applications of ergonomics principle are can enhance the workplace safety, job satisfaction to the employees and also increase their productivity. This study will assess assembly worker's abilities and limitations, job tasks, equipment and working environment, and the interaction between them. The analytical hierarchy process design methodology for ergonomics risk prioritization compatibility allows decision makers to obtain occupational perspective in risk evaluation. The knowledge based ergonomics assessment system to facilitate the employees in automotive plant to evaluate on workplace in a sustainable way. Better understanding among automotive component manufacturer's workers in human factors and ergonomics assessment. Thus occupational ergonomics risk will be considered primarily in early project development phase and it's as an entity interacting with other types of risk that must be managed in automotive assembly plant. Further research needs to be done is to conduct occupational ergonomics risk assessment at automotive assembly plant.

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Quality Management in Toy and Children's Furniture Manufacturing

Mieczysław Rajkiewicz, Anna Walaszczyk and Zbigniew Wisniewski

Abstract The aim of the article is to present, on the basis of a case study of a selected enterprise, the architecture of children's product quality creation that takes into account the requirements set down in the European Toy Safety Directive. The requirements of the directive 2009/48/EC concerning in particular toy safety, ergonomics, packaging, marking, etc. will be discussed in the article. The article reports the results of pilot studies on the conformity of a specific group of toys in Poland with the requirements of the European Directive and confirm the significance of the problems. Critical processes which determine elimination of product defects by business process quality management, identification of customer requirements, technical and organizational infrastructure provision, design, planning, manufacturing, warehousing, distribution. How the quality of those processes is managed is a decisive factor for the effectiveness of building quality into the manufacturing process, reducing the number of errors to manufacture a defect-free product that meets customer requirements. How the quality of those processes is managed is a decisive factor for the effectiveness of building quality into the manufacturing process, reducing the number of failures to manufacture a defect-free product that meets customer requirements. The overarching goal of such an approach is customer satisfaction which can be effected by achieving such process efficiency that each product is defect-free and is consistently conforms to standards.

Keywords Management · Quality · Toy · Legal requirements · Standards

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1 Introduction

About 6 million children (persons under 14 years of age) live in Poland. This constitutes over 15 % of the entire population of the country. Therefore, it appears worthwhile to take a closer look at the market of products for this group of consumers. Undoubtedly, toys are the most frequently used products by children.

The quality as defined in ISO 9001:2005 is 'the degree to which a set of inherent characteristics fulfills requirements'.

Product quality is measured in terms of defects in the product (the fewer defects there are, the better the quality of the product), where defect is defined as each such negative characteristic—negative from the point of view of the customer—that the customer may not expect to occur [1].

In order to determine product quality, a broader approach needs to be taken. Aspects which require special attention are presented in Fig. 1.

Frank Price discussing the concept of quality observes that the customer should be provided with what the customer needs today at the price that the customer will pay and that it should be remembered that something even better should be provided to the customer tomorrow. The concept of quality is differently construed. Below, a few examples are given which are relevant to the group of products under analysis:

- non-conformity with the requirements of the Toy Safety Directive,
- perfection approximation,
- fitness for use,
- meeting manufacturer's expectations,
- first time right manufacture.

It is important not limit the concept of quality to the product itself but rather to extend it to include processes which need to be managed so as to effect a product of good quality at a reasonable cost. The following processes can be distinguished which are common practice of organizations providing products to the market: marketing, design, manufacturing, distribution, warehousing, using, utilization etc. Properly high quality of the entirety of actions in all those processes builds proper architecture of the product, which makes it likely that the customer will be provided with and will be able to use a product that meets the customer's expectations.

It is vital to build such customer-provider relations which enable consistent perceptions of quality. Frequently, these are hard to achieve due to the fact that the customer expects the product to realize its inherent properties to the highest possible extent whereas the provider wants also to profit economically and achieve desirable market position.

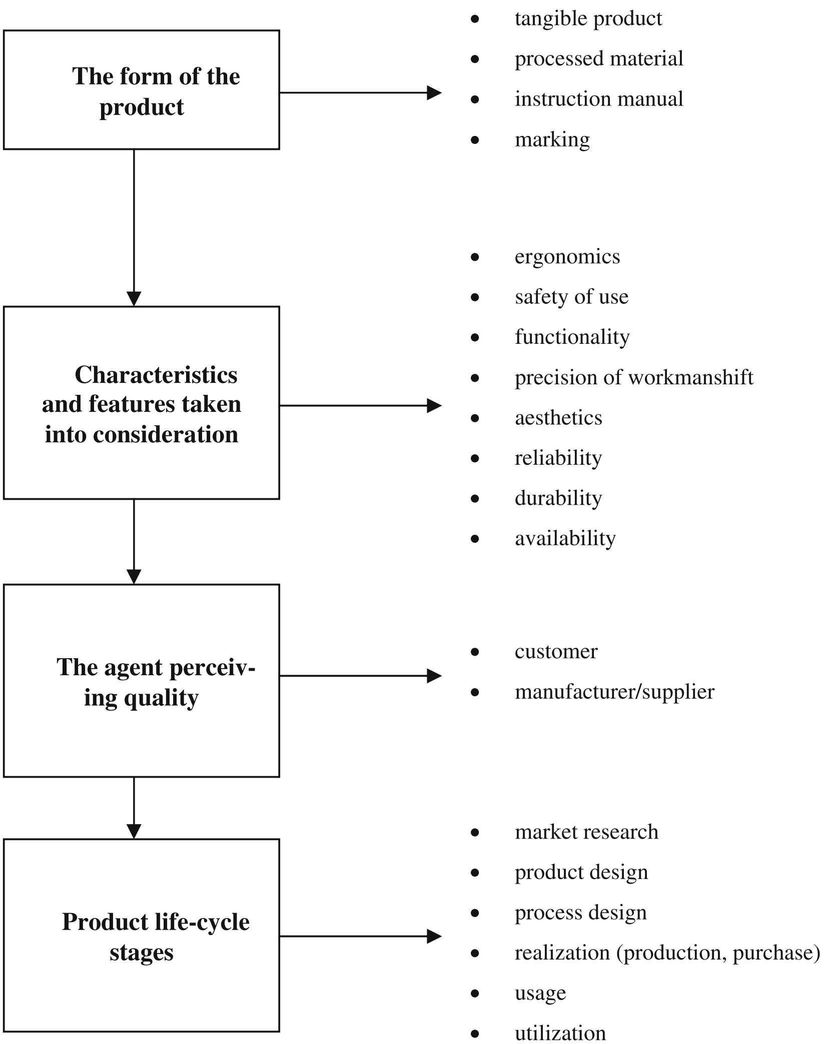

Fig. 1 Aspects of toy quality perception. *Source* Authors' analysis based on Hamrol A., Zarządzanie jakością z przykładami, Wydawnictwo Naukowe PWN, Warszawa 2007, p. 18 [2]

2 Architecture of Product Quality—Toys and Children's Furniture

Architecture of product quality is present in the ideas of William Edwards Deming whose philosophy can be found in the PDCA cycle that leads to continual improvement. One may therefore claim that efforts towards better quality should be a continuous action which eventually leads to an increase in profitability. Higher quality means lower costs. The Deming's chain reaction known also as the 'Deming profitability chain' which illustrates the importance of investing in the improvement of the quality of manufactured products lends support to this claim. Quality improvement reduces costs related to correction of defective products, among others. 'Doing it right the first time' and manufacturing products free from defects means eliminating errors especially during the initial stages of process realization. Sustained efforts to maintain such relations may even lead to a reduction of product prices, gaining a competitive edge, increasing the organization's market share. Therefore, improvement of the quality of manufactured products is—for a number of reasons—necessary. The Architecture of Product Quality Program must not rely on the operator's/provider's responsibility for the quality of the product. By focusing on finding out customers' expectations, detailed analysis of legal requirements laid down in the Toy Safety Directive, conforming with the standards, avoiding late changes it is possible to strive for 'Embedding Quality'. 'Embedded Quality' is the driving idea of projects currently carried out by many organizations. In keeping with this idea, the primary emphasis should be placed on achieving quality during the design process, the pilot run, production start-up, full-scale production, which as a result makes it possible to avoid expensive and time-consuming finished product testing. When analyzing production process in terms of 'Embedded Quality' it is important to differentiate between errors and defects: an error means a departure of any kind from the planned process and constitutes the source (cause) of a defect; a defect means that the product is out of specifications and it is the result (effect) of an error.

Due to the high cost of defects identified especially in the final stages of the production process, it is paramount that the process be prepared well. A production process that has a solid quality program should ensure identification of non-conformities (errors) at the point of their occurrence in order to prevent defects and in particular to prevent a defective product from reaching the customer.

The pre process is where errors can be prevented at the lowest cost. This stage includes among others:

- product design,
- development of technological documentation,
- preventive maintenance,
- verification of material supplies,
- employee training,
- verification of the pilot run and pre-assembly,
- verification of process parameters.

This stage should ensure that all inputs are as planned and are ready to perform the tasks assigned to them in the task processes. The moment of moving on to the next stage may as well be called the point of no return. When the production is in full swing (process execution stage), all that remains to be done is to control those elements that may impact product quality:

- machine control parameters,
- critical activities sequence,
- the course of critical stages in the process.

During its execution stage the process is controlled in order to ensure that is runs within its variation limits. During this stage, it is important to signal when the process starts to exhibit non-standard behavior. By the time the stage of process execution is finished, the quality has been embedded. The resulting product is complete and cannot be changed unless by reworking/reprocessing.

The final stage, the so-called post process, is related to the finished product release. In the case of non-conformities (product defects) repair is necessary and the organization bears the costs of the so-called poor quality regarding e.g. the need to segregate, reclassify or even utilize. Releasing a defective product to the customer is the worst and the most expensive scenario. According to the 1-10-100 rule in quality costs, one unsatisfied customer means that ten more will know and the organization will lose a hundred of others. It may lead to off the balance sheet costs—lost sales opportunities, which means loss of income.

Architecture of Product Quality is a program the main tenets of which are:

- identification of non-conformities when they are still production errors and not product defects,
- actions focused on inputs (x) and not on outputs (y) of processes,
- improvement of systems not people.

3 Conformity Assessment—CE Marking for Toys

CE marking on a product means that it complies with the principal requirements laid down in the relevant directives. The CE marking does not bespeak the quality of the product. In contrast to certification marks, it is obligatory. The CE marking does not indicate compliance with standards, either. The manufacturer or its authorized representative, on their own responsibility, label the product with the CE marking following successful conclusion of conformity assessment and drawing up of the EC declaration of conformity. Products with the CE marking be freely available on the European market. The CE marking does not bespeak the origin of the product, which mean that products with the marking may not necessarily be manufactured in the European Union. Conformity assessment procedures are to ensure that the principal requirements have been met. Such procedures may include:

- meticulous examination of the product,
- drawing up technical documentation,
- drawing up a decalration of conformity/obtaining the EC-type examination certificate.

Each product must undergo a conformity assessment procedure. Sometimes directives indicate which procedure should be applied—they are based on modules A to H which describe particular actions. Some of the modules do not include the participation of third parties, while others require that notified bodies be involved. Manufacturers, prior to labelling the product with the CE marking, should perform the following activities:

- determine all directives and other legislation applicable to the product,
- perform risk analysis,
- review harmonised standards assigned to each directive,
- selection and carrying out of the procedure for conformity assessment,
- drawing up a declaration of conformity.

The CE marking is affixed by the manufacturer and it is the manufacturer who bears responsibility for it, however, in some cases, an independent body—a notified body may participate in the process. Toys, are used in play by millions of users globally, must be safe for use. In the world as well as in Europe or Poland there are many are which applicable to toys. The main law used in the European Union member states is the Directive 2009/48/EC of the European Parliament and of the Council of 18 June 2009 on the safety of toys [3]. Directive 2009/48/EC defines toys as 'products designed or intended, whether or not exclusively, for use in play by children under 14 years of age'. The definition provided in the directive is very general and manufacturers frequently are confused whether their product falls within the scope of Directive 2009/48/EC. Annex I to the Directive lists several products which are not considered toys within the meaning of the Directive. These are, among others: Christmas decorations, baby soothers, puzzles with more than 500 pieces or products for collectors. The manufacturer decides whether a product is to be used in play by children. This does not mean that the manufacturer is allowed to arbitrarily declare a product not to be a toy in order to evade an assessment of conformity with the requirements.

4 Toy Quality and Conformity Assessment—Research Results and Analysis

The toys purchased by Preschool X in July of 2014 were analyzed during the study. The toys were purchased online through the supplier's website. All products were bought from the same supplier which is a company specializing in providing supplies for educational establishments. The company does not manufacture toys.

Table 1 Frequency of non-compliance

Non-compliance	Number of toys		
	Toys made in Poland	Toys made in the EU	Toys made in China
No CE marking	1	–	2
Incorrect CE marking	1	2	7
IO information about the importer/manufacturer	4	1	7
Warning in English	–	–	1
No instructions for use	–	1	–
Instructions in English	–	–	2
No required warnings	1	–	6
Misused warning	1	–	3
Age-group of intended users not stated	2	2	2
No indication to keep the packaging	7	2	3
Conflicting information on the packaging	–	–	1
Total	17	8	34

Source Compiled by the authors based on their research

Rather, it distributes toys purchased from Polish and international manufacturers. The company's offer includes toys made in China.

44 toys manufactured in Poland, in other European countries and in China as the only country that is not a member of the EU were examined. Among the toys were board games, creative toys, soft toys, developmental and activity toys.

Table 1 presents the frequency of non-compliance of the studied toys with the fundamental requirements specified in Directive 2009/48/EC.

Lack of information about the manufacturer or importer and no indication to keep the packaging were the most frequently occuring non-compliances. One case of a conflicting warning and of a warning only in English with no Polish translation provided were observed. Instructions for use were not provided for one of the toys. Another non-compliance occured in the case of all of the products. Selling toys online, the supplier should provide warnings, user age limitations and the risks involved in using the toy. Warnings concerning the use of the toy should be clearly visible for the consumer also in the case of online purchases, which ensures that the consumer makes an informed decision during the transaction. Polish manufacturers often fail to specify on the toy packaging the requirement for the consumer to keep the packaging or the label. This non-compliance was observed the most frequently for the toys made in Poland. As regards toys made in China, manufacturers as well as importers fail to provide the required information and only place their corporate logo on the packaging. Lack of warnings required by the directive or standards is another

Table 2 Comparison of the number of the suspect and the verified toys

Toy origin	Suspect	Verified
Poland	11	16
European Union	6	8
China	17	20
Razem	34	44

Source Compiled by the authors based on their research

non-compliance. Very frequently, toys made in China are labeled with an incorrect CE marking (non-compliant with the requirements specified in directives). Summing up, the most non-compliances with the European legal requirements concerning conformity assessment occured in the case of toys imported from China whereas the fewest non-compliances were noted in the case of toys imported from the European Union member states (excluding Poland which was analyzed separately).

A comparison of the number of the suspect toys against the number of the verified toys is presented in Table 2.

The information presented in Table 2 reveals that only 10 out of the total number of the 44 analyzed toys comply with the requirements of the toy safety directive to the extent sufficient for making them available on the market and permitting their use.

5 Conclusions

Anyone one asked to think about the significance of quality would certainly respond that it is considerable or may even be enormous but do we really have a good grasp of the concept? In literature, there is a profusion of definitions of quality and it is not an easy task to describe it in clear unequivocal terms. The difficulty stems from the fact that 'the quality of a product is taken for granted as long as the product has it; what is dramatically conspicuous is its lack'. Thus, the consumer who buys a toy with labeled with the CE marking has the right not to expect that the toy does meet the safety requirements set for toys. It is worth mentioning that the level of quality may be different for different consumers due to their individual preferences.

The foregoing analysis shows product quality management issues in regard to toys through the lens of production management and legal requirements applicable to toys. The results of the study, some of which are presented in the article, indicate that there is still a lot of room for improvement as far as the broadly construed quality is concerned. The main issue in this case is the process of control of imported products and—related to it—process of control of non-compliant products. The market of toys is so large and so diversified that the task may prove to be a serious challenge.

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Modelling Formation of Attitudes to Change

Zbigniew Wisniewski, Aleksandra Polak-Sopinska, Mieczyslaw Rajkiewicz, Malgorzata Wisniewska and Piotr Sopinski

Abstract The article presents the results of analyses the objective of which was to determine a method of description of employee attitudes to change. The analyses were conducted during the process of implementation of changes to the organization of workstations in order to improve their ergonomics. Such a model is prerequisite for analyzing the dynamics of change implementation in the organization and should have the following characteristics: it should be unambiguous, adequate, complete and disjunctive. The phenomena analyzed in the study had not been thoroughly researched or described in literature. Neither engineering assumptions nor the possibility of controlling social phenomena during the implementation process is taken into account in the currently existing theories of organizational change in the social and management sciences. Therefore, sociological exploration appeared to be the only way to discover the specific character and regularity of the examined processes. The research and analysis strategy is based on the methodology of the grounded theory. Estimations of individual factors and their subsequent comparison make it possible to identify the direction and the pace of the formation of employee commitment to organizational change.

Keywords Change management · Grounded theory · Human resources management

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1 Introduction

The results of analyses reported here are part of a project whose the objective was to identify the dynamic characteristics of the organization and the change. The description presented in this article refers to that part of the project which dealt with the determination of the manner of description of employee attitudes to change. The details of how this was accomplished are discussed in the 2010 monograph [1], whereas the results achieved make it possible to utilize the methods of description of attitudes to change in other studies. The analysis of attitudes and activities of a group of employees of the organization where various organizational changes are introduced allows identification of the primary social phenomena which occur during change implementation common to different organizational contexts regardless of the type of activity the organization is involved in, its industry, size or specific character of its functioning. By comparing the situation in the researched organizations and by identifying employee attitudes to change implementation analytical categories were determined which allowed description of the process of organizational change as regards its social aspects. These analytical categories were applied to the reconstruction of the examined phenomena and development of their models. They were also used to identify the factors which shape the process of change in terms of its social aspects and to predict how this process proceeds based on an analysis of the occurrence, intensity and dynamics of individual phenomena. This allowed the persons coordinating the implementation to monitor employee attitudes as they occurred and to anticipate their impact on the change implementation and to take appropriate corrective actions as necessary. Figure 1 illustrates this mechanism.

It was assumed that the persons in charge of the organizational change were able to control its course provided that they were informed of the current state of the implementation and of the employee attitudes to it. To this end, they needed to receive feedback about the change, which meant that they needed to know what they were supposed to monitor (what phenomena, processes or social factors could determine the process of change implementation). That is the reason why identification of such critical social phenomena constituted one of the specific objectives of the foregoing study.

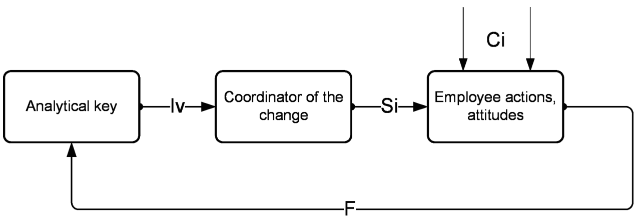

Fig. 1 Control of work during change implementation. *Iw*—information verifying undertaken actions, *Si*—strategic influence on employees during the implementation, *Ci*—structural or situational intervening conditions affecting employee actions, *F*—feedback about the progress of organizational change in terms of social aspects [1]

2 Research Methods

The combination of concepts specific to the social sciences with engineering knowledge, which is the hallmark of the innovative approach taken in this study, necessitated the exploratory character of this research. The research and analysis strategy adopted for this study is based on the tenets of the Grounded Theory. The methodology was developed in the 1960s and 70s by Glaser and Strauss in response to the problem of the discrepancy between theoretical proposals and empirical research. However, what renders this methodology unique and effective is not the particular method of analysis that it provides but rather the fact that it fuses analysis and data collection into one process where they both influence each other and by doing so modify the course of the study [2–5]. The theory emerges gradually during the study; all new data enrich its content by contributing new analytical categories or complementing their properties [6] which, in turn, modify the data collection process directed to the grounding of the concepts that have emerged. Combining inductive and deductive reasoning at particular stages of the analytical activity, this methodology leads to utilizing abductive explanations.

Data sampling does not rely on probability because effectiveness and usefulness for hypothesis generation are the foremost selection criteria [7]. Sampling is supposed to enable diversification of comparisons made at a particular stage of the study, increasing or decreasing variability of cases [7], capturing changeability of conditions and supplementing data resources [2, 8, 9]. It is not selective sampling because there are no preliminary assumptions. It is not random sampling either as cases for analysis are determined by the researchers' need to collect data that will allow them to conceptualize categories, develop a theory and comprehend phenomena that are the focus of their research [2, 3, 10, 11].

That sampling has been performed properly and that the procedure is now complete is signaled by theoretical saturation which is a situation where new data do not contribute to the explanation of phenomena and do not supplement in any way the generated conception [2, 4, 12]. The achievement of the theoretical saturation is a necessary condition if the emerging theory is to be conceptually dense, to have internal integrity and to refer to the empirical reality [3, 8, 11, 13], all of which provide its grounding.

Fourteen organizations took part in the study. They included manufacturing, service and financial and service organizations. The number of employees varied and ranged from a hundred employees at one organization to several thousand employees employed at organizational branches around the country. For purposes of the foregoing study, however, it is more important to consider the number of employees in particular organizational units of the organizational structure. The smallest group of employee consisted of a four-employee team at one of the representative offices of the organization, whereas the largest one was a group of more than one hundred production workers.

Two major data collection techniques were used in the study: unstructured interview and overt non-participant observation (see CSS questionnaire in: [14], pp. 148–149).

The unstructured interviews were directed retrospectively, which means that they were aimed at obtaining elaborate narration and description [15] that referred to past events and their links to the present. This allows respondents to present their idiosyncratic perception of phenomena that accompany changes [16]. Subsequent analysis makes it possible to capture the complexity of activities, processes and events experienced by many people at the same time (see [17]).

Overt non-participant version of the observation technique was used. Routine operation of production floors and workstations in the organizations selected for the study was observed at various points of the implementation or planning of the organizational change.

The observation made it possible to capture phenomena in their natural context and better understand the significance of that context for the course of events and for people's activities [18–20]. At the same time, it also allowed verification of data collected during the unstructured interviews, and in the analysis, go beyond the selective observations of the respondents and gain access to phenomena that escaped their perception [20].

3 Results of the Study—Properties of the Phenomena Accompanying Change

Understanding the manner in which employees react to organizational change requires that the complexity of exhibited attitudes be analyzed and the process representing employee attitudes be identified. One such process has been identified, namely employee engagement during change. Employees may choose not to engage during the change and remain indifferent to it or resist and counteract it or they may become very engaged and support the innovation or cooperate in its implementation. The evaluation and description of the level of employee engagement usually reflect their attitudes indicating at the same time how supportive or how resistant to change they are going to be during the implementation. Nevertheless, employee engagement is a complex process which is shaped by various contextual factors connected with the specific character of the organization and its activity, with the characteristics of interpersonal relations in the organization, but also with the characteristics of the change itself. The study allowed identification of five major factors influencing employee engagement.

- *Evaluation of the current situation*—is how the current work situation is perceived and judged. This assessment is critical for the determination of the necessity of change. If the current situation before change implementation is regarded as bad, the change is deemed necessary and employees are more inclined to engage in the change and make every effort to facilitate its prompt implementation. On the other hand, the better the situation before the implementation is perceived to be, the weaker the perceived need to introduce the change, the lower the level of engagement and the slower the pace of efforts towards the implementation. Therefore, it is practical to lower the evaluation of the current situation in the initial stages of the change and to improve it after the implementation when it is the situation after the change that is subject to the evaluation.

- *Anticipatory evaluation*—includes all expectations and predictions that refer to situations that may occur at work in the future. Prior to the change, anticipatory evaluation refers to all forecasts for the implementation and its expected impact on the functioning of the organization and employee work activity. Whereas following the implementation, the anticipation is concerned with situations that may occur due to the nature of the change itself and of the phenomena that take place in the organization.
- *Level of expectations*—reflects the foremost needs of employees which are revealed at times of change. Each innovation may raise hopes that employee needs will be met (improvement of work conditions, salary rise, reduction of the number of job responsibilities etc.). The higher the expectations the stronger the engagement and the efforts in favor of the prompt implementation of change. On the other hand, low employee expectations whether caused by the feeling of dissatisfaction with the situation to date or related to the fear of the new and disbelief that their work situation may improve will tend to slow down and decrease employee engagement. It needs to be borne in mind however that high expectations before the change may amplify employee disappointment after the change should it turn out that their hopes have been let down and their needs have not been met to the extent expected.
- *Level of interest in the change*—refers to the extent to which employees try to acquire information about the change. High interest in the change is evidenced by the willingness to participate in meetings during which the implementation is worked out and also in the effort to acquire the skills required for work after the implementation. Contrarily, low level of interest is characterized by disregard for information about the change, unwillingness to acquire the qualifications required for the job after the implementation etc. Interest is the necessary factor for inspiring engagement; nevertheless, excessive curiosity may have an adverse effect on employee activity. They will take an anticipatory attitude and while trying to collect new information about the change they will not be inclined to accelerate its introduction. Low level of interest will tend to significantly lower overall engagement during change.
- *Level of activity*—are all actions taken by employees as regards the change. They may be actions directed at co-workers (colleagues, superiors, employee groups) as well as at the change itself (devices, technologies, etc.). Employee activity shows the extent to which they feel responsible for the implementation and for the consequences of the change. Active employees are engaged in favor

of the change, whereas lack of activity indicates employee indifference or disapproval of the implementation. Activity includes employee initiative, submitted proposals or expressed willingness to participate in the implementation, readiness to follow guidelines or suggestions from superiors in regard to getting ready for the implementation.

Individual factors which influence employee engagement during change tend to cluster into certain groups of factors.

- The level of interest, the level of activity and the level of expectations together create the employee *activity dimension.* It covers the entire range of activities connected with disseminating information, undertaking certain initiatives, participating in authorized tasks as well as with expressing one's needs and willingness to satisfy them through change. The activity dimension is directly responsible for increasing employee engagement during change. The more evolved it is (high level of interest, activity and expectations), the higher the employee engagement.
- The evaluation of the current situation and anticipatory evaluation together form the *judgement dimension* which refers to the evaluation of the current work situation and formulation of forecasts. The judgment dimension sits against the employee activity dimension and reflects anticipatory attitudes, refraining from action and taking the position of an observer. Therefore, its effect upon engagement is reversed which means that the more evolved it is (high evaluation of the current situation and high anticipatory evaluation), the weaker the engagement during change arising from taking a reserved and judgmental stance.
- The level of interest and the evaluation of the current situation together form employee *bias towards the present.* This bias is typical of employees who tend to focus on the actual situation and refrain from looking into the future and planning and who reluctantly change their attitudes. For this reason, an evolved bias towards the present (high level of interest in change and high evaluation of the current situation) tends to stall the pace of engagement in the process of innovation implementation.
- The level of expectations and anticipatory evaluation together shape employee *bias towards the future* which basically stands for a shift of attention to future matters, envisaging possible outcomes of the change, its potential benefits. Strong bias towards the future (high level of expectations and high anticipatory evaluation) accelerates employee engagement in the implementation; the employee longs to leave the present behind and is eager to make every effort to get to the anticipated situation as soon as possible.

The interrelated factors may be presented with a graph (Fig. 2) which illustrates the range of the influence of individual factors and of their groups on the evolution of employee engagement. All five factors need to be determined if the direction and the pace of engagement formation are to be specified. Predominance of particular biases and dimensions determines the character of engagement, its increase or

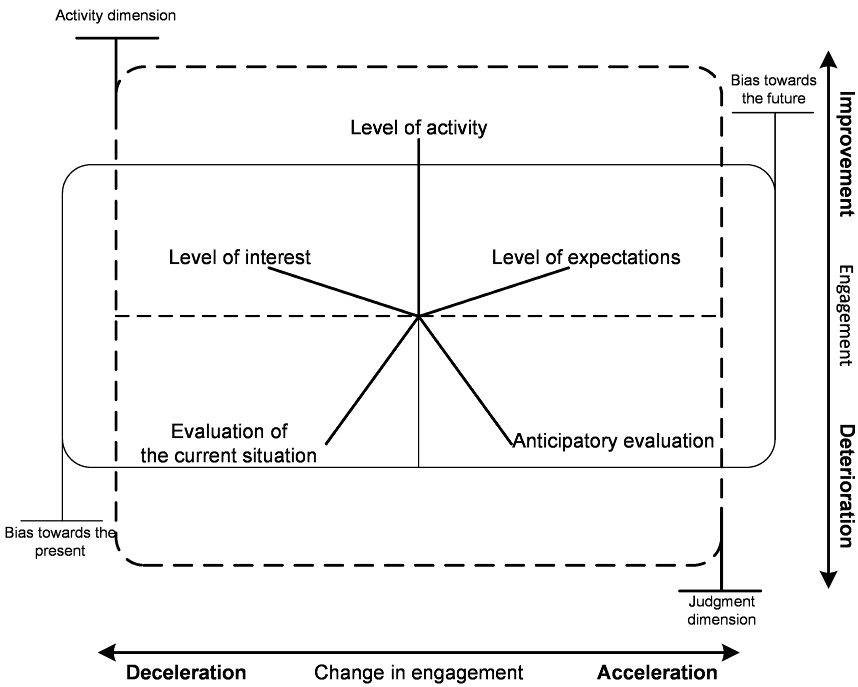

Fig. 2 Employee engagement—distribution of factors and groups of factors [1]

decrease and its pace. A situation where engagement plateaus is possible when dimensions and biases become level. The graph can be best understood when one follows how individual factors play in the formation of employee engagement.

4 Scaling Employee Engagement Factors

The process that identifies overall attitudes and activities of employees during change is an examination of employee engagement. Employee engagement may rise or decline and the pace of the increase or decrease may also vary. Generally, the process of engagement will reflect the influence that people exert upon the implementation contributing significantly to its effectiveness or lack thereof.

It was also an important objective of the study to identify factors that determine the evolution of engagement. Considering the complexity and multidimensionality of social processes (by comparative analysis of analogous processes yet having different properties and in different organizations) and their anchoring in changeable group, organizational, social and cultural contexts, five major factors (subprocesses) which together shape the course of the main process, namely, the formation of engagement, were successfully singled out.

As previously presented, these factors are: employee interest in the change, employee activity as regards the change, formulation of expectations for the change, evaluation of the current situation and evaluation anticipating the effects of the change. Individual factors and groups of factors drive the increase or decrease of engagement as well as the acceleration or deceleration of the pace of change in attitudes. However, further usefulness of the reconstructed model of employee engagement formation requires that individual factors be scaled, which entails determination of gradable properties of each one of them. This makes it possible to estimate the level of interest, activity, expectations and evaluations and therefore to reconstruct employee engagement in a particular situation of organizational change. An analysis of the course of changes in the researched organizations made it possible to recreate various phenomena which occurred concurrently and reflected different levels of the formation of the described factors. Based on that, it is possible to attribute values to them and to place them on an ordinal scale suitable for each factor. In the end, there are five measurement scales showing particular social situations that tend to occur during organizational change with their magnitude values ranging from 0 to 5.

Scales measuring employee engagement:

- Interest in the change
- Activity for the change
- Expectations for the change
- Evaluation of the current situation
- Anticipatory evaluation for the change.

Estimations of individual factors and their subsequent comparison enable determination of the direction and the pace of employee engagement formation during organizational change. The interrelations among the individual factors can be demonstrated in the form of the dynamics of employee engagement formation during change. The identified models of engagement are discussed below.

4.1 Quick Improvement of Employee Engagement (QIE)

The first information about change sparks heightened employee interest. Employees develop detailed expectations for the change believing that it may improve their job situation and become involved in the implementation preparatory activities. Simultaneously, they regard the current situation with criticism concluding that the change is necessary and inevitable if the functioning of the organization and their jobs are to improve. They also believe that the change will fulfill their expectations, they anticipate its success and positive outcomes. Therefore, what is dealt with is a situation where the activity dimension is very evolved and characterized with a high level of interest, high level of activity and of expectations while employees exhibit a bias towards the future with a high level of expectations and high anticipatory evaluation.

4.2 Slow Improvement of Employee Engagement (SIE)

Information about the planned change do not arouse much enthusiasm among employees. They are interested in the plans of introducing the innovation and relatively active in preparing for the implementation. They may for example participate in trainings their superiors asked them to take part in but they do not develop such detailed expectations, which arises from the fact that they are generally satisfied with the current situation and regard the change as unnecessary and potentially disadvantageous in comparison to the current situation. In this case, what is dealt with is a relatively evolved activity dimension, this time, however, the predominant bias among employees is towards the present.

4.3 Plateauing Engagement (PE)

Engagement plateaus when as a result of the implemented change employees decrease their activity levels but remain moderately interested in the change. Similarly, expectations decline in confrontation with the reality even though employees' primary needs which they expect to be satisfied are still formulated. Concurrently, employees start to anticipate the future based on their observations of the present state (the state of implementation). Therefore, anticipatory evaluation and current situation evaluation become level as do biases: employees concentrate equally on the future and on the present while activity is on par with judgment.

4.4 Slow Deterioration of Employee Engagement (SDE)

The situation after the implementation of the change is not disappointing, employees are satisfied and are getting used to the new. They approve of the new situation. Employees can see actual benefits of the implementation and thus lower their expectations and envisage a positive future yet at the same time focus on the present situation and on the advantageous results of the implementation. Getting accustomed to the new reality, they gradually lower their activity and their interest.

In this situation, the judgment dimension tends to dominate over the activity dimension whereas the bias towards the present tends to prevail over the bias towards the future.

4.5 Quick Deterioration of Employee Engagement (QD)

The feeling of disappointment dominates among employees after the introduction of the change. The frustration with the situation after the implementation is the cause of the employees' unwillingness to make any effort for the change and of their desire to return to the situation as it was prior to the change.

The hope that the negative effects of the change can be reversed makes them anticipate a favorable future for themselves and expect that their needs will be met even if that were only to happen by limiting the change-related solutions which they consider detrimental. Their interest in the change, due to the disappointment it has caused them, rapidly drops, they do not want to receive new information and frequently distrust their superiors.

5 Conclusion

The level and dimension of engagement are dependant on the particular situation and the people that it involves. It has been observed however that in communities in which a change is introduced, one or two different paradigms tend to occur. This arises from the fact that a given type of engagement is strongly determined by the conditions in which a group of employees operates. A group of employees who work towards a common goal and complete the tasks that this goal requires create a team not only because they are organized as one or because they are issued a production order. Most frequently, they are teams which have been established long before and their members share the same system of values as regards the organization. Many opinions expressed by individual members of a given group strongly feature group opinions. Group members partake in the collective consciousness in which they exist within the organization. There are of course exceptions which may result from a specific attitude towards a particular situation that individual members of the team may exhibit or from a clear disagreement between individual and group interests. On the basis of the observations, the authors conclude that the range of engagement models within the narrow community of the organization is limited.

From amongst numerous possible configuration models of employee engagement during change, for all organizations that participated in the study, five configurations that prevail over all others have been identified and discussed in this article. They are the models which describe the most representative attitudes.

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Employment of Persons with Disabilities in Poland: What Do Small and Micro Enterprise Employers Know?

Aleksandra Polak-Sopinska, Zbigniew Wisniewski and Marta Jedraszek-Wisniewska

Abstract Observation of Polish enterprises in the open labour market reveals a marked reluctance to employment of disabled people. Entrepreneurs appear to hold a common belief that a person with disabilities is a risk to productivity and a source of additional costs. Further, employers tend to think that it is truly difficult to find a job that a disabled person could perform. The authors of the article decided to find out whether these convictions might possibly be a consequence of employers' insufficient knowledge as regards disability employment. 50 large, 80 medium-sized and 149 small employers (including micro employers) agreed to participate in the study. Individual, researcher-administered survey was used in the study. The article only presents the results for small and micro organizations as regards employers' knowledge concerning the definition of a person with disabilities, the degrees and causes of disability; statutory working time of disabled workers; matching jobs and adapting the workplace to the needs and capabilities of disabled employees; financial support to employers of the disabled as this information was deemed fundamental in employment of people with disabilities.

Keywords Knowledge · Employment · Small and micro enterprises · People with disabilities

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1 Introduction

The growing number of people with disabilities in developed countries (in the EU, there are about 50 million people with disabilities—at least 10 % of the population), which to a large extent is a result of the population aging [1], is one of the most difficult challenges that national governments and employers are facing today. This problem is also present in Poland. Following the enactment of the law of 11 May 2012 amending the law on pensions from the Social Insurance Fund and certain other laws [2] (regulations concerning, among others, old-age pensions provision were revised including gradual raising of the retirement age to 67 both for women and for men from 60–65 years of age, respectively), the working age population of the disabled has been growing each year, which, in the near future, will result in a decline of the already low employment rate of people with disabilities (in 2014, it was a meagre 22.8 % [3]), and will simultaneously increase social exclusion of the disabled. In 2014, more than one half of workers with disabilities (139,000) were employed at 1263 sheltered workshops. In the open labour market, only 22,260 out of 1,771,000 employers took on 103,000 people with disabilities [4].

A certain reluctance of Polish enterprises to employ the disabled is markedly noticeable in the open labour market. Employers tend to hold a conviction that a disabled worker has a negative impact on productivity and generates additional costs. Moreover, employers think that finding a job for a disabled worker is a daunting task. The authors of the foregoing article set out to find out whether such convictions may possibly result from employers' inadequate knowledge about disability employment. 50 large enterprises, 80 medium-sized and 149 small enterprises (including micro enterprises) were studied. The article only presents the results for small and micro organizations as regards employers' knowledge concerning the definition of a person with disabilities, degrees and causes of disability; statutory working time of people with disabilities; matching jobs and adapting workstations to the needs and capabilities of people with disabilities; financial support to employers who employ persons with disabilities.

2 Research Methods

The research was conducted with individual, researcher-administered structured interviews. The standardized questionnaire included 19 elaborate questions dealing with the subject of the study and 11 questions concerning the socio-demographic background of the respondent.

Small and micro enterprises (the number of employees $\geq$ 49) classified in Section C—Manufacturing of the Polish Classification of Activities located throughout Poland participated in the study. They were open labour market organizations not employing persons with disabilities. A majority of the respondents were owners of the businesses. In a few cases, organization representatives—HR staff members or OHS specialists—were interviewed. The sample was randomly selected and based on the availability of data. The sample size (entire Poland) was 149 enterprises. The survey was conducted in the years 2013–2014.

3 Research Results

3.1 Analysis of the Level of Employers' Knowledge of the Definition of a Disabled Person, the Degrees and Causes of Disability

In Polish law, the definition of a disabled person that meets the requirements of the definition for rehabilitation purposes is provided in the statutory law of 27 August 1997 on occupational and social rehabilitation and employment of people with disabilities [5]. As set forth in the Act, 'disability is a permanent or temporary inability to perform social roles due to permanent or long-term limitations of the abilities of the body, and especially inability to work'. Furthermore, the Act classifies disability by its severity into the following three groups: considerable degree of disability; moderate degree of disability; light degree of disability.

During the procedure of the determination of the degree of disability as considerable, moderate or light, the extent of the limitation of the person's body functioning caused by: 01-U—intellectual development disorders; 02-P—mental disorders; 03-L—voice and speech disorders, hearing impairments; 04-O—diseases of the eye; 05-R—musculoskeletal system disorders; 06-E—epilepsy; 07-S—respiratory and circulatory system diseases; 08-T—digestive system diseases; 09-M—genitourinary system diseases; 10-N—neurological diseases; 11-I—other diseases, including endocrine, metabolic, enzymatic disorders, infectious diseases and zoonoses, malformations, deformations and disfigurements, blood-formation diseases, 12-C—pervasive developmental disorders is considered pursuant to the Regulation of the Minister of Economy, Labour and Social Policy of 15 July 2003 on the determination of disability and degree of disability.

The owners of the small and micro businesses were asked to:

1. Provide the definition of a person with disabilities as set forth in the Act on vocational and social rehabilitation and employment of people with disabilities.
2. List the degrees of disability as set forth in the aforementioned Act.
3. Provide definitions of light, moderate and considerable degree of disability.
4. List causes of disability as provided in the Regulation on the determination of disability and degree of disability.
5. Match particular diseases with the relevant classes of diseases.

The results showed that none of the respondents could provide a complete definition of a person with disabilities. Only 29 respondents (19 %) provided a partially correct answer. They were HR staff members or workers responsible for occupational safety and health at their organizations and defined a person with disabilities as 'someone whose body functioning has been impaired and whose capability for work has been limited or who has been entirely incapacitated as a result'. The other respondents contributed the following answers: 'a person with dysfunctions incapable of working', 'a person with limited movement and mental functions which render him/her incapable of working or capable to work under special conditions', 'a person with limited movement functions hindering him/her in the performance of his/her work and other daily activities', 'a person who has a disability certificate', 'a person incapable of performing certain activities', 'a person incapable of performing any kind of work', 'a person who is ill and incapable of working', 'a person who works less efficiently and who has certain mental and physical deficits', 'a person suffering from various ailments which make him/her incapable of working under normal conditions' etc. Sadly, most of the definitions provided are extremely unfair to people with disabilities because they express the view that the disability renders the person unfit for work. Such attitudes held by people who have a decisive influence upon employment in the enterprise exclude people with disabilities from the recruitment process at its very start. Moreover, they may prejudice employees of lower rank against people with disabilities.

As regards the questions concerning the degree of disability, 45 % of the respondents managed to correctly list all of them. 10.1 % identified two and 11.4 % only one degree. 33.6 % were not able to name any one of the three degrees of disability. The respondents frequently mixed terms, e.g. they would use the term 'heavy disability' or 'Class I Disability' for 'considerable degree of disability' and the term 'Class III Disability' for 'light degree of disability' etc. These answers were construed correct.

Only 23 % of the respondents (32 persons) managed to provide the correct definition of the degrees of disability. Most of them were employed in the position of OSH specialist or HR specialist. Only 5 business owners answered correctly and they all had disabled relatives. Most of the respondents believed that people with disabilities are not capable of working or are only capable of working under 'special positions', in 'special establishments'. Furthermore, they did not include in their definitions the necessity of providing the assistance of another person in task performance. Management representatives, in particular production managers at large organizations, responded alike [6].

The question concerning the causes of disability proved the most challenging for the respondents. None of them managed to list all 12 causes. 11 causes were indicated only by three interviewees, HR staff members, (2 % of the respondents) who previously worked for organizations which employed people with disabilities. The respondents were most frequently able to identify the following five causes: musculoskeletal system diseases, visual (the blind) and hearing (the deaf) impairments, mental diseases, intellectual development disorders. It needs to be emphasized that these responses were provided mostly by people who had no previous experience of working with people with disabilities. Therefore, they only pointed out disabilities which are readily noticeable on contact with a disabled person not realizing that many causes of disability are hidden from the eye (internal organ diseases). A majority of the organization owners were not aware that there may be people with disabilities related to internal organ disorders among their employees who had not disclosed their disability to their employer for fear they should lose their jobs. About 11 % of all respondents also identified respiratory and circulatory system diseases, epilepsy and neurological diseases. Only a few respondents mentioned digestive and genitourinary system diseases as well as pervasive developmental disorders.

In summary, HR specialists tended to be the most well-informed group of respondents among the business owners and persons in charge of recruitment and employment as regards the definition of a person with disabilities, the degrees and causes of disability. Unfortunately, their knowledge was lacking. Most gaps were observed for the causes of disability. A majority of the business owners could not provide the definition of a person with disabilities let alone list disability causes.

3.2 Analysis of the Level of Employers' Knowledge of the Statutory Working Time of a Person with Disabilities

The enterprise owners and their representatives were asked to respond to the following questions:

1. How many additional days of annual leave (vacation) is a person with a particular degree of disability entitled to? Light degree: 0 days; 5 days; 10 days; Moderate degree: 0 days, 10 days; 15 days; Considerable degree 0 days, 10 days; 15 days.
2. How much total break time are people with disabilities entitled to in a working day? 10/15/30 min.
3. What is the maximum working time of a person with a moderate degree of disability within any 24-hour period? 7 h/8 h/12 h.
4. Are people with disabilities allowed to work at night? Always/Never/Only if approved by an occupational health physician.
5. Can a disabled employee work overtime? Always/Never/Only if approved by an occupational health physician.

The business owners and their representatives did best in the questions whether people with disabilities were allowed to work at night and to work overtime and with the question concerning the length of break time in one working day (from 82 to 84 % of correct answers). The respondents were the most inaccurate with regard to the maximum working time of a person with a disability within any 24-hour period. Only 46 % (69 respondents) gave the correct answer. They may not have been aware of the laws amending the law on occupational and social rehabilitation

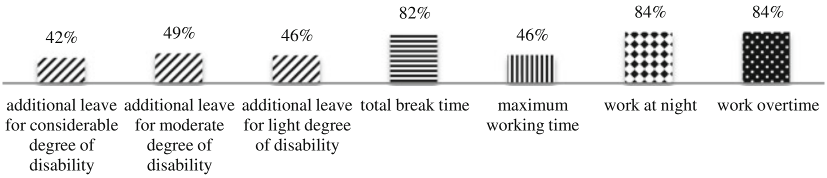

Fig. 1 The level of employers' knowledge of the statutory working time of a person with disabilities (correct answers)

and employment of people with disabilities enacted in 2013–2014. The question concerning additional days of annual leave turned out to be equally problematic. 51 to 58 % of the respondents provided incorrect answers. The respondents were most frequently wrong about the number of additional days of annual leave for persons with the light (54 %) and considerable (58 %) degree of disability (Fig. 1). HR specialists at large enterprises in Poland were similarly mistaken [6].

The responses provided by the owners of small and micro enterprises in Poland show that a majority of them are indeed quite familiar with the additional entitlements of disabled workers despite the fact that such workers are not employed in their enterprises. These results, however, raise a few doubts. It appears that the respondents would not have provided correct answers, had the questions been open-ended. Instead, the respondents were given a choice of answers and may have deduced the correct ones by elimination of the incorrect ones. This hypothesis is confirmed by the wrong answers and, in many cases, a lack of any answer to questions in the first part of the survey questionnaire concerning the level of employers' knowledge as regards the definition of a person with disabilities, the degrees and causes of disability.

3.3 Analysis of the Level of Employers' Knowledge as Regards Matching Jobs and Adapting the Workplace to the Needs and Capabilities of People with Disabilities

The enterprise owners or their representatives were asked to do the following:

1. Indicate the posts at the enterprise that disabled people could be employed in.
2. Describe what exactly should be changed at a selected workstation in the surveyed enterprise in order to accommodate the needs of a person with a specific disability (the workstation was preselected by the authors after they analyzed the specific character of the enterprise production activities.
3. Select jobs in which persons with the specified disabilities could work: (a) the hearing-impaired; (b) wheelchair ambulators (lower limb paresis); (c) diseases of the urinary system.

4. Select working conditions favourable to workers with the specified disabilities: (a) epileptics; (b) diseases of the digestive system.
5. Select factors which would be a contraindication to employing persons with the following disabilities: (a) diseases of the eye; (b) mental disorders.

Questions 3–5 were multiple choice questions. A majority of the respondents stated that people with disabilities could be employed as ‘cleaners’ (40 %). 35 % of the interviewees (52 persons) specified the position of ‘security guard’ or ‘janitor’. 22 % indicated ‘office jobs’ and ‘IT specialists’. Only 22 % of the respondents (22 persons) mentioned ‘ancillary labourer jobs’ and only two respondents (1 %) (who had previously worked for organizations employing the disabled) answered that a person with a light degree of disability could be employed in managerial position provided that he/she would have the relevant qualifications. 56 % of the owners of the small and micro enterprises would not employ a disabled person at all. They held that there was not one position in their organization in which a disabled person could work. The results corroborate the conclusions made by Gąciarz and Giermanowska [7], Arendt [8] that any increase of disability employment in Polish enterprises not employing people with disabilities is hindered by stereotypical perceptions of a disabled worker. Business owners are convinced that a disabled person is vulnerable and only fit for undemanding jobs. They justify it with the possibility of disruptions in the organization’s operations due to, above all, increased absence due to health problems that disabled workers might experience, but also their limited self-reliance, lower efficiency, limited availability, lower professional qualifications, confrontational and excessively demanding attitude towards the employer.

Only 25 respondents (17 %) attempted to answer the second question. Among them, there were 10 business owners, 13 h and payroll specialists and 6 OSH specialists. They defined essential adaptations that would have to be introduced in the workplace in order to make employment of a person with the specified disability possible. The respondents complained that they did not have adequate tools (e.g. a reference list) that would help them decide whether a person with disabilities, and with what disabilities, could be employed in a particular job or what accommodations would have to be implemented in order to permit such employment. Once they had been provided with a reference list developed by Polak-Sopinska, and following a one-hour training, most of the respondents could determine the necessary adjustments that would have to be introduced in the workplace to make employment of a person with a particular disability possible.

The respondents fared much better in the next three questions. Having been provided with a choice of answers, they intuitively, based on their own experience managed to choose the correct responses.

Over 90 % of the respondents selected at least two corrects answers for each of the specified disabilities. The choice proved to be the easiest for the urinary system diseases and for wheelchair ambulators (respectively, 75.2 and 71.8 % of the respondents selected all correct answers). The scores for the particular specified disabilities are presented in Figs. 2, 3 and 4. The solid grey bars illustrate the

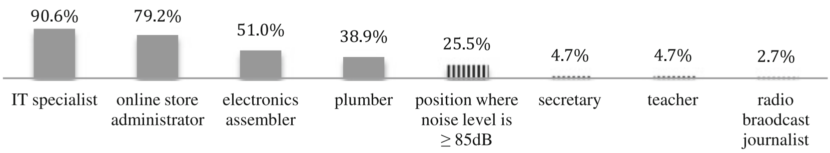

Fig. 2 Positions selected by the respondents for the hearing-impaired

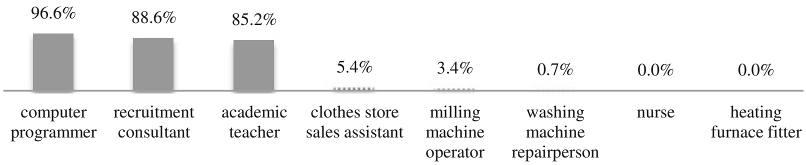

Fig. 3 Positions selected by the respondents for wheelchair ambulators

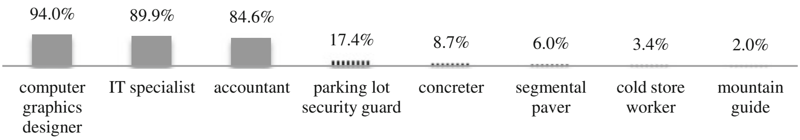

Fig. 4 Positions selected by the respondents for persons with diseases of the urinary system

correct answers, whereas the patterned ones—the wrong answers. This systems is applied throughout the remaining part of the article.

54.4 % of the respondents marked all the correct answers to the fourth question with regard to people suffering from epilepsy and 44.3 % for people with diseases of the digestive system. 4 respondents failed to provide any correct answer. It is unsettling that as many as 18.8 % of the respondents did not consider the impossibility of eating regular meals a contraindication to employing people with a digestive system related disability in the job. Likewise, 14.1 % of the respondents did not perceive the risks associated with working at night. The scores for the specified disabilities are presented in Figs. 5 and 6.

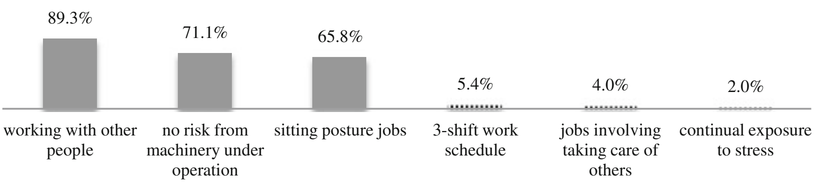

Fig. 5 Working conditions selected by the respondents for persons suffering from epilepsy

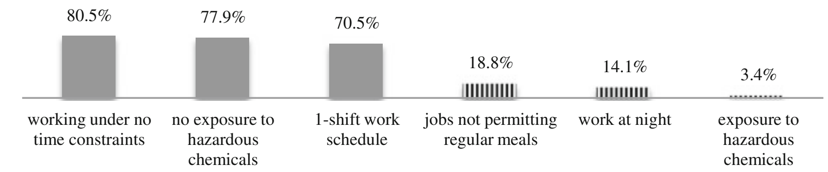

Fig. 6 Working conditions selected by the respondents for persons with diseases of the digestive system

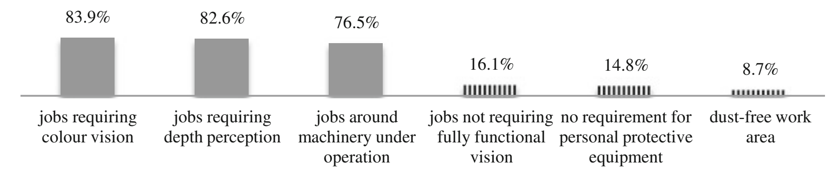

Fig. 7 Contraindications selected by the respondents as regards persons with diseases of the eye

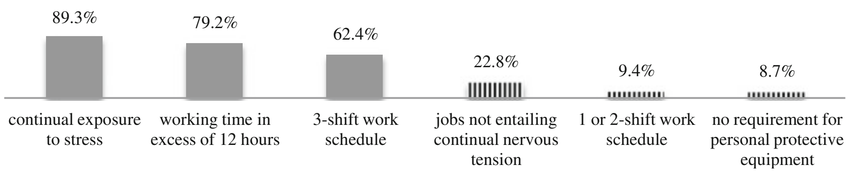

Fig. 8 Contraindications selected by the respondents as regards people with mental disorders

More than one half of the respondents managed to select all the correct answers to the fifth question. 63.8 % for people with diseases of the eye and 57 % for people suffering from mental disorders. Figures 7 and 8 illustrate the distribution of the answers provided by the interviewees.

Small enterprise employers are characterized by a relatively low level of knowledge with regard to job selection and adaptation of the workplace to the needs and capabilities of persons with disabilities. Unadvised, business owners and their representatives are not able to determine positions in their organizations in which disabled people could be employed nor do they know where to look for guidance (they do not consult with occupational health physicians). They are uninformed of the necessary organizational and/or technical adjustments which would make it possible for persons with various disabilities to work in their organizations. Marginally more than one half of the respondents identified all the correct answers to questions number 3 and 4 despite the fact the choice was rather obvious. Moreover, the respondents provided contradictory answers. Responding to the first, open-ended question, the interviewees stated that a disabled person could only perform simple jobs in their organization, e.g. work as a cleaner or a security guard.

However, replying to the closed-ended questions, a majority of them selected demanding and responsible positions, e.g. accountant, personnel consultant, computer programmer, electronics assembler. During the study, the interviewees started to realize that disability employment is doable, only they did not have the relevant knowledge, did not use the assistance provided by the government and non-governmental organizations and were misled by their stereotypical perceptions of the disabled as incapable of working or inefficient and capable to perform only simple jobs which did not require additional qualifications and education. This constitutes yet another confirmation of the assumption that employers need a tool to help them choose suitable actions to facilitate disability employment in their organizations.

3.4 Analysis of the Level of Employers' Knowledge as Regards Financial Support for Disability Employers

The owners of the enterprises and their representatives were asked to answer the following questions:

1. When is the employer eligible for a wage subsidy for a disabled employee?
2. When is the employer exempt from the payment of contributions to the State Fund for Rehabilitation of Disabled People (PFRON)?
3. What financial support is available to the employer employing persons with disabilities?

Each of the questions was a multiple choice question. Only 32 % of the respondents (48) answered the first question correctly. A majority of the respondents specified employers employing fewer than 25 disabled FTEs (full-time equivalent posts). They failed to remember that employers employing at least 25 workers and attaining 6 % disability employment rate are also eligible for financial support. This may have stemmed from the fact that most of the survey participants were organizations which have fewer than 25 employees (70 % of the surveyed businesses). Their owners failed to specify wage subsidy eligibility criteria for enterprises employing at least 25 FTEs.

Only 11 % of the interviewees (17 respondents) provided the three correct answers to the next question. They were HR specialists in the enterprises. As many as 15 % (23) of the respondents failed to provide a single correct answer. 73 % (109) of the respondents selected one or two correct answers. The owners explained their ignorance by stating that 'tax affairs and other such matters are taken care of by the accountant'. Figure 9 illustrates the distribution of the answers selected by the respondents.

73 % of the respondents (108 persons) selected at least one correct answer to the third question, including: 19 % (25 persons) who identified all 5 correct answers, 30 % (44 persons) who provided 4 correct answers, 1 % (1 person) with 3 correct

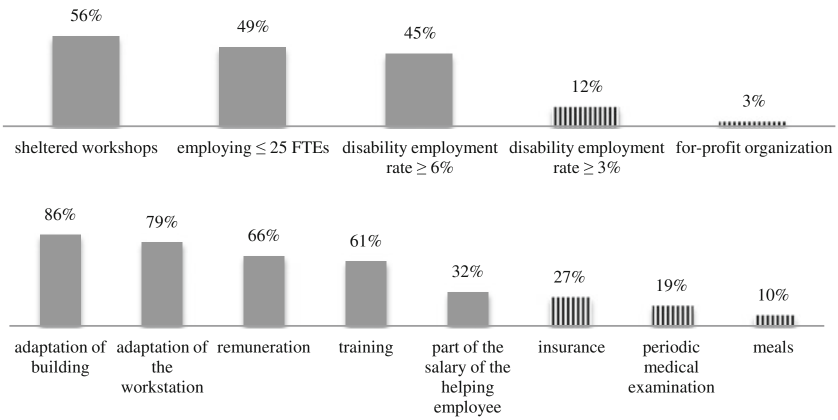

Fig. 9 Distribution of answers to the second question

answers, 20 % (30 persons) with 2 correct answers and 3 % (5 respondents) with 1 correct answer. Figure 9 illustrates the distribution of the answers selected by the respondents.

The owners of the small and micro enterprises know that disability employment is financially supported by the state. Unfortunately, they are not familiar with the procedures of applying for and granting the funding, the amount of the support, the period for which the support may be granted etc. In the interviews, many respondents explained that ‘getting the support is difficult and time-consuming’, that ‘there is a lot of red tape involved’, that ‘it requires competent staff who could handle the process’. At the same time, they admitted that it had not been their personal experience and that they only repeated the opinions they heard other disability employers express. Barczyński found during his research that those employers who have had previous experience of employing the disabled (sheltered workshops) regard the following as the main barriers to the employment of people with disabilities: complex application procedures, volatile legislation and eligibility criteria, contraindications due to health conditions, confusing legal provisions and requirements for built environment adaptations [9].

The costs of employing a disabled worker in a small enterprise are not spread over a larger number of employees and therefore, they are higher than would be the case for a larger organization. One solution that small enterprises may find useful is to use outsourcing services provided by organizations employing the disabled. Cooperation with such organizations constitutes a basis for lower PFRON contributions without the requirement for employing people with disabilities [8]. Regrettably, few of the surveyed enterprises were aware of this opportunity.

4 Conclusions

The level of knowledge that owners of small and micro enterprises (not employing people with disabilities) demonstrate with regard to disability employment is rather low. The situation is a little better in large and medium-sized enterprises. Nevertheless, the results of the study do not inspire much enthusiasm. The results show that in corporations which do not employ disabled people it is HR specialist who demonstrate the highest level of knowledge as regards employment of people with disabilities. They can indeed provide a definition of a person with disabilities and they are indeed familiar with the entitlements of disabled workers, yet they do not know the principles governing job selection or adaptation of the workplace to suit the needs and capabilities of people with disabilities. Compared to the HR specialists, the OSH specialist fared slightly worse. The lowest level of knowledge, however, was observed for production managers who, along with the OSH specialist, ought to demonstrate the highest level of awareness with regard to job selection and adaptation of the workplace to the needs and capabilities of persons with disabilities.

The inevitable conclusion is that the barriers which people with disabilities encounter should not be associated with the disability as such but rather with the society's inability to create equal opportunity for all citizens. Therefore, what emerges as the most seminal challenge is the methodical development of a model of human rights, which mostly means that this group of people must no longer be considered exclusively through the lens of their rehabilitation and care. Unless effective interventions are made in this area, the discussed issues concerning people with disabilities will result in a higher demand on the system of benefits and allowances and therefore, cause an increase in public expenditure.

With the above ideas in mind, the authors of the foregoing article intend to use the results of the study to design a diagnostic tool, adjusted to the reality of Polish enterprises, that will make it possible to determine the enterprise capacity (including its shortcomings) in the area of disability management and directions of future development. The tool will take the form of a reference list. It will provide the means to evaluate solutions and practices used in the organization. It will offer an objective picture of the current situation and will allow for identification of the strengths and weaknesses of the organization from the point of view of disability management strategy. All that complete the list of questions will receive feedback—both quantitative and qualitative—commensurate with the results of the analysis. The tool will be adjustable depending on the level of knowledge of the management in charge of recruitment and hiring of people with disabilities, enterprise financial resources, its size, industry and type of ownership.

Obviously, the tool alone will not suffice. Employers' knowledge with regard to disability employment needs to be improved by virtue of, among others:

1. Introduction of systemic changes in education. The curriculum in the fields of study connected with management of the enterprise, human resources, production or occupational safety etc. ought to be modified so that future entrepreneurs, management, HR and OSH specialists could implement programs to

encourage economic activity of people with disabilities based on the knowledge they have acquired during their studies.
2. Introduction of free training programs and consultations (including online) for employers, managers and HR and OSH specialists at county labour offices and city offices.
3. Development of postgraduate non-degree courses for managers on disability management in the workplace. The curriculum is being designed by the Faculty of Organization and Management of Lodz University of Technology.
4. Increasing the number of career consultants in job centres who could cooperate with employers during the recruitment, job placement and initial stages of employment of people with disabilities.

The proposed actions are expected to increase employers' knowledge with regard to the employment of persons with disabilities.

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Part III
Modeling and Systems in Occupational Ergonomics

Proposing a Conceptual Model for Examining the Influence of Individual and Work-Related Factors on Work Ability

Jacky Y.K. Ng and Alan H.S. Chan

Abstract Given the very fact of rapid ageing of population and drastic decline in skilled and experienced construction workers, it is anticipated that the problem of shortage of construction workforce in Hong Kong will exacerbate in the coming decades. In order to alleviate the problem, the work proposed here aims at identifying the effective measures for extending the working lives of the construction workforce in Hong Kong by proposing a conceptual model for examining the influence of individual factors and work-related factors on work ability. A better understanding of the potential factors affecting the current and future work ability of construction workers will greatly assist the formulation of evidence based interventions to retaining the workforce in the Hong Kong construction industry.

Keywords Work ability · Construction · Ageing workforce

1 Introduction

According to the figures of the Construction Workers Registration Authority, as at the end of December 2015, the total number of validly registered construction workers in Hong Kong was 368,983 and over 43 % of these registered construction workers were aged over 50, in which those have reached 60 accounted for 14.82 % of the total number of registered construction workers. In the coming five years, it is anticipated that Hong Kong construction industry will experience increasing shortages in labour force due to the ageing challenge and the continuous growth of public and private sector infrastructure projects such as the Guangzhou-Shenzhen-Hong Kong Express Rail Link. The estimated growth rate for jobs in the construction industry increased 13

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per cent per year from 2011 to 2013 [1] and this rate is likely to continue or even increase given the fact that the construction industry is already suffering shortages of skilled workers.

As construction workers are usually at higher risk of work-related disabilities than workers in other industries which is due largely to the heavy physically demanding nature of the work and the awkward postures required, it is to be expected that there is a general deterioration in physical capacity during the ageing process [2]. In fact, it has been consistently reported that as a result of its physically demanding job nature [3, 4], construction workers are always at a higher chance of suffering from occupational disability than are the workers in other industries, which is deemed as the main reason of early dropout of construction workers worldwide [5]. Therefore, in order to prevent construction workers from prematurely quitting the workforce as a result of work-related disability, the concept of work ability measurement has been increasingly regarded as an effective tool for formulation of pragmatic worksite intervention programs in recent years. The concept of work ability was first introduced in Finland in the 1980s and is a measure of '*how good is the worker at present and in the near future, and how able is he/she to do his/her job with respect to work demands, health, and mental resources?*' [6].

In order to quantify the work ability of workers and provide a work capacity indicator of current workers, the Finnish researchers—Juhani Ilmarinen and Kaija Tuomi—developed a set of questions to evaluate and indicate the work ability of a worker by means of Work Ability Index, WAI [7, 8]. The WAI has been widely used for assessment of work ability in workplace health prevention and occupational health and re-integration. Ilmarinen and Tuomi [6] found that workers with higher WAI showed lower tendency of premature retirement or dropout, and the WAI is improvable provided the right measures are taken [9, 10]. In a nutshell, knowing the work ability of workers can facilitate better age management of working lives, such that the quality of work and life, and productivity can also be improved by thorough consideration of the interplay between personal factors and work demands. Therefore, the proposed model here will help identify the possible linkages (associations) among the many different individual and/or work-related factors and the work ability of the Hong Kong construction workers, so as to provide useful and realistic information for the formulation of effective intervention programs to extend their working lives and enable their higher-quality retirements [11].

2 Associations of Individual and Work-Related Factors with WAI

Individual factors (demographics characteristics, life-style factors, health factors, and individual competency) and work-related factors (physical and psychological demands at work) will be examined extensively in the model to identify their influences on work ability among Hong Kong construction workers.

2.1 Work Ability

Perceived work ability will be measured by the Work Ability Index (WAI) questionnaire developed by Tuomi et al. [7]. The WAI is derived as the sum of seven distinct dimensions concerning the physical and mental ability of workers in relation to their work, diagnosed diseases, work impairment due to disease, sick leave, work ability prognosis, and mental resources (Table 1). The range of the WAI score is from 7 to 49 and it can be classified into excellent (44–49), good (37–43), moderate (28–36), and poor (below 28) work ability [12]. The details of the seven measurement items are shown in Table 1 [7, 13]. The WAI score will be treated as the dependent variable in the model.

Table 1 Measuring items for Work Ability Index (WAI) proposed by Ilmarinen and Tuomi [6, 7]

Item	Range	Explanation
Current work ability compared with the lifetime best	0–10	0 = very poor
		10 = very good
Work ability in relation to the physical and mental demands of the job	2–10	2 = very poor
		10 = very good
Number of current diseases diagnosed by a physician	1–7	1 = 5 or more diseases
		2 = 4 diseases
		3 = 3 diseases
		4 = 2 diseases
		5 = 1 disease
		7 = no disease
Estimated work impairment due to diseases	1–6	1 = fully impaired
		6 = no impairment
Sick leave during the past year (12 months)	1–5	1 = 100 days or more
		2 = 25–99 days
		3 = 10–24 days
		4 = 1–9 days
		5 = 0 day
Own prognosis of work ability 2 years from now	1, 4, 7	1 = hardly able to work
		4 = not sure
		7 = fairly sure
Mental resources (enjoying daily tasks, activity and life spirit, optimistic about the future)	1–4	1 = very poor
		4 = very good

2.2 Individual Factors

Individual demographic factors in the questionnaire will be age, gender, height, weight, marital status, education level, working years, direct employer, job category, anticipated age of retirement and family scenario. Demographic factors will be treated as the moderators to evaluate their effects on the WAI. Individual lifestyle factors will cover smoking, alcohol consumption, and frequency and amount of leisure-time physical activity; these factors have been studied in other countries in relation to lower WAI [14, 15]. To assess individual physical and psychological capacity, health factors will be determined through questions covering general health status, musculoskeletal disorders (MSDs) and psychological distress. Poor health status and musculoskeletal and psychosomatic symptoms have been associated with a lower WAI [16, 17]. Individual competence has rarely been studied but its association with work ability cannot be ignored [18] because professional/career competence is one of the determinant factors of work ability. Here the Career Competencies Questionnaire (CCQ) developed and validated by Akkermans et al. [19] will be used to measure the professional competencies of the construction workers.

2.3 Work-Related Factors

The work-related factors in this study will be the physical and psychological demands at the workplace. A majority of studies have found a lower WAI to be associated with high physical and psychological demands [18]. The Job Content Questionnaire (JCQ), a job demand measure which has been widely used for many occupations will be used in this study to assess the physical and psychological workloads of construction workers. According to the 'Job demand-control (-support) (JDC (-S)) model' [20], the three important factors determining workplace quality are: work demand, job control and social support. Workers exposed to high demand and low control jobs are expected to suffer from high strain level [21], and high demand, low control and low social support jobs lead to strong level of anxiety and depression [22]. Here the Job Content Questionnaire (JCQ) will be used to assess workers' perceived level of job control and social support at work.

3 The WAI Conceptual Model

A WAI conceptual model including the above mentioned life-style factors, work-related factors, health factors and individual competence will be developed and its validity will be tested (Fig. 1). For investigation of the WAI conceptual model, individual health factors will be the mediator variables between the life-style factors (independent variables) and the WAI (dependent variable) and between the work-related factors (independent variables) and the WAI. As well as the direct

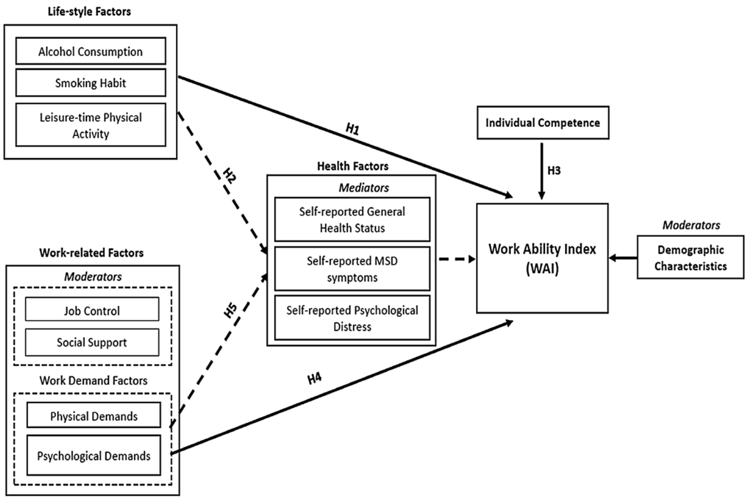

Fig. 1 A simplified schematic diagram of the WAI conceptual model proposed to be tested in the present study (*Solid lines* are direct effects and *dashed lines* are indirect effects)

effects of the two sets of independent variables on the WAI, the indirect mediation effects of life-style factors and work demand factors on the WAI through the individual health factors will be explored. Individual competence is an important factor affecting work ability, and its direct effect on the WAI will also be examined here. In addition, given the fact that the associations between the work demand factors and the WAI are very likely to be dependent on the size or sign of the factors of job control and social support, the effect of work demand factors on the WAI through individual health factors will be estimated for various levels of job control and social support factors. Below are the set of possible hypotheses that can be examined in the model.

- H1: Life-style factors will be associated with the WAI.
- H2: The associations between the life-style factors and the WAI will be mediated by health factors.
- H3: Individual competence will be positively associated with the WAI.
- H4: Work demand factors will be associated with the WAI.
- H5: The associations between the work demand factors and the WAI will be mediated by individual health factors.

4 Conclusion

The major deliverables of the testing of this proposed model will be that it should be possible to identify the main factors affecting the work ability of Hong Kong construction workers and to study the characteristics of workers with comparatively higher intention or possibility to quit the workforce prematurely. Such findings will greatly facilitate the design of practical intervention measures that can effectively target the affected group of workers and the significant factors in order to promote improved work ability. Specifically, the significance of the individual factors here will provide solid evidence for formulation of interventions considering the construction workers' life-style, health, and job competence; whilst the significance of the work-related factors will encourage employers to establish an appropriate work system with reference to the physical and psychological work demands in the workplaces. The outcome should be that effective measures can be in place not only to keep younger workers from early dropout of the workforce but also to extend the working life of older workers. In addition, the WAI model proposed here will form the basis of a longer term longitudinal study to assess the trends of changes of the WAI in the construction industry for, say, every three years. The more information we have, the more confident we can be in formulating successful work ability interventions and promotion programs among construction workers in Hong Kong, so as to sustain the workforce in the industry.

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The Participatory Ergonomics in the Design of Safety Systems in Complex Work Systems

William German Barón Santoyo

Abstract In systems theory, safety is an emergent property of the interactions among the system components, that is, how the work system is obtained without affecting its constituent components or the system as a whole, providing that the expected result operates at the prescribed level of reliability. However, if the system becomes unbalanced due to the undetected failure of one of its components or interactions, that can produce a dysfunction that materializes as an adverse event (accident). Therefore, as of the design stage, interactions among the components must be identified as a series of potential dysfunctions and converted into safety layers that contribute to the functional balance of the system. That stage is successful if end users, work safety and health personnel, design engineers, and project managers all participate actively in the group, using participatory ergonomics principles and tools.

Keywords System · Systems theory · Safety · Safety systems · Participatory ergonomics · Reliability · Engineering design · Design project

1 Introduction

A work system comprises, among others, technical, administrative, legal, and operational criteria in constant material and non-material interaction through its social and technical components at levels of complexity defined by the type of process, facilities, and technology used, to name a few of such characteristics.

One of the greatest difficulties in achieving safe, reliable work systems lies in the dynamics involved in their conception or design when there is no formal structure or team (stakeholders) to visualize and articulate the interfaces and interactions among all of the work system components and levels. That leads to systems that are

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structured without safety responsibilities being assigned to each component, level, interface, and interaction; in other words, there is no manner to transform each potential dysfunction into a safety layer with control measures.

Including the various stakeholders in a determined work system during the design and building stages, using participatory ergonomics principles, enables the system to take advantage, at the onset, of the information, experience, knowledge, skills, and competences that come from their ideas and constructive analysis. And the fact that the various stakeholders will play roles that may be diametrically opposed in the definitive system enriches the final construct even more.

2 Framework

2.1 System

Real Academia Española (Royal Spanish Academy) [1] defines system as "A set of things that are related to one another in an orderly manner to contribute to a determined purpose". Bertalanffy [2] states that "a system can be defined as a set of elements that interrelate among themselves and with the surrounding environment" (p. 263) and Brown [3] quoting Webster defines a system as "an aggregation or assemblage of objects united by some form of regular interaction or interdependence; a group of diverse units so combined by nature or arts as to form an integral whole, and to function, operate, or move in unison and, often, in obedience to some form of control; an organic or organized whole" (p. 4). In other words, a system comprises more than one constituent component and such components carry out an action within a specific time and space and under specific conditions.

2.2 Systems Theory

Although nowadays multiple disciplines have embraced the term, it was Bertalanffy who presented the so-called general systems theory in 1937. It has served as a springboard for several disciplines and areas of knowledge, such as cybernetics, the information theory, the game theory, and the decision theory. Bertalanffy [2] explains it as follows: "the general systems theory (GST), in the strictest sense of the word, starting with a general definition of «system» as complexes of interacting components, enables deriving concepts of organized totals, such as interactions, sums, mechanization, centralization, competences, ends, etc., and applies them to concrete phenomena" (p. 94). In the applied sciences, the theory has its own spaces in the guise of systems engineering, operations research, systems analysis, systems management, human talent engineering, and ergonomics, among others. Bertalanffy established two basic types of systems: closed and open. A closed system is one where there is no input or output of material and non-material elements; that is to say, there is no exchange with the environment of any kind. An open system has inputs and outputs with the surrounding environment and within itself and it is in a state of equilibrium when there are constant, dynamic interrelations among its components.

According to Leveson [4] the systems theory approach centers on the whole as a unit and, even more importantly, the system properties of reliability and safety are the remit as a product of the interaction among the components (*see reliability and safety*).

2.3 Work System

It is important not only to understand the concept per se but also to explore each part of the definition. Chapanis quoted by Haro and Kleiner [5] defines a system "as an interacting combination, at any level of complexity, of people, materials, tools, machines, software, facilities and procedures designed to work together for some common purpose (Chapanis 1996, p. 22). Additionally a system can be a combination of smaller systems. Changes in one part of the system can possibly affect other parts and the system as a whole." (p. 453). That indicates that the goal of every system is obtained through the result of a series of interactions among the system components in a specific time and space and under specific conditions. As occurs with the goal, the number of components and required interactions determines the complexity of the system.

Figure 1 illustrates a typical structure of a work system with a determined number of components (letters) that have constant internal and external interactions.

As time goes by, technology development is directly proportionate to its advances involving nanotechnology, biotechnology, robotics, control software development, and new artificial materials. Therefore, work systems (macro and micro and/or systems and subsystems) are becoming more complex in order to be

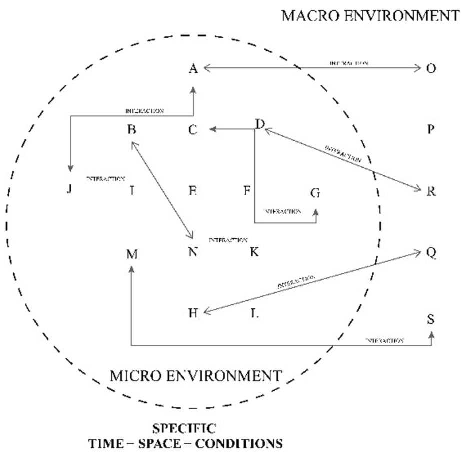

Fig. 1 Work system, developed by Barón Santoyo, G

able to meet the goal for which they were designed. That has repercussions on input requirements, the number of components, system structure levels, and the number of horizontal or vertical interactions, among others.

Using Leveson [4] as a reference, a general model for complex systems may be expressed in terms of a hierarchy of interaction levels with the ability to generate emergent properties in every interaction. As mentioned above, reliability and safety are highlighted. Another characteristic of such systems is communication and control, the latter being seen as a process that takes place in interactions among levels.

It is also important not to assume that a system is complex because it is controlled by automated processes, such as a nuclear plant, aeronautics systems or hydro-electrical ones. An academic building with chemistry laboratories, a hospital, and an industrial fertilizer production plant are also examples of complex systems. Indeed, they boast multiple levels of interaction, endless inputs, materials, processes, industrial waste, administrative procedures, employees with different operational and administrative roles, and they operate under diverse technical standards and legal norms. Moreover, the subjectivity that results from the knowledge and experience of the persons who handle the system analysis or design is what determines a greater or lesser degree of system complexity.

2.4 Interface—Interaction

- Real Academia Española [1] defines interface as the physical and functional connection between two independent devices or systems; that is to say, the material or non-material space in which a direct relation is established between components or levels.
- Real Academia Española [1] defines interaction as “The reciprocal action that occurs between two objects, persons, agents, forces, functions, etc. or among more”, that is to say, the mutual exchange of actions in the interface.

Consequently, it is important to bear in mind that the interface(s) and the interaction(s) between each one of the components or levels of the work system positively or negatively affect their relations with one another and/or the overall equilibrium of the work system.

2.5 Safety

In Managing for Performance Perfection, Pope (1990), quoted by Smith [6] states that the term safety lacks an absolute definition (p. 200). In that sense, Smith [6] says, “Even today, the meaning of the term safety is not uniformly understood within the safety community and elsewhere” (p. 200) and Petersen [7] suggests that “safety is not a resource; it is not an influence; it is not a procedure; and it certainly is not a program. Rather, safety is a state of mind, an atmosphere that must become an integral part of each and every procedure that the company has." (p. 26). In Webster's Dictionary [8] safety is defined as a condition or state of being safe, free of danger or risk; lack of harm, injury or loss. According to Leveson [9] "safety can be defined as the absence of accidents, where an accident is defined as an event involving an unplanned and unacceptable loss" (p. 57). In general, although there is not one sole definition or unification for the term, it can be inferred that safety is a condition of positive equilibrium obtained through a preconceived action of control.

2.6 Reliability

In her article Applying Systems Thinking to Analyze and Learn from Events published in 2011, Leveson [9] affirms that "Reliability in engineering is defined as the probability that a component satisfies its specified behavioral requirements over time and under given conditions, i.e., it does not fail" (p. 57).

2.7 Dysfunctions

Figure 2 shows how dysfunctions refer to losses of control over the interactions among the system components or levels in each one of the system interfaces that interrelate them.

2.8 Safety Systems

Industrial safety systems came into being in the 1960s; they were the result of the need to generate a systematic strategy aimed at modern engineering systems for industrial fields such as aeronautics, nuclear plants, communications, military technology, and the space race. However, the current needs of all industries have

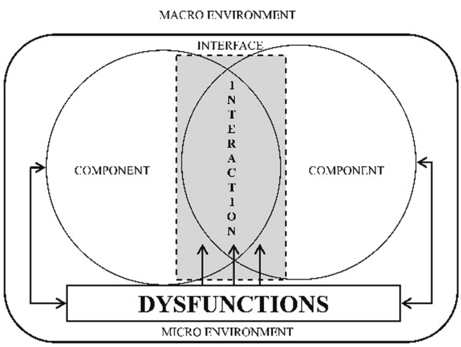

Fig. 2 Space where dysfunctions occur, developed by Barón Santoyo, G

led to an adaption of the concept in the every day events of the industrialized world. In his book Systems Analysis and Design for Safety, Brown [3] defines a safety system as “the total set of men, equipment, and procedures specifically designed to be superimposed on an industrial system for the purpose of increasing safety” (p. 10). That view is fundamental to a concrete safety approach that aims to anticipate possible work system dysfunctions.

Also, Stephans [10] proposition establishes that basically the whole group of stakeholders in an organization or work system have a role in the safety system, as may be appreciated in Fig. 3. The group includes end users (with knowledge of requirements and end operation), work safety and health personnel (with administrative, legal, and technical knowledge in the areas of safety and health), design engineers and architects (with knowledge of the project and the assurance that safety problems and possible dysfunctions in the interactions are addressed as of the design stage), and project managers (knowledge of the system, direction, objectives, goals, and decision-making capacity).

Furthermore, Leveson [11] suggests that, in the systems theory approach, safety in work systems is considered an emergent property of the interaction among components (p. 249). Along those lines, Leveson [12] states that, in a safety system, technically speaking safety is a problem of interaction control in lieu of a problem of component reliability (p. 3), as is shown in Fig. 4.

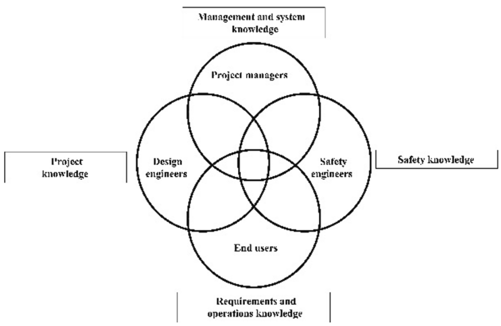

Fig. 3 Safety system working groups (Taken from Stephans, R [10])

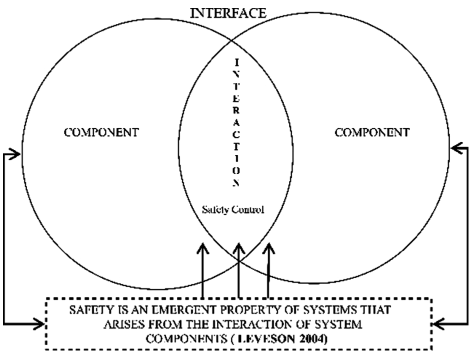

Fig. 4 Space where safety control arises, developed by Barón Santoyo, G

2.9 Participatory Ergonomics

The concept of participatory ergonomics was created in the 1980s and more specifically in 1983 when Kageyu Noro and Kazutaka Kogi discussed it in Singapore. In essence, participatory ergonomics (PE) is the active participation of the employees (stakeholders) applying their knowledge, experience, skills, and competences to their work systems.

Some of the most relevant definitions of PE, found in the literature on the topic, are listed below.

- Lewis (1988), quoted by Wilson and Haines [13] defines PE as "the rationale behind participatory ergonomics is to involve the end user in the change process so that he or she becomes an advocate and an active change agent rather than a passive recipient of the process" (p. 492).
- Imada (1991), quoted by Forsman [14] defines PE as "one perspective in system (macro) ergonomics, which requires end-users as the beneficiaries of ergonomics to be involved in developing and implementing technology" (p. 196).
- In Ergonomy and Participation, Wilson (1995), quoted by Ogden Brown, Jr. [15] defines participatory ergonomics as "the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals" (p. 36).
- Nagamachi (1995), quoted by Forsman [14] defines PE as "the employees' active involvement in the complementary ergonomics knowledge and procedures in their workplace…supported by their supervisors and managers in order to improve working conditions and product quality" (p. 196).
- Hendrick and Kleiner [16] define PE as "the involvement of employees in the ergonomic analysis and design of their work environments and activities." (p. 395)

The participatory ergonomics (PE) structure proposed by Haines et al [17] includes nine (9) dimensions with a series of associated categories for each one. As is shown in Table 1, the ergonomic intervention structure is defined according to the complexity of the system, process or task being addressed.

Also, Kuorinka [18] proposes ethical criteria as a prerequisite to all participatory processes; among them, the following are worth highlighting: "The goals of a participatory project must be transparent and honest. Differences in opinion must be dealt with openly. Rules on how to deal with disagreements must be established and agreed to. The formal position of the participatory project in relation to other organizational functions, collective agreement, etc., must be defined and agreed to. The ownership of the results must be defined at the start. Rules for dealing with possible unexpected results must be defined." (p. 2238)

Table 2 below shows successful cases of safety interventions using participatory ergonomics principles.

Table 1 The participatory ergonomics framework (PEF) (Taken from Haines et al. [17])

Dimension	Categories
Permanence	Ongoing—Temporary
Involvement	Full direct—Partial direct—Representative
Level of influence	Entire organization—Department/Work group
Decision—making	Group delegation—Group consultation—Individual consultation
Mix of participants	Operators—Supervisors—Middle Management—Union Personnel—Specialist/Technical Staff—Senior Management
Requirement	Compulsory—Voluntary
Focus	Designing equipment or task—Designing Jobs, terms or work—Organization—Formulating policies or strategies
Remit	Process development—Problem identification—Solution generation—Solution evaluation—Solution implementation—Process maintenance
Role of ergonomics specialist	Initiates and guides process—Acts as a team member—Trains participants—Available for consultation

Table 2 Examples of safety interventions based on participatory ergonomics or participatory design

Authors	Title	Location
Simone Nyholm Andersen, Ole Broberg	Participatory ergonomics simulation of hospital work systems: The influence of simulation media on simulation outcome	In: Applied Ergonomics Vol. 51 (2015); pp. 331–342
M. C. Leva, F. Naghdali, C. Ciarapica Alunni	Human factors engineering in system design: a roadmap for improvement	In: Science Direct Procedia CIRP. 38 (2015); pp. 94–98
Steven C. Mallam, Monica Lundh, Scott N. Mackinnon	Integrating human factors and Ergonomics in large-scale engineering projects: investigating a practical approach for ship design	In: International Journal of Industrial Ergonomics Vol. 50 (2015); pp. 62–72
Lene Bjerg Hall-andersen, Ole Broberg	Integrating ergonomics into engineering design: the role of objects	In: Applied Ergonomics Vol. 45 (2014); pp. 647–654
Boy, g.a., Schmitt, k.a.	Design for safety: a cognitive engineering approach to the control and management of nuclear plants	In: Annals of Nuclear Energy. Vol 52 (2013); pp. 125–136
Isaac José Antonio Luquetti dos Santos, et al	Using participatory ergonomics to improve nuclear equipment design	In: Journal of Loss Prevention in the Process Industries Vol. 24 (2011); pp. 594–600
Rikke Seim, Ole Broberg	Participatory workspace design: a new approach for ergonomists?	In: International Journal of Industrial Ergonomics Vol. 40 (2010); pp. 25–33
Pikaar R.N.	New Challenges: ergonomics in engineering projects	Meeting Diversity in Ergonomics (2007); pp. 29–64

This author has applied the above-exposed concepts and related experiences following the next premises:

1. Safety systems are built with the stakeholders' active participation.
2. Safety is an emergent property to be established and visualized in the interfaces and interactions among system components and levels.
3. Each potential dysfunction must be structured so as to simultaneously work as a safety layer.
4. System reliability and safety are designed in.

3 A Model for Designing Safety Systems in Complex Work Systems

This model (Fig. 5) is established using the precepts of the systems theory supported by the principles of participatory ergonomics to facilitate implementation, based on the relations among components, levels, interfaces, and interactions. It defines interactions as the area in which dysfunctions among the system components materialize (Fig. 2). In the proposed model, dysfunctions are a situation or property inherent in each one of the interactions among the work system components or levels that can potentially materialize as an adverse event (accident).

The problem of complexity is addressed by analyzing and designing all of the work system and all of the safety system, with the participation of the stakeholders comprising the design group focusing on understanding each component and how it interacts with the others and with each level, for the purpose of predetermining possible dysfunctions and establishing safety layers (*safety is an emergent property*

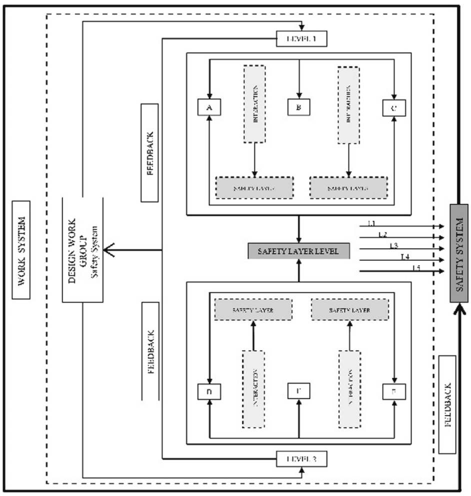

Fig. 5 Model for building safety systems, developed by Barón Santoyo, G

and a control property) in each interface and for each interaction among components. The same principle is applied to the interfaces and interactions among levels as many times as required. Thus, the safety layers among components and the safety layers among levels are obtained, to finally achieve the safety system design; as can be appreciated, the whole is greater than the sum of its parts (Fig. 5).

Moreover, the safety system overlaps the work system (*although it is a part of it*) (Fig. 5) offering constant feedback (systemic nature). Along the same lines, it is important to remember that, in this proposition, the safety system involves the whole organization and it has its place at the strategic level of the organization.

4 Discussion

The details of how to put the model structure and guidelines into practice have not yet been refined; they are currently being built. However, a general version of the model was proposed to be implemented for constructing a new building of chemistry and biology laboratories in Bogotá, Colombia.

Having so clarified, the model presents some interesting challenges to be resolved. Initially, it requires forming a group of stakeholders that will be able to identify all of the possible states of the work system through its components, levels, interfaces, and interactions, project potentially hazardous dysfunctions and then determine if it is possible to materialize the work system. And here is where some limitations of the model arise. Given, first, that the group formed does include all of the stakeholders and, second, that the participants' experience and knowledge can address the magnitude and complexity of the system, then perhaps the next greatest challenge is how to select the work system design group, so as to meet expectations.

It is worth highlighting that participation in all of its implications is a process diametrically opposed to marginality and exclusion because the individual or group stakeholders involved contribute valuable characteristics such as knowledge, experience, and competences, which establish one of the foundations for designing safety systems and, thus, achieve work systems that come close to being in equilibrium. After 45 years of experience working on ergonomic applications in work systems, Hendrick [19] established 23 important lessons regarding the topic, among which he highlights participatory ergonomics as a macro ergonomics methodology that enables guaranteeing the duration of the interventions. Likewise, Andrew Neal and Mark A. Griffin [20] define participation "as behavior that does not directly contribute to an individual's personal safety but that does support safety in the wider organizational context" (p. 16).

Also, this author's paper La ergonomía participativa y su implicación en la seguridad industrial (Participatory Ergonomics and Its Implications on Industrial Safety) [21] states that developing projects using principles of participatory ergonomics has its difficulties, including those listed below. Participation may be considered a threat in companies at management or supervision levels as those levels may assume that it creates a space for personnel empowerment. It is a time-consuming process because it requires building trust and credibility among the participants. It takes great, constant efforts to generate true participation awareness. It demands economic support and logistics resources. All of the above may lead to the perception that the participatory process is not a very profitable investment. Nonetheless, its positive aspects are seen through time and that must be made clear to all of the parties involved from the very onset of the process. Here, it is worth reflecting on how to find more opportunities to create participatory design processes that, in turn, generate safety systems in work systems, for example, through government safety and health policies or through rapprochement between academicians-researchers and the industry. There is a broad gamut of possibilities to be explored.

Furthermore, one of the reasons for system imbalances lies in safety systems being derived from badly structured design processes with biased goals. In such situations, safety is not understood as a control process (with safety layers) and an emergent property in interfaces and interactions; rather, the mindset is that each component is implicitly a guarantee of safety. That occurs when the persons involved in the process forget that the safety of a system depends on the sum of its whole and not on the particularity of a component. Based on that consideration, the presented model emphasizes a safety system design that uses redundancy, through which all components, levels, interfaces and interactions are subjected to a safety analysis for the purpose of evidencing and controlling their possible dysfunctions that are in turn structured as safety layers that actively participate in the proper operation of the work system.

5 Conclusions

This model proposes a change of paradigm regarding building safety into work systems by using participatory ergonomics principles, with an emphasis on early identification of dysfunctions in the interactions of the system components or levels through the active participation of all of the stakeholders as of the design phase.

Likewise, embracing the principle of systems theory, the focus is on analyzing and designing the system as a whole, not as specific components, in order to build the safety system that overlaps the work system and interacts throughout its entirety.

Safety systems are not standards, codes, instruments, procedures or software; they are rather the instrumentalization of a vision characterized by being an operational control process in the interfaces and interactions of a work system.

In synthesis, the development of a safety system should be conducted as of the very conception of the work system (to the extent possible). Design groups should include the representation of all of the stakeholders (administrative staff, technical personnel, operators, supervisors, work safety and health personnel, and architects, among others). The safety system should be aimed at dysfunction management (identification and control). It should act in the interfaces and interactions among the system component and the system levels (dysfuntion or imbalance control). Each component, interface and interaction should be assigned a safety responsibility. The safety system should be ascribed to the strategic area of the organization. And it should be dynamic and flexible enough to be able to adapt to process changes.

Finally, as Leveson [12] affirmed, the basic problem is that current systems are so complex that all possible interactions among the system components and the system levels cannot be identified. Nevertheless, it is also true that "the property of "safety" only makes sense when all the interactions among the system components are considered together". Therefore, this topic represents an immense, quite interesting challenge for system design groups.

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Elements of Workforce Diversity in Japanese Nursing Workplace

Yasuyuki Yamada, Motoki Mizuno, Teruko Shimizu, Yuji Asano, Takumi Iwaasa and Takeshi Ebara

Abstract Movement of diversity management (DM) is gradually spreading in Japanese hospitals. However little has been discussed about the effectiveness of DM in organizational ergonomics domains. Hence, this case report aimed to extract the elements of workforce diversities in Japanese nursing workplace. We conducted a semi-structured interview to four nurses with enough career to response the interview. Three were administrative nurses (male = 1, female = 2) and one was non-administrative nurse (male = 1). As the results, twelve elements of diversities with narrative evidences were extracted; (1) Seniority, (2) Career, (3) Age, (4) Gender, (5) Nationality, (6) Role orientation, (7) Employment pattern, (8) License, (9) Personality, (10) Disability, (11) Family, (12) Benefit package. According to their interviews, their workplace has been received the diversities of seniority, career, age, gender, employment pattern, disability, family and benefit package. On the other hand, they regarded the acceptance of license, personality, nationality and role orientation diversities as future issue. These diversity elements may be key points for the practical DM in Japanese nursing organization.

Keywords Diversity management · Nursing · Organizational ergonomics

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1 Introduction

Management of workforce diversity (Diversity Management: DM) in health care organization has been recommended internationally [1, 2] to improve patient satisfaction, increase the quality of care and enhance clinical outcomes for minority populations [3]. For the practical intervention, researchers have discussed about effective approaches to accept cultural, ethnic and racial diversities [4–6]. Through the empirical study, they examined useful DM programs [7, 8] and guidelines [9, 10]. The medical fronts began to remain a good practice report of the DM [11]. Furthermore, best practices were collected and released on the Internet and printed publications [12–14].

According to the current trend, the movement of DM is gradually spreading in Japanese health care organization [15], subsequently that leads to academic discussion about the necessity of human resource development concerning to minority workforces. In Japan, the topic of the DM has discussed in the contexts of human resource development of the male nurses, foreign nurses and part-time nurses. In the process of developing such social awareness, these minority nurses received an expectation as supplemental human resource merely to improve nursing shortage. However, after the movement of DM, they expected as a key person to enhance organizational performance.

As mentioned above, recent attention has been increased to the further function of DM, especially focusing on the elements of diversities which can contribute to vitalizing nursing organization in Japan. However little has been discussed about the effectiveness of diversities in organizational ergonomics domains. Hence, this case report aimed to extract the elements of workforce diversities in Japanese nursing workplace.

2 Methods

2.1 Participants

Cooperation medical institution of this study was a hospital employing about 130 nurses. This hospital has about 130 beds, affiliated hospitals, clinic and a nursing college. For our research, a nursing director selected four nurses from the hospital with enough career to response the interview. Three were administrative nurses (male = 1, female = 2) and one was non-administrative nurse (male = 1).

2.2 Procedures

In 2016, we conducted a semi-structured interview with forty to sixty minutes to each participant. On the basis of the conventional diversity frame-work, we structured the question items including the acceptance levels of the seniority, career, age, gender and nationality as the structured question [16]. Three academics with Ph.D and two administrative nurses discussed and found other diversity elements from the narrative data of the interview.

2.3 Ethics and Conflict of Interest (COI)

This study was approved by the ethical committee of Juntendo University Graduate School of Health and Sports Science. Moreover, there was not potential COI to disclose with this study.

3 Results

We extracted twelve categories as elements of workforce diversities; (1) Seniority: freshman, mid-career, expert, (2) Career: managerial position, clinical experience, employment history, academic background, (3) Age: generation, (4) Gender: male, female, (5) Nationality: country, culture, language, (6) Role orientation: teacher oriented, clinical oriented, (7) Employment pattern: part-time work, full-time night shift work, full-time day shift work, (8) License: nurse, public health nurse, midwife, assistant nurses, certified nurse, (9) Personality: assertiveness, aggression, slow learner, awkwardness, withdrawal, (10) Disability: employment of individuals with disabilities, (11) Family: duty of childcare, care for elderly relatives, double-career household, (12) Benefit package: on-site day care user, childcare leave user, sports and culture class user. Practice of DM and narrative evidence of these elements were shown in Table 1.

Table 1 Extracted diversity elements, practices of DM and narrative evidence

Diversity elements	Practices of DM	Narrative evidence
Seniority: freshman, mid-career, expert	•Keeping a good seniority balance in a job placement and working shift	•In the past, senior nurses had self-centered working pride that "my efforts contributed to a hospital growth." This mentality brought a strict teacher-student relationship between seniors and juniors. However, these trends were changed with acceptance of seniority diversity. Recent senior nurses became to have other-centered working pride that "our teamwork contribute to the hospital growth." Accordingly, they began to deal with freshman nurses like a daughter or little sister. The strict teacher-student relationship was also changed to a warm family relationship
Career: managerial position, clinical experience, employment history, academic background	•Employment of nurses with various background	•Even if our hospital improved working condition surrounding nurses, first career nurses without working experience in other hospitals couldn't appreciate the value. Since such nurses believed there were better workplace in other hospitals, sometimes, they moved to the other hospitals. On the other hand, nurses with career in other hospitals tended to remain this hospital because they could understand real value of the improvement. We expected to spread latter's perspective to the former nurses through the DM practice •In my workplace, a difference of academic back ground was not concerned. Certainly, I sometimes felt lack of skills and knowledge in my routine works, however, this issue was

(continued)

Table 1 (continued)

Diversity elements	Practices of DM	Narrative evidence
		different dimension from the academic background. This hospital and my co-worker accepted me as a professional regardless of my academic background
Age: generation	•Employment of elderly and/or retired nurses •Setting a chance for the communication between generations in nursing conference and training workshop	•As the results of strategic employment of elderly and/or retired nurses, an mean age among working nurses was increased. Now, mean age is reaching about thirty-six. In common with seniority and career diversities, generation gap has been accepted in this hospital
Gender: male, female	•Promotion of entering affiliated nursing college toward working males •Holding a career fair for male nurses •Bringing in self-reporting promotion system	•The number of male nurses has been increasing because of the efforts to recruitment and education in the affiliated nursing college. The career fair for males has also been successful. The self-reporting promotion system enhanced a percentage of male administrative nurses because every nurses had a change to the promotion •In our hospital, male nurses have been appreciated by other members because they have performed specific. Hence, female nurses could apply themselves to safe work with feeling thanks to males. Moreover, I have never faced any unfair situations because of gender difference
Nationality: country, culture, language	•Employment of foreign nurses especially in Southeast Asia	•Although our hospital has been progressed in the employment of foreign nurses, the number of employment has been on the decrease recently. I think fundamental issue with employment of foreign nurses is barrier of language rather

(continued)

Table 1 (continued)

Diversity elements	Practices of DM	Narrative evidence
		than that of ration, nationality and culture. Actually, a rapport building with patients seemed difficult without sufficient Japanese communication skills. Moreover, language barrier also seemed to disturb mastering nursing skills and growth as nursing professional •I felt admiration for their stance of humility in the nursing job. It expected that Japanese nurses should learn from their learning attitude through the integration of diversity
Role orientation: teacher orientation, clinical orientation	•Enhancement of cooperation between theory oriented nurses and practice oriented nurses	•In general, theory oriented nurses preferred to be a teacher in future in the nursing college. The practice oriented nurses tended to remain in the hospital and to train their own nursing skills. Under these conditions, nursing teachers and clinical nurses should cooperate each other to promote the integration of theory and practice in the nursing education. As for the strategy, I believe it is better that nursing teachers and clinical nurses organize OJT and Off-JT for the graduated nurses to integrate theory in the textbook and clinical practice
Employment pattern: part-time work, full-time night shift work, full-time day shift work	•Active perception of a personal request of working style through an individual interview with nursing director	•This hospital has actively accepted a request of working style from nurses to the extent that it has not impeded the team performance. In this system, the immediate manager performs an individual interview to all nurses and complies with their requests. When the immediate manager found it reasonable, the request was accepted.

(continued)

Table 1 (continued)

Diversity elements	Practices of DM	Narrative evidence
		Actually, some nurses are allowed to work as the full-time night shift worker or full-time day shift worker. Since all nurses have the chance to negotiation, nobody complained about other's working style
License: nurse, public health nurse, midwife, assistant nurses, certified nurse	•Active employment of midwives	•I think, basically, there are no psychological barriers between nurses, public health nurses, assistant nurses and certified nurses. In fact, I have never seen a situation of special treatment by holding specific nursing licenses. However, in our hospital, midwives has been comparatively given preferential treatment in a salary and a limit of employment because it has been hard task for hospital to keep enough number of midwife employment under a serious midwife shortage. Moreover, midwives were not required to transfer to the other department. Hence, acceptance of the working condition among midwives is future issue
Personality: assertiveness, aggression, slow learner, awkwardness, withdrawal	•Putting the right people in the right jobs on the basis of personality traits	•Our hospital has been tried various job placement to accept personality diversities of assertiveness, aggression, maladdress, slow learner and withdrawal. One of the good practices was a non-assertive nurse who couldn't sufficiently communicate with patients. She became to be indispensable clinical research coordinator through transfer to a clinical research department. Additionally, supported nurses took much time to build rapport with patients to assign

(continued)

Table 1 (continued)

Diversity elements	Practices of DM	Narrative evidence
		a department specialized in a long-term follow-up work for the limited outpatients. Moreover, the slow leaner and awkwardness nurses tended to be assigned to kind of repetitive work from educational perspective
Disability: employment of individuals with disabilities	•Fostering an or organizational climate of accepting persons with disabilities	•This hospital has been progressed in active employment of persons with disabilities. Currently, some of such persons are working as the assistant nurses or office workers
Family: duty of childcare, care for elderly relatives, double-career household	•Supporting a work-life balance	•Since a lot of married nurses have been worked in this hospital, this hospital has been made much efforts to create a comfortable work environment to keep their good work-life balance. Actually, my workplace has a climate to respect family reasons each other. Hence, nobody complains about sudden absence or early leaving for family reasons. Thanks to this mutually supportive environment, I have been worked as a nurse and, in parallel, contributed to my partner and children for a long time
Benefit package: on-site day care user, childcare leave user, sports circle and culture class user.	•Preparing on-site day care •Promotion of taking childcare leave •Providing sports and culture community	•The use of day-care center has been promoted to continue their nursing career among married people. Although female nurses tended to take childcare leave, almost all male nurses didn't use this system. As one of the benefit packages, this hospital provides sports community and English conversation class for all of the employee. Since I feel attracted to the sports events, I'd like to participate when I get leeway

4 Discussion

Through the interview research, we confirmed twelve diversity elements in Japanese nursing workplace with narrative evidences. We named the elements of seniority, career, age, gender and nationality by the conventional framework of diversity management [16]. Others were original categories of this study.

In our research, all of participants satisfied the acceptance levels of seniority, career, age, gender, employment pattern, family and benefit package. On the other hand, acceptance levels of license, personality, disability, nationality and role orientation remained as the issues to be improved. For the accomplishment of effective diversity management in the nursing organization, in the next step, we would like to assess the acceptance levels of diversities and to examine the relationship with diversity outcome.

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Research on Urban Rail Driver's Mental Workload Based on Extenics

Lan-peng Li, Zhi-gang Liu, Hai-yan Zhu and Lin Zhu

Abstract The evaluation model produced by the research on urban rail driver's mental workload based on original science and Extenics. This paper uses the SHEL model to establish an index system including 13 important indexes that reflect the influence on individual mental workload of the urban rail train drivers. The SHEL model and the index system are also used to design the driver pressure source questionnaires. Our researchers randomly selected 300 qualified drivers from Shanghai Urban Rail Transit Company to participate in questionnaire survey and psychological interview. According to the basic principle of Extenics, using Extension method, we determine the weights of 13 indexes in the questionnaire data, then structure each rating section's classical domains and the joint domains of all levels, and calculate the correlation degree between the mental workload and the evaluation degree for confirming individual driver's mental workload level, forming the mental workload evaluation model of Extenics. Finally, through a concrete sample instance of the application, we managed to test the feasibility and reliability of this method. The evaluation results can provide decision-making reference for drivers' performance on management aspects and they are also good for enhancing and ensuring urban rail traffic safety and efficient operation.

Keywords Urban rail driver · Mental workload · Extenics method · Evaluation model

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1 Introduction

Along with the development of urban rail traffic modernization, the drivers, as one of the most important factor, have become the focus of research of traffic safety problems. The driving workload reflects drivers' perception, attention, memory, thinking and action of comprehensive information processing ability changed due to the hardware, psychology, software change, and explains the amount of energy expenditure of drivers in a series of activities such as accepting outside information, rapid processing and clear judgment. Jahns believe that mental workload is composed of three parts with functionally interconnected, namely, input workload, operators' efforts and the performance of operation. Sheridan, scientist in the United States, elaborated the meaning of mental workload from the perspective of "control", which thought the category of mental workload is information processing and emotional workload. Kahneman put forward Single Resource model about attention, as well as Wickens's Three-Dimensional System of Resource model; most of them regard subjective mental workload as resources concept that with multiple dimensions [1–3], which become the main theory of mental workload model. On the whole, the burden degree of mental workload that drivers bear is closely connected with ability, character, task, and, physiology. There is a correlation between mental workload and occupational safety that has important influence on their operation.

Researchers have done much in key fields as the influence of the mental workload, measurement method, etc. The mental workload measurement methods were induced to two categories, subjective evaluation and objective quantitative measurement [4]; The NASA conducted a series of flight experiments at the GAT to analyze the pilots' mental workload by using the secondary task analysis; Hart et al. developed the NASA-Task Load Index (NASA-TLX) with fairly reliable because of more points scale and resolution [5]; G.B. Reid et al. put forward Subjective Workload Assessment Technique (SWAT), the workload was treated to the three-dimensional structure and determine the corresponding workload evaluated value [6]; Moon et al. discussed the sensitivity of EEG and ECG signal in the evaluation of mental workload through fuzzy system to found that the results from nonlinear fuzzy algorithm could reflect the variation of workload more clearly than using linear function [7]; Recently, some researchers constructed the OCC controller workload model based on time weights and its results showed the correlation coefficient with IWS assessment value met the requirements, they connect with each other significantly [8]. In quantitative measurement field, there are studies for the air-traffic controllers' physiology measurement to get workload [9]; In particularly, the heart rate variability (HRV) is a good physiological index with frequently applied, many study results proved that the index had higher sensitivity to mental workload fluctuation [10–13]. Integrated the advantages of subjective evaluation and objective measurement, Myikae combined the physiological indexes and subjective evaluation indexes into a more sensitive index to evaluate mental workload [14].

Due to the particularity and complexity of the specific profession, urban rail transit driver, those methods above with the limitations of preference for qualitative analysis are not suitable for the comprehensive analysis of the drivers' mental workload. The SHEL model in this paper is a mature human factors engineering model in aviation ergonomics [15], so that we can analyze, based on the system correlation among person, machine and environment, the influence factors of drivers' occupational workload systematically. We get two categories stress resources and 13 indexes under the model, and then mental workload evaluation system is established. Besides the SHEL model first time applied to urban rail transit driver's study, classical domain and the joint domain model set up under the original Extenics theory, finally, to realize ideal effect with qualitative and quantitative analysis.

2 Methodology

2.1 The SHEL Model Theory

The SHEL model is the most widely research model used in the human factors field of aviation, which was first put forward by Edwards, and get improvement by Hawkins in 1975 [16] (Fig. 1). It is a typical system orientation model. The ICAO divided aviation system into people, hardware, software and environment four components [17].

SHEL model contains four elements, including Software (S), Hardware (H), Environment (E) and Liveware (E). The Liveware, which is a people element, is in the center position of the various elements and relationships, where is the events' starting from and the results point to. All of the relationships among Liveware and the other three elements, S, H, E, L, are named interface: L-H, the relationship between the workers and the physical environment of hardware facilities, is the

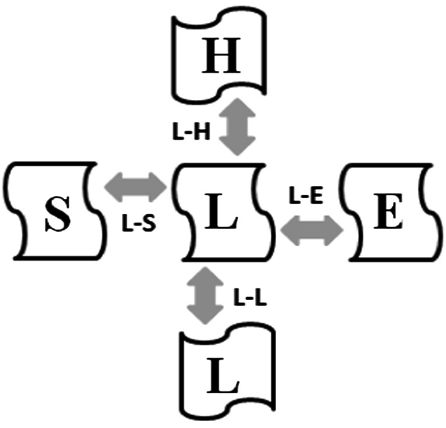

Fig. 1 SHEL model. (The core module in the model established contact with the four modules around through four interfaces)

object that hardware's design thinking for about ergonomics and engineering; L-S represents the relationship that workers get along with system factors, from where considering workers' safety and efficiency in a management and program whole perspective; L-E is the relationship between worker and environment, representing workers' adaptive in operation environment; L-L interface means the human relationships with managers, colleagues and even the self-adjusting and attitude. As we can see from the SHEL model, the relationships (interfaces) between people (Liveware) and the other four elements are not perfect (between each module is not fully fit, but uneven edges) because of the human factors' obvious feature of uncertainty and instability. Workers' (drivers') mental workload is exactly from those interfaces' gaps. The mental workload thus leads to defective relationships, which have significant influence on operators' behavior.

2.2 Applications of SHEL Model in Urban Rail Driving Occupation

Through data investigation and analysis, some scholars found that China's railway locomotive driver's mental workload mainly comes from the working environment, workload, organization management, management behavior, relationships, career development, etc. [18]. In the paper, we draw lessons from the human-centered system relationship in the SHEL model and put the element, drivers, into the core module in the model to analyze drivers' mental workload factors, which produced by physical, psychological, social status, people-systems relationship, people-environment relationship, namely, the mental workload index system, as Table 1.

According to the index system, design the urban rail driver questionnaire to analyze the degree of these indexes' influence on the driver's mental workload.

Table 1 The index system of urban rail transit driver's mental workload

The source interface	Mental workload indexes
Human-system	c_1 The train and the signal system state
	c_2 Management system and working procedures
	c_3 Ergonomic design of equipment
Human-environment	c_4 Train line type (e.g., ground or underground)
	c_5 The weather conditions
	c_6 Cabin space
	c_7 Traffic noise
Self-state	c_8 Driving operation and emergency disposal capacity
	c_9 Physical condition
	c_{10} State of health
Human relationship	c_{11} Relationship with the managers
	c_{12} Communication with colleagues
	c_{13} Self-adjusting and attitude

Table 2 Reliability statistics

Cronbach's Alpha(Raw reliability)	Normalized Cronbach's Alpha(α)	Number of items
0.900	0.902	13

Table 3 KMO & Bartlett test

Numbers enough for Kaiser-Meyer-Olkin test		0.901
Bartlett sphericy test	Approximate chi-square	924.095
	df	81
	Sig.	0.000

With the above conditions, we conducted a questionnaire survey and some interviews, a total of 300 participants who are the on-the-job drivers were selected randomly from Shanghai metro company, and the valid response rate is 98.7 % (296 of 300 are effective questionnaires).

In order to validate the consistency, stability and reliability of the questionnaire results with driving occupation, we select the Cronbach's alpha (α) homogeneity reliability coefficient method to test the consistency of the indexes, with results shown in Table 2.

(The alpha (α) closes to 1, the higher reliability, and the alpha (α) coefficient should be greater than 0.7.)

Validity test (Bartlett sphericy test and KMO test), which reflect the correlation level between indexes and mental workload, are shown in Table 3.

(The Significant difference(Sig) of Bartlett sphericy test is 0.000 (< 0.001), which shows the difference is significant; The KMO test data is 0.901 close to 1, also regarded ideal level.)

From the results of the reliability test and the validity test above, we can sure that the indexes (Table 1) of drivers' mental workload are reliable, and then we used the SPSS [19] data analyze software in factor analyze method to calculate the 13 indexes' weights, as the results shown in Table 4.

2.3 *The Extenics Theory*

Research has already been done to solve the contradiction. CAI Wen, a professor in China, proposed the formalization method to solve the contradiction [20], achieving the purpose that the contradiction problem solved intelligently [21]. All results of those studies deduced the Extenics [22]. The Extenics is an interdisciplinary committed to researching the transformation of incompatible problems and solving methods (e.g., mental workload evaluation and quantitative analysis here). The Extenics, put the matter-element as the basic-element that including object, characteristics and value to build model for describing contradiction, regards matter-element transformation as the means to solve problems.

Table 4 Mental workload index system and weights

The source interface	Weights	Mental workload indexes	Weights
Human-system	0.41	c_1 The train and the signal system state	0.14
		c_2 Management system and working procedures	0.18
		c_3 Ergonomic design of equipment	0.09
Human-environment	0.19	c_4 Train line type (e.g., ground or underground)	0.02
		c_5 The weather conditions	0.09
		c_6 Cabin space	0.01
		c_7 Traffic noise	0.07
Self-state	0.29	c_8 Driving operation and emergency disposal capacity	0.09
		c_9 Physical condition	0.11
		c_{10} State of health	0.09
Human relationship	0.11	c_{11} Relationship with the managers	0.07
		c_{12} Communication with colleagues	0.02
		c_{13} Self-adjusting and attitude	0.02

The extension theory, the basic theory of Extenics, consists of basic-element theory, extension set theory and extension logic theory. The basic-element can describe the contradiction problems formally; the extension sets, which are the basic of describing the things' quantitative change and qualitative change, make a dynamics classification with object things and solve problems with mathematical methods.

2.4 Extension Matter-Element Theory

The matter-element in the Extenics is basic element to describe things, presented by an orderly triples $R = (N, c, v)$. As the relation shows, N represents thing; c represents the name of feature; v represents the value of c in N. They are the necessary three elements of the matter-element. The feature-element M_i (c_i, v_i), which describe the feature of the thing (N), is constituted by name c and value v [21]. Only single feature in one thing is named one-dimensional matter-element, in fact, the thing always with more characteristics, according to the corresponding relations between c_i and v_i,we can get multi-dimensional relations: $(c_k \in C, v_k \in V, k = 1, 2, \cdots, n)$

$$\mathrm{R} = \begin{bmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \cdots & \cdots \\ & c_n & v_n \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \\ \cdots \\ R_N \end{bmatrix} \tag{1}$$

3 Extension Model

3.1 Classical Domain and Joint Domain of Drivers' Mental Workload

The Extension evaluation's most important partial is establishing domain of mental workload level and index system, at the same time having a clear definition about classical domain and joint domain. Then the correlation between index system and mental workload level can be concluded by correlation function, finally, the Extension model modeled and used to measure the drivers' mental workload level.

The classical domain of drivers' mental workload established:

$$\mathrm{R_j} = \left(\mathrm{N_j},\ \mathrm{c_1},\ \mathrm{v_{ji}}\right) = \begin{bmatrix} N_j & c_1 & v_{j1} \\ & c_2 & v_{j2} \\ & \cdots & \cdots \\ & c_n & v_{jn} \end{bmatrix} = \begin{bmatrix} N_j & c_1 & < a_{j1}, b_{j1} > \\ & c_2 & < a_{j2}, b_{j2} > \\ & \cdots & \cdots \\ & c_n & < a_{jn}, b_{jn} > \end{bmatrix} \tag{2}$$

Where the N_j represents there are j levels of mental workload, $j = 1,2, \ldots,m$; c_i means the characteristic index of N_j, $i = 1,2, \ldots, n$; v_{ji} is the value domain of ci, namely, the classical domain $< a_{jn}, b_{jn} >$.

The joint domain can be given by:

$$\mathrm{R_W} = \left(\mathrm{W},\ \mathrm{c_1},\ \mathrm{v_{Wi}}\right) = \begin{bmatrix} W & c_1 & v_{W1} \\ & c_2 & v_{W2} \\ & \cdots & \cdots \\ & c_n & v_{Wn} \end{bmatrix} = \begin{bmatrix} W & c_1 & < a_{W1}, b_{W1} > \\ & c_2 & < a_{W2}, b_{W2} > \\ & \cdots & \cdots \\ & c_n & < a_{Wn}, b_{Wn} > \end{bmatrix} \tag{3}$$

The W means all levels of mental workload, and v_{Wi} is the value domain of c_i.

3.2 The Correlation Function of Mental Workload

According to the definition of correlation function in the Extension evaluation theory [21], we assume that an urban rail transit driver's matter-element model is (R_x is the mental workload.):

$$\mathrm{R_x} = \left(\mathrm{W_x},\ \mathrm{c_i},\ \mathrm{v_i}\right) = \begin{bmatrix} W_x & c_1 & v_1 \\ & c_2 & v_2 \\ & \cdots & \cdots \\ & c_n & v_n \end{bmatrix} \tag{4}$$

Then the correlation function of level j is:

$$\mathrm{K_j}(\mathrm{v_i}) = \begin{cases} \frac{\rho(v_i, v_{ji})}{\rho(v_i, v_{Wi}) - \rho(v_i, v_{ji})} & v_i \notin v_{ji} \\ -\frac{\rho(v_i, v_{ji})}{|v_{ji}|} & v_i \in v_{ji} \end{cases} \tag{5}$$

Where

$$\rho(v_i, v_{ji}) = \left| v_i - \frac{a_{ji} + b_{ji}}{2} \right| - \frac{1}{2}\left(b_{ji} - a_{ji}\right) \tag{6}$$

$$\rho(v_i, v_{Wi}) = \left| v_i - \frac{a_{Wi} + b_{Wi}}{2} \right| - \frac{1}{2}(b_{Wi} - a_{Wi}) \tag{7}$$

3.3 The Evaluation Model Based on Correlation

The correlation degree is a bond that connects correlation function and index system, transforming the external influence factors into the mathematical problems that can be calculated and presenting the intrinsic properties of drivers' mental workload by clear data. In this method, according to the correlation function [formula (5)] and indexes (Table 4) of mental workload above, we could calculate the correlation degree, K_j (W_O), of j, grade of the drivers' mental workload. Where W_O is driver's mental workload:

$$K_j(W_0) = \sum_{i=1}^{n} \lambda_i Kj(v_i). \tag{8}$$

The grade of mental workload as following:

$$K_j = \max K_j(W_0) \quad \mathrm{j} = 1, 2, \ldots, \mathrm{m}.. \tag{9}$$

After the indexes of drivers' mental workload transformed into evaluation grades by correlation degree, what we need is the more concise and scientific level system that can reflect mental workload grades. In the model, aviation controllers' classification standard [23] of human factor is referenced. We divided drivers' mental workload level into four ranks, including severe (grade 1), heave (grade 2), little (grade 3) and normal (grade 4) with classical domains, respectively, [0.75, 1], [0.5, 0.75), [0.25, 0.5), [0, 0.25). The joint domains of all grades and classical domains of every grade can be given against the indexes.

The joint domain of drivers' mental workload on all levels:

$$\mathrm{R_W} = (\mathrm{W},\ \mathrm{c_{13}},\ \mathrm{v_{W13}}) = \begin{bmatrix} W & c_1 & <0,1> \\ & c_2 & <0,1> \\ & \cdots & \cdots \\ & c_{13} & <0,1> \end{bmatrix} \tag{10}$$

Every grade classical domains on individual level:

$$R_1 = \begin{bmatrix} grade\,1 & c_1 & <0.75,1> \\ & c_2 & <0.75,1> \\ & \cdots & \cdots \\ & c_{13} & <0.75,1> \end{bmatrix} \tag{11}$$

$$\mathrm{R_2} = \begin{bmatrix} grade\,2 & c_1 & <0.5,0.75> \\ & c_2 & <0.5,0.75> \\ & \cdots & \cdots \\ & c_{13} & <0.5,0.75> \end{bmatrix} \tag{12}$$

$$\mathrm{R_3} = \begin{bmatrix} grade\,3 & c_1 & <0.25,0.5> \\ & c_2 & <0.25,0.5> \\ & \cdots & \cdots \\ & c_{13} & <0.25,0.5> \end{bmatrix} \tag{13}$$

$$\mathrm{R_4} = \begin{bmatrix} grade\,4 & c_1 & <0,0.25> \\ & c_2 & <0,0.25> \\ & \cdots & \cdots \\ & c_{13} & <0,0.25> \end{bmatrix} \tag{14}$$

(The R_1, R_2, R_3, R_4 are classical domain with different grades.)

4 Applications and Validations

To validate the extension model whether it meets the requirement of the practical operation for evaluating the drivers' mental workload level, we made a computing validation by using the original questionnaire data under the model. We selected one driver's questionnaire answer data from the all questionnaire randomly, and did a normalized processing to get the corresponding value of index system, the purpose of the step is to make the indexes value within [0, 1], as shown in Table 5.

Table 5 The sample data after a normalized processing

c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}	c_{11}	c_{12}	c_{13}
0.8	0.8	0.7	0.6	0.7	0.6	0.7	0.7	0.7	0.7	0.7	0.6	0.6

Table 6 Correlation of driver's mental workload indexes

Mental workload indexes	$K_1(v_i)$	$K_2(v_i)$	$K_3(v_i)$	$K_4(v_i)$
c_1	0.333	0	−0.060	−0.733
c_2	0.333	0	−0.060	−0.733
c_3	−0.125	0.500	−0.400	−0.600
c_4	−0.273	0.143	−0.200	−0.467
c_5	−0.125	0.500	−0.400	−0.600
c_6	−0.273	0.143	−0.200	−0.467
c_7	−0.125	0.500	−0.400	−0.600
c_8	−0.125	0.500	−0.400	−0.600
c_9	−0.125	0.500	−0.400	−0.600
c_{10}	−0.125	0.500	−0.400	−0.600
c_{11}	−0.125	0.500	−0.400	−0.600
c_{12}	−0.273	0.143	−0.200	−0.467
c_{13}	−0.273	0.143	−0.200	−0.467
K_j (W_0)	−0.0112	0.3150	−0.2772	−0.6239

Calculating the driver's correlation degree of indexes on the basis of formula (5):

Drivers' mental workload grades are judged by the max K_j (W_0), according to the formula (9). Obviously, we can find the answer from Table 6 and the driver's mental workload is $K_2(v_i)$, grade 2 with a 'heave' description. Through consulting the driver's questionnaire, we found that his personal information show that he was off work from driver position two hours ago, which explains the high mental workload level to some extent. Besides, we calculated one hundred drivers' questionnaire data of 296, the statistics about mental workload grades and relevant data are shown in Table 7.

From the Table 7, we found that drivers involved with working activities had higher mental workload grades than those in the rest. As we known, intense work must have obvious effects on mental workload. The evaluation model shows the fact clearly. On the one hand, we revealed the problem that drivers working with heave mental workload and hidden peril of safe operation; on the other hand, it illustrates that the extension evaluation model is feasible for urban rail drivers' mental workload measurement.

Table 7 Drivers' mental workload grades data statistics

Grade	1	2	3	4	Total (number of people)
Working activities	0	19	47	2	68
Rest	0	4	11	17	32
Total (number of people)	0	23	58	19	100

The *Working activities* item means the driver have participated into the work task within three hours

5 Conclusions and Suggestions

This thesis finally established the urban rail transit drivers' mental workload evaluation model based on Extenics. We build the index system through the SHEL model to design special drivers' questionnaire for original data, and weights of every index calculated. Then, the key and innovation is to applied correlation degree to the conversion with mental workload grade and get driver's mental workload grade. On the premise of guaranteeing the reliability and rationality relatively, we turned the abstract problem, mental workload evaluation, solved by qualitative analysis into the subject combined with quantitative analysis; therefore, objective and effective evaluation model applies to every driver's mental workload estimate. The corresponding relations between correlation degree of indexes and mental workload level make the results clear.

An increase in mental workload (a more demanding task) leads to a decrease in situation awareness, which, in turn, leads to lower performance [24]. So, the purpose of the study is monitoring the drivers' mental workload within appropriate status and mastering the initiative of safe operation, in fact, we give three suggestions such as: (1) The influence factors (index system) that have a significant effect on drivers' mental workload should be avoided and diminished, for example, the management procedures (c_2) need to be optimized and reliable hardware facilities (c_1) here; (2) The driver's mental workload status should be paid close attention and concerned, drivers with bad state should have a rotation based on a good rotation system; (3) Mental workload is inevitable, drivers should strengthen their psychological endurance.

The research on urban rail transit driver's occupational mental workload can draw lessons from other fields not only models, but also methods, such as the eye-related measures [25], the novel stimulus stream approach [26], etc. As the further research on this thesis, more accurate correlation function and more subtle and comprehensive index system (age and the driving complexity also impact on drivers' mental workload [27]) will be the focus of our research in the future.

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Analyzing the Impact that Lack of Supervision Has on Safety Culture and Accident Rates as a Proactive Approach to Curbing the South African Railway Industry's High Incident Occurrence Rate

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Abstract An internal summary of the findings from the 2014–15 final investigations reports highlighted that the human factor element contributed to 71 % of the occurrences recorded in that year. Of these recorded human factor related contributions, 32 % were attributed to the category, lack of supervision (the largest contributing category), as having had either a direct or indirect effect on the recorded occurrences. The findings of the summary indicated that while there were procedures in place with the intent of managing safety, these procedures were not successfully executed due to a lack of supervision. This paper proposes that a lack of supervision could be understood as contributing to an ineffective safety culture because a supervisor plays a vital safety role in reinforcing proper procedures and work practices to correct systemic weaknesses. This study suggests that the failures in supervision noted indicate an ineffective safety culture within the South African Railway Industry that may potentially increase accident occurrence rates.

Keywords Human factors · Safety culture · Railway accidents · Lack of supervision · Swiss cheese accident model · Safety management

1 Introduction

The South African railway industry currently has a high railway incident occurrence rate. An analysis of the South African Railway Safety Regulator's occurrence register shows that there is an average of 5 reported railway incidents a week, an unenviable safety record. While operator investigation reports are conducted following incidents,

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these typically focus mainly on railway engineering related findings and safety aspects (and consequently, on engineering controls). This means that other factors that can contribute to an incident, such as Human Factor related causes, are overlooked in this growing industry, often leading to limited incident causation considerations.

Research has indicated that accidents rarely have a single cause primarily because they usually result from a number of hazards combining in response to multiple failures of management direction, procedures, equipment, or people [1]. Thus an accurate incident causation analysis would benefit from considering the multiple failures, some which may occur simultaneously, that produced the incident. This mandates that any attempts made to understand the root causes of incidents or implement effective changes must consider all contributory factors.

2 Safety Culture and the Role of the Manager/Supervisor

Safety culture is a concept that is fairly difficult to define due to its complexity. Although it has several definitions, it can be succinctly understood as the way things are done in an organization [2]. O'Toole [3] understood it as a term which commonly explained how safety was placed as a priority within an organization.

Authors, Ember and Ember [4], define it as the set of learned beliefs, attitudes, behaviors, values, and ideals characteristic of a particular society or population. This definition is similar to that of the Health and Safety Executive, which defines safety culture as "… the product of the individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety programs" [5]. Culture, in this context, is understood as an organizational conceptual type of thinking expressing organizational ideals, values, attitudes and beliefs. D'Andrade [6] definition of safety culture as a learnt system of meaning—transferred by means of language and other symbol systems, capable of creating cultural entities and particular senses of reality and possessing a collection of representational, directive, and affective functions—further highlights the degree of complexity involved in finding a satisfactory definition. The above definitions highlight particular key attributes of safety culture. These are that it is shaped by specific learned cultural traits, within an explicit setting, that have a direct impact on the safety functionality of the organization. Put differently, safety culture is a concept that can be taught, modified and adopted and thus be somewhat within the control of the organization.

Hudson (1999 in Farrington-Darby et al. [7]) notes that the promotion of a positive safety culture is now considered to be a viable risk management method; ultimately, this aids in the creation of a culture within an organisation where ensuring safety is everyone's responsibility. O'Toole [3], suggested that safety culture was paramount to a company's safety record when he postulated that the decline in injury rates were directly related to the company's shift in safety culture.

Farrington-Darby et al. [7] collected research showing that factors such as immediate supervisors, management, individual and behavioural factors, reporting systems, rules and procedures, organisational subcultures and communication were instrumental in the development of a positive safety culture; it can be inferred that these same factors, if managed poorly, could lead to a negative safety culture. Additionally, it is understood that management contribute to accidents when they place people in error prone situations [8].

Vredenburgh [9] noted that management practices, generally, reliably predicted injury rates and that hospitals which employed proactive measures to prevent accidents had low injury rates in comparison to hospitals which implemented reactive practices.

O'Toole [3], in the 2002's study, found that the factor with the largest positive perception by employees was the commitment of management to safety. This preliminary study identified that management leadership was able to influence employee perceptions of the safety management system, perceptions which would influence employee decisions. Employee decisions that could be influenced related to on-the-job decisions and at-risk behaviours [3].

The Institute of Rail Signal Engineers states in the [8] Technical Committee report that every accident, regardless of magnitude, is a failure of management. While this assertion seemingly discounts research that suggests that accidents rarely have a single cause, in actuality, this assertion is based on the perception of management having the central safety responsibility of adequately equipping employees with the means necessary for detecting and handling unsafe situations accordingly. Although managers and supervisors, undoubtedly, have an influence on an organisation's Safety Management System in the same way that policies and procedures do, they have a distinct influence specifically on employee behaviour.

In assessing methods to improve safety through behaviour modification, Duff et al. [10], noted inappropriate behaviour or equipment usage as the dominant reported accident causation factors. Additionally, research has showed that the feedback given to employees can have an influence on their behaviour; for instance, the tendency to reward speed of performance and not safe working procedures, can foster negative safety behaviour [10]. McAfee and Winn, (1989 in Duff et al. [10]) noted that safety behaviour could be improved through systematically monitoring safety related behavior and providing feedback in conjunction with goal setting and/or training.

In a guide for the Railway Industry on understanding Human Factors, the Railway Safety and Standards Board indicated that the role that supervision and appraisal played in the continuous development of front line staff in the railway industry was crucial [11]. While it is understood that effective supervisors utilize management (inclusive of the assessment of professional competency, and workload), staff development (concerned with the appraisal of staff performance to identify training needs), support and mediation as primary skill sets, these skills are underpinned by the essential skill of clear and effective communication. Essentially, an effective supervisor is able, through the organisation, to minimize the negative effects of workload through design, selection, recruitment, and training [11].

Farrington-Darby et al. [7] research that noted the role of supervision, along with training, risk assessments and rules and procedures, in managing the range of risks associated with high-risk industries is instrumental in aiding in a more holistically focused accident causation understanding. Farrington-Darby et al. [7] presented evidence that suggested that a shift in the focus of investigations in high risk industries from a reliance on accident and incident data and direct health and safety systems to investigating the culture and climate that may contribute to incidents on the wake of the suggested link between safety culture and major accidents was crucial.

3 Putting Lack of Supervision into Perspective

According to the Swiss cheese accident model (a basic model of accident causation), a typical accident is made unavoidable because numerous (human) errors have occurred at all levels in the organisational hierarchy [1]. In a typical company, organisational safety is ensured through the placement of protection barriers within a system that act as defences. These barriers can exist in the form of procedures. Procedures often serve a regulatory function of the process of safe operations. In other instances, procedures serve as a guide to how the interaction with the technology should occur [1]. Reason [1] defined an accident as resulting from a situation in which latent conditions combine unfavourably with local triggering events (weather, location, etc.) and with active failures (consisting of errors and/or procedural violations) committed by individuals or teams at the sharp end of an organization. The Swiss Model outlines latent factors as having an accident causation impact beyond proximate causes, able to affect the safety equilibrium both dynamically and statically [1]. Reason [1] classified latent conditions as those arising from cultural influences or management decision practices and considered active failures to consist of errors and/or procedural violations. In this way, one can interpret his model to have included safety culture and managerial/supervisory actions/inactions.

In cases where lack of supervision was the root cause of an accident, the latent condition would have been a supervisor’s inability to, for example, to ensure that the safe working procedures were adhered to in general, leading to recurring failures to monitor and maintain the track (an active failure) resulting finally in cracks on the crown of the rail (exasperated by local triggering events such as weather) that make derailments easier.

Essentially, the dynamics of accident causation as outlined in the Swiss cheese model of defences, outlines an accident as emerging due to holes (failures) in barriers and safeguards. Reason [1] postulated that the immediate/proximal cause of the accident is a failure of people at the “sharp end” directly involved in the regulation of the process or in the interaction with the technology [12].

Structurally, the Swiss cheese model addresses a hierarchical organizational structure, inclusive of decision makers (which tend to include high-level managers who manage and set goals to maximize system performance), line management (inclusive of departmental managers responsible for implementing the goals and strategies of the decision makers within their areas of operation), preconditions (qualities acquired by people, machines and the environment at the operational level), productive activities (inclusive of actual performance at operational levels) and defences (referring primarily to safeguards and other protections aimed at managing foreseeable negative outcomes) [1].

It is thus possible for an accident to result after a multiple-failure of these elements [1, 12]. The failure of each element will thus affect the equilibrium of safety in a unique way. Since this model proposes that an accident becomes unavoidable because of “windows of opportunity” or weaknesses open in all levels of the production system, closing the weaknesses in a single element could stop an accident from occurring. This will be possible because accidents would be traced back to weaknesses in all (or any) levels of the system that move through the entire structure causing an unavoidable accident.

While there are a vast number of accidents that occur as a result of ‘human error’ by an individual or group, beyond the control of management, accidents related to lack of supervision are a category of procedural defence failure accidents that are completely within the control of management. It is clear from this accident causation model that lack of supervision can play a subversive role as both a latent factor/condition and as an active failure. As such, lack of supervision can be viewed as a procedural (and therefore organisational) defence failure as it entails the inability of a procedure to be followed as prescribed resulting in a defence failure. Lack of supervision can also be understood to play a multiple failure role (failure of one kind of procedural regulation leading to the failure of another defence).

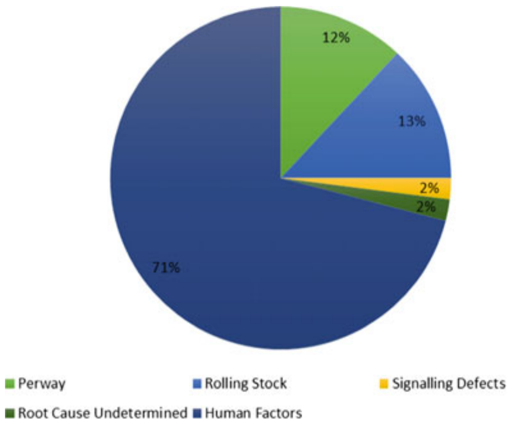
4 Methods and Results

The aim of the analysis of the findings from the 2014–15 final investigation reports was to identify train accident trends that occur in the railway industry. The analysis was conducted by looking at all the findings from the 2014–15 final investigation reports and separating them into categories. Separating each finding according to the category it addresses was done with the intention of assessing the contribution of the specific category to the total number of findings. The categories used included perway related findings, rolling stock related findings, signaling defects related findings, and human factors related findings. An additional category was created to include undetermined root causes (Fig. 1).

The results from the analysis showed that the human factor element contributed to 71 % of the findings from the recorded occurrences. Of these recorded human factor related contributions, 32 % were attributed to the category lack of supervision as having had either a direct or indirect effect in the recorded occurrences. 26 % of lack of supervision-related findings were identified as the root cause.

The human factors-related findings category included additional classifications; these were lack of communication, train working rules knowledge, negligence, lack

Fig. 1 Findings from the 2014–15 final investigation reports



of supervision, poor train handling, training, and human factors contributed by the public.

The lack of supervision-related findings included failures to: renew expired train driver road knowledge accordingly, manage inspection processes formulated to identify and eliminate unsafe wagon conditions as well as failures to ensure adequate task observation and monitoring during shunting movement. Also among the notable characteristics were failures to monitor train crew activities, promote familiarity with locomotive operating procedures and maintain clear roles and responsibilities of train crew. These findings were then further grouped into 9 sub-categories according to the type of failure. The sub-categories for lack of supervision included the following failures: monitoring, inspection, performance with no authority, enforcement, fitness for duty, awareness, human resources, risk assessment and contingency plan.

The monitoring sub-category was inclusive of findings related to a supervisor's failure to adequately monitor safety procedures while the inspection sub-category included a supervisor's failure to ensure that inspections were conducted routinely. The performance with no authority sub-category grouped all instances where an employee routinely performed a task with no authority. The enforcement sub-category included cases where a supervisor failed to enforce safety regulations, policies, processes and procedures. The contingency plan sub-category included failures by management to secure a working plan to manage emergency and likely events. The awareness sub-category included cases in which management failed to provide adequate training, critical safety information and safety risk exposure cognizance for their employees. The fitness for duty was inclusive of findings related to a supervisor's failure to ensure that employees were fit, not under the influence of substances, and up-to date on training. The human resources sub-category included a supervisor's inability to correctly profile and manage high risk employees, and meet, monitor and manage staff vacancy needs (Fig. 2).

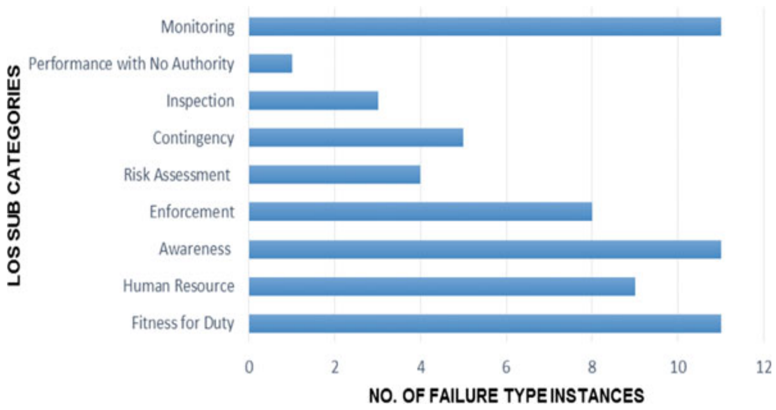


Fig. 2 Lack of supervision division categories. Where: "LOS" means lack of supervision

The results indicated that the monitoring, fitness for duty and awareness sub categories were the least adequately supervised. These sub categories were followed by the human resource then by the enforcement failures.

5 Discussion

The enforcement of safety regulations, policies, processes and procedures is an important supervisory function due to the essential role that it plays in error control and reduction. A supervisor can use the enforcement of safety regulations, policies, processes and procedures as a tool to influence behaviour and performance to limit human errors [5]. Ensuring fitness for duty is essential as it plays a crucial role in limiting potential accidents that could emerge as a result of psychologically and physically related ill-health, poor alertness on duty, mismatched task demands, stress induced ineffectiveness and competency failures [5]. There may be instances when rules are broken due to pressures from the job such as being under time pressure or due to an insufficient staff to workload balance; it is here that supervisors can play a fundamental role in ensuring that staffing needs are met swiftly and seamlessly [5].

Since lack of supervision was the largest contributor in the year 2014–15, it is essential that supervision methods are modified, regulated and standardized to address this need. Managers and supervisors could benefit from training that equips them with skills that will allow them to improve the working environment, establish a positive health and safety culture, and improve job design, Managers could also receive skills to allow them to react ideally during abnormal and emergency situations, to reduce the time pressure on staff, and to act quickly in novel situations, ultimately allowing them to provide appropriate supervision [5]. While lack of supervision is not always the sole cause of an accident, in many accidents, that specific failure tends to contribute (along with technical failures) to the outcome. Lack of supervision also increases the chance of misapplication of safety critical operating procedures. In light of the fact that the role of the supervisor is that of a facilitator of change, the finding that the monitoring, fitness for duty, awareness, human resource and enforcement sub categories were the least adequately supervised is alarming. This is due to the fact that the areas in which the weaknesses were located were the very areas which urgently needed the engagement of supervisors. Failures of this kind are especially concerning as they indicate prominent weaknesses in crucial organizational safety areas.

It is generally accepted that the actions, decisions and behaviours of management can contribute to accidents. This is because supervision can be used as a way of reinforcing administrative defenses, such as rules and procedures, which are designed to protect against incidents that may result from human error, reducing the risk of an accident. It has been stated that organisational culture and managerial goals and priorities can influence whether health and safety rules are broken [5]. A supervisor can play a vital role in reinforcing proper procedures and work practices to correct systemic weaknesses. This means that supervisors also have a key role to play in behaviour control. Essentially, supervisors need to positively influence standards of behaviour and set a good example. Finally, adequate supervision can be the tool through which safety standards are set and monitored.

An organisation's commitment to a positive safety culture can be reinforced through the use of adequate supervision. If we accept Farrington-Darby et al. [7] proposition that factors such as immediate supervisors, management, individual and behavioural dynamics affect the development of a positive safety culture, we could accept an inference that these same factors, if managed poorly, could lead to a negative safety culture. If we adhere to the Swiss Cheese accident causation model (a model that outlines accidents as occurring due to failures in barriers and safeguards) and agree that the role of the supervisor, to a degree, involves monitoring, reinforcing and managing safety, we could attribute a portion of the high railway accident rate in South Africa to lack of supervision and a negative safety culture. We can trace the accidents to weaknesses in supervision which affect the equilibrium of safety. What may be needed to curb the high accident rate in the South African railway industry is a promotion of a positive safety culture; a promotion that would assist in the formation of a culture within an organisation where ensuring safety is everyone's responsibility [7].

6 Conclusion

The investigations into the lack of supervision related factors revealed notable weaknesses in controls such as failures to: suitably manage high risk factor drivers, assign personnel to vacant positions and provide adequate human resources to safely perform the required tasks, among other failures. Although the actual detail of each failure differed, the resultant contribution to rail accidents was conspicuous.

The findings of the summary indicated that while there were procedures in place with the intent of managing safety, these procedures were not successfully executed due to lack of supervision. This finding suggests that a gap exists in the regulation and maintenance of safety efficient procedures where the human factor element is concerned. Because a supervisor plays a vital safety role in reinforcing proper procedures and work practices to correct systemic weaknesses, a lack of supervision can be understood as contributing to an ineffective safety culture. In many instances, an ineffective safety culture will have a direct impact on the safety functionality of the organization, potentially increasing accident occurrence. This implies that the South African Railway Industry may likely continue experiencing a high accident rate due to this self-perpetuating cycle. If this cycle is to be interrupted and occurrence rates are to be reduced, the focus may need to shift to managing safety culture and providing standardized competency training courses for management and supervisors to equip them to systematically, strategically and unapologetically apply, enforce, reinforce and demonstrate leadership with regards to the application of procedures, processes, and work practices to correct systemic weaknesses.

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Part IV
Job Satisfaction, Workload and Musculoskeletal Disorders

Video Gaming and Its Implications on the Epidemiology of Office Work Related Upper Limb Disorders

Shao-Sean Yap and Gunther Paul

Abstract Work-related upper limb disorders (WRULD) is noted in instances of excessive video gaming. This research aims to identify the plausibility of video gaming as a confounding factor in WRULD epidemiology. A questionnaire was deployed to 327 participants to measure gaming behaviour and pain on a dichotomous scale. 2×2 Pearson Chi-square cross tabulation was utilised for statistical analysis of all pain-related variables. Analyses indicated that gaming impacts on office-work pain in most circumstances, and must thus be considered a confounder. 66.36 % of office-working participants play video games, and this number is expected to increase. 63.3 % office-workers indicated ergonomically designed workplaces; 19.8 % of video gamers indicated ergonomically designed gaming areas. Finally, 68.2 % of video gaming office-workers indicated that they play video games for more than 3 h per day, without rest breaks or pauses. Preliminary findings indicate that further research is warranted for purposes of identifying the relationships in more detail.

Keywords Work related upper limb disorder · Video game · OHS · Epidemiology · Ergonomics · Stress-Strain

1 Introduction

The main purpose of this research was to investigate the plausibility of video gaming as a confounding factor when analysing the epidemiology of work-related upper limb disorders (WRULD).

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It has been acknowledged that popularity for video gaming has significantly increased in contemporary society [1, 2]. Unfortunately, excessive video gaming has also been labelled as a type of addiction with significant negative effects on the physical and mental capacities of a person [3, 4]. For example, a WRULD that is associated with excessive video gaming is tenosynovitis due to repetitive motions, and poor ergonomic conditions [5, 6]. However, it has been indicated that a significant amount of office workers also suffer from the same disorder due to similar reasons [7, 8]. By utilising the stress-strain concept [19], it could be hypothesised that the office-work task and video game task are resulting in strain superposition, therefore this particular WRULD may be inaccurately diagnosed as purely an OH issue. This hypothesis may then be tested via analyses of pain prevalence reported by both office-workers and video gamers as pain is a common symptom of excessive strain.

It is important to acknowledge that there are very limited studies pertaining to the negative effects of video gaming on occupational health. Additionally, current occupational health textbooks and other relevant bodies of knowledge have not yet explored the possibility of video gaming as a confounding factor [9, 10]. As such, this necessitates the need for this particular research project.

2 Methods

2.1 Participant Selection

The target participants of this research project were 384 Australian-based office-workers. Sample size was calculated from a population of 1.4 million, with a confidence level of 95 % and confidence interval of 5. Population size was determined from an approximated labour force of 11.75 million persons [11], in which approximately 12 % are office-workers [12]. A total of 327 participants presented with viable data, which indicates an overall response rate of 85.15 % or 327/384.

With regards to the video-gaming population group, participants were extracted from the viable office-worker participant group, in which 66.36 %% or 217/327 office-workers indicated that they play video games. This two-layered recruitment method was utilised due to two reasons. The first reason was for the purpose of determining a plausible population of video gamers amongst office-workers. This is an integral factor in understanding the significance of video gaming as an issue, i.e., if it was discovered that the population of video gamers amongst office-workers is negligible, it would imply that video gaming is also a negligible confounding factor. The second reason was for resource conservation purposes due to budget and time constraints.

All participants involved with this research were provided with written informed consent prior to any survey questions. Participants were given the right to choose whether or not they wished to proceed with the survey, and were also allowed to exit the survey at any time.

2.2 Study Design

A cross-sectional research design was utilised as the basis for this research project within the stress-strain concept as the theoretical framework for the research. Data collection was performed via distribution of an online survey to thirty-three organisations located within Australia, using QUT KeySurvey [13].

The survey was separated into three sections. The first section was for purposes of controlling demographics; only data from participants whom were 'Australian-based' and 'office-workers' were collected. The second section was to determine the prevalence rates of different pains currently experienced by office-workers while office-work activity is being performed. The third section was to determine the population of video gamers amongst office-workers, and the trauma and pain they experience while playing video games.

Survey questions were generated based on literature reviews regarding 'pain' and 'impact areas' associated with office-work, as well as various forms of video gaming, e.g., arcade, mobile, console, and computer. It was indicated that the most common 'pains' and/or likely 'impact areas' associated with both office-work and video gaming were as such: fingers, hands, wrists, shoulders, back, and eyes [8, 14–16]. Office-workers and video gamers were also asked if any ergonomic interventions were present at their respective workplaces and/or gaming areas. An additional question was presented to video gamers only: "*Do gaming sessions last 3 h or more, and without rest breaks or pauses*?", as it has been shown that such gaming behaviour carries a higher likelihood of pain occurrence in the aforementioned areas [17].

2.3 Data Collection—Authenticity and Security

Human research ethics approval was granted by the Queensland University of Technology Office of Research Ethics and Integrity on 28 May 2015—approval number 1500000442. The research project fully abides by Queensland University of Technology Code of Conduct for Research, and the Australian Government NHMRC National Statement on Ethical Conduct in Human Research 2007.

Several measures were employed in order to ensure the authenticity of collected data. The main researcher was 'blinded', whereby no contact was established between the researcher and participants. Data collection methods also excluded identifiable markers which assisted in preserving the anonymity of participants. Moreover, distribution of surveys was handled by the HR department of each individual organisation; all participating organisations (and HR departments) had agreed to distribute the online survey to 20–50 random employees.

The QUT KeySurvey system also places response restrictions on IP addresses; only one response is allowed per digital device. Additionally, surveys questions cannot be changed after surveys have been launched and distributed. Finally, all aspects of the research project including ethics reviews were approved by the project supervisor.

2.4 Statistical Analysis

The Pearson's chi-squared test was applied to test dependency between variables of three main groups, i.e., non-gaming office-workers; office-workers that game for less than 3 h, and office-workers that game for more than 3 h. Statistical analyses were computed in the SPSS v22.0 software package.

3 Results

For the office-worker group, 327 participants presented with viable data. With regards to the video gaming population, viable data was extracted from 66.36 % (217/327) of the participants from the office-worker group. Table 1 displays all results regarding finger, hand, wrist, shoulder, back pain; eye strain; ergonomic interventions "E.I."; and gaming behaviours reported by the video gamers. "G.S" refers to gaming session, or time length of gameplay.

3.1 Significant Findings

Statistical analyses of Table 2 above indicated some significant findings. Firstly, dependency of variables was indicated for back pain when comparing the non-video gaming office-workers (OW1) with video gaming office workers gaming

Table 1 Summary of results pertaining to survey questionnaire with valid percentages

Survey items	Office Workers (n = 327)				Video Gamer (n = 217)			
	Yes	%	No	%	Yes	%	No	%
Finger pain	131	40.1	196	59.9	80	36.9	137	63.1
Hand pain	130	39.8	197	60.2	82	37.8	135	62.2
Wrist pain	216	66.1	111	33.9	151	69.6	66	30.4
Shoulder pain	162	49.5	165	50.5	109	50.2	108	49.8
Back pain	192	58.7	135	41.3	155	71.4	62	28.6
Eye strain	95	29.1	232	70.9	72	33.2	145	66.8
E.I.	207	63.3	120	36.7	43	19.8	174	80.2
G.S. over 3 h, without rest or breaks	N/A	N/A	N/A	N/A	148	68.2	69	31.8

Table 2 Statistical analyses of survey results with X^2 and asymptotic significance (2-sided) values

Test group												
Survey items	OW1–OW2		OW1–OW3		OW2–OW3		OW2–G2		OW3–G3		G2–G3	
	X^2	Sig.	X^2	Sig.	X^2	Sig.	X^2	Sig.	X^2	Sig.	X^2	Sig.
Finger pain	0.821	0.365	0.013	0.910	1.435	0.231	0.211	0.646	8.370	0.004**	0.306	0.580
Hand pain	0.694	0.405	0.757	0.384	1.293	0.256	0.275	0.600	4.313	0.038*	0.771	0.380
Wrist pain	0.534	0.465	0.590	0.442	1.534	0.216	0.001	0.981	15.426	0.000**	0.003	0.960
Shoulder pain	0.016	0.900	2.274	0.132	0.029	0.866	1.144	0.285	15.661	0.000**	0.672	0.413
Back pain	3.907	0.048*	0.344	0.557	1.169	0.280	0.387	0.534	9.601	0.002**	1.674	0.196
Eye strain	1.296	0.255	0.244	0.621	0.752	0.386	0.284	0.594	3.532	0.060	1.002	0.317
E.I.	0.000	1.000	0.781	0.377	1.045	0.307	0.139	0.710	3.046	0.082	0.548	0.459

*Dependent, **Highly Dependent

less than 3 h (OW2)(p = 0.048*). Essentially, factors other than gaming must impact on back pain in office work in this case, as gaming is not present in group OW1; therefore back pain is not impacted by gaming of less than 3 h. All other group comparisons however have displayed independency between variables, i.e.: <3 h video gaming office workers (OW2) and >3 h video gaming office workers (OW3); and <3 h video gamers (G2) and >3 h video gamers (G3), such that it can be concluded that gaming impacts on office work pain, and gaming duration impacts on gaming pain. Hence gaming may be considered a confounder for office work pain.

Moreover, in the comparison of the non-video gaming office-workers (OW1) with >3 h video gaming office workers (OW3), back pain was indicated as independent. This indicates that for longer gaming, back pain in office work is impacted by gaming similar to other pains measured.

Analysis of the >3 h video gaming office workers (OW3) with >3 h video gamers (G3) has indicated dependencies for finger (p = 0.004**), hand (p = 0.038*), wrist (p = 0.0**), shoulder (p = 0.0**), and back pain (p = 0.002**). Interestingly, this is different from the independency between variables of the <3 h video gaming office workers (OW2) with <3 h video gamers (G2). It is concluded that gaming >3 h without rest breaks or pauses confounds office work pain, while gaming <3 h does not. The duration of video gaming therefore plays a significant role in its impact on office work pain; however this needs to be further studied to identify a threshold.

It must be acknowledged that even though current data may indicate that gaming-related activities and behaviour are impactful on office-work pain, the exact causative process of the pain cannot be established, i.e., based on current data, the initial pain source cannot be properly attributed to office-work or video gaming.

4 Discussion

4.1 Stress, Strain and Pain

In this context, the manifestation of physical pain on a particular anatomical area, e.g., fingers, hands, wrists, is due to that particular anatomical area experiencing strain from a workload (stress) being applied to it. Similar physical pain from strain on the same anatomical site from two different work tasks may indicate that stressors are similar. The stress-strain analysis concept infers that all tasks will produce ‘stressors’ [18], and in this situation, the stressor produced by both office-work and video gaming are items such as: repetitive force, pressure, friction and impacts from button pressing; sustained posture; constant extension and retraction of digits; prolonged eyesight focus; and electronic device gripping, lifting and handling.

Figure 1 above which was adapted from Rohmert's "Ergonomics Concept of Work, Stress, and Strain", displays the cyclical loop model depicting the 'ideal' office-work task [19], in which video gaming activities are excluded. This is a simplistic model utilised in typical work task analyses, and only focuses entirely on the occupational setting. The office-work task, such as report typing on a computer, generates impact-based stress from constant typing. Strain is then placed on the digits of the office-worker, and endurance limits are tested. The 'ideal' workplace will implement ergonomic interventions to reduce the impact-based stress, and as such the strain on the office-worker is reduced. Assuming the ergonomic intervention is effective, it will ensure that the recovery capabilities of the office-worker are not exceeded. This leads to a positive strain reaction whereby the office-worker will recover properly; allowing the office-work task to resume undisrupted [20].

Figure 2 above which was adapted from Rohmert's "Ergonomics Concept of Work, Stress, and Strain", displays the cyclical loop model depicting the 'non-ideal' office-work task in which video gaming activities are included [19]. As opposed to the previous model, this model is considered 'non-ideal' as it integrates a task

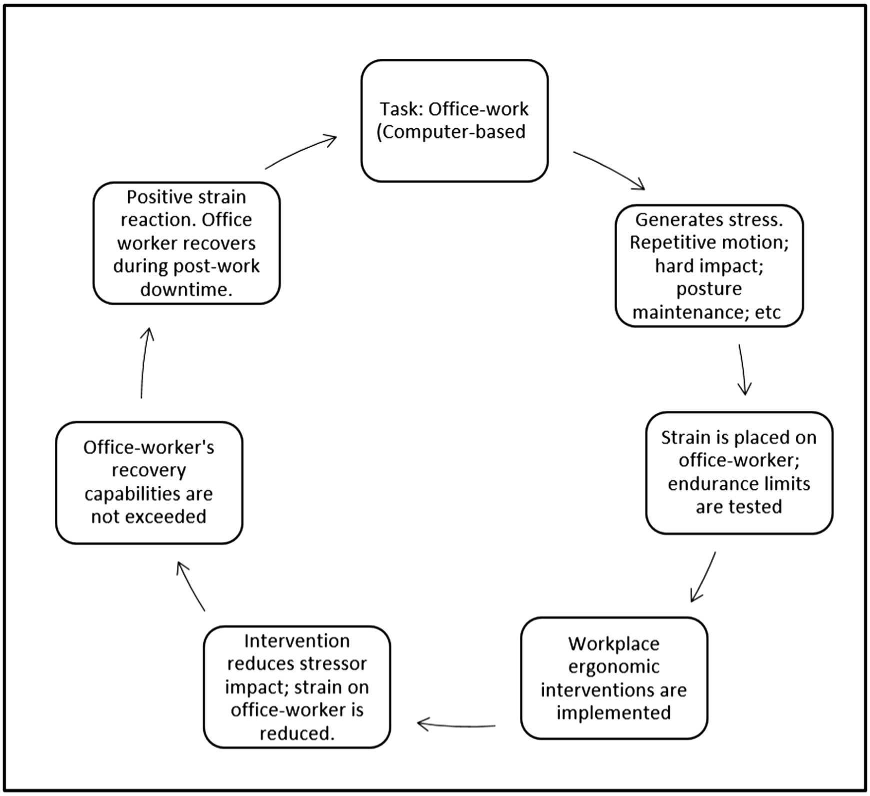

Fig. 1 Stress-strain model of the 'ideal' office-work task, excluding video gaming

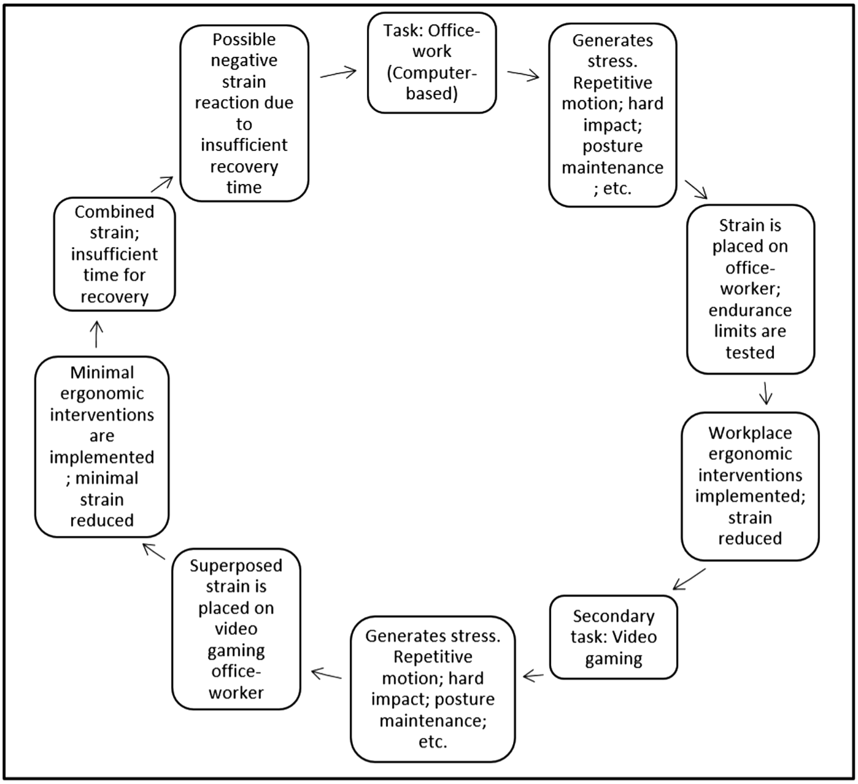

Fig. 2 Stress-strain model of the 'non-ideal' office-work task, including video gaming

external to the occupational setting. It explains how an external task (video gaming) is relevant to office-work due to the application of additional stress. Utilising the same work task and processes as stated previously, the implementation of an effective ergonomic intervention leads to less strain on the office-worker. However, rather than rest and recover as before, a secondary task is undertaken whereby the office-worker chooses to play video games. The secondary task produces the same type of stress, causing a superposed strain on the video gaming office-worker. Moreover, as per the results in Chap. 6.2, the majority of the video gaming population have minimal ergonomic interventions in place—19.8 % (43/217). Additionally, 68.2 % (148/217) of video gamers have also reported that they game for at least 3 h per day without taking rest breaks or pauses. As a result of combinative strain; minimal ergonomic interventions; and less overall recovery time, the likelihood of a negative strain reaction is greater. Basic observations of typical biomechanical motion patterns indicate that plausible negative strain reactions within this context might include: tendinitis, tenosynovitis, bursitis, carpal and cubital tunnel syndrome [21].

4.2 Overview of Contemporary Video Gaming Culture and Associated Issues

Video gaming within contemporary society has become commonplace and widely accepted amongst different genders and ages, which in contrast to the former stereotypical demographic of video gamers, e.g., adolescent, male-dominated, and nerd culture [22]. This cultural shift is mainly due to a combinative effect of various aspects, which includes: greater social acceptance; graphical advancements; technological convergence, access and portability; modernised method of socialisation; improving levels of language, literacy and numeracy; and globalisation [23–25].

Within the context of this research project, the main concern of video gaming does not only lie with its rate of acceptance and/or level of accessibility, but also the changes in video gaming design, and the outcomes of these changes on video gaming behaviours. A majority of the previous generation of video games were mostly single-player based, and designed in a whereby the video game world remains static and unchanged without player input, which allows total progress saving [26]. This means that switching off a video game and/or focusing on other activities will not disrupt one's position within the video game world, merely requiring the video gamer to load the save file and continue where he and/or she left off.

However, current generation of video games are shifting to multiplayer platforms, which means that the video game will continuously progress and change due to the input of multiple players within one single gaming world. For example, the massive multiplayer online role playing game (MMORPG) World of Warcraft has a player rate of approximately 100 million users, and it possesses its own political hierarchies; economic structures; socio-cultural groups; technological and ecological systems within the gaming world. Essentially, it means that the virtual world has become an analogue of the real world, and changes will occur on a constant basis. While video gamers are allowed to save the progress of their own in-game character/avatar, they are now unable to maintain a static gaming environment. This may evoke a sense of 'losing control' [4, 27], and prompts the gamer into initiating an addiction feedback loop as described in Fig. 3.

Assuming a video gaming office-worker does initiate an addiction feedback loop, the likelihood of a negative strain reaction due superposed strain is further increased as per the discussion in Chap. 7.1. Moreover, as with any addiction, both physical and mental health aspects of a person will be negatively affected [3, 4]. This is an important factor to note as the number of video gamers amongst office-workers is quite significant—66.36 % (217/327), and this number is expected to increase in the near future [1, 2].

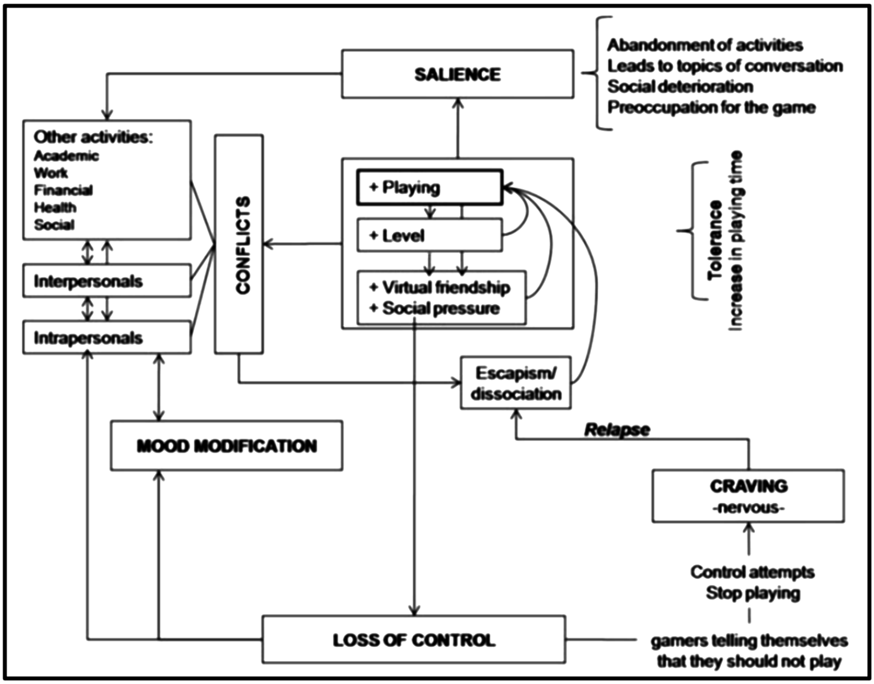

Fig. 3 Diagnostic Elements for MMORPG/Video Game Addiction. Extracted with permission from: Ref. Beranuy et al. [27]

4.3 Implications for Office-Work Occupational Health and Epidemiology

From an epidemiological and occupational health perspective, this is a unique issue as video gaming is becoming ubiquitous, and is likely to cause a distortion in the aetiological process. Aetiology however, is vital in establishing an appropriate management, treatment or intervention plan [28]. Moreover, it must also be acknowledged that poor aetiological foundation is also likely to affect other relevant OHS practices such as: workers compensation; risk assessment and mitigation; injury management and rehabilitation; and workplace design. As a result of this, it is likely that there will be failure in the preservation of worker health, and that resource wastage will occur.

5 Bias, Limitations and Further Research

All biases and limitations of this research project must be recognised in order to allow improvement in subsequent research. With regards to the data collection method, reporting bias may be present due to the nature of self-reporting [29]; subjects may choose to selectively reveal and/or supress certain information. Selection bias is plausible as exact characteristics of participants are unknown, and distribution of surveys were handled by human resources departments of participating organisations [29]. Additionally, due to limited time and resources, as well as the fact that studies of a similar nature were limited, true validity and reliability (test-retest reliability and inter-method reliability) verification with regards to the survey questionnaire has not yet been established.

It must be acknowledged that this research project is akin to a pilot study, whereby it seeks to explore the plausibility of video gaming as a confounding factor. While there is a clear indication of a problem, it can only be studied sufficiently in a double-blinded randomised controlled trial. In order to ensure the highest degree of data validity and reliability, it will also have to include items such as: physiological measurements; quantitative pain scales; and real-time observations. Additionally, it will also be important to account for the different 'gaming platforms' and associated stressors, e.g., console (Playstation/Xbox/Nintendo); computer-based; mobile and cellphone (Android; iOS; Symbian; Windows; Blackberry); and arcade-based.

6 Conclusion

In conclusion, the collected data has shown an association between the pain reported by both office-workers and video gamers. This is a significant result as the stress-strain analysis concept explains that that video gaming is capable of exacerbating current office-work WRULDs; similar pains and strains on a particular anatomical area implies similar application of stress/force. Moreover, the increasing popularity of video gaming, along with its addictive game design may complicate the epidemiology of occupational health issues. Epidemiological research focusing on occupational health issues, e.g., WRULDs, may be distorted if video gaming is not considered as a confounding factor. Poor epidemiological foundation can lead to inaccurate intervention, management and treatment. Further research into this matter will be required, and more precise research methodologies should be utilised.

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Occupational Stresses on Employees in Lean Production Systems

Uwe Dombrowski, Anne Reimer and Stefan Ernst

Abstract Many enterprises have implemented Lean Production Systems (LPS), for German Enterprises they are an industry standard. The main target of LPS is the reduction of waste. In LPS, all processes that do not contribute to value adding are considered as waste, e.g., waiting or unnecessary motions of the employees. Therefore, LPS have a strong influence on the design of work systems. For instance, there are reports about a work intensification, a reduction of "hidden" breaks and a high degree of repetitive work tasks. These work conditions are identified as the cause for physical disorders of employees. Other sources claim a high potential of LPS for improving labor conditions. All in all, there are significant knowledge gaps considering the impact of LPS on the work system, workload and labor conditions in manufacturing. Thus, the article presents a structural analysis with the aim to identify connections between LPS and changes of work system and work conditions.

Keywords Lean production system · Work systems · Occupational stresses

1 Introduction

Many manufacturing companies design their work systems according to Lean production systems (LPS), which became an industry standard with the publication of the VDI 2870 [1, 2]. Although LPS have always company-specific characteristics, those follow a basic structure that anchors them in the long term goals in the

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company and, therefore, differ from conventional, more short-term optimization approaches. LPS are based on the company's objectives and the necessary processes for the achievement of objectives. According to VDI 2870, LPS are used to establish a comprehensive and integrated design of processes [2]. In practice, LPS are mainly oriented towards the optimization of quality, time and costs [3]. The objectives are then cascaded for individual functional areas. For the implementation of LPS, design principles are selected which include various methods and tools. Avoiding waste is the fundamental design principle for LPS. The aim is to avoid job content for which the customer is not willing to pay [4]. In practice, these are e.g., waiting times or unnecessary movements. Following the elimination of waste, there is new and improved standardized operations and recurring continuous improvement processes. However, it is unclear how these far-reaching changes by LPS affect work system and working conditions of employees [5]. From the trade unions perspective, an increased pressure to perform as well as an intensification and densification of work is reported. However, LPS is also granted the potential to improve the working conditions [6]. Weichel characterizes the changes in working conditions in LPS with the increase in compression of performance, an elimination of hidden breaks and compensation movements as well as high repetitiveness of movements. These conditions also lead to physical complaints of employees [7].

The above examples show that LPS have profound impact on the daily work of employees. Overall, however, significant deficiencies exist in accurately understanding the diverse effects of LPS on working conditions [6]. In order to gain an understanding of the causal relationships, a systematic analysis of the impact of LPS on load factors for employees is required. It has to be determined how changes are made to the load situation of workers through LPS. In this way, systematic stress critical measures and combinations of measures in LPS are uncovered, but also positive aspects of LPS for employees are determined. The aim of the presented paper is a systematic analysis of the impact of LPS on the work stress on employees. For this, a reference model is needed that maps the relationships between the work design by LPS principles and its impact on the working conditions.

2 LPS

A LPS is defined as "an enterprise-specific, methodical system of rules for the continuous orientation of all enterprise processes to the customer in order to achieve the objectives set by the enterprise management." [1, 2]. In general, it focuses on technical and even more on the organizational design of processes. The top target is elimination of waste in all company processes in order to reach higher efficiencies and, consequently, to be more competitive [2, 3, 8]. Waste in this context are all activities that are not increasing the customer value of the product. Seven different kinds of waste can be distinguished:

- Over production
- Waiting time
- Transportation
- Over processing
- Inventory
- Motion
- Defects and touch up [2, 8].

Methods and tools are used in LPS to eliminate waste. They are systematically integrated into the LPS-structure consisting of the elements: targets, company processes, principles, methods and tools. The structure of an LPS is shown in Fig. 1.

The following example clarifies the structure of the LPS. The top target of a manufacturing company can be quality improvement. Sub-targets are stable processes in the production. To reach this sub-target, relevant company processes need to be defined, e.g., for turning, milling or grinding. A suitable principle is "zero-defects-production". The principle combines methods and tools that are used to reduce the number of defects that are passed to the next production step and to

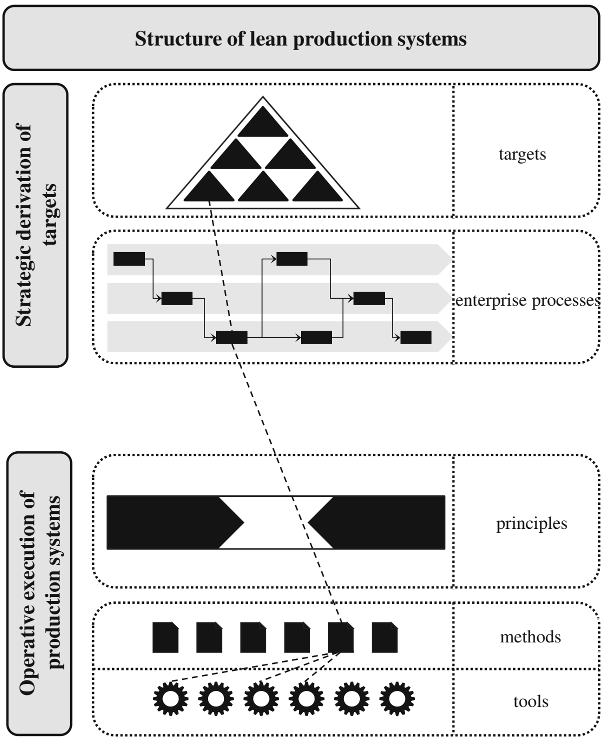

Fig. 1 Structure of production systems, based on [2]

ensure a high product and process quality [2]. Especially 5× Why, automation, poka yoke, six sigma are methods of this principle.

As it is mentioned above, LPS are used to design technical and organizational processes. The processes are optimized either to lower costs, save time or improve quality. However, by reaching the strategic goals there are eventually tradeoffs in the production systems. This can happen when the work system of the employee's is negatively affected [9]. Although technical improvements such as new production methods lead to high savings, it can cause higher status of employee's illness. In the next section, effects of LPS on the work systems are further described.

3 Effects of LPS on Workers

In addition to the impact on efficiency, a LPS has a major impact on the employees and the working system. According to DIN EN ISO 6385, a working system is defined as a system comprising the interaction of a single user or multiple users with the work equipment in order to fulfill the function of the system in the workspace and the working environment under the conditions imposed by the work tasks [10]. S.6 Due to this, a change in a work system leads subsequently to a change in working hours, salaries, and especially health effects [1]. This is also shown in Fig. 2.

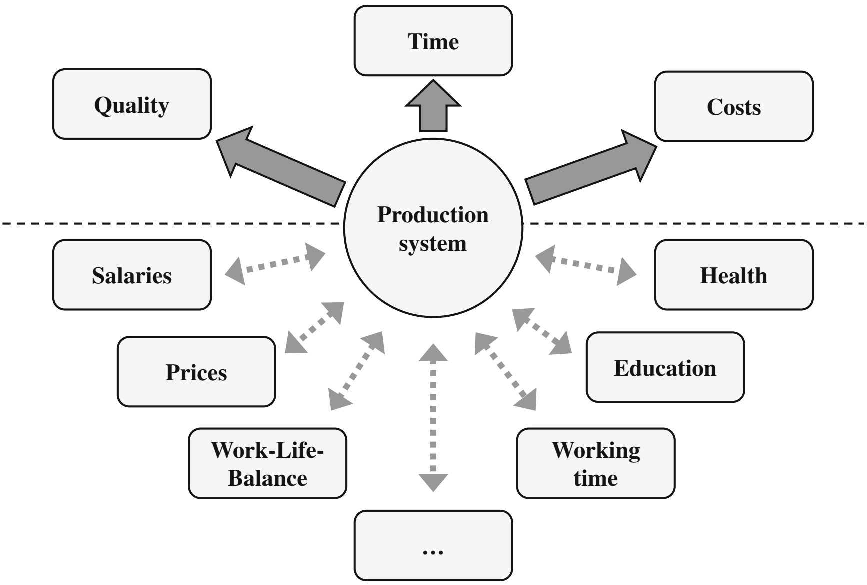

Fig. 2 Impacts of LPS on different parts of the working system [1]

Depending on the working conditions and their design, the employee has to handle a multitude of heavy loads during the working hours. According to DIN EN ISO 6385, the work stress is described as the totality of external conditions and requirements in the working system, affecting the physiological and/or psychological state of a person [10]. As an example, a higher weight exposure of the employee may be the result because of the zero defects principle. As a consequence, this can lead to additional pressure at work for the employee. However, the type of load change for the employee must be known in order to prevent negative consequences for the health.

In the section above, the seven kinds of waste, as part of the aim of LPS, are described. In order to show the effects of LPS on working conditions, each kind of waste and the impacts on a working system is described.

3.1 Over Production

Avoiding over production may be associated with smaller lot sizes, which results in frequent changes of the product to be manufactured by the worker and, consequently, in a higher diversity of work tasks. This frequent change does not explicitly lead to a positive or negative influence on the work load of employees. So on the one hand side, a more diversified work leads to the prevention of monotony, which is a positive change in an employee's work load. On the other hand, the workers have to adjust frequently to changes in work tasks, which can cause a higher occupational stress for the worker.

3.2 Waiting Time

The second kind of waste is waiting time. For the purpose of the continuous improvement process, it is important to eliminate times during which the worker is doing no productive work tasks. Those waiting times usually contain so-called hidden breaks during which the worker has the opportunity to rest. Eliminating the waiting times by using a continuous improvement process can cause work intensification for employees. Therefore, the elimination of waiting times is associated with an increasing occupational stress on the employees.

3.3 Transportation

Avoiding transportation can be equivalent to a reduced variation in work tasks and can result in a reduction of compensation movements. Compensation movements lead to a change in the work stress situation of an employee. From an ergonomic standpoint, changing work stresses are necessary for the prevention of musculoskeletal disorders and have, therefore, a positive influence on the workers' health.

3.4 Over Processing

The fourth kind of waste over processing has neither a positive nor a negative effect on the occupational stress of an employee. Eliminating an ergonomically questionable processing step will have positive effects for the employee's health. However, does this processing step contain compensating movements, this elimination leads to an intensification of work.

3.5 Inventory

A reduction of stocks, which is the fifth kind of waste, is equivalent to a reduction of buffers for employees. Buffers relieve the employees from certain work tasks to the extent that they reduce the pressure to perform. Conversely, the work stress is increased and the worker has to perform his tasks quickly and correctly in case these buffers are not available. This can lead to a work intensification for employees and increase the level of occupational stresses at work.

3.6 Motion

Motion as the sixth kind of waste describes unnecessary movements by the worker which do not add value to a product. Those unnecessary movements may include compensating movements of the workers like walking. In case inventories and buffers are reduced or eliminated, unnecessary movements are omitted as well. With this example is shown that with the use of LPS elements can affect the work stress of employees in either ways.

3.7 Defects and Touch Up

The seventh kind of waste is called defects and touch up. Those are usually outside the normal, often clocking bonded labor. Therefore, it can also be made by workers who can no longer work stroke bound. For other employees, it may represent a change in work flow and thus relieve the congestion. An elimination of rework can therefore carry monotonous working conditions that pose a burden.

3.8 *Using the Principles of LPS*

As to overcome these kinds of waste, the eight principles of LPS are used which were introduced in the previous section. These examples illustrate that a systematic analysis of the relationships between the work design by LPS and the employee's work stress is necessary in order to prevent the employee from overwork.

The explanations show that a production system can have a strong impact on the staff and profoundly change a working system. Rising demands on the employees through a continuous improvement process can lead to an uncontrollable work stress level which may cause in the worst case an inability to work [11]. The stress can be both physically and mentally. In addition to individual health consequences for the employee, the absenteeism also has a negative impact on the employer. In the short term, organizational measures must be taken, such as a substitute. In case of a prolonged illness of the employee, the tasks needs to be taken over by another employee and, later, reintegration of the affected employee must be planned [12].

Therefore, the first step is to identify which occupational stresses exist in a company in order to be able to determine potential relationships between principles of LPS and work stress.

4 Analysis and Results

As shown in the previous section, LPS principles have an impact on an employee's work stress. Hence, a systematic analysis of occupational stresses is crucial in order to determine the relationships.

The options for categorizing work stresses are as varied as the work stresses themselves. Thus, for the analysis three validated, widely-used models for the systematic analysis are used. Those are described in the following.

The first model from Rohmert et al. determines the connection between work strains and work stresses and is shown in Fig. 3 on the left side [13]. There, work

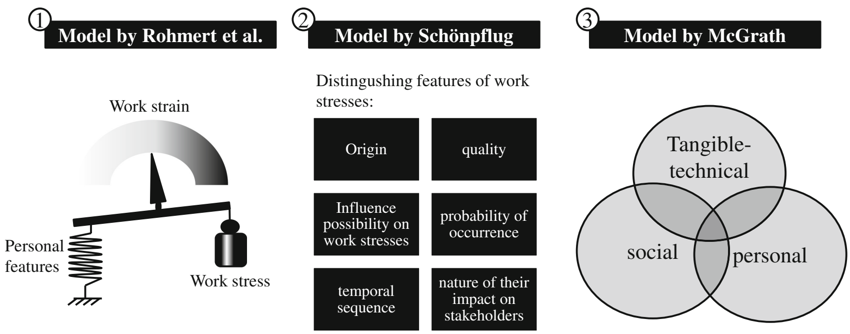

Fig. 3 Models describing work stresses

strain and work stresses are described as a mechanistic system. The system consists of a scale, a weight, a spring and a display. On the one side of the scale, the weight is attached which symbolizes the work stress. On the other side of this scale, a spring is attached which stands for the personal performance requirements of the worker. To show the amplitude of the scale, a display is attached on top of the scale which represents the level of work strain.

The second model is called action-oriented stress model and was introduced by Schönpflug. According to Schönpflug, work stresses can be grouped into the following six dimensions:

- origin,
- quality,
- influence possibility on work stresses
- probability of occurrence
- temporal sequence
- nature of their impact on stakeholders [14].

The last model was introduced by McGrath and divides work into three different work stress segments which are tangible-technical, social and personal. In each segment can work stresses be generated. The tangible-technical segment contains outer environmental effects such as heat, noise or even ergonomic work strains. The social segments describe work strains which are caused by social conflicts or mobbing. Lastly, work stresses can be created by personal circumstances such as family conflicts or character features such as fear for tasks, failure or criticism. In addition, those segments can overlap which creates four additional cross-segments [15].

For the systematic analysis, in the first place it is necessary to compare the different models. The basis for the comparison is the evaluation of work stresses in LPS which was outlined in the previous section. The results are shown in the following Table 1.

The comparison of the different models shows that each model has a different consideration of work stress.

In order to reduce over production (1) smaller lot sizes are attempted. This leads to the alteration of the work system in a way that the work stress is changed. This change in work stress can only be almost determined by the model of Schönpflug since this model distinguishes the work stresses in different dimensions. Therefore, the dimensions can be more precise for example in the description of the number of manufactured products. With this model, each work stress can be determined in its characteristics. The models of Rohmert et al. and McGrath do not distinguish in different dimensions and just group the work stresses. Especially the model of Rohmert et al. summarizes all the work stresses and relates the impact of work strain on a worker to his personal features. Therefore, the work stresses do not need to be determined in depth. The same applies for the model of McGrath. There, the work stresses are categorized in the above-described segments. With this, the work stresses can be identified and do not need to be further determined e.g., in numbers. Thus, both models only describe half of the work stresses.

Table 1 Comparison of evaluation possibility with introduced models

	Rohmert et al.	Schönpflug	McGrath
Over production (1)	◑	◕	◑
Waiting time (2)	◔	◔	◔
Transportation (3)	◕	◕	◕
Over processing (4)	◑	◕	◑
Inventory (5)	◕	◕	◕
Motion (6)	◔	◔	◔
Defects and touch up (7)	◑	◕	◑

Legend: ○ Not determinable ◔ Hardly determinable ◑ Partly determinable ◕ Almost determinable ● Completely determinable

Waiting times (2) contain times in which the worker has to wait for a process to end or for further instruction. Therefore, he is not able to add a customer value to the product. Sometimes those waiting times are hidden breaks for the worker which is a positive influence on the work stress. Due to this, all models are just hardly able to determine the correct impact on a workers work strain. The model of Rohmert et al. is not able to show a positive effect of work stress since the beginning of the scale is in the green segment. The model of Schönpflug can determine the work stress but is not able to give an evidence of positive effect on the workers' strain. The same applies to McGrath' model.

Avoiding Transportation (3) consequently reduces the work task diversification and the ergonomic change of body positions. This has a negative impact on the employee. All models are able to determine and describe the change in work stress on the worker. In the model of Rohmert et al., the work strain changes from green to orange or even red. With the different dimension of Schönpflugs model, the work strain can be quite precisely described. Lastly, McGrath model with its segments can determine which work stress is involved and, therefore, be described.

Over processing (4) means that additional steps or movements are made which do not add to the customer value. However, avoiding over processing can either lead to the reduction of ergonomic critical movements in case of a not ergonomically movement or it increases work load by eliminating compensation movements. This example shows that over processing can have a positive or negative effect on work stresses. So the models of Rohmert et al. and McGrath are just partially useful to determine the work stresses due to the aggregated structure. On the contrary, the dimensions of McGrath allow a more specific evaluation of the work stress.

Inventory (5) describes the establishment of buffers in the production which consequently leads to a reduction of walking distances for the employees which gives the employee more time for further production steps. In case inventories are avoided, the walking distance increases which leads to reduced times. This negative impact can be determined by all models.

Motion (6) is necessary for the worker in order to get the needed materials. However, an optimization towards no motions for the worker is with respect to ergonomics not to be aimed. The same applies for far distances which lead to a high number of motions. Thus, the optimal amount of walking distances has a positive influence whereas too less resp. too much motion has a negative impact on work stresses. Because of this optimal range of motions for a worker, all models are only hardly able to determine the work stress reasonably.

Defects and touch ups (7) are additional work tasks in case the quality level was not reached. Therefore, the worker is not bound to a work cycle which leads to a reduction in work load. Furthermore, it enlarges the work tasks of the worker and has a positive influence on the work stress. The models of Rohmert et al. and McGrath are partly able to determine the work stress due to the difficulty in description of the parameters. Schönpflugs model with its dimension can determine and describe the work stress almost precisely which leads to an adequate evaluation of it.

All in all, the comparison showed that all three models are useful for the first determination of work stresses. However, no model has the ability to define the work stress parameter in the way that leads to the understanding of the relationship between work stress and work strain. Further research needs to be done in the field of work stress models. The first step needs to be a thoroughly literature search in different scientific fields since the introduced models mostly derive from psychological research.

5 Summary

In this paper, a deeper insight of the impact of LPS on a work system was given. For this, it was necessary to introduce the general elements of the LPS. Furthermore, the effects of the LPS on the work system were outlined. It was shown that most design principles of LPS, which serve to overcome the drawbacks of the seven kinds of waste, not only affect the production system but the work system as well. An evaluation of the effects showed that most methods of LPS can lead to a deterioration of the workers performance. As a consequence, the relationship between the change of work systems and work strains need to be further investigated. For this, three different models to determine work stresses were introduced.

The model of Rohmert et al. focuses on the relationship between work strain and work stress. There, the impact of work stress depends on the personal features of a human. The better a person is prepared for the work tasks, the lower does the work strain impact the workers performance. However, the model does not distinguish between different work stresses. Those external factors are just summarized to work stresses. The model of Schönpflug is more precise and distinguishes between different dimensions of work stresses. With this it is possible to evaluate each work stress. McGrath model is similar to Rohmert et al. model which determines segments for the different work stresses. However, it does not give any evidence of dependence to work strains and is, therefore, only partly useful for determining work stresses. Further research need to be done to identify different models which derive from other fields of science. Otherwise, a new model needs to be developed to meet the requirements for an adequate determination of work stresses.

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Customer-Related Stressors and Effects on Burnout: A Study in Turkey

Serpil Aytac and Mustafa Aytac

Abstract Customer aggression is a significant organizational problem in modern working life, particularly for employees in the service sector who are in direct contact with customers. For employees in this sector, the high level of customer interaction may be the reason for undesired consequences like stress and burnout. In the context of a service, it is possible to define customer aggression as a customer's behavior aimed at harming or discomfiting those giving service. Customer aggression has a negative effect on the employee's health and safety. This study aimed to demonstrate the effect on the burnout level of salesman and cashier exposed to customer related stressor. The study sample comprised 403 employees of service sector. In the data analysis, T-test, correlation and regression analysis were used. From the results of the analyses, the finding was obtained that verbal abuse significantly increased the emotional burnout, job stress and depersonalization levels of workers. According to the results obtained from the research, while a positive significant relationship was determined between customer aggression and Burnout tendency.

Keywords Human factors aggression · Customer · Burnout · Stress

1 Introduction

The service sector is currently the fastest growing sector. However, for employees in this sector, the high level of customer interaction may be the reason for undesired consequences such as customer aggression.

Customer aggression became a master issue of working life through the last decade. This type of aggression is a significant organizational problem in modern working life, particularly for employees in the service sector who are in direct contact with customers. In the context of a service, it is possible to define customer

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aggression as a customer's behavior aimed at harming or discomfiting those giving service.

This definition includes some sub-dimensions. Firstly, customer aggression is seen in a wide area such as retail sales, restaurants, hotels, airlines and railways, call centers and the banking sector. Secondly, psychological aggression (shouting, gestures, threats etc.) and physical violence (physical attacks), which harm employees both physically and psychologically, must be considered in the framework of a series of behaviors. Thirdly, just as the interaction between customer and employee may be direct face-to-face interaction, it may also occur in the form of service given via e-mail or telephone [1]. In other words, customer aggression has two dimensions. These are involves verbal threats, threatening behavior or physical assaults by an assailant who either receives services from or is under the custodial supervision of the affected workplace or the victim [2]. This aggressive behavior varies according to demographic differences and professional groups.

As understood Just as aggressive behavior by the customer may be psychological, such as rudeness, verbal abuse or hostile behavior (shouting, swearing etc.) and threats, it may also be in the form of physical aggression including violent actions [3]. However widespread customer aggression has been shown to be, it cannot be said to occur in every sector.

This kind of workplace violence has many negative consequences upon worker and also organization. Increased rates of turnover in the labor force, decreased employee performance, increased unease between employees, increased absence because of illness or on request are only a few of the negative consequences of this kind of behavior from an organizational perspective. On the other hand, these types of aggressive events have an some negative effect on an individual's involvement and behavior related to work. These go from dissatisfaction and decreased organizational commitment, low morale and motivation to absence from work [4] tendency leave job to stress and burnout can be observed.

For this reason, the approachment of organization and the policies it has developed to combat customer violence is also important for preventing violence and compensating its damages.

Although almost all literature on burnout implicitly assumes that burnout is primarily caused by stressful employee-customer interactions, only a few studies have addressed this empirically. Job Stress and Burnout tendency can be described as the physical and emotional devastation arising from job and workplace conditions.

Customer aggression has a negative effect on the employee's health and safety. According to studies conducted on this subject, the individual feels worthless and levels of depression and stress increase [5] causing somatic symptoms of emotional burnout and emotional dissonance [1, 6]. In a study by Boyd [5], it was reported that 53 % of employees in the airline and railways sector had been exposed to verbal abuse in the previous 12 months. According to the results of a study by Akgeyik and Gungor [12], 77.2 % of supermarket cashier, 85.2 % of call center operator and 64.5 % of sales clerk employees had suffered customer violence at least once in their career. This phenomenon which threats workers physical and mental health is more prevalent especially among the cashier [12].

2 Methodology

This study aimed to evaluate the effects of verbal abuse from customers on the burnout levels of Shopping Mall employees (cashier, sales clerk employees, sales man etc.).

2.1 Sample and Measurement Scales

In this study, a questionnaire was created which made use of the measurement scales in previous studies, whilst also taking into consideration particular Turkish cultural characteristics. The dimensions in the questionnaire and the measurement scales are as follows.

- Verbal Abuse Scale [8]: This scale used in the measurement of verbal abuse directed at employees was the social stresses scale related to customers which was developed by Dormann and Zapf [8], consisting of 5 questions of the verbal abuse dimension. The items in the scale are of a 5-point Likert type with answers varying from 'never true' to 'always true'.
- Burnout Scale: The Maslach Burnout Scale, which was developed by Maslach and Jackson (1986) and evaluated for validity and reliability in Turkey by Ergin (1992) was used in the study. The scale consists of 22 items in the 3 sub-dimensions of emotional burnout, depersonalization and low personal accomplishment. The items in the scale are of a 5-point Likert type with answers varying from never to always.
- Job Induced Tension Scale: Job-induced tension was measured using a 7-item sub-scale of an anxiety-stress instrument developed by House and Rizzo (1972).

Measures all scales used a 5-point Likert scale format with responses ranging strongly agree to strongly disagree.

The study was conducted on Shopping Mall cashier and sales clerk employees. The study sample consisted of 403 employees whose are working in a Big shopping Mall in a Bursa city in Turkey. Questionnaires were delivered in sealed envelopes, completed by voluntary participants and collected one week later. Of 500 distributed questionnaires, 417 were returned (return rate, 84 %) and 14 were excluded from the study due to incomplete data.

3 Result

The mean age of the study participants was 22.20 ± 4.79 years (mean ± standard deviation), ranging from 18 to 50 years. The mean duration of employment in the Mall was 1.91 ± 0.86 years. 43.9 % of the participants were female and 56.1 % were male. Educational status of the participants was determined as 14.3 % high school and 12 % postgraduates. Marital status was 55.6 % married and 44.4 % single.

The results of the reliability analysis of the scales used are shown in Table 1. As seen in Table 1, the reliability values obtained from all scales are within the limits accepted in the social sciences, and it is seen that ranged from 0.70 to 0.88.

According to the findings shown in Table 2, there is a significant correlation between the all scales. All correlation coefficients realized in line with the expectations and generally appeared at levels that can be considered high for this type of work.

When the correlation analysis results of verbal abuse and the burnout dimension were examined, a positive significant relationship was seen between verbal abuse and emotional burnout (r = 0.30; $p < 0.01$), depersonalization (r = 0.35; $p < 0.01$) and Job stress (r = 0.28; $p < 0.01$).

Verbal aggression of the customer is affected by age? The answer to the question was sought, As shown in Table 3, verbal aggression varies by age of the person. (t = −2.12; $p < 0.05$) The difference between the averages is statistically

Table 1 Results of the reliability analysis of the scales

Variable	Item	Mean ± SD	C. Alpha
Burnout	22	37.47 ± 9.06	0.75
Emotional burnout	9	11.66 ± 6.72	0.88
Depersonalization	5	4.08 ± 3.44	0.70
Personal accomplishment	8	21.59 ± 4.81	0.72
Verbal abuse	5	10.0 ± 3.21	0.80
Job stress	7	16.02 ± 5.80	0.83

Table 2 Results of the correlation between variables

	1	2	3	4
1. Verbal Abuse	1			
2. Emotional burnout	0.302 (**)	1		
3. Depersonalization	0.350 (**)	0.681 (**)	1	
4. Personal accomplishment	−0.145 (**)	−0.227 (**)	−0.121 (*)	1
5. Job stress	0.280 (**)	0.593 (**)	0.711 (**)	−0.147 (**)

**$p < 0.01$

Table 3 Customer verbal abuse difference by age

Variable	Under 30 age	Upper 30 age	Total	t	p	Mean difference
Verbal abuse	2.22 ± 0.70	2.38 ± 0.72	4.60 ± 0.71	−2.12	0.03*	−0.16

*$p < 0.05$

Table 4 Customer verbal abuse difference by education level

Variable	High school	University	Total	t	p	Mean difference
Verbal abuse	2.28 ± 0.69	2.43 ± 0.76	2.35 ± 0.72	−2.02	0.04*	−0.15

Table 5 Customer verbal abuse difference by gender

Variable	Woman	Men	Total	t	p	Mean difference
Verbal abuse	2.40 ± 0.76	2.27 ± 0.68	2.33 ± 0.72	1.79	0.07	0.13

*$p < 0.01$

Table 6 Results of the regression analysis of the effect of verbal abuse on burnout

Model	Unstandardized coefficients		Standardized coefficients	t	p
	β	Std. error	β		
(Constant)	1.309	0.067		19.514	0.000
Verbal abuse	0.163	0.027	0.285	5.947	0.000

[a]Dependent variable: Burnout

**$p < 0.01$; 1 All coefficients are standardized

significant. In other words, people with average age 30 and older are higher victim than up the 30 years old (Table 4).

Table 5 is present to verbal abuse and gender difference. As it seen is not significant relationship (79; $p = 0.07$).

According to Table 6, in the model established for burnout, In the regression analysis performed to explain the burnout levels of the employees, the variable of verbal abuse was found to be statistically significant. Thus, verbal abuse caused an increase in the level of burnout ($p < 0.01$). The variable of verbal abuse was found to be statistically significant ($p < 0.01$).

4 Discussion and Conclusion

Aggression in working life causes significant problems for an individual's health and safety. Although employees in every sector are at risk of being exposed to aggressive behavior, the risk is much greater for employees in the service sector. There is increased risk of violence more often in interaction with people outside the workplace for employees in this sector. The high level of interaction with customers brings with it the risk of exposure to aggressive behavior for employees in the service sector. Significant findings of the analyses performed in this study show the effect on burnout levels of employees who suffer verbal abuse.

In this study, in the data analysis, correlation and regression analysis were used. From the results of the analyses, the finding was obtained that verbal abuse significantly increased the emotional burnout and depersonalization levels of employees. According to the analysis results of the current study, customer verbal abuse was determined to have a significant positive effect on emotional burnout and insensitivity ($p < 0.05$). Thus with increased customer verbal abuse the emotional burnout and depersonalization levels of the employees also increased. No significant effect of customer verbal abuse was found on personal accomplishment ($p > 0.05$). Similar findings have been reported from other previous studies on this subject in the service sector. For example, in a study by Grandey et al. [6] of call center employees, a significant positive relationship was determined between the frequency of customer aggression and emotional burnout. In a similar study by Dierendonck and Mevisen [7] of tram drivers, a significant relationship was determined between aggressive behavior and burnout. Dormann and Zapft [8] studied different occupations (airline staff, travel agency employees, sales personnel) in the service sector and a significant positive relationship was determined between customer verbal abuse and emotional burnout and depersonalization while a significant negative relationship was determined between customer verbal abuse and personal accomplishment. A study of hotel workers by Karatepe et al. [9] and in a study of travel agency, hotel and restaurant employees by Kim et al. [10] results were obtained demonstrating that customer verbal abuse significantly increased emotional burnout. In another study by Ben-Zur and Yagil [11] was determined that customer aggression increased employees' levels of emotional burnout and depersonalization. In the another study [13] the burnout dimensions of customer aggression found to have any significant effect on personal accomplishment [11]. At last we can discusses and suggest that individual and organizational prevention strategies that incorporate ergonomic and occupational therapy concepts can increase work productivity and job satisfaction.

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Using Axiomatic Design to Identify the Elements That Affect the Evaluation of Comfort/Discomfort Perception

Nicola Cappetti, Alessandro Naddeo, Rosaria Califano and Mariarosaria Vallone

Abstract Knowledge about the effects of primary factors on comfort level is useful in Human-Machine-Interface (HMI) design. The study and the mathematical modeling of these effects strongly depends on cross relations between the different kinds of comfort, the primary factors' effects, and the modifiers' actions. Starting from a sizeable bibliographic analysis, this paper describes a study, based on the axiomatic design approach, of the interactions between the results, factors, and modifiers in comfort/discomfort evaluation. The modifiers' influence was determined by measuring the changes in information content. This study allowed us to validate and optimize our equation for the perceived "level of well-being" in order to better study the perception of comfort/discomfort in HMI.

Keywords Discomfort · Axiomatic design · Evaluation criteria · Comfort rating · Perception

1 Introduction

What are new lines of research into the evaluation of comfort and the objective and predictive techniques for quantifying and qualifying its perception? Many researchers have attempted to answer this question. However, it is clear from the literature that only a few aspects have been studied in any detail.

Only a small number of researchers (e.g. Moes [1] and Vink-Hallbeck [2]) have studied the problem of comfort perception and evaluation from a wider perspective. Nevertheless, certain aspects have still not been taken into account.

Naddeo and Cappetti [3] extended the Vink-Hallbeck model in order to build a comfort evaluation matrix in which four kinds of comfort perception were studied

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and linked to range of characteristics in a working environment, and to take into account expectations (E) and changes in perception due to testing devices.

Generally, "comfort" can be defined as "the level of well-being perceived by people in a working environment". This level is extremely difficult to detect and measure as it is affected by individual judgments that can only be analyzed using quantitative and qualitative methods. Some methods, such as the "Rating of Perceived Exertion" method [4], have been developed to objectively "measure" postural comfort under conditions of exertion. In literature, the majority of papers discuss the relationship between environmental factors (temperature, humidity, applied forces, etc.) that can affect the perceived comfort or discomfort [5] or study the relationship between self-reported discomfort and musculoskeletal injuries, with these injuries affecting the perceived level of comfort [6]. The few papers examining the concept of product-related comfort include Helander and Zhang [7], De Looze et al. [8], Kuijt-Evers et al. [9] and Moes [1].

Five main factors regarding the relationship between subjective perceptions of comfort/discomfort and products, processes, interactions, environment, and users have been identified and are recognized by most scientists: sensory input [10, 11]; activities that occur during measurement and that have an influence on comfort [12–14]; different regions of the body [15, 16]; the effect of product contours on comfort [17–20]; and physical loading [21–24].

The authors' previous work represented the comfort experience using a large matrix in which the comfort-related elements were classified and studied. According to the Naddeo and Cappetti model of perception (NC-model) [25], the experience of comfort or discomfort in a generic environment is represented by the logic sum of four main aspects that contribute to HMI description and classification: Person (Pe), Product Characteristics (Pr), Task-Usage (T), and Working Environment (WE) as in Fig. 1:

Interaction (I) with an environment is caused by contact (including nonphysical contact) with a consequent internal body effect (H). The perceived effects (P) are

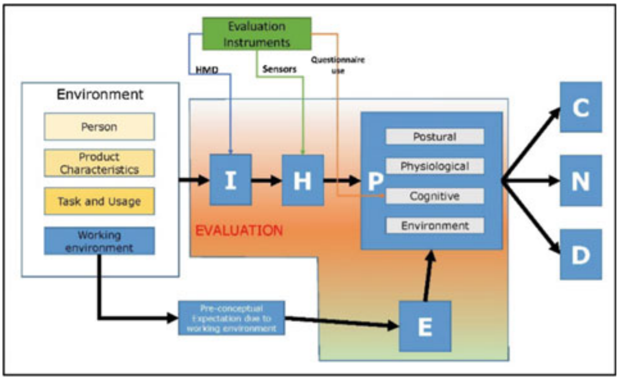

Fig. 1 Vink-Hallbeck model modified by Naddeo-Cappetti

influenced by the body effects but also by expectations (E). These are interpreted as "comfortable" (C), "you feel nothing" (N), or leading to "feelings of discomfort" (D) [2].

The following main aspects contribute to HMI description and classification:

- *Person (Pe)*: represents the geometric (physical) and personal (psychological) characteristics of people involved in tasks;
- *Product (Pr)*: represents all geometric and non-geometric characteristics that describe the element that comes into contact with the body during the execution of the task (shape, materials, color, surface treatment, and so on …);
- *Task-Usage (T)*: represents all of the tasks or usages that occur as part of the HMI experience (type of contact, timing, type of interaction);
- *Working environment (We)*: represents the set of parameters that characterizes the working environment, both in terms of climate and layout (temperature, humidity, lighting, working seat, type of workspace);
- *Satisfaction/Gratification level (Gl)*: represents the set of work characteristics that contributes to the satisfaction/dissatisfaction of a worker (position in organization, shift work, gratification, salary, and so on) and is broadly related to the general environment.

The Vink-Hallbeck model directly connects the working environment with the expectation through the coding of several pre-conceptual aspects relating to both the working environment and the cultural/experiential background of the worker in question. For example, in Naddeo et al. [26], it is demonstrated that if the product has a particular design, and therefore a higher cost than other products, the users have higher expectations, thereby influencing the perception of comfort. This model also takes account of the perception to be modified by experimental devices required for comfort evaluation—an aspect that cannot be underestimated, as it is always present in any comfort/discomfort evaluation. These devices can modify most of the factors contributing to the way that comfort/discomfort are perceived.

2 Comfort Contributes Fusion Rule

Naddeo and Cappetti's NC-Model of Perception is able to synthetize the concept that comfort and discomfort are the measure of the degree of appreciation linked to expectation, due to the perception of the interaction level (I) between the person (H) and the environment (Env).

Our work starts from a definition of the wider number of elements that can be linked to the environment, which are classified via two main axioms. Each element involved in an HMI experience can contribute to one or more of four types of comfort: Postural, Cognitive, Physiologic and Environmental [27]. These types of comfort are hence not decoupled.

This macro-schematization of the comfort/discomfort experience allows us to individuate the majority of elements contributing to comfort/discomfort, and to classify them in terms of body effects related to four types of comfort/discomfort perception.

Each element involved in the HMI experience can be classified as either a "primary" element or a "modifier". A primary element is defined as "an element that directly contributes to the formation of the comfort/discomfort perception" (such as anthropometric measures for postural comfort [28]. A modifier is defined as "an element that can modify a previously formed perception" (such as time of sitting in physiological comfort). Primary elements are those that affect our ability to interact, while secondary elements (modifiers) affect our ability to perceive and are related to both individual (personal) and environmental characteristics. The way that expectation acts upon us can influence the threshold level between comfort and discomfort. Thanks to these axioms, and the NC-Model, comfort (C) and discomfort (D) can be represented by the following formulas:

$$C_i = f_i(I, H) * P_i - E_i \text{ and } D_i = g_i(I, H) * P_i + E_i \tag{1}$$

for i in $\{Postural, Cognitive, Physiologic, Environmental\}$.

Immediately, it is apparent that the Comfort Rule is different to the Discomfort Rule (the first is not the negation of the second). The extended form of the formulas can be written by taking into account that modifiers (function mod) can be used as a scale-factor for perceptions:

$$\begin{aligned} C_i &= mod(P) * m_C(H) - E \\ &= mod(P) * m_C(h(I)) - E \\ &= mod(P) * m_C(h(f(Pe; Pr, T, We, Gl))) - E \end{aligned} \tag{2}$$

In the same way, the Discomfort Rule can be written as:

$$D_i = mod(P) * m_D(h(f(Pe; Pr, T, We, Gl))) + E \tag{3}$$

Both m_C and m_D can be written as general functions. A number of studies about the functional links between one or several parameters/characteristics have been has been deployed and detailed. However, some important aspects were not taken into account. The NC-model offers a more complete solution. For each kind of interaction (I), we have identified one or more body effects (H) detailed in the ergonomic/comfort literature. Our research took shape while looking for the most important factors related to comfort and discomfort, including those not discussed in the literature. In a previous study, the all actors in the "movie" of comfort/discomfort has been identified and organized in five classes, whose characteristics affect the interaction-related comfort/discomfort:

- “Human”—characteristics of the individual; these characteristics identify all those features and information that can affect an individual’s perception of comfort.
- “Product” and “Task”—characteristics of work activities that identify the parameters of tasks and products with which people are faced.
- “Environment”—characteristics of the working environment in which these tasks are performed. Includes all those aspects related to the environment, as well as thermal, visual and acoustic qualities and the layout of workspaces.
- “Degree of Gratification”—intrinsic characteristics that affect the entire comfort experience and are related to the content of the work, the relationships between colleagues, and the position within the organization or company.

These classes correspond exactly to the five aspects that contribute to the HMI experience: Pe, Pr, T, We and Gl. The framework is designed to explain the connections between the interactions (I) and the body effects (H), in order to evaluate how and if these effects are perceived (P), and how and if they affect the four variants of comfort/discomfort perception (postural, cognitive, environmental and physiological).

Table 1 lists all identified elements in comfort/discomfort perception, divided by class, and their principal or modifier role in each comfort evaluation.

The *first class* of factors is related to personal characteristics (physical characteristics, mental state, personal data, lifestyle and expectations). It has been verified that these characteristics influence physiological, cognitive and postural comfort. However, there is no correlation between these characteristics and the quality of the work environment. Each subclass has been examined to identify its own specific aspects.

The *second class* of factors concerns the characteristics of the work itself. If comfort is the result of the interaction between the person and the activity, both the characteristics of the work itself and the environment should be considered. These factors concern aspects related, for instance, to workstation/seating properties, the type of activity, and the objects used in the execution of a particular task.

The *third class* of factors concerns the characteristics of the work environment. If we consider that a person has to stay in a specific place for several hours, it follows that a pleasant environment may significantly affect their well-being. The work environment is composed of: visual, olfactory, acoustic and thermal well-being; well-being associated to the workspace; and well-being associated to the condition of the environment.

The *fifth and final class* of factors concerns the degree of gratification. Both the content and the context of a job or activity can be more or less satisfying. The content includes several factors, including the level of recognition, the direct responsibility entailed, and the possibility for growth [29]. The content of a job can be either too great or too small, leading to the absence of incentive and a decreased level of comfort. Relationships with the colleagues and managers, or the rigidity of norms and procedures, are all factors that require consideration.

Table 1 Elements interacting with humans and their principal (P) or modifier (M) role in comfort evaluation (physiological, cognitive, postural, environmental)

1.	*PHYSICAL CHARACTERISTICS*: anthropometric measures (M, P, M, X), physique (BMI) (P, P, M, X), physical problems (chronic illness, trauma, and previous fractures) (P, P, M, X); *MENTAL STATUS*: personality (M, M, P, X), psychological diseases (anxiety, stress) (M, M, P, X); *PERSONAL DATA*: gender (P, P, P, X), age (P, P, P, X); *LIFESTYLE* and *EXPECTATIONS*: lifestyle (diet, smoking, sports, sedentary lifestyle, etc) (P, M, M, X), expectations (M, M, P, X)
2.	Work/task characteristics *WORKSTATION*: posture: angles and joints (M, P, M, M), individual safety equipment: overall dimensions and heaviness (M, M, M, M); *WORK ACTIVITY* and TASK: type of loads and actuation (lifting, pulling, pushing) (M, P, M, M), oparating speed (M, M, M, P), actions' frequency (M, M, M, P), rest-pause duration and frequency (M, M, M, P), level of precision (M, M, M, P), time maintaining of the posture with and(or) without loads (M, P, M, M), time and duration of work activity or tasks (M, M, M, P), workshifts (M, M, M, P); *CHARACTERISTICS OF TOOLS/OBJECTS WITH WHICH A PERSON INTERACTS*: shape (M, P, M, M), weight (M, P, M, M), relative position between person and object/tool (M, P, M, M), frequency of lifting or pulling or pushing (M, M, P, M), handling characteristics (grip, grasp, pinch, ….) (M, P, M, M), customization of the workstation (sitting) (M, P, M, M), commands' layout (M, P, M, X)
3.	Working environments' characteristics *VISUAL WELL-BEING*: colors (M, M, M, P), artificial lightinging conditions (M, M, M, P), natural lighting conditions (M, M, M, P), lights' reflection and refraction on walls and objects (M, M, M, P); *OLFACTORY WELL-BEING*: air quality (M, M, M, P), odors (M, M, M, P); *AUDITIVE WELL-BEING*: noises (M, M, M, P), vibrations (M, P, M, P); SPACES: workspace (M, M, M, P), plant-layout (M, M, M, P), condition and inclination of the floor (standing posture) (M, M, M, P); *ENVIROMENT CHARACTERISTICS*: cleanliness (M, M, M, P), tidiness (M, M, M, P); *THERMAL WELL-BEING*: air-temperature (M, M, M, P), interface temperature (P, M, M, M), humidity (M, M, M, P), thermal resistance of clothing (P, M, M, M), persistence in a thermal condition (P, M, M, M), contact pressure (P, M, M, M), air speed (M, M, M, P)
4.	Level of gratification *GRATIFICATION LINKED TO THE CONTENT OF WORK*: rewards and money-grants (M, M, P, M), direct work responsibilities (M, M, P, M), growth opportunities (M, M, P, M); *ORGANIZATION/ ENVIRONMENT*: collaboration with colleagues (M, M, P, M), rigidity of the regulations and procedures (M, M, P, M), relationship with managements (M, M, P, M), attractiveness of the environments and furniture (M, M, P, M), level of tiredness (M, M, P, M)
5.	Tools and instruments for comfort measuring: invasivity (M, M, M, M), obstruction (M, M, M, M), tactile interference (M, M, M, M), restriction of movements (M, M, M, M), visual limitation (M, M, M, M), override of action/ position (M, M, M, M)

2.1 Comfort Research Overview

We define an "effect" as "any modification in a person's physical, physiological or psychological condition due to environmental variation". For example, variations in muscular stress intensity due to posture changes, or tiredness levels due to the repetitiveness of a specific activity. Both of these would be termed "physical effects".

The interaction that an individual has with the above five classes of factors, and the resultant effects, contributes to changes in perceived comfort. There are several effects for each type of postural, cognitive, physiological and environmental comfort. The comfort matrix explains each class and describes the relationships between the causes (interactions) and effects (body effects) for each type of perceived comfort.

An examination of the state of the art related to comfort reveals that researchers have always studied the influence of one aspect on one or more combined effects. However, there has been no comprehensive examination of all effects and all aspects, encompassing all types of comfort. Clearly, each aspect has a different relevance in terms of comfort modification. It is hence necessary to list these research activities in order of priority. A large number of scientific papers deal with comfort optimization in product or HMI design. However, these studies only consider those aspects and effects related to a particular design problem. There has been no attempt to extend this knowledge into a general comfort evaluation model.

Table 2 gives a general summary of comfort literature; the same was done for physiological, cognitive and postural comfort, as well as personal characteristics. Tables for other classes have been omitted due to their excessive length. Crosses are used to indicate where scientific studies examining the influence of certain aspects or effects on comfort are available.

3 A Brief Introduction to Axiomatic Design

It is difficult to assess the clarity of links between comfort and its influencing factors relying solely on the above tables. The correct measure of the information content, as defined by the second axiom of design, is inversely proportional to the complete understanding of the phenomenon under observation (the indication of scientific accuracy regarding a specific interaction between a cause and an observed phenomenon).

In 1990, Suh [30] proposed the use of axioms as the scientific foundations of design. From the twelve axioms first suggested, Suh introduced the following two basic axioms, along with six corollaries, that a design needs to satisfy:

- *Axiom 1*—The Independence Axiom: Maintain the independence of the functional requirements
- *Axiom 2*—The Information Axiom: Minimize the information content in a design

In the Axiomatic Design approach [31], the engineering design process is described as in Fig. 2, in which the array of functional requirements (FRs) is the minimum set of independent requirements that completely characterizes the design objective based on customer attributes (CAs). Design is defined as the creation of a synthesized solution to satisfy perceived needs through the mapping between the

Table 2 Map of the state of the art in comfort evaluation

Personal characteristics class	aggressiveness	body temperature	heart rate	lack of attention	level of perceived safety	level of perceived tiredness	localized blood pressure	metabolism	muscle complaint	muscle effort	muscular exertion	nervousness	posture overload	stress	tactile sensation	tiredness	work overload
Global comfort literature																	
Physical characteristics																	
Anthropometric measures	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–
Physique (BMI)	–	X	X	–	–	X	X	X	X	X	–	–	X	–	–	–	–
Physical problems (chronic illness, trauma, and previous fractures)	–	X	X	–	–	X	X	–	X	X	–	–	X	–	X	–	X
Mental status																	
Personality	X	–	–	X	X	X	–	–	–	–	–	–	–	X	–	–	X
Psychological diseases (anxiety, stress)	X	X	X	X	X	X	–	–	–	–	–	–	–	X	–	–	–
Personal data																	
Gender	–	X	X	–	–	–	X	X	–	–	–	–	–	–	–	–	–
Age	–	X	X	X	–	–	X	X	–	X	–	–	–	–	X	–	–
Lifestyle/expectations																	
Lifestyle (diet, smoking, sports, sedentary lifestyle)	X	X	X	X	–	–	–	X	–	X	–	–	–	–	–	–	–
Expectations																	
Expectations	X	–	–	–	X	–	–	–	–	–	–	–	–	X	–	–	–

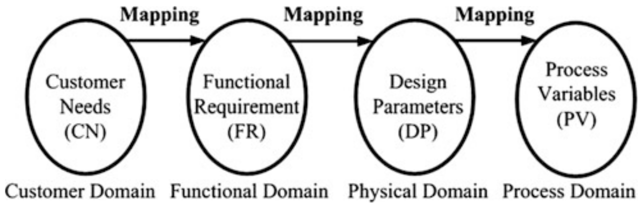

Fig. 2 The axiomatic design framework

FRs in the functional domain and the design parameters (DPs) in the physical domain, and through the mapping between the DPs and the process variables (PVs) in the process domain.

The physical and process mappings can be expressed mathematically as

$$\{FR\}mx1 = [A]mxr\,\{DP\}rx1 \tag{4}$$

$$\{DP\}rx1 = [B]rxn\,\{PV\}nx1 \tag{5}$$

where {FR}mx1 is the vector of independent functional requirements with m components, {DP}rx1 is the vector of design parameters with r components, {PV}nx1 is the vector of process variables with n components, A is the physical design matrix, and B is the process design matrix.

Axiom 1 implies that [A] should be either a diagonal matrix or a triangular matrix.

After satisfying Axiom 1, design simplicity is pursued by minimizing the information contents for Axiom 2, where the information content is defined as a measure of complexity. One popular measure of information content is entropy [32]. FRs' entropy is related to the probability of satisfying its specification in the physical mapping (the DP in the process mapping) [33–35].

Entropy and information content can be mathematically expressed in different ways; the more useful measures are those that evaluate the probability of meeting design specifications, which is the area of intersection between the design range (dr), (design specifications) and the system range (sr), (process capability). The overlap between design range and system range is called the common range (cr). The probability of success is defined as the area (probability) ratio of the common range to the system range, i.e. the common measures are based on the logarithmic function. In terms of probability, the information related to an event of probability p is I = log2 (1/p). And our information content evaluation is based on this concept [34, 35].

4 Towards an Improved Comfort

4.1 Hypothesis

- *Completeness of basic effects list*: We consider the list of effects taken from the literature to be sufficiently complete. In the course of our research we discovered a wide range of literature examining comfort optimization or discomfort reduction relating to the principal functions of the body.
- *Substance of principal aspects*: knowledge of the principal's influence on comfort is a prerequisite to knowledge of the modifier's action on the principal. A larger number of scientific papers hence conduct experiments and tests on principals, while modifiers are either ignored or merged into a suitable number of "designed experiments".
- *Level of knowledge about principal aspects*: if studies are available about effects acting on aspects, then the knowledge about the resultant influence can be considered "full-scale knowledge".

4.2 Analysis

There are many elements to be investigated in order to complete our knowledge of actions influencing body effects in comfort and discomfort evaluation. And this knowledge needs to be ordered according to certain priorities (principals and modifiers), as in Table 2. Moreover, we know that certain aspects are more relevant to our research than others.

The measure of knowledge level in comfort research seems to be similar to the information content in the second axiomatic design axiom. Starting from the hypothesis in Sect. 4.1, we define the probability of completing each type of comfort research for aspect k as

$$p_k = E(C_i)/E(C). \tag{6}$$

where *E(Ci)* are effects evaluated in the literature for aspect k for a type of comfort and *E(C)* are effects evaluated in the literature for all types of comfort. Consequently, the information content can be evaluated as:

$$I_k = \log(1/p_k) * w_k. \tag{7}$$

where w_k is 1 for principals and <1 for modifiers due to their different relevance. To ensure numerical stability, infinite information was set to $1000 * max(I_k)$ in $p_k > 0$.

The w_k weight is useful to represent the effect of a modifier on a principal, and is very difficult to determine. This is particularly the case when considering effects

Table 3 Lack of information in comfort modeling for certain personal characteristics

	Physical characteristics			Mental status	
	Anthropometric measures	Physique (BMI)	Physical problems (chronic illness, trauma, and previous fractures)	Personality	Psychological diseases (anxiety, stress)
p_{phy}	0.000	0.500	0.444	0.000	0.286
p_{pos}	1.000	0.375	0.333	0.000	0.000
p_{cogn}	0.000	0.125	0.222	1.000	0.714
p_{env}	–	–	–	–	–
I_{phy}	300.000	1.000	1.170	300.000	0.542
I_{pos}	0.000	0.425	0.475	300.000	300.000
I_{cogn}	300.000	0.900	0.651	0.000	0.146
I_{env}	–	–	–	–	–
I_{tot}	600.000	2.325	2.296	600.000	300.688

that have not yet been researched. In our calculations, w_k was set to 0.3: the maximum comfort alteration due to modifier effects.

Table 2 shows the results of our calculations where the information content is the additive value of the effects' total contributions to the information content for each aspect (Table 3).

5 Conclusions

In HMI design, several parameters have to be correctly evaluated in order to guarantee a good level of safety and user well-being, including the avoidance of health problems such as muscular-skeletal or psychological diseases.

Several papers follow the assumption that there is a relationship between self-reported discomfort and musculoskeletal injuries, and that those injuries affect the perceived level of comfort. More than 100,000 papers have been written dealing with comfort and discomfort, and most of these address the relationship between environmental aspects and perceived comfort/discomfort. However, the theories relating comfort to products/processes and their design characteristics are rather underdeveloped.

A tool has been developed to help researchers improve results and address those aspects missing from the body of existing research. Using literature analysis via the NC-model, a list has been drawn up based on the information content that is most important to overall comfort evaluation. Various types of sensation and perception have all been classified and linked to the relevant body effects, and the proposed framework indicates the best direction for future research in comfort studies. Accordingly, the areas that researchers should address most urgently are as follows:

Postural comfort evaluation: significance of rest posture and of joints' neutral position; gravitational effect; arm(s) support (headrest, armrest or other rest surfaces); postural equilibrium (weight distribution and operative spatial conditions); handhold type; frequency of repetitive actions; time spent in a single posture; muscular fatigue; tools to measure the angle of joints in both static and dynamic postures.

Cognitive comfort evaluation: devices to evaluate HMI tactile interaction (without altering it during the measurement process); devices/methods to evaluate HMI visual interaction; methods for allowing users/workers to describe and analyze their own sensations during operations/uses (without affecting their perception); a method to integrate the other three senses in the evaluation (hearing, taste and olfaction).

Physiological comfort evaluation: devices to measure HMI temperature (without altering it); devices to measure HMI pressure (without altering it); devices to measure HMI transpiration (water-vapor migration) (without altering it); a method to correlate the previously described parameters with each other; a method to correlate parameter values and their combination to an accepted level of comfort; a method for taking into account physiologic condition versus elapsed time (prolonged postures).

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A Model of Improving Individual Satisfaction in Group Conversation Based on Estimation of Group Status

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Abstract We generated a model to improve the satisfaction individual group members involved in a decision-making conversation by the intervention such as eliciting opinions from the members that cannot express in the discussion for group decision. We assume to estimate the group status by measuring the utterance (phonetic) characteristics in the conversation. Our goal is to develop a model that would provide decision support. In group decision making, some members may hesitate or yield their position to superiors, or they may offer no concrete ideas or suggestions, and thus may feel frustration during the conversation. Members who are in a weak position may not be as confident and may not be able to clearly express their intentions. As a test case, we consider the challenge of providing support to a group during a decision-making process (e.g., route, stopover) while traveling in a car. We sought to measure the satisfaction of each member during the process of decision making. Furthermore, the relationship between individual satisfaction and receptivity depended on how a member was accepted during the group discussions. We found that several participants in the test conversations exhibited increasing levels of stress when proposals were rejected or not thoroughly discussed. Thus, we think that reducing the frequency of such situations may be relevant in improving decision-making satisfaction. Therefore, we propose that a model in which all members of the group are given an equal opportunity to make proposals, and in which no members face continuous rejection during the decision-making conversation, will produce the greatest satisfaction. We plan to continue to study this model to facilitate the design of a decision support system.

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Keywords Conversation estimation · Group status estimation · Utterance feature · Conversational agent · Intention extraction

1 Introduction

1.1 Objective

As a test case, we considered ways to provide support to a group of people discussing decisions to be made while traveling in a car (e.g., route, stopovers). Our objective was to clarify the degrees of satisfaction felt by each member of the group regarding each step in the decision-making process. We hope to use this information to develop a decision support method that would improve the degrees of satisfaction of each group member.

1.2 Background and Motivations

In group decision making, members may have different opinions, and some may be frustrated with final decisions. We sought to address this problem using speech recognition and the extraction of intentions based on a group dynamics approach.

Prior to developing a method of decision support, we conducted a conversation experiment in which the emotion and satisfaction of members were determined via electroencephalogram (EEG) during a group conversation.

We sought to clarify the efficacy of a system for estimating the classification and status of a group according to the utterance characteristics of the group members. In particular, we are interested in the possibility of identifying all utterances in a conversation using time course information and intention information extracted from words.

2 Related Work

2.1 Group Dynamics

Group dynamics refers to a system of behaviors and psychologically influential interpersonal processes [1]. Previous research on group dynamics has found groups to have many measurable characteristics, including relationships, homogeneity durability, permeability, common objects, common results, and size [2]. Groups are often classified by such characteristics, and the relationships between these characteristics are both various and can change dynamically based on their particular classifications and current status [3].

2.2 Group Decision-Making

Decision making via group conversation is affected by the classification and status of the group. For example, there are usually higher levels of sympathy in groups with a high degree of aggregation. The members of a group are more easily satisfied with the process of forming a consensus if members can argue for their opinions and some of these opinions are adopted in the course of conversation [4, 5].

Group decision support systems using electronic communication and other computing methods have already been investigated in previous research [6]. However, we focused on the actual speech used in group conversations, and how group decision making can be supported mechanically by the provision of information or suggestions via a conversational agent system.

2.3 Extraction of Utterance Features

Prior studies of utterance analysis technology have found that utterance feature values in dialogue (e.g., tone, speed, overlapping) can be used to identify various types of group status (e.g., tuning trend, familiarity, upsurge) [7–9]. Examples of utterance feature values for group status estimation are shown in Table 1.

Utterance feature values have also been used to estimate tension in group members [10]. In this paper, tension is defined as the mental manifestation of physiological responses. In particular, we focus on whether group members are experiencing high tension. When an individual is experiencing a state of high tension, several kinds of issues may arise, such as decreased efficiency in group meetings.

2.4 Intention in Spoken Dialogue

Prior studies have established methods of intention extraction for spoken dialogue utterances, and the accuracy of intention recognition has recently improved [11, 12].

Table 1 Examples of utterance feature values for group status estimation

Parameter	Unit	Calculation method
Length	msec	Length (time duration) of each utterance
Times	times/min	Times of occurred utterances per minute
Power level	dB	Power level (loudness) of each utterance
Tone (F_0)	Hz	Fundamental frequency
Mora	mora	Unit numbers in phonology that determines syllable weight
Speed	mora/sec	Number of moras per second
Overlap	times/min	Times of overlapped utterances per minute

We define “intention in spoken dialogue” as a plan or an expectation held by a speaker with respect to something that has been mentioned in their speech. Intentions, themes and categories of utterances can be estimated by comparing text data between speech recognition results and spontaneous dialogue corpora.

2.5 Extraction of Emotion by EEG Measurement

It is difficult to evaluate satisfaction because this emotion is not associated with an explicit expression. Like many other human emotions, satisfaction has several implicit aspects. However, Matsunaga et al. showed that subjective psychological information corresponding to satisfaction can be objectively evaluated via electroencephalogram (EEG), which provides information about emotions and physiological activity [13, 14].

Human emotions can be observed by EEG, which is a time sequential signal that contains compounded α and β waves. Methods for measuring EEG signals, which have a frequency ranging from 1–64 Hz, have been established in previous studies. A simple headset-type EEG device, named the Emotion Analyzer, was developed by Mitsukura et al. It can measure the degrees of emotion such as stress every second [15–18].

We used the Emotion Analyzer to measure the emotion of members of a group engaged in a conversation trial. We then analyzed the status and satisfaction of the group members regarding the process of group decision-making.

3 Models

3.1 Model of Group Status Estimation

We propose a model in which group status can be estimated according to an analysis of utterances. This analysis is based on prior studies of group dynamics and utterance analysis. In this model, we first investigate the relationships among group members according to the results of a process to extract intention information and an estimation of tension in each utterance during conversations among group members. Such analyses can reveal which members communicate with whom, and in what manner. We can then apply the findings of these estimations of intimacy and group structure to the whole group.

Thus, we can classify the group according to the relationships among group members and the intimacy and structure of the whole group. Examples of extracted relationships and utterance feature values among members are shown in Fig. 1, Table 2.

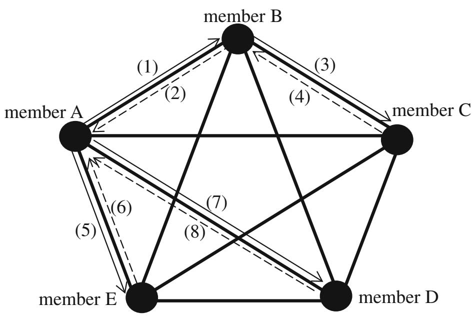

Fig. 1 Examples of extracted relationships among members (*Numbers (1) to (8) refer to the descriptions provided in Table 2)

Table 2 Example of extracted utterance feature values among members

No.	Utterance direction	Utterance intention	Utterance times	Utterance overlaps
(1)	A – > B	Proposal	2	0
(2)	B – > A	Approval	2	–
(3)	B – > C	Question	1	0
(4)	C – > B	Answer	1	–
(5)	A – > E	Proposal	1	–
(6)	E – > A	No reply	–	–
(7)	A – > D	Proposal	1	1
(8)	D – > A	Opposition	1	(15 ms)

In the next step, we investigate the current status of group members using the results of the extraction of intention and estimation of tension in each utterance during conversations among group members. In particular, we focus on what opinions members express and the manner in which they express them, and on the progression of their discussion and decision-making process.

3.2 *Model of Group Decision Support*

We propose a model of group decision support in which the quality of group decision-making is enhanced by the intervention of a conversational agent system. The system would use a synthetic voice and intervene at an appropriate time based on an estimation of the classification and status of the group. We hypothesize that this intervention will lead to more satisfactory decision-making results.

In group decision-making, reference information may not be dealt with in discussion if it is not provided appropriately [19]. Therefore, we aim to develop a model of decision support in which appropriate reference information is provided based on the group classification.

We hypothesize that this intervention will lead to more satisfactory decision-making results. In the following sections, we provide examples of our proposed intervention for the various group classifications. The conversational

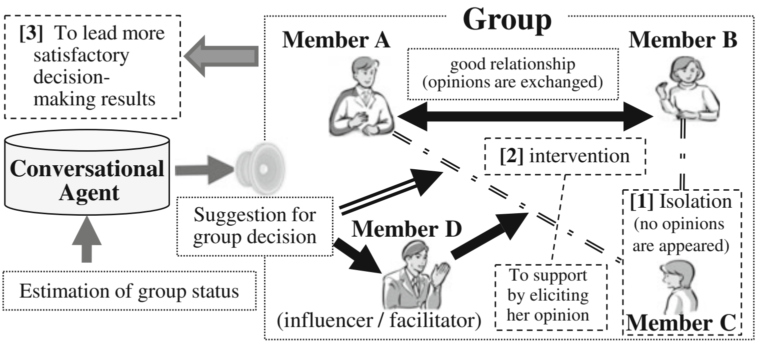

Fig. 2 Example of group intervention in our proposed model

agent acts like a facilitator in conversations, and provides information to a target member via the influencer, if such an influencer exists. Otherwise, the agent provides the information to a target member directly.

High Intimacy and Flat Relationship Group. The members of this group classification are assumed to share their opinions frankly. For example, it is possible to determine whether the members have any specific ideas or requests, and then the agent can provide detailed information based on the situation of each member. Thus, every member can propose an opinion for discussion.

High Intimacy and Hierarchical Relationship Group. In this group classification, an older member has the leadership role and knows the views of each member.

For example, the dialogue may start with the conversational agent asking the older member what kind of information is preferred by all the members. Then, the conversational agent can provide the appropriate information. Thus, it will be easy for the group to discuss or make a selection from the available options.

Low Intimacy and Hierarchical Relationship Group. In this group classification, an older member controls the group and junior members may be hesitant to express their feelings directly.

Thus, the conversational agent works to identify members in a weak position, for example, those who experience isolation from other members, and aims to support such members by eliciting their opinions using appropriate reference information or suggestions (Fig. 2.)

3.3 Satisfaction in Decision-Making Conversation

We sought to measure the degree to which the group members were satisfied with the decision-making conversation. Specifically, we wanted to understand how members expressed their own opinions, how those opinions were discussed with

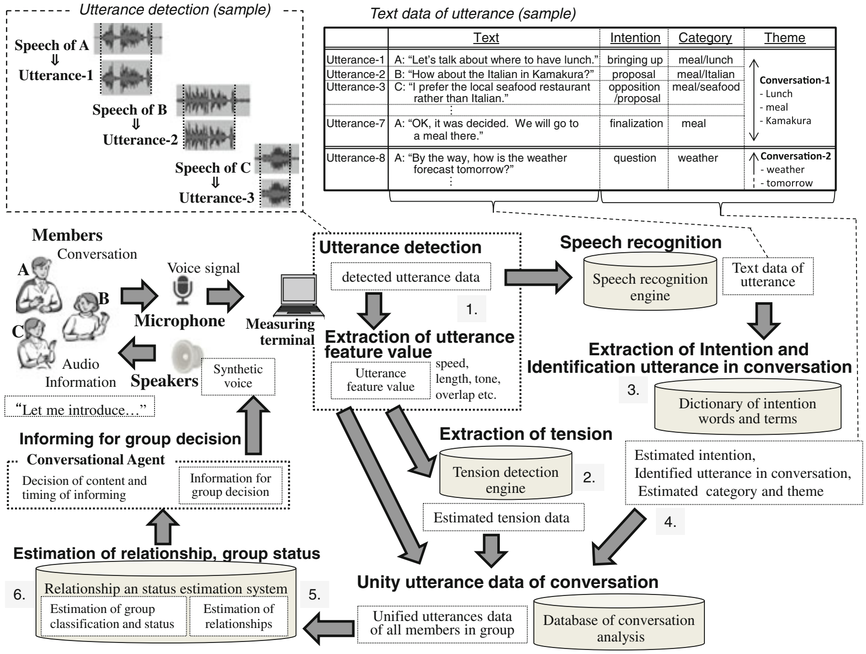

Fig. 3 Processes of group status estimation and provision of group decision-making (*Numbers 1 to 6 refer to the descriptions provided in the main text)

other members, and how the final group decision was reached. We obtained the degrees of satisfaction by extracting the intention of utterances at different time points in the conversation.

The processes to infer the classification and status of the group by measuring the utterance characteristics of group members are shown as follows, as well as in Fig. 3. The tension strength of each utterance is estimated by a calculation using the extracted utterance feature values (Fig. 3-1).

Then, the strengths of the relationships among the group members are estimated using the results of the intention and politeness level estimations, the presence of childish or instructional words (Fig. 3-3), and the estimated tension levels (Fig. 3-2).

3.4 *Provision of Information for Group Decision*

By estimating the content of the utterances among group members, we can also estimate the relative status of those members. These data also serve as reference information for estimating the classification and status of the group (Fig. 3-6).

We assumed that the conversational agent system provides reference information and suggestions that take into account the wishes of each group member. In

Table 3 Example of content and timing data relating to requests and provision of information to each group (*"beginning of discussion": beginning of discussion in same theme for decision)

Contents of informing	Timing
Question of each ideas or requests	Beginning of discussion, occasion of no opinions from specific member
General information related the topic	Begging of topic, after getting request
Detailed overall information related the topic	After getting request, as the result of intension extracting
Specific information related the topic	Occasion of confliction, high tension reply, longer discussion, inclination to specific member's intention

addition, the system identifies whether some members have difficulty voicing their opinions clearly. The conversational agent system therefore brings each member's opinion to the conversation, resulting in greater overall group satisfaction with the decision-making process.

The proposed method for group decision support is preferred for continuous multiple decision-making processes within the same group. Because it is difficult to input multiple requests simultaneously, it is better to consider each member's request in succession during multiple decision-making processes. For this reason, we aim to apply our proposed model to the cases which have a duration of more than several hours, such as multiple decision-making processes are occurred.

Examples of the content and timing data relating to requests for and provision of information to each group for the purposes of group classification are shown in Table 3. We assumed that questions were asked at the beginning of the conversation, and that relevant information was provided in the cases of group member requests, such as conflicts among members, high tension replies by some members, and extended discussions, as part of the estimation of group status, as well as the intentions and tension of each member.

4 Preliminary Experiment

To test the feasibility of our proposed method of decision support, we implemented trial conversations with several groups of participants. In our preliminary experiment, which took place in November 2015, we measured emotion via EEG and analyzed the speech feature values of specific members in group conversations.

We analyzed test conversations with 24 groups (age: 20-65, four members each); these conversations each lasted for approximately 8 min. In the test discussion, the groups were asked to decide upon a place to have lunch in Tokyo, or to make a plan for a group weekend tour. One member of each group was assigned the task of Emotion analyzer Sect. 2.5, where they were required to measure the emotion ("interest", "like (preference)", "concentration", "stress" and "drowsiness") in the conversation.

We assume that we will apply the proposed model to group discussion in a car. However, we have not prepared the appropriate noise reduction system for a car as yet. Then, we will implement the model in the conference room, which is hardly affected by noise at all. In the next step, we will prepare the appropriate noise reduction system, and implement the test in a car. The results and a discussion about this experiment are shown below.

4.1 Extraction of Groups Status via Utterances in a Conversation

We tested whether the test system would be able to estimate the classification and status of the group by measuring the utterance characteristics of the group members. The test system could obtain large portion of utterance feature values and combine them with the extracted intention of each utterance, in the specific condition such as the conversation with the voice uttered clearly and loudly. Thus, we can say that the inferring of classification and status of groups by measuring the utterance characteristics of their users is possible.

4.2 Degrees of Emotion in a Conversation

When we measured the degrees of the emotions such as stress in the group members in terms of EEG signals, we found similar trends among the members in each group. We found some factors that linked the status of discussion (own proposal, opposite proposal, final decision) with the degrees of the emotion in the conversation.

When an individual heard an opinion that was opposite that of another group member, we observed a change in the degrees of various emotions, including stress. This is shown in Fig. 4. Similarly, when the opinion of a group member was rejected, we observed a change in the degrees of various emotions, including stress. In both cases, the increasing degrees of stress corresponded with an event that the members disliked. This tendency was found in six of the 24 groups.

4.3 Estimation of Satisfaction in a Conversation

The relationship between the degrees of stress in a group conversation for decision-making and the level of receptivity appears to depend on how a member's opinion was received during the group discussion, as reported in Sect. 4.2. Thus, it is likely that the level of satisfaction in a decision-making discussion and the

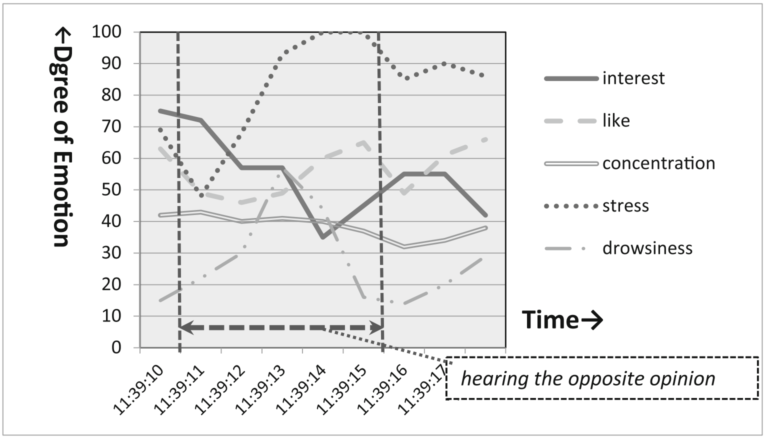

Fig. 4 Example of the emotion in the case of hearing an opposite opinion

resulting final decision can be estimated by extracting the status of each member. The degree of satisfaction may be higher in conversations with lower stress.

The variables identified in the trial conversation may be related to the efficacy of our method, as described in Sect. 3.2. That is, such variables may be useful in attempting to increase the satisfaction of the members in the decision-making conversation. For example, by providing an equal opportunity for proposals from all members, and avoiding cases in which members do not make a proposal or face continuous rejection, the stress of each member may be reduced in decision-making conversations.

Thus, we plan to attempt to support decision-making in group conversations by extracting the status of specific members in the discussion. As member emotions and satisfaction cannot be obtained in ordinary conversations, we plan to extract the status of members in conversation by measuring the utterance features of group member speech. We will continue to study methods to facilitate satisfaction in decision-making conversations according to the variables identified in the trial conversations. Specifically, we plan to further analyze the linked time sequential data of utterance feature values, contents of conversation text, and the degrees of the stress in detail (Sect. 2.5, 4.2).

5 Conclusion

In our preliminary experiments, we measured the degrees of five emotions in a conversation via EEG. We found that some variables were associated with high stress and low satisfaction. Additionally, both satisfaction in conversations for decision-making and final decisions could be estimated according to the status of each member in the discussion. We suggest that satisfaction regarding the discussion and final decision may be higher in conversations with lower stress, and be increased by providing an equal opportunity for proposals from all members. We will continue to study the possibilities for decision support in decision-making conversations.

We also plan to further verify our method via continuous field tests, and we hope to verify that our method can increase group member satisfaction with the group decision-making process via the use of a conversational agent. Specifically, in our future work, we plan to collect many additional kinds of utterance-test data and further clarify the appropriate parameters for estimation and information provision using machine learning and other strategies.

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The Place of Health Design for Health Promotion: The Pediatrics Design Process Focus in Humanization at Santa Casa's Hospital Montes Claros—Brazil

Janice Gomes Zumba

Abstract Child who remains long periods in hospital are the one that suffers most from the influence of hospitals, but is the largest contributors to the humanization of studies. This work has its origin in the project process of Santa Casa de Montes Claros-Brazil hospital analysis focus in the concepts of humanization. It analyses the relationship between the health pediatric environment and the importance of the proposals of the humanization programs dedicated to the admitted child. One APO (post-occupation analysis) was adopted with cognitive approach, in order to diagnose, describe and analyze the built environment, perception and environmental cognition from the point of view of users. As there is a lack of studies in Brazil about that, from the information obtained from this paper, you can to propose suggestions for structural improvements to the hospital that contributes to the effective healing process of patients.

Keywords Humanization · Health design · Healing environment · Pediatric

1 Introduction

As we know the child who remains long periods in hospital or often returning to the hospital is the one that suffers most from the influence of hospitals, but is the largest contributor to the humanization of studies, their perception of spaces and medical interference on your body. Knowing that the attendance based on humanization concepts collaborates with the patient's autonomy, improves the psychological relations of them with the physical space and turns the admission experience into a less traumatic one, this work has its origin in the project process of Santa Casa de Montes Claros-MG hospital analysis focus in the concepts of humanization. It looks for relating the emerging paradigms of modern architecture to health with pediatric units of hospital environment from the investigation and perception of the users

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(patients, companions and workers). It analyses the relationship between the health pediatric environment and the importance of the proposals of the humanization programs dedicated to the admitted child. Involves the perception of spaces from the perspective of the users, showing the appreciation of humanization in pediatric environment as a procedure able to contribute to the therapeutic process, providing physical well-being, mental and spiritual, helping reduce the length of stay in hospital and reducing the consumption of drugs.

However, to understand the hospital space as it is current understood, it is necessary to understanding its transformation, the evolutionary process in which the health institution had been through. Until mid-17th century, the hospital was a kind of tool of mixed exclusion, assistance and spiritual transformation, in which the medical role did not appear. The hospital also had a social responsibility, it essentially was a poor people assistance institution and also of segregation and exclusion. Poor people had the need for assistance, and as ill, a disease carrier and possibly contagious, they were dangerous. For these reasons, the hospital should be there both to gather them, and to protect the others from the danger they represented.

Until the 18th century, the main character in the hospital was not the ill person who needed to be cured but the poor one who was dying. It was correctly said then that the hospital was a place to die, and people who worked at the hospital area were not destined to cure the patient, but to get their own salvation. The patient was someone who should be assisted materially and spiritually, someone to whom the final cares should be given, as the final sacrament. This was the essential function of the hospital [1].

However, by the end of the 18th century, there are records of the first hospital projects based on scientific therapeutic concepts. At this time, the importance of organizing the therapeutic space appears, with the division of patients by pathologies and/or symptoms, as rigorous asepsis practices [2]. Then, by the end of the 18th century, around 1780, the disease was then acknowledged as a pathologic factor and the hospital has become a tool destined to cure. But, the great revolutionary change on the hospital institution was the phenomenon called “Hospital Medicalization”, described as the union of medical and hospital series and, which occurred when the hospitals acquired a therapeutic role with the patients, through functional and administrative command of the medical class. It is on the two processes adjustment—medical intervention displacement and hospital space discipline—the medical hospital is to be found [1].

On the 19th century, the main theme of the hospital architecture was concerning the salubrity of the buildings and the environmental comfort. In England, the nurse Florence Nightingale changed the concept of nursing, by creating the Nightingale infirmary. To her, the main flaws at the hospitals were the lack of ventilation and inappropriate illumination, as well as the overcrowding, which would be solved at the infirmary. Her concept has contributed a lot to the hospital humanization, transforming them in a diseased-aimed institution [3].

It might be said that the first transformation factor of the health space was not looked for a positive action of the hospital toward the diseased or the sickness, but the annulment of the negative effects of the hospital, a concern that has oriented the humanization and can be found at the hospitals until today. Since 19th century the hospital has been transformed from an exclusion space into a treatment and healing space, with this process being conducted by the physician [4]. Despite all the developments, according to Ceccim and Carvalho [5], the children who remains long periods admitted or the ones who regularly return to the hospital are the children who suffer the most with the hospital environment influence.

2 Humanization

2.1 The Humanization Process

In the 1970s the concept of humanization has been discussed in a national symposium named Humanizing Health Care [6]. The movement defended the need to put the patient on the focuses of the treatment and healing processes, and give him power.

There are many scientific research at *Planetree* that prove the application of its concepts brings series of benefits to the patients and other users of health buildings: faster recovery, lesser cost with medicine, requisition of support from nursing reduction, moral elevation on health professional, besides higher productivity and reduction of admission cost. In Brazil, the movement has arrived through an area of Mental Health, with the Psychiatric Reform. The movement sensitized public instances and the Federal Government, with the support of the Health Ministry [7].

The program was developed based on the daily experience of public attendance on health services and on the results of services assessment surveys, which demonstrated the quality of the attention to the user is one of the more critical matters on health care system, more than the absence of a physician.

To Ulrich [8], it is necessary neutralize the patient's tension and the habitual coldness of a health environment, creating a therapeutic environment, or Healing Environment, in which the physical structure participates and contributes on the healing process, with the objective of creating spaces for caring the patient and reducing external sources that may cause stress, which would provide peace, hope, motivation, joyful, reflection and comfort. The physical space interferes positive and negatively on the recovery of the patients, through aspects that might help or hamper the activity, by exposing the patient to infection.

Bitencourt *apud* Nord (2006) [9] shows as the result of the research about "The environment and the perceptive sensorial factors" that comfort is capable of producing relevant results for the humanization of health assistance, for instance: promoting stress reduction of health professionals and improvement of assistant efficiency, improving patient's security, reducing patient's stress and amplifies the possibility of clinical success and promoting a wide improvement on the quality of assistance given.

2.2 Pediatric Wing Requirements

For Dougherty and Simpson [10] it has been made a substantial progress on developing quality measures and implementing improvement strategies for the children health care, this one is still behind while compared to the adults conditions. To make significant progress will demand not only the attention supported by those concerned about the child health improvement and health care, but also activities to build a wide support basis in health care and deciders of the key public. The authors recommend that at least 4 fixed-activities: (1) to build public support to assess the quality and improvement on children health care; (2) to create information technology infrastructure that can make obtaining and using data easier; (3) to improve reliability, validity and feasibility of existent measures; and (4) to create a basis of evidences to the quality improvement measures development.

Considering that the hospital project must consider the necessities and preferences of patients, Ribeiro [11] demonstrates in his studies about humanization of assistances to the admitted child that strategies, which evolve exchanging relations between the health professionals, admitted child and family, should be used. They may be through ludic activities, music, children stories readings. It is also cited the use of the architecture itself as a way to promote well-being to the child and family, also facilitating the development of the work process of health professionals. Reassuring this idea, Brito [12] shows that play therapy has a therapeutic value and it needs to be incorporated in the process of pediatric nursing, for, despite not being effective on Brazilian institutions, the results are pointed by the motivation/gratification, lack of effort, initiative and impotence categories.

The health professionals know that a family has needs, being inseparable part of the assistance. Souza [13] testifies that it is also possible to verify that despite the existence of a strong trend of valuing the technical and mechanical aspects of the assistance represented by direct care, the nursing staff realizes a series of indirect cares that aim an integral and human approach. It is affirmed that is necessary a nursing staff which assists the admitted child to execute dynamically its attention to the providing of the family needs, being apart from a technical template, valuing in this way its job, becoming more visible and humanitarian.

Barrera et al. [14] insists that the best pediatrician to the child is the mother, and sometimes she is excluded on the hospitalization. It is highlighted that benefits have been noticed with the mother presence on the quality of medical attention, keeping the affective relation and the nutritional estate, reducing the infection, reducing medicine and, hence, with a lesser cost on the admission. It is also informed that even some difficulties in keeping them close appear, these would be smaller and solvable, for they may reduce the nuisance of familiar compassion, maternal angst and anxiety. The importance of having psychological support to the family with long hospitalizations is also highlighted.

Silva et al. [15] testifies that on general pediatrics field and on first line attendance, the new ways of understanding the process health-disease and the development on the knowledge about involved factors on disturb genesis are not on an isolated way. The everyday hospital may seize the potential role as therapeutic resource, which allows the child to express his/her emotions, it helps to understand the proceedings that are done and might make the child closer and cooperative to the health staff. It highlights that the results show that the therapeutic toy has been used in Brazil through different ways, from the waiting room of a child clinic to the assistance of children with cancer. It informs that a child enjoys unexpected situations to play and, in all cases, there has been improvement on the patient's conduct concerning the proceedings, a higher comprehension of the family toward the disease and its treatment. It emphasizes that the main difficulties pointed out are little related to the little time available for the therapeutic toy technique application on the daily professional routine.

Therefore, the physical environment can help the relation between patients, companion, nursing staff and medical staff to be issued, the architecture must create spaces dedicated to pediatric treatment. According to Judkins [16], the changes on the physical environment in which pediatric emergencies are treated increase the level of satisfaction of the users, and the staff gets more confident by dealing with patients in a pediatric dedicated area.

To Bergan [17], his work aimed to investigate the aspects of architecture and the environment built on the humanization process of the pediatric hospital and its influence on the recuperation of admitted child. It affirms that at the core of the representation appears the element "attendance", while "reform", "medicine", "organization" and "care" appear on the peripheral system. And concludes by informing that the humanization for these subjects appear to be strongly attached to the right of health and access to services. However, aspects that model the quality of attendance, and that have been listed as humanization, are not neglected. The comprehension, planning and quality of the health building projects with rationalization, adequation and humanization of the spaces have become fundamentally important.

3 Context

3.1 The Santa Casa Hospitals in Brazil and in Montes Claros MG—Brazil

According Leme [18] the hospital came up as a way to control the progress of sicknesses, and also to contribute to the basic sanitation politics.

According to the Revista Tempo magazine [19], due to the clear need of hospital cares in the city and the existence of a licensed physician, it was stablished that the first institutional building that should comprise the structure of the new city would be a hospital. In 1871, fourteen years after the emancipation, it was opened in Montes Claros the “Hospital da Caridade”, after named as “Santa Casa de Caridade”.

In agreement with Santos and Silva [20], Santa Casa de Montes Claros was founded with the goal of gathering the most needed and to improve the health of the city, after all the diseased treatment was conducted, until then, in houses or private clinics.

3.2 Pediatrics in Santa Casa de Montes Claros-MG Hospital—Brazil

The Pediatrics in Santa Casa de Montes Claros hospital is a reference to high and medium complexity, as certified by the CNES (Health Establishment National Register/Cadastro Nacional de Estabelecimentos de Saúde) register, and it has 47 pediatric beds and an average occupation of 80.62 %.

To Souza et al. [21] on the professional day to day of a health space architect and on the living of the health environment it is known that the pediatrics unit is surrounded by some singularities on the hospital context; the child loses the references for being away from home and from all that is common to his/her daily routines. Moreover, the hospital environment causes fear and restrictions. Considering that a child needs more attention and care, and that whichever destabilization in his age group interferes in quality of life and in the development, taking care of an admitted child demands an interaction in the nursing team and the admitted child’s family. This offers various benefits to the recovery of the child, but on the other hand, it might present a source of conflicts that may alter the assistance into a complex exercise, especially due to the possible cultural shock.

However, to Pinto et al. [22] since the family is emotionally shaken due to the disease of the child, taking care of the family is also a responsibility and a moral commitment of the nursing and it is necessary to exist a caring environment that favors the relationship between nursing and family so as to build a practice that helps facing the difficulties, especially in cases of sickness. The hospital, might be understood, by the child and the family as a strange environment: which breeds physical and emotional suffering. This fact makes them exhausted and uncomfortable to take care of the child and, generally, being neglected in its needs, the family has a traumatized experience at the hospital, and so does the child [22].

The assistance professionals refer that the inexistence of a physical structure and proper accommodations imply in a lack of care, not contemplating the necessities of the family in the pediatric unit. To them, the lack of proper accommodations is a potential factor of the hospitalization suffering [23].

4 Material and Methods

4.1 Study Lineation/Research Place

This study is composed of a quantitative, exploratory and analytic study.

The scenario for developing this study will be the biggest hospital in north Minas Gerais, Irmandade NossaSenhora das Mercês Santa Casa de Montes Claros, Minas Gerais, Brazil. General Hospital Class I, awarded ONA level II of excellence, part of Emergency and Urgency (level III), with 385 registered beds in CNES, with 80 % of these destined to attendance through Public Health System. Nowadays it realizes more the 100 thousand proceedings per month and it is registered as a Childen's Friend Hospital. The hospital is a reference in health assistance for more than 110 counties. It has been there for 144 years and it has more than 2.100 collaborators, composed of more than 400 physicians and other professionals, who compose the clinical, assistant and administrative body of the Institution. There are more than 682 employees among nursing technicians and assistants, divided in 48 sectors that include: maternity, medical clinic, pediatrics, surgical block, intensive care unit, among others.

4.2 Participants

This study will count on the universe of nursing technicians and assistants active in Santa Casa de Montes Claros, MG—Brazil. Currently in the pediatric ward has 55 employees between technicians and nursing assistants and 05 physicians to meet 47 pediatric beds.

Inclusion Criteria. The inclusion criteria are: the individual has to be patients, companions, physicians and workers a nursing technician or assistant at Pediatric area Santa Casa de Montes Claros; to be found on the reference sector until a second attempt; to accept the participation on the research under agreement via signing an informing document.

Exclusion Criteria. The exclusion criteria are: individuals who do not work directly in the pediatric area of the hospital or refuse to participate.

4.3 Data Collection

Prior contacting physicians, coordinators, managers and supervisors from the sectors with an objective of propagating the research and scheduling the most proper day and hour for data collection. The tools used by the researches through visitations to the professionals in a previously scheduled hour. The visitations realized by the researches and other collaborators, properly trained and identified. Privacy and free will of the interviewees guaranteed, as well as their working routines observed.

4.4 Tools

To Rheingantz et al. [24] to identify and attribute qualities in a space is a complex task, for the meaning of the place, in most cases, comes from human intentions and experiences of the people who use the space. An APO (post-occupation analysis) is an interactive, systemized and rigorous evaluation process of the built environment performance, after some time of its construction and occupation [24]. On the field research it will be adopted an APO with cognitive approach, with the purpose of diagnosing, describing and analyzing the constructed environment, perception and environment cognition from the point of view of the users, the applied tools are:

Exploratory Visit. Done without a previous course organization and with no influence of other people's opinion. It is part of the concept of incorporated observation, and it also can be defined as "an specific practice that incorporates an open approach of the experience" (Varela et al. 2003) [24].

Walkthrough—With Environmental Inventory. It might be defined as a discussed course, complemented by photographs, sketches, audio recording, in which physical aspects are suited to articulate the participants reactions in relation to the studied environment [24]. The tool enables the descriptive identification of positive and negative points of the analyzed environment, suiting the articulation of the reactions of the subjects in relation to the environment. Used by researcher.

Questionnaire—Structured. A research tool that contains a group of questions related to a given topic or problem (Zeizel 1981) [24]. The tool will be used to enable the discovery or regularities and compare the answers related to a group of questions. Used for staff (coordinators, nurses and physicians).

Visual Selection and Visual Map. The visual map allows the identification of the users' perception in relation to a given environment, with focus on the localization, appropriation, territory mark, inadequacies to existent situations, exceeding or improper furniture and barriers. The visual selection, allows the imaginary to come up, the symbols and cultural aspects, as well as assessing the impact caused by some architectonic typologies, spatial organizations, colors and texture about quality of life and people well-being [24] Used for companions.

Wish Poem. It allows the users of an environment to declare, through drawings, their needs, feelings and wishes related to the analyzed environment, representatives of the demands and expectations of the users [24]. Used for patients.

The APO will be done with patients, companions, coordinators, nurses and physicians in order to understand the demands for the Pediatric admissions, which will allow us to understand the "profile" of the users, and also to comprehend the transformation that the "clients" of pediatric admission pass through. On the APO, it will be analyzed physical structures with notes about: green areas interaction, illumination, ergonomics, family and workers accommodation spaces, nourishment, spirituality, artistic space and if there are other alternative healing practices.

5 Expected Results

It is expected to prove that the spaces perception, from the users' view, reveals the valuation of humanization in pediatric environment as a proceeding capable of contributing to the therapeutic process, providing physical, psychical and spiritual well-being, contributing to reduce the time of admission permanence and reducing the medicine consumption. The research has also the pretension of recommending project guidelines for similar projects.

6 Final Considerations

To elaborate hospital architectonic projects is needed to build environments that attend all sides of health area, in a way that it may be above all functional, pleasant, proper to the needs and not only a structural environment, for, after all, it is an environment which is related to safety, besides beauty and efficiency. As affirmed by Goes [25], health environment architectonic projects go beyond particularities. The building architectonic project on the health sector is a complex challenge. The projects must consider the needs and preferences of the patients, users and relatives. The humanization appears as an ally of these aspirations; to the patients it is strongly bound to the right of health and access to services and not only to the technical character. It is necessary value the work on a more humanized way, which contributes to the well-being of the child and family, besides facilitating the development on the working process of the health professionals, making the admission experience less traumatic.

To discuss the fundamental implications to the project basis, based on the synthesis of records and evidences, makes easier the conceptual development, which may support and guide the conception and assessment of interventions, and as related by Benetti [26] "the well-solved and quality architecture may be a great medicine for health problems".

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Prevalence of Work Related Musculoskeletal Disorders Among the Iranian Working Population in Different Sectors of Industries

HA Yousefi, Ehsan Habibi and Hideyuki Tanaka

Abstract MSDs are one of the major causes of occupational disease in the work places and disability among the work force. A Meta analysis was used to determine the prevalence of the work-related MSDs among the Iranian working population in different occupational sectors. Data were collected from 50 research papers, scientific reports that have addressed the problems on musculoskeletal symptoms for workers in industry, service and health sectors. The techniques were used to study including Nordic Musculoskeletal Questionnaire, Rapid entire body assessment (REBA), Rapid Upper Limb Assessment (RULA), PATH (Posture, Activity, Tools and Handling), Ovako Working Analysis System (OWAS), self-report and the Quick Exposure Check (QEC). Workers were with a mean age of 36.5 years with the average 16.5 years duration of employment in their jobs. Prevalence of MSDs in the target anatomical areas included Neck ranged from (20–81 %), shoulder (30–80 %), low back (30–70 %), Hand and wrist (20–60 %), Knee (40–70 %) and foot (20 %). Conclusion: The highest disorder were observed in back and knee. The epidemiological evidence on the work-relatedness of these disorders is needed thus high quality studies in cause and effect were recommended to show this association. The results likely to be useful to researchers and managers to minimise the occurrence of these disorders through prevention measure.

Keywords MSDs · Population groups · Iranian · Industries · Ergonomics · Ergonomic

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1 Introduction

Musculoskeletal disorders (MSDs) are the most common occupational diseases and represent a substantial cause of morbidity worldwide. The various epidemiological and laboratory-based researches established relation of work to these disorders [1–7].

MSDs are associated with high costs to the employers, the increased health care and worker's compensation costs. It decreases productivity at work because of lost work time and disability. MSDs are frequent causes of absenteeism in developed countries [8–10].

MSDs represent one of the leading causes of occupational injury and disability in the developed and industrially developing countries. Work related MSDs are of interest to multiple areas such as ergonomics, orthopedics and occupational health, workers, and all those involved in disease prevention [11, 12].

Nowadays, musculoskeletal diseases are among the most prevalent occupational diseases. They are one of the main reasons for absence from work and probably reduced productivity. Improper conditions at workplace can result in MSDs. Poor design of workstation, work tasks, static or repetitive load, improper lifting and carrying, and awkward postures and inadequate recovery time could increase this risk of developing MSDs [11–15].

Work-related MSDs describe a wide range of inflammatory and degenerative diseases and disorders. These conditions result in pain and functional impairment and may affect, besides others, the neck, shoulders, elbows, forearms, wrists and hands. They are work related when the work activities and work conditions significantly contribute to their development or exacerbation but are not necessarily the sole determinant of causation. The classification and the need for standardized diagnostic methods for assessment of MSDs and the epidemiological evidence on the work-relatedness of these disorders needed. Intervention strategies in the workplace for the reduction of both exposure and effect should focus upon factors within the work organization as well as actively involving the individual worker [11–14].

An employee who has an MSD diagnosis may experience a limited ability to work, which may in turn lead to lost wages, unwanted time away from the workforce, lowered self-esteem and social disconnection. An employer may experience lost productivity, loss of personnel or a rise in sickness payments and staff absenteeism. Conversely, employees who have better physical and mental health are likely to have lower stress levels and are more likely to engaged and satisfied with their job [6–8, 10].

A major proportion (21 %) of global disability (YLD) is cause by MSDs. The annual cost of work related MSDs ranges from 13 to 20 billion USD; these disorders are associated with both work-related and non-work-related factors; and interventions at the workplace can decrease their incidence [16, 17].

Biomechanical risk factors in the occupational activities, such as repetitive motion, strenuous effort, and extreme joint postures associated with work-related MSDs. [10].

The findings from the Global Burden of Disease 2003 study that show how non-communicable diseases pose an increasing threat to Iranians' health. It is enlisting help from diverse sectors to tackle Iran's health problems, and in work settings, employees and managers across the country can play a role in improving the country's health. The total global disability-adjusted life years (DALYs) indices for low back pain, knee arthrosis and other MSDs reported to be 307772, 291305 and 872633 respectively, which have caused the work related diseases to occupy the second position in the country, after cardiovascular diseases. On the other hand, in accordance with occupational health indices of Iranian health ministry, 37 % of all working population had poor work postures with 15 % of all working population had been working with inappropriate working tools in the year 2003 [18–20].

2 Method

In this study, A Meta-analysis used the data of previous studies to determine the prevalence of the work-related MSDs among the Iranian working population in diverse work settings. Data were collected from N (=50) research papers, that have addressed the problems on musculoskeletal symptoms for workers in agriculture, industry (steel, oil, car, rubber, mine, assembly, dairy, sugar, carpet,), service (administrative jobs, office working, bank,) and health (nurse, dentistry) sectors distributed throughout the country. The citations found in the biomedical science Citation Index, a thorough Web search on the Internet. The following websites searched to collect our database of articles: PubMed, Emerald, Google Scholar, and the sid.ir, magiran, Civilica for articles text in Persian.

The selected articles that used in this study mentioned in the reference list. Criteria for inclusion were outcomes related to musculoskeletal complain in the working population. Common methodological limitations included sampling size, inadequate reporting of reliability/validity of outcome measures, lack of operational definition of work-related MSDs and no statistical significance testing. The resulting 50 articles published between 2006 and 2016, with more than 50 % published since 2010.

The data related to population of 34,519 workers including 28,306 male and 6120 female. They were with a mean age of 36.5 ± 14.5 years with the average 16.5 ± 12.5 years duration of employment in their jobs.

3 Result

Main study on work related MSDs including rates, clinical diagnosis, has been conducted in agriculture, hospitals, industries, ports, mine, construction, administration, housewives and among office personnel, 34,519 workers (28306 male and 6120 female).

Table 1 Gender differences in Prevalence of various work related MSDs in the Iranian working population by occupation sectors

Occupation sector	Total	Percent	M	Percent	F	Percent
Agriculture	1542	4.26	350	22.70	1192	77.30
Health	2363	19.15	2317	98.05	46	1.95
Industry	21815	44.68	21253	97.42	562	2.58
Administration	8908	27.66	419	47.09	4713	52.9

Table 2 Frequency of the Iranian working population by occupation sectors

Variable	Mean	St. Dev.	Min
Neck	39.99	20.21	8.10
Shoulders	37.75	15.22	3.50
Elbows	26.44	21.63	4.60
Wrists/hands	38.46	16.71	4.60
Upper back	43.53	18.73	4.00
Lower back	44.10	19.64	12.00
Knees	46.20	17.93	19.10
Ankles/feet	26.36	17.25	4.00

The methodologies used within these studies (80 %) the Nordic Questionnaire of Musculoskeletal symptoms (NMQ), and 20 % others included Rapid entire body assessment (REBA), Rapid Upper Limb Assessment (RULA), PATH (Posture, Activity, Tools and Handling), Ovako Working Analysis System (OWAS), self-report and the Quick Exposure Check (QEC) methods [20–65].

Prevalence of various MSDs in different workplace reported in Table 1. Gender differences in Prevalence of various MSDs in workers at different workplace reported in Table 2.

All of the 50 studied papers were included in the review inclusion criteria, but five of the studies linked one specific disorder to workers; two of them measured normal and discomfort states. The studies occupation sectors included industry (21 studies), Administration service (15 studies), health (nine), construction (three) and agriculture (two studies).

3.1 Figures

Prevalence of various MSDs in different anatomical region reported in Fig. 1.

Frequency of different occupational sectors were reported in Fig. 2.

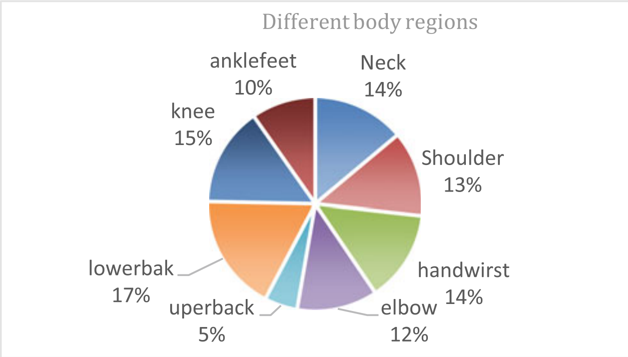

Fig. 1 The prevalence of MSDs in different anatomical area of Iranian workers

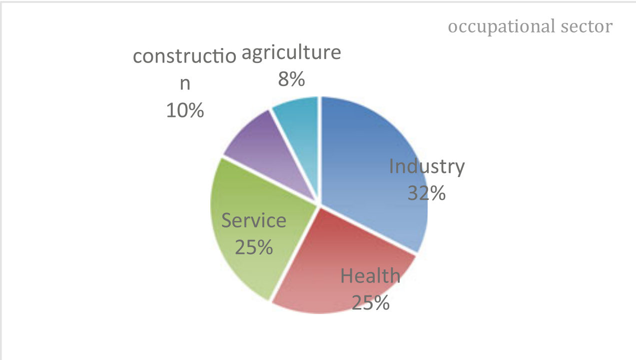

Fig. 2 The prevalence of MSDs in different occupational sectors

4 Conclusion

The most common data-gathering tool was the Nordic Questionnaire (NMQ) that enable to compare results of MSDs among the studied workers.

The prevalent MSDs among Iranian workers population was 37.855 with highest frequency in knee (46.20 %), followed by lower (44.1 %) and upper back (43.53 %).

The prevalent of MSDs in anatomical regions of Iranian workers were including Neck (8.10–83.00 %), Shoulders in industry (3.50–60 %), Elbows (4.60–64.5 %), Wrists/Hands (4.60–56.8 %), Upper back (4.00–79 %), lower back (12.00–81.3 %) followed by, knee (19.10–85 %), Feet and ankles (4.00–68.2 %).

4.1 The Gender Differences in Prevalence of MSDs in Workers Were as Follows

The most prevalent MSDs among Iranian male workers population in different anatomical region were as follow: Neck in administration service (83 %) then in health sector (75.5). Shoulders in industry (60 %) followed by health sector (60 %), and administration service (59.6 %). Elbows in administration service (68.4 %), then in health sector (21 %). Wrists/Hands in administration service (65) followed by health (64.5 %) and industry (59.2 %) sectors. Upper back in industry (83 %), in administration service (79 %), then in health (56.8 %). Lower back in industry (81.3 %) followed by administration service (75 %), and health sector (71.5 %). Knee in administration service (85 %) in industry (64.6 %), and then in agriculture (58.3 %), Feet and ankles in health (68.2 %), followed by industry (37.4 %), and administration service (31.7 %).

The most prevalent MSDs among Iranian female workers population in different anatomical region were as follow: Neck in administration service (75.6 %) then in health sector (54.2). Shoulders in industry (59.7 %) followed by health sector (42.7 %), and administration service (59.6 %). Elbows in administration service (31.6 %). Wrists/Hands in administration service (61.7) followed by health (27.9 %) sectors. Upper back in industry (51.33 %), then in agriculture (41.9 %). Lower back in administration service (59.5 %) followed by (38.5 %) in health sector. Knee in administration service (42.7 %) followed by health (30.6 %). Feet and ankles in administration service (33.7 %).

4.2 The Most Prevalent MSDs of Workers Gender Differences by Various Occupational Sectors Were as Follows

In the agriculture sector the highest prevalence of MSDs were in knee (58.3 %) of male workers, followed by Upper back region (41.9) of female workers.

In the health sector, the highest prevalence of MSDs was in foot (68.2 %) of male workers. Then in neck region of female (54.2 %) followed by male (53.62) workers. low back region (41.9) in male workers.

In the industrial sector, the highest prevalence in male was low back region (46.5 %), followed in knee region (44.3 %) and Upper back region (42.8).

In the administration sector the highest prevalence was in male knee (52.8 %), followed in hand by female (49.47) and male (34.27). Then neck region in female (46.5 %) and in male (41.75).

The Although 50 studies were included in the review; only three of these identified which MSDs linked to Construction. The methodologies used within these studies included PATH (two studies), WERA (one study). The most 80 % of work posture were in a neutral position and about 51 % of them did not lifting during their task.

In agriculture sector, the knee 58.3 among male and hand 41.9 among female, were the mostly reported body part with pain, in health sector neck 54.2 % among male and 53.62 % among female.

In industry sector, low back 46.5 % among male and 27 % upper back among female. In service sector, symptoms in the low back 48 % among male workers and elbow 49.47 % among female workers.

There were statistically significant differences in MSDs by gender of workers were significant ($p = 0.004$), except in the neck region in Health sector because sameness of their jobs MSDs did not significant.

MSDs in male were more than female, because most of the industry workers were male. In administration service they did not engineering our management control measure such as industry, this was reason of high frequency of MSDs among the workers in this sector.

In general, prevalence of disorders of cervical area, shoulders with hands, vertebral column, back, knees, thigh with feet were higher in exposed group due to poor work posture. Meanwhile, female workers inflicted more than males. On the other hand, these disorders seen more with increased work records and age in which, improvement of work postures, training for better execution of tasks and conducting periodic screening tests recommended.

Work-related MSDs were a problem in among the Iranian working population with the prevalence of any musculoskeletal disease ranging from 4 to 85 %.

Despite the increasing research on work-related MSDs, there is no comprehensive survey on MSDs in Iranian workers population.

Therefore we develop this study to understanding of the incidence and prevalence of MSDs in the community, to estimate the relative frequency of musculoskeletal pain in multiple anatomical sites of the Iranian workers population in different occupational sector.

The rapidly increasing global burden from MSDs, also in Iran. The risk of MSDs in Iranian workers is high. Prevention and control of their disability are required, along with health system changes. Further research is necessary to improve understanding of the predictors and clinical course across different settings, and the ways in which MSDs can be better managed and prevented.

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Causes of Workplace Stress in Textile Industry of Developing Countries: A Case Study from Pakistan

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Abstract The Textile industry is the largest manufacturing industry at Pakistan that has good reputation in global supply chains. Organizations want to achieve excellence by optimally utilizing their human capital. Socio-technical complexity of working systems along with high level of expectations, workplace stress management has become an area of deep concern where textile sector is no exception. It is highly important to address stress related issues so that organizations can capitalize benefits related to their human resource by ensuring their well-being at all levels. People involved in management, are expected to be vulnerable to stress because of their critical role in organizations. The objective of this study is to identify causes of workplace stress among managers of textile industry. In this cross-sectional study, data through a questionnaire has been collected from 125 managers from different areas of textile sector like spinning, weaving and apparel manufacturing. Exploratory factor analysis has been carried out where factors like physical agents at work, training and development, support at work, family/work interface, work environment and role have been found to be the major causes of workplace stress.

Keywords Workplace stress · Causes · Stressors · Textile sector · Managers · Organization performance

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1 Introduction

The Textile industry in Pakistan is the largest manufacturing industry in the country. The textile sector is framed up to assume a focal part in country's economy. Pakistan is the 8th largest exporter of textile products in Asia. This sector contributes 9.5 % to the GDP; provides employment to about 15 million people which is about 30 % of 49 million workforce of the country and keeps on being the pillar of Pakistan's exports containing $\sim$52 % of aggregate exports furthermore speaks to the major job creating boulevard in the regulated and big industrial fragment [1].

In the volume of aggregate world textile exchange of about US $18 trillion for each annum, Pakistan's slice is under one percent. Pakistan is the fourth biggest cotton producer ($\sim$12mln bunches/yr), with the third biggest spinning limit in Asia after China and India, and adds 5 % to the worldwide spinning capacity [1]. The different sectors, which form part of the textile value chain, are: Spinning, Weaving, Processing, Apparel/Garment Manufacturing, Socks Manufacturing/Knitwear and Jute Products manufacturing [1]. The sectors under study are: Spinning/Weaving, Apparel/Garment Manufacturing and Socks Manufacturing.

Competitiveness is one of the biggest challenges for the organizations of textile sector. Improvement in the quality, productivity and optimal use of the assets are among the key variables in meeting business requirements. The accentuation of top management towards the improvement in quality and increase in production, put a huge weight on the employees that eventually causes stress. Workplace stress has all through been a typical issue which has now turned out to be more regrettable and its prevalence is increasing day by day. It is the main driver of more than fifty percent of all maladies, however sadly, the reasoning of stress still hasn't been profoundly contemplated. The goal of this study is to find conceivable reasons for work place stress. Literary work, on the subject, has been examined and it has been found that stress is a segment of our lives which is unavoidable; however, treatable.

To get the best results for the organizations, it's highly important to use the HR appropriately. Thus; the prosperity of HR is the worry of countries, nations and companies; where 'workplace stress' is a noteworthy issue for those concerning prosperity of the HR. It is critical to address the stress related issues, as man is a key component influencing execution and security. Steadfastness of the HR is firmly connected with the workplace stress [2, 3].

Numerous studies have been carried out on workplace stress where main emphasis has been observed in sports and employment in general. Some sectors like education where teachers have been observed encountering high level of stress [4–6]. Workplace stress is believed as a genuine wellbeing issue for organizations and employees. Stressful working conditions lead to negative outcomes such as anxiety, cerebral pain, stomach trouble and cardiovascular illness [7]. Stress influences all working in the organization, hence due consideration ought to be given for its end [3]. Be that as it may, the sources, outcomes and potential intervening and moderating elements of the stressor-strain relationship are still not unmistakably saw, along these lines, it is basic to take a stab at better comprehension of the procedure of workplace stress [8].

Stress is coincidental with weakened individuals working at the workplace [9] and a noteworthy obstacle to organizational achievement [10]. Later gauges propose that about 91.5 million working days are lost every year through stress-related ailment [9]. Negative impacts incorporate diminished efficiency, diminished ability to perform, hosed activity and lessened enthusiasm for working, expanded inflexibility of thought, an absence of sympathy toward the organisation and companions, and lost obligation [11].

Research has demonstrated that organizational change, for example, cutting back, execution of new gear or plant and rebuilding, can and frequently leads to stress and increments in harm/disease [12]. Absence of autonomy, poor communication in the organization [13], absence of family friendly policies, poor social environment and "absence of backing or assistance from colleagues and managers" are as considered occupation stressors [5]. Unpalatable or hazardous physical conditions, for example, swarming, noise, air contamination, or ergonomic issues [9, 11, 13] and unreasonable due dates, low levels of backing from directors lead to occupational stress [5]. Also, stress is made when legislative issues instead of execution influence organizational choices. Office politics can be unpleasant for experts and professional workers [14], [15]. Working in a huge, progressive, bureaucratic organization where employees have little control over their jobs can be extremely stressful. Line manager's totalitarian administration style brings about high turnover, high absenteeism, and low level of enthusiasm among their subordinates. An absence of compelling interpersonal communication, exorbitant formality, and apparently unending paperwork has been found exceptionally distressing for internal auditors [6, 14–17].

2 Method

The study involved four stages: In the first and second stages, the goal was to give an investigative hypothetical and methodological base. Wide assortments of records in the form of published articles and reports on work related stress and its possible causes, effects and ways to overcomes have been studied. The goal of the third stage was to investigate the most uncovered occupational circumstances with the high degree of stress, and then putting focus on the recognition of stress risk components in textile sector. The objective of the fourth stage of the project was the elaboration of investigation methodology (beginning the survey in the textile industries: defining the investigation area, the variables/indicators necessary to draw up the questionnaires); and finally the stage for examination of the information retrieved.

2.1 Participants

An aggregate of 125 male and female employees from management cadre have been randomly selected for data collection. Four major areas of textile industry, namely: spinning/weaving; apparel manufacturing; socks manufacturing and home textiles were selected. They were belonging to four different organizations concerning each area. Both male and female employees from different age groups, working on managerial positions were eligible for inclusion in the study.

As the objective of this study was to identify causes of workplace stress among the managers in textile industry, so lower and middle management employees have been involved in this; further divided into 2 categories: supervisors/foremen and managers. They were belonging to different departments of the organizations: which in our study were classified as: HR, Finance, Marketing, Technical, Administration or Any other.

2.2 Survey

A cross-sectional overview outline was utilized to achieve the destinations of this study. Data was gathered by using self-administered questionnaire which incorporated the demographic variables like gender, marital status, department, and years of work experience, position and salary, along with 72 variables for causes of workplace stress. Before managing the survey, prepared specialists disclosed to every subject the motivation behind the study, the substance of the poll and how it ought to be finished. As the respondents filled in the polls, the agents were available to answer any inquiries. Additionally, they instantly checked every one of the surveys for missing information and requested that the members supply the data. To minimize data predisposition and to guarantee that they would not shroud delicate data, all surveys were unknown. The members were consoled that the information would be utilized for exploration purposes just and that the surveys would not be disclosed to the organizations.

2.3 Instruments

The perceived sources of occupational stress in these employees were recognized by researcher-made structured questionnaire. Some of the items in the questionnaire were adjusted from the survey created via Cary Cooper utilized as a part of past studies in UK [18–20]. The numbers of items were lessened according to the extent of this study. More items were included on the basis of extensive literature review. In all there were 72 items that covered the following domains: factors intrinsic to the job, career and achievement, relationship with others in the work, safety, managerial role, and interface between job and social, family life. Respondents were asked to respond different statements on 5-point Likert-type scale, used for each item, ranging from 1 (indicating no stress) to 5 (indicating high stress): 5_ Always or Strongly Agree, 4_Often or Agree, 3_Sometimes or Partially Agree, 2_Seldom or Disagree, 1_Never or Totally Disagree, contingent on the prerequisites of the study. Articulations were similar to, 'I am clear what my duties and responsibilities are', and 'my line manager encourages me at work'. The respondents were to pick one number from the scale as their reactions.

2.4 Statistical Procedures

Since the goal of the analysis was to identify the causes of stress (or variables) from the information, exploratory factors analysis using extraction method: Principal Component Analysis with Rotation Method; Oblimin with Kaiser Normalization was deployed. The suitability of factor analysis as expository apparatus was substantiated by utilizing the Bartlett test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. When components have been recognized from the available information, it is likewise standard to decide the reliability of the components via calculating Cronbach alpha coefficient [21]. For the factual examination, the software program SPSS 17.0 [22] for Windows was utilized.

3 Results and Discussion

3.1 Bartlett Test of Sphericity and the KMO Measure of Sample Adequacy

The examination was started by computing the suitability to continue with factor analysis by method for both the Bartlett test of sphericity and the KMO measure of sample adequacy. The results of these tests are shown in the Table 1. The KMO measure gives back an acceptable value of 0.776. From the same table, the Bartlett's test of sphericity gives back an ideal value of zero (which is less than the required value of 0.05) as well. Subsequently, it can be closed that the quality of the

Table 1 Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and Bartlett's test of sphericity

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.776
Bartlett's test of sphericity	Approx. chi-square	1306.810
	df	231
	Sig.	0.000

relationship among variables is solid and that the information are suitable to be subjected to multivariate statistical analysis (such as a factor analysis).The terms factor and component are used interchangeably here giving the same meanings.

3.2 Exploratory Factor Analysis

Outcomes from the factor analysis are shown in Table 2. Altogether, 6 components were distinguished after rotating the component matrix utilizing Oblimin with Kaiser Normalization. The components names are likewise appeared in the table. An aggregate of 22 items loaded onto the six variables. The statements which did not load onto a particular component with a variable loading of 0.30 or higher have been disposed of. The components have been described in the detail below.

Table 2 Pattern matrix and loadings

Pattern matrix						
Items	Component					
	1	2	3	4	5	6
My job exposes me to breathing fumes, dusts, or other harmful substances (allow to be subjected to an action, influence, or condition; have to face)	**0.915**	0.006	−0.001	−0.029	−0.050	−0.101
I work in an environment where the level of background noise disturbs me	**0.845**	−0.042	−0.022	0.047	0.078	−0.116
Physical dangers exist on work place	**0.723**	−0.244	−0.076	0.003	0.009	0.186
My workplace is too hot	**0.715**	0.093	−0.043	0.083	0.054	−0.016
My job requires me to touch potentially harmful substances or material	**0.709**	0.050	0.006	−0.044	−0.122	0.163
This organization is providing me with job specific trainings	−0.097	**0.813**	−0.134	0.140	0.084	−0.138
I have the opportunity to be involved in activities that promote my professional development	−0.036	**0.797**	−0.139	0.027	−0.042	0.088
There are enough development opportunities for me in this organization	0.028	**0.767**	−0.067	−0.221	−0.058	0.143

(continued)

Table 2 (continued)

Pattern matrix						
Items	Component					
	1	2	3	4	5	6
An employee's career development is important to this organization	0.029	**0.756**	0.057	−0.001	−0.014	0.106
My line manager encourages me at work	0.087	0.104	**−0.825**	−0.016	−0.046	−0.013
I get help and support from my superiors	−0.053	0.165	**−0.766**	−0.042	−0.078	0.097
I can rely on my line manager to help me out with a work problem	0.140	0.002	**−0.766**	0.082	−0.117	−0.078
My job does not allow me enough time for my family	−0.006	0.003	−0.175	**0.869**	0.214	−0.166
I am unable to maintain balance in my work and family life	0.061	−0.002	0.040	**0.766**	−0.093	−0.039
Family worries or problems distract me from my work	0.015	−0.157	−0.045	**0.610**	−0.057	0.247
Family obligations reduce the time I need to relax	0.192	0.083	0.184	**0.589**	−0.222	−0.011
My family life is adversely affecting my work	0.118	0.194	0.272	**0.517**	−0.232	0.162
I experience too much discrimination in the organization	0.058	0.116	−0.006	−0.096	**−0.855**	−0.277
I am subject to personal harassment in the form of unkind words or behavior	−0.025	−0.075	−0.154	0.202	**−0.758**	0.203
I am subject to bullying at work	0.036	−0.100	−0.310	0.081	**−0.681**	0.184
I know how to go about getting my job done	−0.049	0.027	0.017	0.037	−0.023	**0.852**
I am clear what my duties and responsibilities are	0.118	0.191	−0.022	−0.061	0.093	**0.791**

Factor 1: **Physical Agents at Work**. All the items loading onto factor 1 concern with the individual's discernment about the physical and operational conditions of the workplace. Altogether, five items loaded onto this factor, loaded intensely, even one vigorously (more than 0.90) (Table 2). Among the remaining four, one item loaded exceeding 0.80 to the factor and rest three exceeding 0.70. The item loading vigorously is: "My job exposes me to breathing fumes, dusts, or other harmful

substances" (0.915) which implies that air contamination causes trouble; and the other one loaded intensely is: "I work in an environment where the level of background noise disturbs me" loaded as (0.845), demonstrates the vicinity of clamours contamination too. All the other items have also significant leadings (in abundance of 0.70). All the items share a typical pattern, namely the Physical operators at work. In this way, the factor is thus marked as "Physical agents at work". This factor is the most essential factor to be extracted from the analysis because it explains the most variance of all factors. The factor explains more than a third of the total variance explained, namely 25.347 %.

Factor 2: **Training and Development**. Four items loaded onto factor 2 and each had high factor loadings, surpassing 0.70. The items are all concerned to the trainings and professional improvement of the employees. Once again two items loaded intensely (one above 0.80) on the factor. The first item is: "This organization is providing me with job specific trainings" (0.813). The second item is: "I have the opportunity to be involved in activities that promote my professional development" (0.797). The item "There are enough development opportunities for me in this organization", loaded as 0.767 and the item "An employees' career development is important to this organization" loaded as 0.756, and taking a gander at table-3, the mean of this factor is '2.44' which demonstrates that the organizations are not much concerned with the training and career development of their employees. After thought of the four items, the factor is marked as "Training and Career Development". The factor is the second most critical factor as it explains a variance of 16.661 %. However, this is significantly lower than the first factor's variance (25.347 %), the factor is likewise re-graded to be an imperative factor.

Factor 3: **Support at Work**. An aggregate of three items loaded onto factor 3. All these three items have overwhelming factor loadings, one of them is higher than 0.80. Every one of these items has an unmistakable commonness, namely 'support during work'. In essence, the factor is named "Support at Work". The factor explains a variance of 8.771 % and is the third most critical factor. Mean value, of this component, in Table 3 demonstrates a value of 2.234 (on a 5-point scale) with a standard deviation around 1, implying that the majority of the employees are not

Table 3 Descriptive statistics: reliability and variance explained

	Factors (components)	No. of items	Mean	Variance explained	Standard deviation	Cronbach's alpha
1	Physical agents at work	5	2.2640	25.347	1.17405	0.859
2	Training and career development	4	2.4440	16.661	1.01100	0.839
3	Support at work	3	2.2340	8.771	1.08600	0.822
4	Family/work interface	5	2.7160	7.586	0.71400	0.785
5	Working environment	3	2.3780	6.312	1.08200	0.802
6	Role	2	1.8600	4.712	0.81700	0.711

comfortable with the support at work by their line managers. In this way, “support at work” is identified as a stress factor.

Factor 4: **Family/Work Interface**. Five items loaded onto this component. Two items had high factor loadings above 0.80 and near it. Rest three had loadings somewhere around 0.51 and 0.61. All the five items are directly concerned with the work-family life of the employees. In this way, this factor is named as “Family/Work Interface”. The factor explains 7.586 % of the variance. However, seeing Table 3, the mean value of 2.6768 on the 5-point scale (and a standard deviation below 1) proposes that more than a half of the employees are under constant mental pressure in managing their work-family relationship. Beyond any doubt, this could lead to increased stress on them. Thus the factor, “Family/Work Interface” is also recognized as a stressor in the employees of lower and middle management cadre.

Factor 5: **Work Environment**. Three items loaded onto the factor. One of the items had loaded intensely (exceeding 0.80). That is: “I experience too much discrimination in the organization” (0.855) which can bring about a feel of depriveness in employees and in this manner bringing about a stressful situation. The second item “I am subject to personal harassment in the form of unkind words or behaviour” (0.758) which likewise brings about extreme mental pressure along with physical problems adversely affecting employees’ performance. The third item: “I am subject to bullying at work.” (0.681) brings about extreme upsetting circumstance as well. This item had loadings on factor 3 too which is about “support at work”. Since the loading on factor 5 is more on factor 5 and the difference between the two loadings is much more than the threshold, 0.20, hence item is retained (on the factor where loaded intensely) [22]. The factor explains a variance of 6.312 % and is the fourth most vital factor of stress among the employees belongs to lower and middle management cadre of Textile industry. All the three items fit in with the work environment of the organization so the factor is named as, “Working Environment”.

Factor 6: **Role**. Just two items loaded onto this factor. However, these two items have high factor loadings (one greater than 0.80 and other closer to this). The items are: “I know how to go about getting my job done” (0.852) and “I am clear what my duties and responsibilities are” (0.791). Both of the items have shared trait about the role of employees while discharging their official obligations and that’s why the factor is named as “Role”. From table-3, mean value of this factor, 1.86, shows that the employees are not clear about their role in the organization thereupon circumstance is making trouble among them. This factor is recognized as an organizational stressor too. A variance of just 4.712 % is explained by this factor.

Figure 1 show the factor extraction conjoined with variance which demonstrates the substantive significance of a factor. It is imperative to figure that when deciphering a diagram of this sort which speaks about the factors of the study, the bigger variance explained is considered for discourse. For the most part by diagramming these equivalents, significance of every component gets to be obvious. In this case, component one which speaks for ‘Physical Agents at Work’ beneath the causes of stress has a high explained variance whereas the following factor

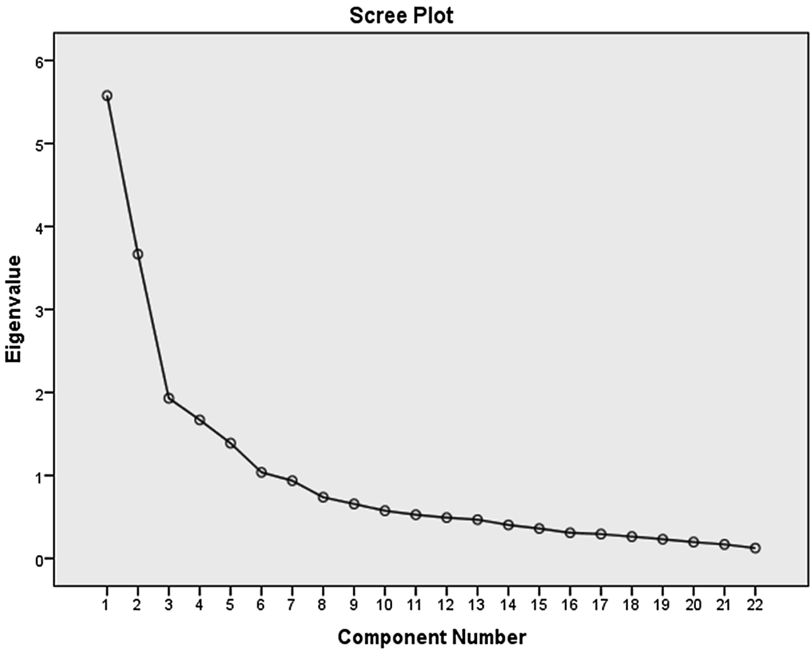

Fig. 1 Point of Inflexion

diminishes altogether in its variance explained. The 'point of inflection' hence graphically speaks to the point of extra minor variance explained by the following factor decreases and the curves flatten. The factors that take after are respected to be less critical than the factors afore the point of inflection because of their minor and absolute addition to the variance explained [21]. This implies that administration ought to commit more thoughtfulness regarding the components explaining higher variance and also those afore the point of inflection in essence capacity administrative inputs ought to yield better returns. Once these components have been taken care of, the focal, could move to the remaining factors. The components explain a palatable cumulative variance of 69.389 %, surpassing the obligatory 60 % variance swimmingly [21].

3.3 Reliability

Table 3 demonstrates the Cronbach alpha coefficients for these factors. In Table 3, components: 1, 2, 3, 4, 5 and 7 all have reliability coefficients that are over 0.70. On warm examination, it is obvious that most of the Cronbach alpha coefficients are more prominent than 0.80, which is respected to be an amazing level of reliability and innate consistency [21]. These eminent reliability coefficients agree with the

Table 4 Component correlation matrix

Component correlation matrix						
Component	1	2	3	4	5	6
1	1.00	−0.052	−0.151	0.344	−0.309	0.174
2	−0.052	1.00	−0.242	−0.035	−0.139	0.156
3	−0.151	−0.242	1.00	−0.003	0.193	−0.022
4	0.344	−0.035	−0.003	1.00	−0.227	0.090
5	−0.309	−0.139	0.193	−0.227	1.00	−0.196
6	0.174	0.156	−0.022	0.090	−0.196	1.00

Extraction method Principal component analysis
Rotation method Oblimin with Kaiser normalization

published material on the sources of stress [23]. Components: 4 and 6, have reliability coefficients of 0.785 and 0.711 which are viewed to be acceptable too, as it surpasses the 0.70 edge dexterously [24].

3.4 Inter-factor Correlations

Table 4 demonstrates the correlations between diverse components. The correlations give back a worth between −1 and 1, meaning perfectly uncorrelated to perfectly correlate. It is obvious that most of them are around 0.1 (and none is beyond 0.5) which is as per the requisite.

4 Conclusion

The point of this article was to set up the reasons for stress among the lower and middle management employees of textile industry. The measurable examination uncovered that physical working conditions; trainings and growth opportunities for the employees; line management support for the employees; work-family relationship; dispositions of the line managers with their subordinates and information of work necessities; and working philosophy are the areas if not overseen legitimately, can deliver a great deal stress for the employees. It is affirmed that sternness working conditions had a direct impact on the employees' mental stress. These six components, brought up above, highlight the possible reasons for workplace stress among the lower and middle management cadre employees of textile sector. At last, in rundown, it is inferred that the six components are critical markers of lower and middle management cadre's stress in textile industry, and that interventions by the organizations are indispensable to turn the corner.

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Quality of Work Life, Depression and Anxiety in Administrative Staff of an Institution of Higher Education

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Abstract The aim of this analytical study was to analyze the relationship between the Quality of Work Life (QWL) and the presence of depression or anxiety symptoms in administrative employees of a public university in Mexico, with a probabilistic sample of 225 people. The CVT-GOHISALO and Goldberg's depression and anxiety questionnaires were applied to the sample to measure their QWL and the presence of depression or anxiety symptoms. Only in one of the seven dimensions of CVT-GOHISALO instrument, the highest percentage of satisfaction was of high level. In all other dimensions the highest percentage of satisfaction was of low level. As for the presence of depression symptoms, 20.9 % of the employees had them and anxiety symptoms occurred in 59.1 %. In all dimensions, the higher satisfaction with the QWL and the absence of depression or anxiety symptoms were related, all crosses were statistically significant. High satisfaction with QWL, is a protective factor for not having depression or anxiety symptoms. The risk of developing depression or anxiety symptoms, is up two times higher for those with low satisfaction levels with their QWL than for those who have high satisfaction levels.

Keywords Quality of work life · Depression · Anxiety · Administrative staff

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1 Introduction

Quality of Work Life (QWL) has been studied in different contexts and related to other variables such as satisfaction, self-esteem, work stress and psychosocial factors among others; all capable of affecting the workers. This has been addressed by different authors for decades, whom have identified the satisfaction that work generates to the employee as one of the elements of this quality and the influence it has had with the management of human resources [1]. Also work psychological wellness has been addressed for the evaluation of QWL, including other dimensions for analysis of the problema [2].

Since the late twentieth century the number of workers who have occupational health or work-related problems has increased exponentially, these problems include unemployment, poor working conditions, risk factors exposure, unpleasant interpersonal relations, stress, temporary employment, among others; in general terms, employment casualization. This has driven the generation of international organizations observations, legislative initiatives and the creation of institutions, whose concern is to improve workers working conditions at the lack of protection that exist by changes in contractual conditions [3].

Quality of Life (QL) relies heavily on people's work activity; time investment and effort given to work suggests that people will have a better and higher level of enjoyment and satisfaction *of* and *in* life. In a detailed analysis of what integrates a person's quality of life, the concept of QWL was created, which includes work humanization and its environment, including: the objective and subjective aspects. The first includes wages, working conditions, job security, work environment, relationships between workers, administrative policies, social position and employment context; while the second aspect refers to working recognition, career advancement, development possibility, achievement, responsibility and self-realization, which means to become all of what one is capable of [4].

When working conditions remain inadequate in labor organizations, the likelihood of psychological disorders are high. The mechanisms that can affect worker's health are mediated by stress response at various levels: emotional response (anxiety, depression, hypochondria, alienation), cognitive level reactions (decreased concentration and memory, learning difficulties at new things, difficulties being creative and decision making), acquire certain risk behaviors to relieve stress (alcohol, tobacco, drugs, destructive behavior) and physiological responses (immunoendocrinological alterations) [5].

Men and women interact in labor organizations, both prone to risks of physical and psychological health as a result of work activities or it's environment (organizational climate), however, according to Artazcoz [6] in the aim of consulted studies is not common to distinguish between gender in terms of strikes or work absences as a result of mental health disorders.

Women participation in global labor market has increased rapidly, even their percentage is fast approaching men's labor force participation. The International Labour Organization (ILO) noted that in the period 2007–2009, there was a trend towards higher female participation in the labor field, represented by the increase of 52.7–53.1 % [7].

The outlook that has been presented in the employment-population ratio over the past decade showed an increase in employment opportunities for women in the services sector. The services sector is characterized for being the economic sector that includes, among others, public administration and so-called public services, as is the education sector.

While the participation of women in the workplace has brought great personal, family and organizational benefits, it has also led them to their own negative effects, whose origin is identified in the labor demands that affect women's physical or mental health.

It is paradoxical that work is defined as the space where the individual finds the posibility to cover much of their needs and, at the same time, is the same space where some workers physical or psychological illnesses are generated from [8].

According to Amezcua and Pando [9] it is possible to notice the increasing number of casualties or work absences for neuropsychiatric diseases or psychological disorders known as dementia, depression, post-traumatic stress disorder and sleep disorders. Based on the above it would be possible to infer that unemployment, job insecurity, employers demands generated by market demand and overall organizational company policy, coupled with workers personal characteristics are determining factors in generating occupational illnesses, such as depression and/or anxiety.

The present study suggests that the QWL is related to the emotional response of female workers, who may have conditions such as depression and anxiety; both disorders have been studied in different environments and different populations; however, it is necessary to highlight that in the Higher Education Institutions (HEI) women constitute the population with the highest labor presence. In the present case, according to the Coordination of Planning and Institutional Development at the University subject of study [10] women predominate by 53 %, while men represent 47 %.

There are few investigations that establish the relationship between QWL and depression and/or anxiety, and even fewer that particularly distinguish between genders. It is important to note that there are little literature on studies to administrative employees in the HEI and the study variables have not been widely discussed in these institutions.

2 Aim

The present study aim to find the relationship between satisfaction with the QWL and depression and/or anxiety of women working in administrative positions of an institution of higher education.

3 Methodology

This is an analytical cross-sectional study, whose universe consisted of the 3358 administrative workers of one HEI in the State of Jalisco; taking to sampling five campuses in the metropolitan area of Guadalajara, 6 Regional University Campus in the State of Jalisco, as well as the Virtual University System, 13 High Schools the metropolitan area of Guadalajara, 5 Regional High Schools and Central Administration of the University.

Instruments that were already tested in other research were used, the CVT-GOHISALO [11] for the evaluation of the QWL and Goldberg's Anxiety and Depression Scale (GADE) which identifies the presence of probable cases of depression and anxiety [12].

The sample was calculated based on the finite population formula, resulting 225 people with a two-stage design. The first stage of sampling was stratified; the same proportion of the universe of administrative staff by workplace was applied to the sample size to know how many people had to be surveyed by dependency and, in a second instance, the employees to whom the questionnaires would be applied were selected by simple random sampling.

The selection criteria were being female and working as a administrative employee, labor antiquity equal or greater than two years and have been randomly selected, excluding all those who did not want to participate.

As for the instruments the CVT-GOHISALO was selected to measure the QWL, wich was developed and validated in mexican population and has validation of content, criterion and construct, has a reliability of 0.9523 with Cronbach's Alpha and measures the QWL in seven dimensions [13].

In the case of depression and anxiety measurement, Goldberg's Anxiety and Depression Scale (GADE) was used in the spanish version, same that was developed in 1988 from a modified version of the Psychiatric Assessment Schedule, validated in castilian version by Montón et al. [14]. It is integrated by two subscales, which are anxiety and depression with 9 items each. The answers are dichotomous (Yes/No) with cutpoint and independent rating for each scale; it assigns one point for each affirmative answer. This instrument allows the detection of "probable cases" of depression and/or anxiety but does not provide information for diagnosis [15].

For results analysis it was used chi square (x^2) and Odds ratio (OR) to determine the strength of association between QWL and depression and/or anxiety.

The study was considered safe, since it is only gathering information without manipulating people.

4 Results

As for the sociodemographic characteristics of the study sample, it can be observed that 32 % of surveyed families are composed of four people, including the studied individual; followed by three people with 20 %.

Regarding marital status, 44 % are married, 36 % are single, 9 % are cohabiting with their couple, 8 % are divorced and 2 % are widows.

An 81 % of workers have vehicle at home, 64 % are owners of their house, followed with 26 % living in a rented house and 9 % are living in a borrowed house.

With regard to the QWL evaluation of the total 225 administrative workers of the HEI: in four of the seven dimensions of the instrument, the administrative staff have low satisfaction, their satisfaction was medium in two dimensions and only in Institutional Work Support dimension their satisfaction is high, as shown in the following table (Table 1).

According to the scale of depression and anxiety applied to the administrative staff, of the 225 respondents 20.9 % presented signs of possible depression (Table 2).

As for the presence of anxiety determined by Goldberg's Anxiety and Depression Scale, 40.9 % of administrative employees presented possible anxiety symptoms, as shown in Table 3.

With respect to the ratio of the QWL with the possible case of depression and/or anxiety, it can be noted that the Institutional Work Support dimension was significant with a p of 0.004, also obtaining an OR of 2.73 indicating it is almost 3

Table 1 Quality of work life in administrative workers

Dimension	High satisfaction	%	Medium satisfaction	%	Low satisfaction	%
Institutional work support	111	49.3	62	27.6	52	23.1
Job reliability	87	38.7	99	44.0	39	17.3
Integration to the job	51	22.7	64	28.4	110	48.9
Satisfaction with the work	35	15.6	52	23.1	138	61.3
Well-being obtained through the job	36	16.0	65	28.9	124	55.1
Worker's personal development	55	24.4	119	52.9	51	22.7
Free time administration	12	5.3	82	36.4	131	58.2

Table 2 Signs of possible depression in administrative staff of a HEI

Depression signs	Frecuency	Percentage
Present	47	20.9
Absent	178	79.1
Total	225	100.0

Table 3 Possible anxiety symptoms in administrative staff of a HEI

Anxiety signs	Frecuency	Percentage
Present	92	40.9
Absent	133	59.1
Total	225	100.0

times more likely than the administrative employees with low satisfaction in this dimension would suffer from depression, compared with 1 administrative employee with medium or high satisfaction of QWL.

In the Job reliability dimension it was also significant the relationship with depresión symptoms, with a p of 0.011 and OR of 2.6 indicating it is 2.6 times more likely that administrative staff with low satisfaction in this dimension would suffer from depression, compared to 1 administrative employee with medium or high satisfaction of QWL.

In the same way as in the previous two dimensions, satisfaction measured in Integration to the job, Satisfaction with the work and Well-being obtained through the job dimensions, the relationship with depresión symptoms had statistical significance and OR value was higher than 2. Only in the Worker's personal development and Free time administration dimensions, no relationship with depression symptoms or OR values that indicate higher risk were found (Table 4).

Like as performed with the depresión symptoms, in the case of anxiety symptoms, the relationship between the low satisfaction with each of the dimensions of the QWL and the presence of anxiety was sought, it was observed significant relationship in all dimensions (Table 5).

Table 4 Relationship between satisfaction with the QWL and depression symptoms

Dimension	QWL Satisfaction	Depression signs	No signs of depression	OR	p value
Institutional work support	Low	18	33	2.73	0.004
	Medium and High	29	145		
Job reliability	Low	14	25	2.6	0.011
	Medium and High	33	153		
Integration to the job	Low	31	79	2.43	0.008
	Medium and High	16	99		
Satisfaction with the work	Low	37	101	2.82	0.006
	Medium and High	10	77		
Wel-being obtained through the job	Low	33	86	2.52	0.007
	Medium and High	14	92		
Worker's personal development	Low	35	89	1.87	0.120
	Medium and High	12	89		
Free time administration	Low	26	105	0.86	0.650
	Medium and High	21	73		

Table 5 Relationship between satisfaction with the QWL and anxiety symptoms in administrative staff of a HEI

Dimension	QWL Satisfaction	Anxiety signs	No signs of anxiety	OR	p value with confidence interval of 95 %
Institutional work support	Low	27	24	1.89	0.046
	Medium and High	65	109		
Job reliability	Low	28	11	2.6	0.011
	Medium and High	64	122		
Integration to the job	Low	56	54	2.28	0.003
	Medium and High	36	79		
Satisfaction with the work	Low	70	68	3.04	0.000
	Medium and High	22	65		
Wel-being obtained through the job	Low	58	61	2.01	0.011
	Medium and High	34	72		
Worker's personal development	Low	59	65	1.87	0.024
	Medium and High	33	68		
Free time administration	Low	58	73	2.26	0.018
	Medium and High	34	60		

5 Discussion

This study was a first approach to the study of the relationship between the QWL and depression and/or anxiety in a HEI administrative workers.

The application of CVT-GOHISALO instrument allowed to respond the first aim of análisis, on the description of the quality of work life of administrative workers.

Satisfaction with the QWL of these employees, was found at a low level in general terms, since in the 7 dimensions, only one had the highest percentage of satisfaction at high level, two dimensions in average level and in four dimensions the highest percentage of response corresponded to low level.

In reference to this Seguró and Agulló [16] noted that the lack of personal development of a worker could be related to not flexible management systems or how communication develops, lack of work promotion and poor job training. Also in an investigation made by the Department of Labor Studies in Chile in 2001 to assess the perception of workers about their QWL, it was found through interviews that the possibilities for personal and professional development were very low, about all by stagnation, gender discrimination, lack of spare time and lack of labor coexistence between different levels [17].

Regarding to the presence of depression and/or anxiety, Gil-Monte [18] commented on the existence of psychosocial risks in the work activities affecting the QWL, caused by the characteristics of the activities, the organization, the employment, the labor intensification, the emotional burdens of work itself, as well as the imbalance between work life and personal life. This author notes that in the VI Survey on Working Conditions in Spain, 70.9 % of workers reported having suffered work accidents, which were related to psychosocial risk factors, distractions, working very fast, tiredness or fatigue, due to workers are exposed to work overload, continuous and repetitive tasks, sleep problems and fatigue.

Different studies have reported the presence of depression and anxiety in secretaries, managers, computer engineers, textile workers, nurses, teachers, social workers, young physicians and petrochemical engineers. Sauter mentions that analysis have been developed in about 104 professions and it has been found that there is a higher prevalence of depression and anxiety in women with professions, female administrative workers and female domestic workers. It has been found a prevalence of 15.6 % among women related to agriculture, forestry and fisheries. The 13 % in male typists, male lawyers and male teachers, standing out especially in jobs that have no direction or planification, as well as those with low pay [19].

According to the World Health Organization (WHO) cited in Mínguez [20], 25 % of the population that has depression has not been diagnosed and the amounts increase according to the country concerned. It also establishes the relationship of depression with anxiety. In Spain recently have detected that depression and/or anxiety are the second leading cause of work absence and the first in long work absences, it has been difficult to quantify the degree of labor incapacity. In the conducted studies concluded that women are more likely to develop this type of psychosocial distress, another feature was found with professions involved with the public.

Likewise it is mentioned that in studies conducted by the WHO it has been observed that the anxiety disorder is the basis for depression up to 75 %. That is, if there is no adequate treatment for anxiety, depression risk can be increased. In the United States the prevalence of depression ranges from 20 to 25 % for women which coincides with the frequency in the administrative employees of the HEI [21].

Regarding the analysis of the relationship between the QWL and depression and/or anxiety in the study population, the frequencies of satisfaction for each of the dimensions were stablished in low, medium and high levels, as well as the frequency in a dichotomously way of the presence or not of risk for both depression and anxiety. It could be observed that the respondents that had a low perception of their QWL presented an increased risk of depression and anxiety, while those who reported a medium and high satisfaction with their QWL, presented lower risk of both depression and anxiety, in all cases tested with chi-square and p values lower than 0.05; this allowed to prove the hypothesis research. When this analysis was complemented by Odds Ratio, it allowed to also identify high satisfaction with the QWL as a protective factor for depression and anxiety.

6 Conclusions

The low satisfaction with QWL is related to statistical significance to the presence of depression and/or anxiety in administrative employees.

The prevalence of depression in the study population was 20.9 % meaning that 1 in 5 workers suffers it.

As for anxiety, the prevalence of 40.9 % tells us almost half of administrative workers of this study are a possible case of this disorder.

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Part V
Accidents and Safety

Stimulation of Voluntary Motivation Toward Safety Management Activities: Activity Inactivation by Mannerism

Keijiro Katayama and Miwa Nakanishi

Abstract Currently, high-risk organizations are implementing various safety management activities such as *collecting incidents* and *pointing and calling*. However, activity mannerisms can reduce the motivation of organization members. In psychology, workers' voluntary motivations are interpreted as a type of intrinsic motivation. One theory posits that intrinsic motivation is increased through internal specifics and adequate gaps in emotion, cognition, and handling ability of the object. We apply this theory to a method that maintains motivation in safety management activities by continuously providing safety-related information at suitable intervals. The pluralistic specific (internal specific) of each worker at a specific time is predetermined by appropriate methods.

Keywords Safety management · Voluntary motivation · Activation

1 Introduction

High-risk organizations are currently implementing various safety management activities, such as *collecting incidents* and *pointing and calling*. If incidents are frequent, the organization can easily show clear, measurable aims. For example, if the safety management activities are shown to halve the number of troubles, workers' motivation is easily engaged. However, if incidents are rare, reporting their number may be insufficient to motivate the workers [1]. Besides the difficulty in clarifying the aim, activity mannerism will also reduce workers' motivation. Rare accidents in organizations often occur when the members' motivation is decreased. In psychology, voluntary motivation is interpreted as a type of intrinsic motivation. Intrinsic motivation is activated in three ways: by internal factors, by interest, curiosity, and the desire to seek information [2], and by action-generated purpose

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[3]. Intrinsic motivation can be summarized as "Do what I want to do." One theory posits that intrinsic motivation is increased through internal specifics and adequate gaps in emotion, cognition, and handling ability of the object [4, 5]. The present study applies this theory to a method that maintains motivation in safety management activities by continuously providing safety-related information to workers at suitable intervals. The pluralistic specific (internal specific) at a specific time is predetermined by appropriate methods. Figure 1 shows the perspective and main steps of this project. This paper reports on step 1 of the project. Our goal was accomplished by two important breakthroughs: (a) distance quantification of each worker's internal, specific, and safety management activities and (b) the relationship between the internal specific and motivation of safety management activities for each worker.

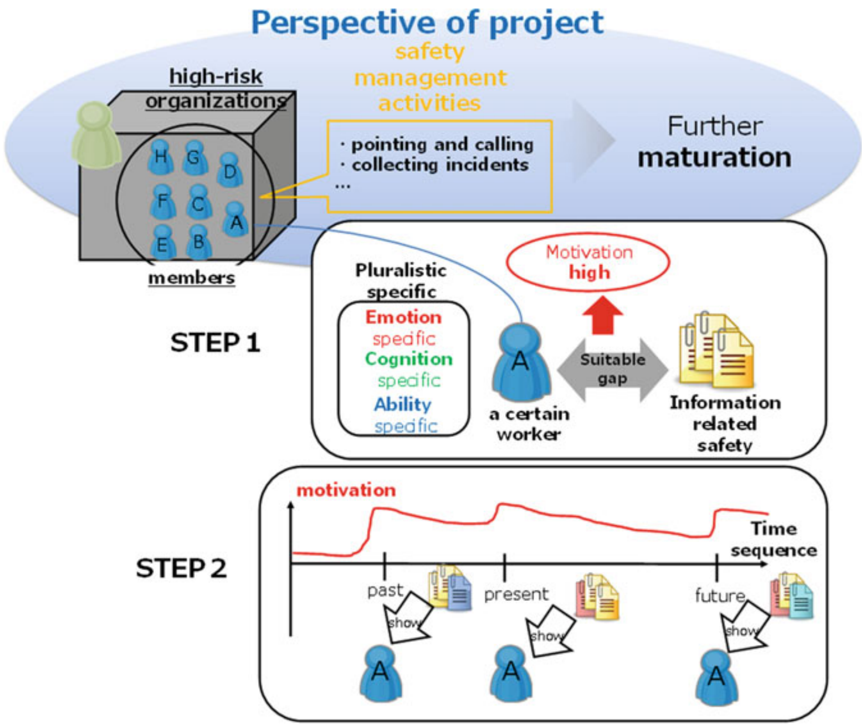

Fig. 1 Perspective and steps of the current project for maintaining motivation in work safety activities

2 Method

2.1 *Distance Quantification of Each Worker with Regard to Internal Specific and Safety Management Activities*

Grouping of Safety Management Activities. We collected 95 information items on safety management activities through personal interviews and from public reports in representative high-risk organizations (medical, aviation, railway, and plant). The information was collated by brainstorming the characteristics of each content and grouping them into 13 items using the KJ method. The items are listed in Table 1. The characterized information was then categorized into 13 blocks by cluster analysis (*k*-means clustering). The 13 blocks (e.g., contact and report and safety inspiring) are listed in Table 2.

Distance Quantification of Workers' Internal, Specific, and Safety Management Activities. We investigated 70 workers from the rail and manufacturing industries and evaluated 13 safety management activities along three scales using a pair-comparison evaluation questionnaire. From the results, we quantified the distance between the internal specifics and safety management activities for each worker. Specifically, we evaluated the workers' scores along an emotion scale (which activity is personally more enjoyable?), a cognition scale (which activity is personally more effective?), and an ability scale (which activity could you best teach to others?). In addition, we evaluated the participants' motivation by asking them which activity they found most interesting. This questionnaire was implemented by a program running on PCs and tablets. Figure 2 shows an example of the questionnaire screen. Each worker's attitude toward various safety management activities was separately quantified on the abovementioned scales by applying the Scheffe method to the provided data. One worker's attitudes toward safety

Table 1 13 items of information characterization

13 items
M-SHELL
The length of service (president, director, section manager, section chief)
Scale of the activity (individual or group)
Participation system (active or passive)
Undergoing training or not
5 senses
Medium with information (paper medium, electronic medium)
Activity contents (positive or negative)
Information sharing with the outside (yes or no)
Competition of duties (yes or no)
Non-technical skill (situation awareness, decision-making, communication, etc.)
4M (men, machine, media, management)

Table 2 13 blocks of safety management activities

Cluster no.	Cluster name
1	Contact and report block
2	Team block
3	Meeting block
4	Education block
5	System maintenance block
6	Safety inspiring block
7	Hearing block
8	Management block
9	Training block
10	Patrol block
11	Confirmation block
12	Improvement block
13	Basic work block

management activities on the emotion, cognition, and ability scales are presented in Figs. 3, 4 and 5, respectively. This particular worker appreciated the training block and evaluated the meeting block lowly. In these evaluations, each of the 13 activities was plotted on a relative scale from −3 (maximally nonmotivating) to +3 (maximally motivating). We also plotted each worker's attitudes in a space generated by three axes representing the three scales. This space was assumed as the internal specific of a worker. Figure 6 shows the internal specific of one participant. This worker rated the training and meeting blocks highly and lowly, respectively. To quantify the degree of each worker's motivation toward each safety management activity, we applied the Scheffe method. The motivation degree of one worker is shown in Fig. 7.

Fig. 2 Example of the questionnaire screen

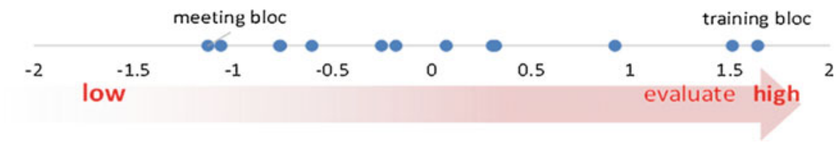

Fig. 3 Attitude quantification of one worker along the emotion scale

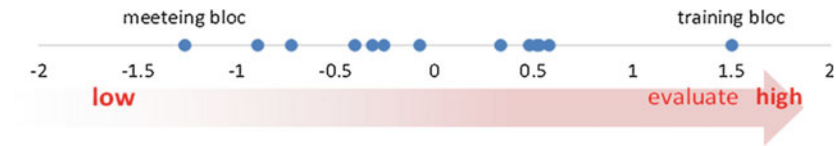

Fig. 4 Attitude quantification of one worker along the cognition scale

Fig. 5 Attitude quantification of one worker along the ability scale

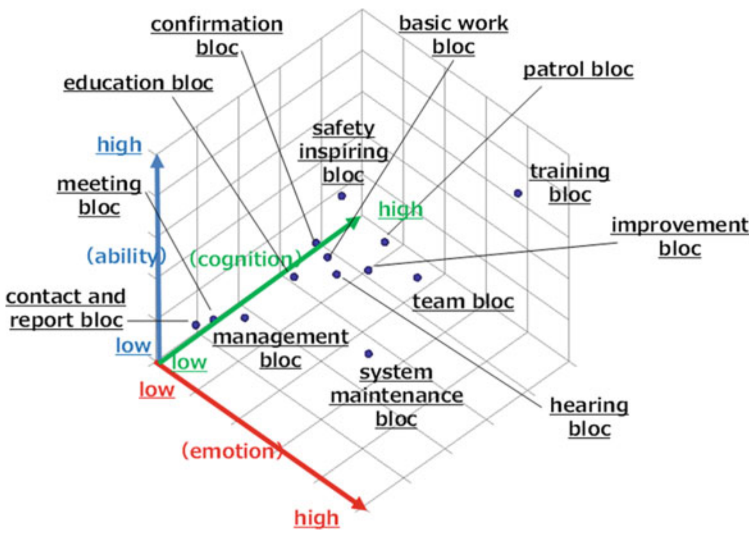

Fig. 6 Internal specific of a worker in the evaluation

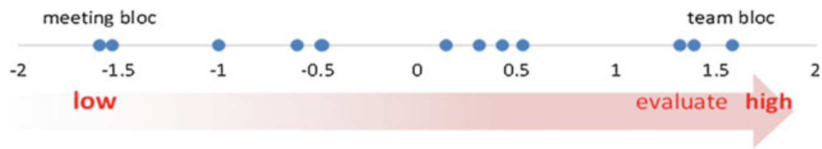

Fig. 7 Degree of motivation of a worker in the evaluation

2.2 Relationship Between Each Worker's Internal Specific and Motivation of Safety Management Activities

For each of the safety management activities, we analyzed the relationship between their positions in the emotion–cognition–ability space and tendency of the motivation. The analysis was conducted as follows. First, each axis on the internal specific plot of each worker was converted to a scale of 0–1 and the variation was standardized. Additionally, the scale was reversed so that higher numbers represented a lower evaluation rather than a higher one; i.e., the shorter the distance, the higher the evaluation. Figure 8 shows the standardized attitude along the emotion axis rated by one worker. The standardization formula is given by

$$p'_{ij} = (p_{i1} - p_{ij})/(p_{i1} - p_{i13}), \tag{1}$$

where i denotes an axis (e for emotion, c for cognition, or a for ability), j is a block index (j = 1, 2,…, 13), and p'_{ij} and p_{ij} are the values before and after the standardization, respectively. Also, p_{e1}, p_{c1} and p_{a1} are the values of the most enjoyable block, the most effective block, and the most mastered block, respectively (the least-scoring counterparts are p_{e13}, p_{c13} and p_{a13}, respectively).

After conversion by Eq. (1), shorter distances refer to higher evaluations. Therefore, the safety management activities plotted near the origin are fun, effective, and mastering, and hence favored by the worker.

We then plotted the standardized evaluations of all workers in the emotion–cognition–ability space. In Fig. 9, this space is divided into 125 grid blocks (5 × 5 × 5) with 0.2-unit intervals. The mean motivation in each grid block was then computed.

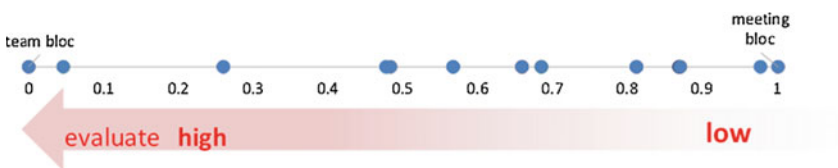

Fig. 8 Standardized attitude of a worker on the emotion scale

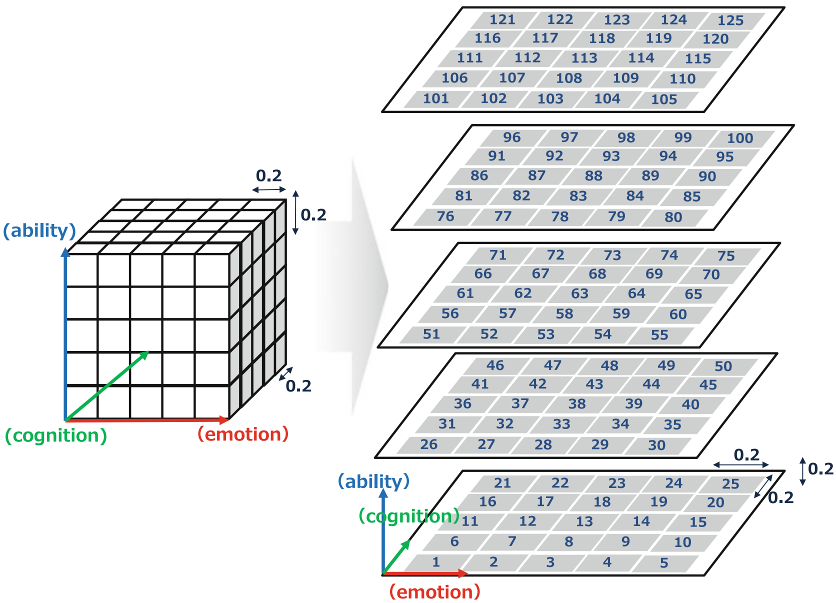

Fig. 9 Division of the motivation space into 125 grid blocks with intervals of 0.2 units

3 Results

Figure 10 plots the scores of all workers for each safety management activity in the motivation space. The colors of the points show the degrees of motivation, where red and blue denote high and low motivation, respectively.

The blue points tend to distribute far from the origin, whereas red, green, and light blue distribute closer to the origin. Therefore, activities that are “not fun,” “ineffective,” and “not mastering” fail to motivate the workers.

Figure 11 shows the mean motivations in the 125 grid blocks, where high and low scores are depicted in red and purple, respectively. The gray regions indicate regions with less than 2 activity scores, where the mean cannot be calculated. Here, we focus on the activities stimulating high motivation. Red and orange regions concentrated around 0.2–0.4 on the cognition and ability axes but were dispersed along the emotion axis. Therefore, safety management activities that stimulate high motivation are concentrated around 0.2–0.4 of the cognition and ability axes. Conversely, safety management activities that stimulate high motivation are lacking along 0.0–0.2 (best evaluation area) of the cognition axis, 0.8–1.0 (worst evaluation

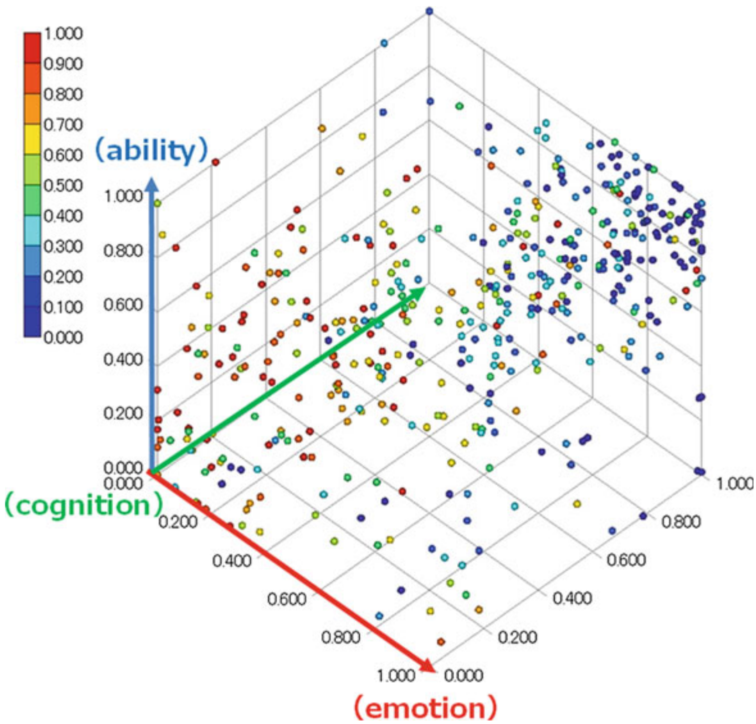

Fig. 10 Scores of all workers in the same motivation space

area) of the ability axis, and 0.0–0.2 (best evaluation area) and 0.8–1.0 (worst evaluation area) of the ability axis. This reveals that workers are not motivated by extreme activities. However, safety management activities inspiring high motivation are rated moderately highly by workers (0.2–0.4). We presume that activities are almost mastered within this area.

Comparing the above results with the psychological theory of *adequate gap* mentioned in the Introduction, we suggest the following.

- Workers are not necessarily motivated by fun, effective, and mastering safety management activities.
- The most motivational safety management activities were rated as 0.2–0.4 on both the cognition and ability axes.
- Motivation to undertake safety management activities is easily achievable.

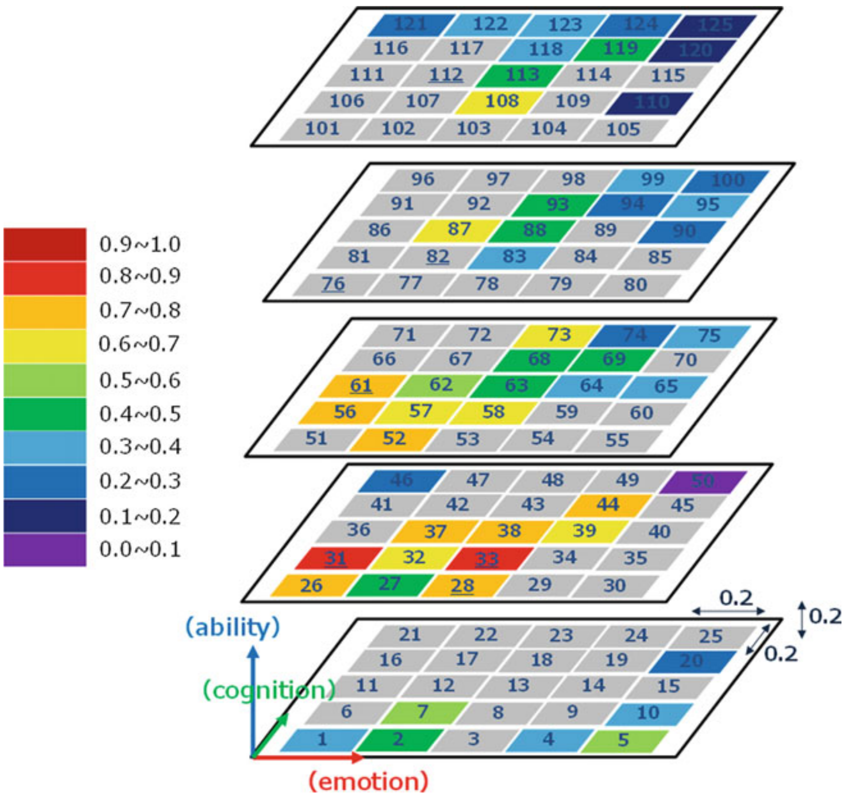

Fig. 11 Mean motivation scores in the 125 grid blocks

4 Application

From the study results, we will develop a method for maintaining workers' motivation toward safety management activities. This goal can be achieved by continuously providing information to workers through tablets or smartphones.

5 Conclusion

In this study, we quantified the distance of each worker's internal specific regarding safety management activities and identified the adequate gap. Specifically, the safety management activities that stimulated high motivation were located at 0.2–0.4 on the cognition and ability axes. The results support our hypothesis; i.e., to maintain motivation for safety management activities, safety-related information should be continuously provided to workers at suitable intervals. However, first, the pluralistic specific (internal specific) of each worker at a certain time should be determined by appropriate methods. Maintenance of workers' motivation is expected to mature the safety management activities of high-risk organizations.

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Development of a Taxonomy of Human Error Causation of Accidents Involving Injuries to Hands in the Harnesses Industry

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Abstract The aim of this study was to develop a taxonomy of human factors that influence human errors and faults that cause injury accidents in hands in the automotive manufacturing industry harnesses. The methodology cultural consensus theory of Cognitive Anthropology with a mixed-method approach to collecting and analyzing data was used. Collection instrument known as free listings to identify about the point of view of members of the security group, successive card sorting was applied in data collection for the classification of the elements of the cultural domain. The statistical models; multidimensional scaling and cluster analysis were applied to obtain mutually exclusive and high-level categories, internal validity and reliability of survey participants were estimated with Cronbach's alpha coefficient. The main result was a taxonomy composed of five categories: unsafe acts, unsafe conditions, personal factors, supervision and organizational factors. Future studies are required to validate the taxonomy.

Keywords Human error · Taxonomy · Accidents · Harnesses industry

1 Introduction

Health and Safety Executive (HSE) describes human factors as the perceptual, mental and physical capabilities of people and interactions of individuals with their job and work environment, and the influence of equipment design and system design on human performance. It also notes characteristics of the organization, which influence safety-related behavior at work [1]. The identification and study of human factors is of particular interest for the field of safety as these factors are involved in human errors. Their field is vast as it "studies the intersection between

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people, technology and work, with the major aim to find areas where design and working conditions produce human error.

Analysis of human error and their role in accidents is an important part of developing systematic methods for reliability in the industry and risk prediction. To obtain data for predictive analysis is necessary to analyze accidents and incidents to identify its causes in terms of component failures and human errors [2]. Therefore, a proper understanding of human factors in the workplace is an important aspect in the prevention of accidents [3], and human factors should be considered in any program to prevent those that are caused by human error.

Human error in accidents has been studied in two different environments. The first one is in manufacturing and the second in high-risk complex systems. The complexity of research in relation to human error is different according to each approach. In manufacturing is oriented to individual accidents (occupational) while high-risk systems approach is focused on organizational accidents. Research in high-risk systems tends to be more complex as organizational accidents, due to it has multiple causes without clear causal links [4]. In the case of occupational accidents, they are associated with unsafe acts that have a big impact, and generally, a person or group of persons is the agent and the victim. In addition, the person or group at risk may be known [5]. One drawback of the current studies about identification and classification of human error and its contributing factors, is that occupational accidents in the manufacturing industry have been neglected to give attention to high-risk complex systems, such as medicine, aviation, military, rail industry and shipping. This implies that there is very little empirical data on human error in the field of manufacturing and it limits the empirical validation of their concepts and classification, in this domain of knowledge.

To prevent and/or reduce occurrence of accidents and incidents, the organizations must work towards reducing human error or making the work system to be more error tolerant. The process of management of human error accidents involves prevention, recovery from errors and containment of the consequences resulting from its occurrence [6]. The first step in this process is error identification, which may allow appropriate prevention and mitigation strategies to be developed for this purpose [7].

The causes of occupational accidents from the human factors perspective have received little attention in the field of scientific research. Available studies related to the topic have been developed mainly for aerospace applications and they have been found insufficient to explain accidents causalities in the manufacturing industry.

The human reliability is defined as "the body of knowledge related to the prediction, analysis and reduction of human error, focusing on the role of the person in operations design, maintenance, use and management of a socio-technical system". The human reliability study aims to human error [8]. Human error is a complex construct that has received constant attention among researchers of human factors, has been consistently identified as a contributing factor in a high proportion of incidents in complex and dynamic systems. The dominant definition of human error is raised by Reason who defines it as "a generic term that encompasses all those occasions in which a sequence of physical or mental activities, fails to achieve its desired result and when these failures cannot be attributed to the intervention of some chance " [5, p. 9].

According to Cañas and Waerns [9], the human error has been studied from three different approaches. The first, taken from the field of engineering has developed a number of techniques known by the generic name of techniques of Human Reliability Analysis (HRA), its basic assumption is that the actions of a person in the workplace can be considered from the same point of view that the operation of a machine. HRA goal is to predict the human error probability and evaluate how the whole system work degrades as a result of mistake alone or in connection with the operation of the machines, the characteristics of the task or the person and the job design system. The engineering methods have been applied in human error analysis in healthcare systems and occupational accidents among which are the method of Failure Mode and Effects Analysis (FMEA), Root Cause Analysis (RCA), Fault Tree Analysis (FTA), Cause Effect Diagram, Study Hazard Operability (HAZOP), Probability Tree Method, Analysis of Human-Machine System (MMSA) and Markov Analysis Dhillon [10]. Although these techniques have made considerable progress in efforts to predict the occurrence of human error, they have been criticized as inadequate. In this regard, Reason [5], points out that, the main difficulty of their application is the estimation of the probability of error. In addition, experts have difficulty making accurate estimates of past or future events.

A second approach is adopted from cognitive psychology; in this case, the interest is focused on knowing the mental processes responsible for the occurrence of errors [5, 11]. The authors state that error are not irresponsible behavior nor occur for poor mental functioning, rather, they may be the result of having ignored how a person perceives, attends, remember and make decisions during the design of the work system. In this perspective, the investigation of causes of human errors is made by analyzing the characteristics of human information processing.

The aim of this study was to develop a taxonomy of human factors that influence human errors and faults that cause injury accidents in hands in the automotive manufacturing industry harnesses.

2 Method

HFACS was developed to identify, analyze and classify human error in naval accidents and mishaps. The taxonomy has been applied successfully to accidents in high-risk systems. However apply this system to occupational accidents in the manufacturing industry has been difficult; for this reason the Human Factors Analysis and Classification System for Harnesses Industry (HFACSH) was developed. In this sense, O'Conor [12] showed that researchers must be careful when adjusting taxonomies that were developed for specific industries, although they show similarities in the general level of the categories, it is likely that this does not happen at the level subcategories, as they depend on the characteristics of the industry and the types of accidents that occur.

The scientific methodology used in the developed of HFACSH corresponds to a combined Cognitive Anthropology approach, with the application of an informal version of the Cultural Consensus Theory. The data collection techniques such as free listing and pile sort (card sorting) were used with cultural domain methods analysis described by Weller and Romney [13] and Weller [14]. These techniques were applied sequentially, that is, each subsequent data collection step was based on the findings from the preceding step, the categories of unsafe acts, unsafe conditions, personal factors and organizational factors were generated from the knowledge of the members of the safety group, composed mostly by supervisors. The supervision category was developed from the knowledge of multifunctional.

Operators and theoretical foundations of HFACS insecure supervision. Consequently, categories and human factors that make up the taxonomy reflect the knowledge that participants have regarding human error and safety system failures. HFACSH framework was integrated by five categories: human error, unsafe supervision, unsafe conditions, personal and organizational factors.

3 Results

A brief description of each casual category is provided in Table 1. The theoretical framework of the proposed taxonomy is consistent with the "Swiss Cheese Model" of Reason (1990), in relation to: the category of unsafe acts corresponds to the active failures, the unsafe conditions, personal factors, supervision and organizational factors are latent failures. In relation to the taxonomy categories there is a complete agreement with those developed for the HFACS, specifically, the category of unsafe acts, which describe human error from Reason's taxonomy, based on the model Skill-Rule-Knowledge of Rasmussen [15].

The category of unsafe conditions is equivalent to the preconditions for unsafe acts, while organizational factors category corresponds to HFACS organizational influences. Human error types described in HFACSH, slips, lapses and mistakes match of Reason's taxonomy predominant types of errors are deviations from operating procedures, standards and existing rules regarding safety and correspond to routine and exceptional violations. The first presented in the skill-based level and occur when the person makes the slightest effort to accomplish the task, the latter are necessary for the fulfillment of the task.

The unsafe conditions category presents a solid theoretical foundation in the conceptual structure of human error, developed by Sharit and Gables [16]. This conceptual framework provides an integrative approach from the perspectives of ergonomics and human factors, cognitive engineering and socio-technical approach. Most factors describing the class, and part of the context corresponding to the technology system, which is part of a socio-technical approach regarding environmental conditions and equipment design workspace.

Table 1 Brief description of human factors analysis and classification system harnesses industry

Organizational factors
Organizational climate. Safety policies, procedures, practices, and the overall importance and the true priority of safety at work
Operational process. The formal process by which the vision of an organization is carried out, consisting of operations, procedures and working methods
Resource management. Human and economic resources, equipment and facilities
Unsafe supervision
Planned inappropriate operations. Management and assignment, including aspects of risk management and the pace of operations
Failed to correct known problems. Those cases where deficiencies among individuals, equipment, training and other security related areas are "known" to the supervisor but are allowed to continue uncorrected
Supervisory violations. The willful failure by the administrators during the course of their duties, in relation to the rules, regulations, instructions or standard operating procedures related to safety
Inadequate supervision. Oversight of management of personnel and resources, including professional guidance, training, supervision resources, motivation, leadership regarding operational safety
Unsafe conditions
Machinery and equipment. Conditions in the machinery and equipment that do not allow the execution of the task safely
Safeguards. The different ways in which human error can be contained
Tools. Instruments that help workers to perform their task
Environmental conditions. Features of the physical environment that may influence occupational accidents such as lighting, noise, vibration, temperature
Personal factors
Physical factors. Physical characteristics of the operators may influence occupational accidents
Social factors. Behaviors resulting from workers' social life that influence occupational accidents
Psychological factors. Behavior characteristics workers that influence in occupational accident
Human error
Mistakes. Errors of conception are based on knowledge and rules established, its detection is difficult, as they can remain dormant over time, can be about rules and knowledge
Slips. Errors that are related to observable facts and are commonly associated with attention deficits, such as the introduction, omission, investment, given orders wrong and untimely actions
Violations. This kind of human error are deviations are operating procedures, standards and existing rules regarding safety, may be: routine, exceptional and sabotage
The routine violations are presented in the level of skill-based behavior and take the least effort to accomplish the task
Outstanding violations are generated in the working conditions and are interpreted as necessary for the fulfillment of the task
Sabotage is intentions to harm people or equipment

According to Reason are known unsafe conditions and underlying causes include poor design of equipment, tools and maintenance failures. The category also presents factors related to barriers. According to Sharit and Gables [16], barriers function is to prevent the propagation of errors that result in an accident. Category factors are located with physical barriers, specifically safeguards machinery. In the model of Swiss cheese defense, this term refers to the various means used to ensure the safety of people and facilities. Accident structure proposed by Raouf [17] presents similarities with that of the category and the author mentions ineffective safety devices as well as its absence, which despite being necessary correspond to physical barriers such as safeguards. Physical, psychological and social issues integrate personal Factors category. In contrast to HFACS, the taxonomy does not show matches within the category preconditions for unsafe acts of HFACS, although it presents a subcategory called personal factors; it is specific for the aviation industry. A new classification within this taxonomy are social factors because such factors are not included in HFACS The category of unsafe supervision was adapted from HFACS taxonomy, the names of the categories are preserved, but their definitions correspond to harnesses industry needs. Supervision is part of the administrative task and could be studied as a subcategory within organizational factors; however, give its importance in preventing risks, it was decided to give the importance of general category. Finally, in the case of the category called organizational factors described failures resulting from administrative tasks of the organization and are theoretically grounded in the model of Swiss cheese defense. These factors are considered by Reason [5] as pathogens in reference to the metaphor with biological systems, because they contribute to latent conditions in work systems. The category was structured with three subcategories: safety climate, operational process and resource management. The conceptual structure of human error and Sharit and Gables [16] provides theoretical support to these subcategories. Taxonomy Application in Harnesses Manufacturing Process.

The data collection was obtained by reports of occupational accidents with lost of work days that occurred during the period from 2001 to 2009 in a Mexican Harnesses Corporation. The amount of occupational accident reports recorded in the database was 368, of which only 225 reports were useful. In order to facilitate data collection form was designed to summarize information about causal factors reported by safety personnel during accident analysis. The category, subcategory, contributing factors and frequency were identified, classified and analyzed using the interpretive method of content analysis. Only four of the five categories that integrates Taxonomy were used, due reports did not present data related to the supervision category. During the analysis of the reports identified the types of injuries caused by accidents and their relationship to human error types. The three types of injuries most frequently were cuts, contusions and fractures with 109, 43 and 23 respectively. Among the types of errors, violations were the most frequent with 141 cases.

The taxonomy was applied in a corporation that manufactures automotive harnesses for the purpose of identifying and classifying the types of errors and their contribution factors whose outcomes are occupational accidents with hand injuries.

The harness is an exportation product, assembled in Mexico and Ciudad Juárez is a city where the mayor companies in this sector (United Technology Automotive, Yazaki, Delphi, Alcoa Fiji Kura, Packard Electric System, Electric Wire Products, and Sumitomo) are located. In 1997, the United States imported 5.9 billion and Mexico supplied 63.4 % of the total U.S. market harnesses. The assembly is done in 58 plants in some states of Mexico: Baja California, Chihuahua, Coahuila, Nuevo Leon, Tamaulipas, Sinaloa, Guanajuato, Zacatecas, San Luis Potosi, Queretaro City, Mexico State, Tlaxcala, and Colima [16, 18]. Harnesses are multiple assemblies with insulated electrical conductors, which are mounted in terminals, connectors, sockets and other wiring products used to connect to a power source (batteries and motors) various electrical components such as lights, instruments and motors and/or care for selected high voltage ignition parts (starters, generators, distributors and spark plugs) in vehicles such as cars, aircraft and ships [20].

According to the results obtained by applying the taxonomy, it can be concluded that accident analysis in the harnesses corporation shows a noticeable tendency to point the worker as the main cause of the accident. In this sense, results coincide with Reason [21] who establishes the human error approach centered on the person. This approach focuses on unsafe acts (errors) and violations of established procedures, and performed by workers who work in direct contact with the production system.

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Ergonomic Risk Assessment of Sea Fishermen Part I: Manual Material Handling

Alessio Silvetti, Elio Munafò, Alberto Ranavolo, Sergio Iavicoli and Francesco Draicchio

Abstract Many epidemiological and questionnaire based studies reported that fishermen had a high incidence of musculoskeletal disorders. To our knowledge this is the first time that manual material handling tasks have been investigated aboard. We investigated several manual material handling tasks in sea fishermen by means of different tools: NIOSH revisited protocol, 3DSSPP and heart rate. We found LI between 2.77 and 6.34, while handling boxes from the boat to the truck, and between 1.63 and 5.83, while transferring boxes outside the cold storage on the boat. Furthermore 3DSSPP© analysis showed low/medium level of low back compression force but low strength capability at shoulder, hip and trunk level. Lastly heart rate measurement while handling crates from the ship deck to the cold storage and inside the cold storage showed a significant increase of heart rate respectively of 42.7 and 40.5 %. Results showed high values of risk for all the tasks investigated.

Keywords Relative cost cardiac · 3DSSPP · CCr · Musculoskeletal disorders · NIOSH protocol · Heart rate

1 Introduction

According to EU data [1], the fishing sector is the one with the highest injury rate of all other sectors. There are several studies reported in literature that confirm EU data [2–4]. These studies, primarily based on medical history survey questionnaires, showed that musculoskeletal disorders are the most frequent diseases among fishermen. Due to the specific characteristics of sea fishermen's work (exposure to extreme temperatures, boat instability, slipperiness of the floor) the commonly standardized protocols for biomechanical risk assessment can hardly be used.

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Several authors [5–7] used physiological parameters such as surface electromyography or heart rate to assess biomechanical overload in fishermen. Also Digital Human Modelling methods [7] or postural analysis methods [8] have been used in fishermen biomechanical risk assessment.

Biswas found an average relative cardiac cost (CCr) of 36 % on 10 land fishermen. Similar values of biomechanical efforts have been found also from Astrand [5] on 14 fishermen. Zhang [7] found high values of surface electromyography (sEMG) from left and right erector spinae and a value of 2643 N at L5/S1 level while handling and stocking 10 kg crates on board simulation; Zhang [7] states that the values obtained are probably underestimated with respect to real working conditions. Lastly Yusuff [8] found REBA values between 7 and 11 in five different lifting tasks corresponding to medium/high risk level.

The aim of the study is to assess, in real working conditions, some manual material handling tasks in which it was possible to use the common standardized protocols or in conditions where although there were some restrictions, assessment according to standardized protocol could provide early indications.

2 Materials and Methods

Depending on the task to be assessed, we utilized the method that best could describe the special features of each task.

NIOSH protocol [9] has been used to assess unloading crates of fish (weight of 12 or 16 kg) out of the boat to the van and while unloading crates, inside the boat, from the refrigerator to the slipway. Due to the large variability of duration, in both tasks we hypothized a short duration (working time <1 h) or a moderate duration (working time between 1 h and 2 h). As suggested by the authors [9], recommended weight limit (RWL) and Lifting Index (LI) at origin and at destination were computed in both tasks.

Unloading crates from the boat to the van has been studied also by means of University of Michigan's 3DSSPP© [10]. 3DSSPP© can estimate lumbar disc compression force at L4/L5 level, strength percent capability for the major joints and worker's stability.

Heart rate (HR) monitor has been used to estimate CCr while handling crates inside refrigerator and while handling crates and using a shovel for scattering ice inside refrigerator; CCr has been chosen because it is a physiological parameter that takes into account the worker's age [5, 11–13]. The method to calculate CCr as proposed by Brouha [11], is below explained:

$$HR_{max} = 220 - age \tag{1}$$

$$CCr = \left(HR_{peak} - HR_{rest}\right) / \left(HR_{max} - HR_{rest}\right) * 100\,\%. \tag{2}$$

3 Results

Table 1 summarizes RWL and LI while handling 12 or 16 kg, for each investigated task and for the working duration hypothesized. Figure 1 shows the crew involved in the investigated tasks.

Table 2 resumes results of lumbar disc compression force, in Newton, at L4/L5 level obtained by means of 3DSSPP©. Figure 2 illustrates the overall analysis obtained with 3DSSPP©. Posture adopted by the operator at the origin (Fig. 2 top) is overloading for trunk, hip and wrist, while destination posture (Fig. 2 bottom) is overloading also at shoulder level.

Figure 3 shows one of the recorded ECG track. CCr of handling fish crates inside cold store was 42.7 %; CCr of handling fish crates inside the cold store and

Table 1 The table below summarizes, for the task investigated, the assessment results carried out with NIOSH protocol. For each task the RWL and the LI has been calculated while handling crates of 12 or 16 kg, at both the start (origin) and end (destination) and for a duration of less than an hour (t < 1) or between one and two hours (1 < t < 2)

Task	RWL	LI 12 kg	LI 16 kg
boat → van (origin and t < 1)	4.32	2.77	3.7
boat → van (origin and 1 < t < 2)	2.52	4.76	6.34
boat → van (destination and t < 1)	4.69	2.55	3.41
boat → van (destination and 1 < t < 2)	2.73	4.39	5.86
refrigerator → slipway (origin and t < 1)	7.36	1.63	2.17
refrigerator → slipway (origin and 1 < t < 2)	4.29	2.79	3.72
refrigerator → slipway (destination and t < 1)	4.70	2.55	3.40
refrigerator → slipway (destination and 1 < t < 2)	2.74	4.37	5.83

Fig. 1 Pictures show the crew involved in the two investigated tasks, handling crates from the boat to the van (*left*) and handling crates from refrigerator to slipway inside the boat (*right*). In this second task NIOSH protocol has been applied to have an early indication of risk, despite environmental conditions and the operator's stability do not allow to use this method (however in mooring conditions and with a value of 0 of Beaufort wind force scale, instability can be considered negligible)

Table 2 Table shows lumbar disc compression force (Newton) at L4/L5 level at origin and at destination while handling crates of 12 or 16 kg from the boat to the van

Task	12 kg	16 kg
boat → van (origin)	3692 N	3946 N
boat → van (destination)	2752 N	3102 N

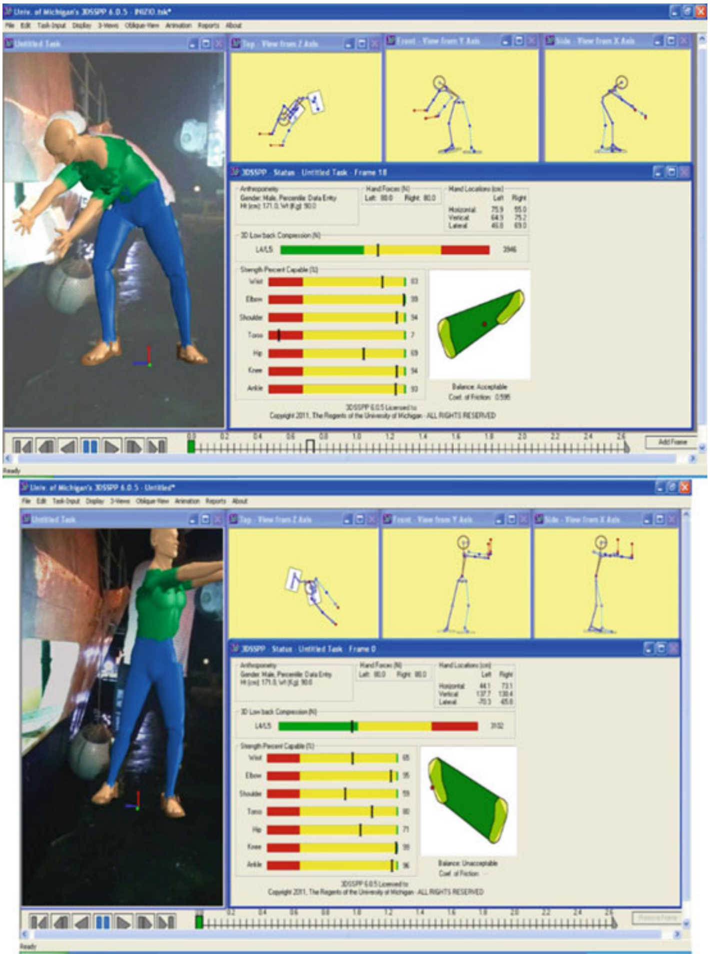

Fig. 2 Images show 3DSSPP analysis while unloading crates of 16 kg from boat to van (*top* is origin and *bottom* is destination). At the *top* the posture adopted by the operator in the three spatial planes (horizontal, frontal, sagittal) is illustrated; in the center lumbar disc compression force at L4/L5 level is illustrated; at the *bottom* are shown worker's stability and strength percent capability for the major joints (wrist, elbow, shoulder, trunk, hip, knee and ankle)

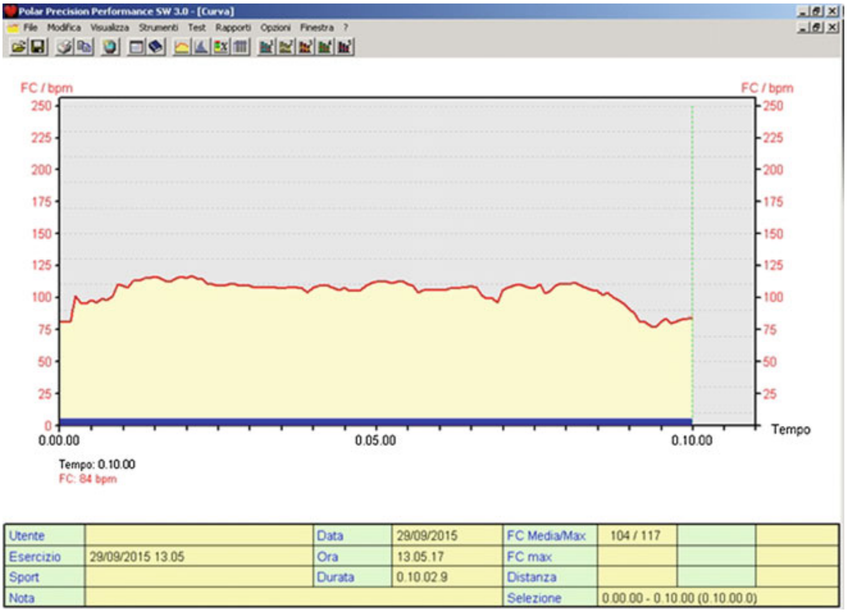

Fig. 3 Image shows an example of the ECG track recorded

Fig. 4 Image shows some improvements adopted by fishermen: a pallet to reduce vertical dislocation (*red arrow*) and load placement at 45° in order to reduce trunk torque (*red lines*)

Fig. 5 Image shows tasks of dragging crates on the slipway. This task can't be assessed with standardized protocols currently available in literature

using a shovel for scattering ice was 40.5 %. Both computed values correspond to a level of risk "probable" as proposed by Chamoud [13].

During the survey, it was observed that crew members, on the basis of their own experience, have adopted improvements to reduce manual material handling risk. Figure 4 shows some of these improvements: a pallet to reduce vertical dislocation (red arrow) and load placement at 45° in order to reduce trunk torque (red lines). During boarding, tasks which can not be assessed with standardized protocols that are currently available in literature, were also noted, such as the dragging of the crates on the slipway (Fig. 5).

4 Conclusions

During boarding we observed several activities that we considered worthy of attention under the biomechanical overload point of view. We investigated only the most strenuous tasks, according to the information provided by the crew. Although the climatic conditions and the instability do not allow the effective use of the NIOSH protocol, we decided to use it to have an estimate of the risk of manual handling. Indeed, despite the environmental conditions and operator stability were not in line with the requirements of NIOSH protocol since in mooring conditions and with a value of 0 of Beaufort wind force scale, instability can be considered negligible. Results obtained using the NIOSH protocol show LIs between 2.55 and

6.34 and a RWL between 2.52 kg e 4.69 kg while handling fish crates from the boat to van. 3DSSPP© analysis reported lumbar disc compression force at L4/L5 ranging between 2752 and 3946 N and low strength percent capability at wrist, shoulder, trunk and hip joints.

Unloading crates from refrigerator to slipway analysis by means of NIOSH protocol reported LIs ranging from 1.63 to 5.83 and a RWL ranging from 2.74 to 7.36 kg.

Analyzing the values of heart rate, we obtained CCr of 40.5 and 42.7 % in the working conditions explained before. Both values fall in the highest risk level score (between 40 and 49 %), as suggested by Chamoux [13].

All obtained values were largely over the proposed limit for all used methods and are consistent with results from studies from all over the world mentioned in the introduction.

We observed manual material handling activities, such as the one shown in Fig. 5, which is not possible to assess with any of the methods currently available in the literature. The study revealed the presence of both ordinary and not ordinary working tasks, that are worthy of attention because may contribute to increase biomechanical risk in fishermen. However due to their features these tasks can not be assessed with standardized protocols currently available in literature because they can't describe the task in its globality or due to their limitations. It was also noted that the workers, based on their years of experience, have adopted enhancements, as much as possible, for the reduction of biomechanical risk particularly by reducing vertical displacement, asymmetry angle and adopting an internal organization of rotation during manual material handling tasks.

There is, finally, the possibility of synergic effects with other risk factors (vibrations, weather conditions, irregular sleep–wake rhythm, work-related stress, upper limb repetitive movements) that, because of their complexity, have not been taken into account in this paper.

Acknowledgments Remembering Romano Conte, friend and fisherman.

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Ergonomic Risk Assessment of Sea Fishermen Part II: Upper Limb Repetitive Movements

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Abstract Despite the continuous mechanization and motorization of vessels, fish sorting and packaging tasks aboard a boat are still not automated due to the peculiar features of the fish sector and the lack of working spaces. To our knowledge, no studies of biomechanical risk assessment on fishermen have ever been made aboard. We found high risk values of REBA score while sorting fish at stern floor due to extreme trunk flexion. Furthermore applying OCRA checklist we found high level of risk also while sorting fish on a table at stern. Lastly we assessed filling crates task by means of surface electromyography (sEMG); we investigated right and left forearm flexor and extensor. We found higher mean values of sEMG for the left side than for the right side. We assessed this task also by means of OCRA checklist using sEMG for force value choice obtaining high risk indexes. Results showed high values of risks for all the investigated tasks.

Keywords Dynamic REBA · OCRA checklist · sEMG · Musculoskeletal disorders

1 Introduction

Despite substantial local differences in fishing methods, several studies [1–3], primarily based on medical history survey type questionnaires, reported that musculoskeletal disorders are the most frequent diseases among fishermen. Grinde [4] found on 878 Norwegian fishermen that during the six months prior to the investigation 77 % of them suffered from musculoskeletal disorders. Torner [5] by a survey questionnaire on 1243 Swedish professional fishermen, found that during

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the 12 months prior to answering the questionnaire 30 % had musculoskeletal symptoms at shoulder, 21 % at hand and 13 % at elbow level. He also found that fishermen estimated an average working time of 68 h/week.

The tasks of sorting, cleaning and filling crates are those that take up most of the time within the production process observed during the three days spent aboard the vessel and are those that, unlike the other many activities that take place on boat, involve the whole crew.

During a first rough sorting on the stern, fish is picked up from the floor; this task can be carried out in a sitting or, more frequently, standing position. Following this first selection, there is a further sorting, carried out by the fishermen in a standing position, where fish is placed on a table by means of a shovel. Finally fish is washed, packaged and carried to blast chiller or to refrigerator.

The aim of this paper is upper limb repetitive movements (ULRMs) risk assessment during the tasks described above using methods that take into account not only the upper limb posture but also trunk and legs movements. We also utilized surface electromyography (sEMG) to objectively quantify the muscular effort. In our assessment not ordinary tasks, such as repairing nets, were not taken into consideration. Such tasks, despite their high level of biomechanical load, were not evaluated due to their occasional nature.

2 Materials and Methods

Depending on the task to be assessed, we utilized the method that best could describe the special features of each task.

Fig. 1 Image shows fishermen while sorting fish on the stern. Due to work organization, some members of the crew carry out this task in a standing position, with trunk bent almost all the time, while part of the crew performs it in a sitting posture

Fig. 2 Image shows crew while sorting fish on a table on the stern

Dynamic REBA protocol [6] has been used to assess the task of sorting fish on the stern (Fig. 1). From a recorded video about 150 frames (one every two seconds) were sampled, thus average REBA [7] index has been computed.

Sorting fish on a table (Fig. 2) has been assessed by means of OCRA checklist [8].

The task of filling crates of cod has been assessed by means of OCRA checklist and sEMG for the choice of OCRA checklist strength values. The fisherman involved in this task takes about 30 s to fill every crate; we acquired the filling of seven crates of cods. Electrical muscle activity was recorded using a 16 channel Wi-Fi surface electromyography system (FreeEMG, BTS SpA, Milan, Italy) at a sampling frequency of 1 kHz.

After skin preparation, surface electromyographic signals were detected from each muscle by two Ag/AgCl pregelled disposable surface electrodes (H124SG, Kendall ARBO, Donau, Germany) which had a detection surface of 10 mm (gelled). Electrodes were placed bilaterally over the muscle belly of Extensor Carpi Radialis (EXTdx, EXTsx) and Flexor Carpi Radialis (FLEXdx, FLEXsx) in the direction of the muscle fibers, according to the Atlas of muscle innervation [9].

In order to elicit the maximal voluntary isometric contraction (MVCi) from each muscle, three isometric exertions were performed, according to the SENIAM indications [10].

The sEMG signals were rectified, integrated with a mobile window of 0.125 s, filtered with a 5 Hz Hamming low-pass filter and normalized to the maximum value of the MVCi. The mean activation value for each muscle was then calculated as percentage of MCVi.

Figure 3 contains a sample of data recorded; Figs. 4 and 5 show fisherman during the task of filling crates of cods.

Fig. 3 A sample of the four sEMG signals recorded. The image shows (from *top* to *bottom*): *right flexor* carpi radialis, right extensor carpi radialis, *left flexor* carpi radialis and left extensor carpi radialis

Fig. 4 Fisherman while filling crates of cods. It is possible to note effort from right extensor carpi radialis

Fig. 5 Fisherman while filling crates of cods. It is possible to note the four probes used for sEMG acquisitions wrapped by a tape to protect them

3 Results

Based on observation and videos, we performed a postural analysis of sorting fish on the stern in a standing posture by means of "dynamic" REBA. The mean REBA score (150 frames analysis) for the right upper limb was 10, instead the mean REBA score for the left upper limb was 8.8. Both scores corresponding to a high level of risk.

The task of sorting fish on a table reported OCRA checklist values of 14.95 for the right upper limb and 12.35 for the left upper limb corresponding to a medium risk (dark red) and to a medium-low risk (light red) respectively.

Table 1 resumes sEMG values (±SD) for each of the four muscles investigated. Figure 6 shows left flexor carpi radialis EMG signal processing.

Table 1 Mean activity (±SD) for each of the four muscles investigated. Values are given as %MCVi

Muscle	% MCVi
Right extensor carpi radialis	16.2 % ± 0.022
Left extensor carpi radialis	24.4 % ± 0.014
Right flexor carpi radialis	20.3 % ± 0.014
Left flexor carpi radialis	30.5 % ± 0.018

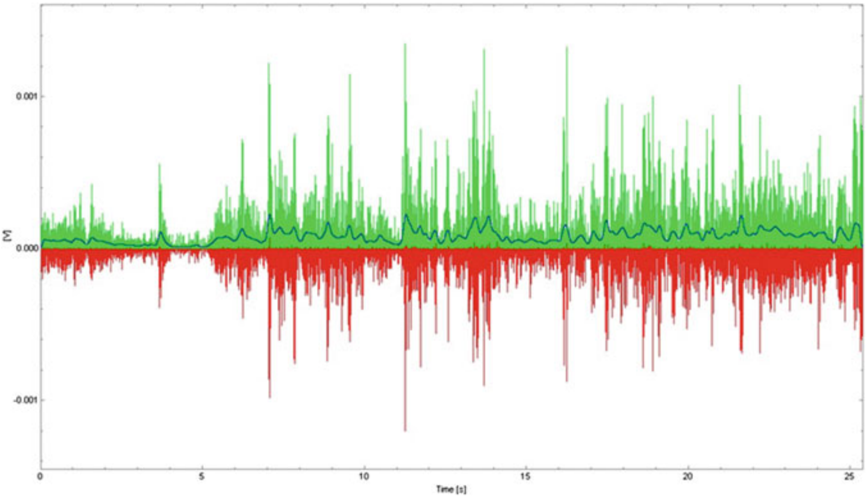

Fig. 6 Image shows *left flexor* carpi radialis sEMG signal processing: "raw" signal (*red* and *green*), rectified signal (*green*) and filtered signal (*blue*)

OCRA checklist scores, using sEMG values shown in Table 1 for force criteria selection, were 13.5 for left upper limb and 11.5 for right upper limb, both corresponding to a medium-low risk level (light red).

Figures 7 and 8 show workers while sorting fish on stern. It has been considered the particular sitting posture adopted by the fisherman with one knee fully extended and the other in a flexion of 90°. Figure 8 shows some improvements voluntarily conceived by fishermen: a stool to improve their sitting and a mutual back support.

Fig. 7 Image shows worker while sorting fish in his common sitting posture

Fig. 8 Two members of the crew while sorting fish in their common sitting posture on the stern. *Red circles* highlight the improvements adopted by the workers: *1* to use a stool for a more comfortable seat *2* mutual support to reduce load at lumbar level

4 Conclusions

The task of sorting fish on the stern assessed by means of “dynamic” REBA reported high values of risk for both upper limbs (10 right upper limb; 8.8 left upper limb) as claimed by Yusuff [11] that, unlike the current paper, used the “static” REBA protocol; the main risk factor affecting the increase of REBA score is the high trunk flexion found in almost all the sampled frames.

The task of sorting fish on a table reported a medium risk (14.95 OCRA index—dark red level) for right upper limb and a medium-low risk (12.35 OCRA index—light red level) for left upper limb; the main risk factor in this case was the frequency of technical actions (75 technical actions/minute). The use of force wasn’t significant since in this phase mainly small fish was selected (prawns and shrimps).

The task of filling crates of cod was assessed by using sEMG; due to the weight of fish, that was always more than 1 kg up to 3–4 kg. sEMG results show mean values of muscle activity included between a minimum of 16.2 % for the right extensor up to a maximum of 30.5 % for the left flexor. Overall, left upper limb was more involved than right because of the workstation placement; indeed left upper limb was used by fishermen for taking the fish and put it into the crate, while right upper limb was used only to put fish into the crate.

Risk assessment by means of sEMG and OCRA checklist reported scores of 13.5 for left upper limb and 11.5 for right upper limb (both corresponding to a light red level of risk).

Upper limb repetitive movements activities were observed, such as the one shown in Fig. 6, which is not possible to assess with any of the methods currently available in literature. It was also noted that the workers, based on their years of experience, have adopted enhancements, as much as possible, for the reduction of biomechanical risk, particularly by using a stool to improve their sitting and by mutually support their back. In this paper not ordinary tasks, such as repairing nets, were not considered. This tasks, despite their high level of biomechanical load, were not evaluated due to their occasional nature.

We hypothesize the possibility of synergic effects with other risk factors (vibrations, weather conditions, irregular sleep–wake rhythm, work-related stress, manual material handling) that, because of their complexity, have not been taken into account in this paper.

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A Novel to Approach to Quantify the Risk Probabilities for a Risk Analysis Methodology

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Abstract There are many risk analysis methodologies to assess the working environments and the tasks. Some of the assessment templates provide generalized frequency, probability and severity values. However, the risk analysis may be successful only if the forms are filled out by experts. The frequency values vary in a specific range and these values have significant importance for determining whether the task or process is in a high or moderate risk level. Therefore, this study presents a novel methodology to obtain more realistic frequency weights. For the purpose of the study, a crane operator who is performing a material handling task is asked to wear a mobile eye-tracker. Data is gathered from the external video recordings and eye movements. The frequency of the predefined risks is calculated from such data as fixation counts and durations regarding with risk factors.

Keywords Risk assessment · Mobile eye tracker · Crane operator

1 Introduction

Risk assessment methods are convenient tools to easily quantify and interpret the risk factors in work environments. The methods are more conceptive especially if the operator is stationary in the work station. In such a case, deciding the risk factors and evaluating them through risk assessment method become a more structured way. However, tasks such as crane operation, require being mobile. Therefore, it is not enough to define the risk factors around the worker, but also it is necessary to understand when the operator gets closer to the risk factors. Since the requirements of considering multiple stimuluses, signs and control panels, crane operation is one of the most risky tasks in a manufacturing plant. In this study, a

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crane operator who is in charge of transferring heavy and massive materials in a steel tube manufacturing facility is considered. Crane operator's task is defined as to transfer the materials that are requested by relevant work stations. During performing the tasks, the operator has to follow the walk way of the workplace besides controlling the crane. This working condition forces the operator to split up his attention for obstacles on the walkway and crane control that leads to a risk for the operator. Therefore, an approach is introduced to quantify the risks through mobile eye-tracker data which may indicate risk perception level of the crane operator.

1.1 Mobile-Eye Tracker

Relevant data were collected through a mobile-eye tracker. Mobile eye-tracker is the most advanced technology among eye-tracker systems. These systems allow conducting experiments anywhere that are related with mobile subjects. They are able to provide totally the same data (fixation, saccades, gazes, pupil sizes etc.) as the other type of eye-trackers. In this study Tobii pro glasses 2 (Fig. 1) was used to gather the data.

Mobile eye-tracker technology allows researchers gathering data from real environments, some studies that are conducted outside the laboratories have become published. One of them [1] focused on performances of expert and novice mathematical teachers. They compare expert and novice teachers in terms of behavior and cognition through the distribution of fixations. On the other hand mobile-eye tracking may become a useful tool in manufacturing as well. Quality Control workers, assembly line workers, material handling operators etc. can be evaluated in terms of cognition and effects of work environment.

1.2 Risk Assessment Methods

Risk assessment can be defined as a structured approach for describing and quantifying the risks associated with dangerous conditions, processes and actions [2]. More than half of the occupational risk related studies choice to use quantitative risk assessment methods [3]. Most of the quantitative risk assessment methods are usually based on observation, expert evaluation, formulation, scoring and interpretation. Most known qualitative and quantitative methods in the literature can be listed as:

Fig. 1 Mobile eye-tracker

- L-type Matrix Method
- Fine-Kinney Method
- What-If Analysis
- Check-Lists
- Failure Modes and Effect Analysis
- Hazard and Operability Method

These methods are useful for quick evaluation of the risk factors. However, they are not completely applicable for working environments where work stations are not defined exactly.

1.3 Crane Operation

Crane operation is an essential component of material handling systems. It is a task that serves multiple stations in a plant. Crane operators are usually under risk of failure that may harm themselves or other workers since they handle the heavy and massive loads. On the other hand, work conditions of the operators are very dependent on exogenous factors such as facility layout, predefined walkways, design of cabinets etc. There are various types of cranes which are used in manufacturing plants. Overhead cranes are one of the best-known cranes. Some of them have cabinets but some of them don't. Overhead cranes without cabinets require operators to walk through the materials handling route. Thus, the operator must both follow the walking way and keep an eye on the crane. This makes crane operation a high-risk task in terms of both cognition and physical.

2 Implementation

The aim of the study is to introduce a new approach to risk assessment and risk factor prioritization for tasks such as overhead crane operation in manufacturing facilities. A mobile eye-tracker was used as a tool for its capabilities to gather data regarding cognition and work environment. One overhead crane operator wearing eye-tracker participated the study. Two hours of data was gathered in two different time periods. The study was completed in a tube manufacturing facility that deals with massive and heavy steel coils.

At the first stage of the study, the risk factors regarding overhead crane operator in the workplace were identified. Data was collected by use of an eye-tracker at the second stage. Each risk factor's screenshot was taken and areas of interests (AOIs) were determined by considering how they can be hazardous in the walkway of the operator. These data were evaluated in terms of frequency of encountering the risk factors (Interval data) and disturbance of the operator (Fixation data). The steps of the approach are represented in Fig. 2.

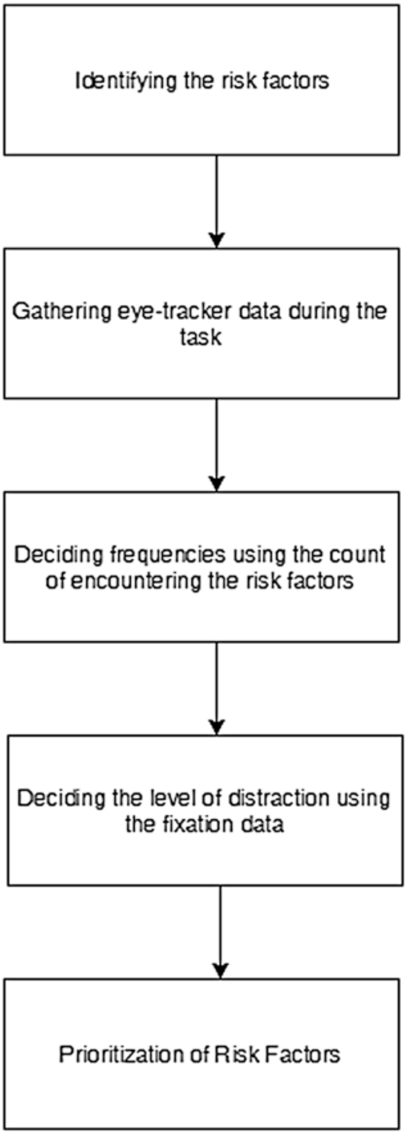

Fig. 2 Steps of the approach

Based on the records, main identified risk factors can be classified as:

- Machine parts on the walking way (partly block the way) (Fig. 3)
- Intermediate products on the walking way (Fig. 4)
- Extremely narrow hallways (Fig. 5)
- Steel coils on the walking way (Fig. 6)

Fig. 3 Partly blocked walking way

Fig. 4 Intermediate products and other equipment narrowing the way

Fig. 5 Extremely narrow hallway

Fig. 6 Steel coils on the walking way

Every risk factor has a potential to cause accidents for overhead crane operator. In case of an accident not only the operator gets injured but also it is possible that he loses the control of the crane and other workers may be seriously injured.

According to the eye-tracker data, Table 1 is acquired. The exposure counts are calculated by using AOI's Interval counts and durations. The most frequent risk factor is determined as A1 (see Fig. 3) and the longest exposure duration belongs to B4 (see Fig. 4).

Table 1 Exposure data

Risk factors	Total count of exposure	Total duration of exposure (secs)	Frequency (counts per hour)	Exposure duration Percentage (%)
A. Machine parts on walking way				
A1	15	144.80	7.56	2.03
B. Works in process on the walking way				
B1	2	5.57	1.01	0.08
B2	13	209.00	6.55	2.93
B3	2	31.20	1.01	0.44
B4	6	1269.00	3.03	17.77
C. Extremely narrow hallways				
C1	3	20.83	1.51	0.29
Total Recording Time: 7140 s				

Table 2 Fixation data

Risk factors	Total count of fixation	Total duration of fixation (secs)	Frequency (counts per hour)	Fixation duration Percentage (%)
A. Machine parts on walking way				
A1	566	18.87	285.38	0.26
B. Works in process on the walking way				
B1	8	0.27	4.03	0.00
B2	961	32.04	484.54	0.45
B3	44	1.47	22.18	0.02
B4	41	1.37	20.67	0.02
C. Extremely narrow hallways				
C1	38	1.27	19.16	0.02
Total recording time: 7140 s				

Table 2 summarizes fixation data. It is clear that the operator's attention was split up and he felt that he had to watch these hurdles on the way. The most distracting factor is determined as B2 (see Fig. 6) and the second one is A1 (see Fig. 3).

3 Conclusion

This study is one of the initiatives for using of mobile-eye tracker in manufacturing facilities. The suggested approach may be useful to evaluate multilateral risky tasks. the contribution of the study is to consider human factor directly instead of observations. A pilot study was conducted and risk prioritization was completed. The risk factor which has the largest number and longest fixation duration of fixations is determined as the large steel coils blocking the walkway where crane operator needs to walk safely. Future studies may focus on relayout of the facility and assess the effects on risky areas.

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Methodology of Risk Analysis to Health and Occupational Safety Integrated for the Principles of Lean Manufacturing

Eduardo Ferro dos Santos and Letícia dos Santos Nunes

Abstract This study aims at presenting a methodology for risks analysis that is carried out incorporating the practices of Lean Manufacturing. This approach shows the opportunities of integrating health and occupational safety with methodologies of process performance improvement and problem analysis. The methodology is supported on the results of the application in a work unit through the development of a focus group that followed a technical and scientific model developed with the integration of theoretical precepts of lean in risks analysis.

Keywords Ergonomics risk analysis · Lean ergonomics · Health and occuptional safety

1 Introduction

It is not unlike all other business areas, ergonomic risk management has received big pressures, like: the very strict requirements of current legislation; the growing demand of clients who require process improvements; high expenses with accidents and diseases, requirements demanded from regulatory organs and the high technological advancements of the resources applied (automation, reengineering, quality, environment), that, more and more, are getting part of industrial processes.

So that they can survive in this environment, the organizations need to look for methodologies and management systems to lead their businesses. Quality and ergonomics management systems are closely linked through objectives and definitions in common [1]. Ergonomics programs as ergonomics management at the companies are key elements to the implementation of an ergonomic culture, working

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environment conditions and increase of productivity. All management methodologies and techniques are valuable. It makes necessary a clear and precise analysis of some aspects before the selections, such as: business segment, organizational culture, comprehension of the concepts of the methodology and its applicability [2]. The top leadership team of the organizations has many doubts on identifying the best methodology or technique to be applied, and very frequent they bring the following questions: how to choose the methodology or technique that will suit better the needs of the business? Which of them fits in the culture of the company? [3].

2 The Analysis of Ergonomic Risks

In this study, integrated methodologies of improvement management will be discussed, more specifically Lean Six Sigma and the practice of ergonomic risk analysis—ELSS—Ergonomic Lean Six Sigma. The approach becomes more and more necessary once ergonomics is considered to be a science that aggregate many objectives, such as health, safety, quality, efficiency and comfort [4], that can also be defined when Lean Six Sigma projects are mentioned.

Integrating the ergonomics with Lean Six Sigma initiatives may mean a systematic-efficient-result-driven application. The proposed methodology of this paper does not tolerate the exclusive experts' opinions and intuition. The decisions are made through a participative view and the projects are led based on data analysis. The key is the quality of information about the ergonomic risks and the justifications of proposals of improvements.

The use of DMAIC (define, measure, analyze, improve, control), proposed on Six Sigma [5], is the strategy that guides the method, termed ELSS—Ergonomic Lean Six Sigma [6]. The analysis aims at the reduction of losses, unnecessary movements, and other concepts proposed by Lean philosophy [7]. Table 1 shows

Table 1 Interconnection of Six Sigma, lean and ergonomics

Ergonomic lean Six Sigma					
Six Sigma	Define the project	Handle the existing losses	Analyze (cause and effect)	Increment (improve the process)	Control the improvements and the gains
Lean	Define the project and the demand	Map the process	Analyse (cause and effect)	Increment (improve the process and reduce the losses)	Control the improvements and the evidences
Ergonomics	Define the demand, reformulate the demand	Analyze the task, pre-diagnosis	Analyse the activities, diagnosis	Propose improvements	Validate and confront the improvements
ELSS	Define	Modeling	Analyse	Increment	Control

these interconnections of ergonomics, Lean and Six Sigma in relation to what is connected with the solution of problems that is proposed by ELSS.

The steps of the proposed method are the following:

- In the steep D, there is the definition of the project (or the situation to be assessed, and its guiding objectives, known as demand)
- In the step M, that for Six Sigma stands for Measure, in ELSS means Model, once it involves the work, tasks and organizational protocols and also includes the need of measuring.
- At the step A, all concepts are about the analysis itself.
- The step I is the moment of improving or increment.
- At the step C, we control, prevent from prospective troublesome situation and implement the management, the control of the situation.

Some relevant technical and conceptual aspects for the comparison of these methodologies are illustrated in the table below (Table 2).

Table 2 Comparison of methodologies (Adapted [3])

Methodology	Six Sigma	Lean	Ergonomics
Theory	Reduce variations	Eliminate waste	Improve working conditions
Guidelines for application	Define, measure, analyze, improve, control	Identify the value, identify the chain, Flow, Pull, Improve	Demand, task, activity, diagnoses, improvements
Reasons	There is a problem; Graphs and figures are important; Results of the system are improved if the variation throughout the process is reduced	The elimination of waste improves the performance of business; Many minor improvements are better than big ruptures	The improvement of working conditions brings health, safety and performance
Focus	Focus on the problem	Focus on the flow	Focus on man/machine system
Major effect	Uniform result of the process	Reduced flow time	Reduction of accidents, diseases and human mistakes
Minor effects	Low stock variations; New accounting systems; Performance appraisal done by the managers; Improved quality	Less waste; Improvement of process output; Low stock; Performance appraisal done by the managers; improved quality	Cost reduction with human factors; Productivity improvement; Staff Satisfaction; Performance appraisal done by SESMT
Criticism	Interaction of the system is not taken into account; Processes are improved independently	Statistical or system analysis is not valorized	System is evaluated in a micro level (isolated process), rarely interacting with the major objectives of the organization

ELSS was planned to function as a safe methodology at the identification of the requirements and opportunities in ergonomics. Because it has a systematic structure, the method can also be used in the verification of the quality of the improvements done at a given situation of work, allowing the comparison of different situations with the same kind of activity. It can be used as an information file on the job post, as an information source for hiring of new staff or even as a platform of legal investigations, assured by the continuous improvement and other elements of management. Its structure and content make the use convenient and adaptable to any kind of organization.

The method consists of a set of tools, techniques, principles and rules, organized in a clear, logical and systematic way so that they can be used to get the objectives reached. The standardization of the use of assessment methods towards reaching a certain objective can provide all with a common language, an understanding and, consequently, a higher commitment with the objectives and goals of the organization [8].

ELSS was born from the improvement of the ergonomic risk assessment methodologies; especially from ERA—Ergonomic Risk Analysis [9]. These studies showed that the methodologies and tools used can be applied in a very efficient way in staff training programs towards the search of realistic and practical solutions for ergonomic problems of the sites [10].

The steps of ELSS DMAIC were taken by a multifunctional team (multi-professional and multi-disciplinary) termed as focus group, composed by selected members of the company, and supported by ergonomic experts [11]. Table 3 shows and abstract of the main objectives and results of each one of the steps.

Table 3 ELSS expected objectives and results

		Objective	Main expected results
DMAIC Steps	D	Define clear objectives of the study	Definition of main action group; Definition of the scope of the actions; Definition of the objectives of the analysis
	M	Understand the work	Selection of the objects of evaluation (definition of homogeneous groups of exposure ergonomics), Understand the analyzed process (modeling of the process, tasks analysis); Preliminary ergonomic Mapping, identifying risks and wastes of the process
	A	Systematically analyze	Systematic study of each problem; Identification of root cause; Confrontation of problems with the operators; Prioritization of risks
	I	Develop attitudes that can bring improvement of the identified conditions	Propose improvement actions; Select the best option; Simulation; Organization and analysis in a standard form
	C	Establish criteria that assures the improvements	Establish a plan that assures the implementation of the improvements; Development of assessment and analysis criteria of the results

3 Conclusions and Considerations

The presented model considers that the proper execution the methods of analysis of Lean and Six Sigma, when integrated to the ergonomic practice, allows the application of a participative ergonomics to project safe, health, comfortable and efficient environments not only in terms of ergonomics, but also in terms of productive efficiency of the activity involved. Once improving the working conditions may also mean improving the production.

The benefits brought thorough the use of this methodology in the analysis and search of solution for problems. DMAIC was used at ELLS as a standard approach on the guiding of the improvement projects, resulting that putting together the philosophies Lean Six Sigma this approach was preserved on the solution and organization of the problems. The Kaizen event may also be used at ELSS. Then, it is possible to join Lean, Six Sigma and Ergonomics in an integrated way on the solution of problems.

In general, the process of generating a plan of step by step implementation, aligned to the reality of the organization, may result significant gains and may positively feed back the efforts to change on the ergonomic management.

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Machine-Man-Task System Approach and Regulatory Standard NR 17—Ergonomics

Norma de Melo Pinto, Maria Manuela Quaresma and Kazuo Hatakeyama

Abstract The standard for ergonomics sets parameters for the working conditions to the psychophysiological characteristics of workers to provide comfort, safety, and efficient performance. The machine-man-task system approach allows the voice of the worker to be included in the design of the production system, the steps of implementation and validation. The aim of this work is to assess the tasks of postal workers in their jobs and propose suggestions to minimize the risks of accidents, injuries and illnesses. The approach used has four ergonomics phases: diagnosis, assessment, design, and validation. The diagnosis showed that levels of illuminance, effective temperature, relative humidity, ventilation, and fire extinguishers coverage met the requirements of standard. The noise level and comfort according to anthropometric measurements didn't met the requirements of the standard. The ambulation of workers was excessive. A new layout ran for ambulation reduction and validated by the workers as well as labor gymnastics.

Keywords Machine-man-task system · Postman work · Ergonomic diagnosis · Ergonomic design · Ergonomic validation

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1 Introduction

1.1 Brazilian Enterprise of Post Offices and Telegraphs

The Brazilian Enterprise of Post Offices and Telegraphs, EBCT, operates in the postal service in several activities as, transport, letters delivery, packages, periodicals, national shipping and international receipt of goods, parts of direct marketing, philately services, receive, transmits and deliver telegrams among others [1]. By the National Classification of Economic Activity (NCEA) the EBCT receives the code 53. The denomination of "Post Office and other activity of delivery" and degree of risk GR 2 according to the Chart 1 of the Regulatory Norm—NR 4 Specialized Services in Safety Engineering and in the Medicine of the Labor (SESML) of the Ordinance Norm 3214/78 of the Ministry of Labor and Employment (MLE).

According [1] among the professional postal clerk, postman represents more than 50 % of the effective of employees of the Post Office and have a complete study of senior high school. In Brazil, the EBCT is the main representative of this branch of activity. The survey performed in the period of August 2013–December 2014 being the results of ergonomic study in the screening sector of orders of the EBCT, called addressing center of orders Santo Cristo (ACOSC). The ACOSC, works in the 3rd floor of the central building of post office located in the President Vargas Avenue, in the city of Rio de Janeiro, Brazil.

Daily the ACOSC is responsible by handling approximately 3200 objects, divided into: delivery of 1800 packages and 700 mail pouches and collect 800 mail pouches/day, divided in 29 districts in the downtown and Tijuca, important commercial and residential neighborhood of the city.

The importance of the ACOSC within the EBCT is due to the function of postman to perform the screening and delivery of packages, as well as, the delivery and collect of mail pouches, executing the services in the established time with the paid tariff and/or agreed with internal and external clients. The packages posted through Express Delivery Service (SEDEX) and Express Delivery Service until 10 o'clock (SEDEX 10) have limited time to reach the clients hands, monitored, via internet, by themselves. The delays are insusceptible of collections of indemnification and/or compensation to the clients by the EBCT.

1.2 Ordinance Norm NR 17—Ergonomics

The Norm called NR-17 Ergonomics created by the Ordinance 3214/78 of the MLE, for the Brazilian workers establishes parameters that allow the adaptation of the work conditions to the psychophysiological characteristics of the workers, in order to provide maximum comfort, safety and efficient performance. The activities of the postman demand concentration and steady attention and must attend the NR 17—Ergonomics that establishes that the level of sound pressure (LSP) must up until 65.0 dB (A) [2]. According to the item 17.5.2, the environmental conditions of the comfort that the business must observe are:

- Speed of the air not be higher than 0.75 m/s;
- Temperature must be between 20° and 23 °C;
- Relative humidity of the air not be below of 40 %.

The above-mentioned NR 17 does not establish the application of anthropometric project to attend simultaneously the physical characteristics of the workers nor institutes the voice of them in the validation of projects for continuous improvements, i.e., the participation of workers in the validation of the changes that performed in the furnishings and layout of work place.

1.3 Characterization and Serial Position of the Machine-Human-Task System in the CEE Santo Cristo

The characterization and the serial position of the SHTM comprehend the target system in which is the ACOSC, displayed in Fig. 1. The goal is the screening and delivery of screened packages and requirements to achieve this are the conveyors, horizontal and vertical circulation area, computers in network, furnishings, lighting and ventilation, as well as the distribution of vehicles. The restrictions or obstacles to implement the requirements are in the organization of screening of the SEDEX 10, number of elevators, maintenance budget and reduced number of postman.

The ACOSC receives the input, which are packages up to 30 kg, consisting of mail pouches, SEDEX, SEDEX 10, Electronic Express Delivery Service (E-SEDEX), addressed to the downtown of the Rio and Tijuca neighborhood. All items pass through the provider system composed by the Center of Screening of Packages Benfica, which added to public and private enterprise, which forward packages to all regions of the State of the Rio de Janeiro. The exits of the target system are screened packages and organized delivery, packages for devolution and mail pouches. The exits provide measure of system's performance. The lost packages, stolen and the absenteeism are the unwarranted results that link the failures or deviation of the target system.

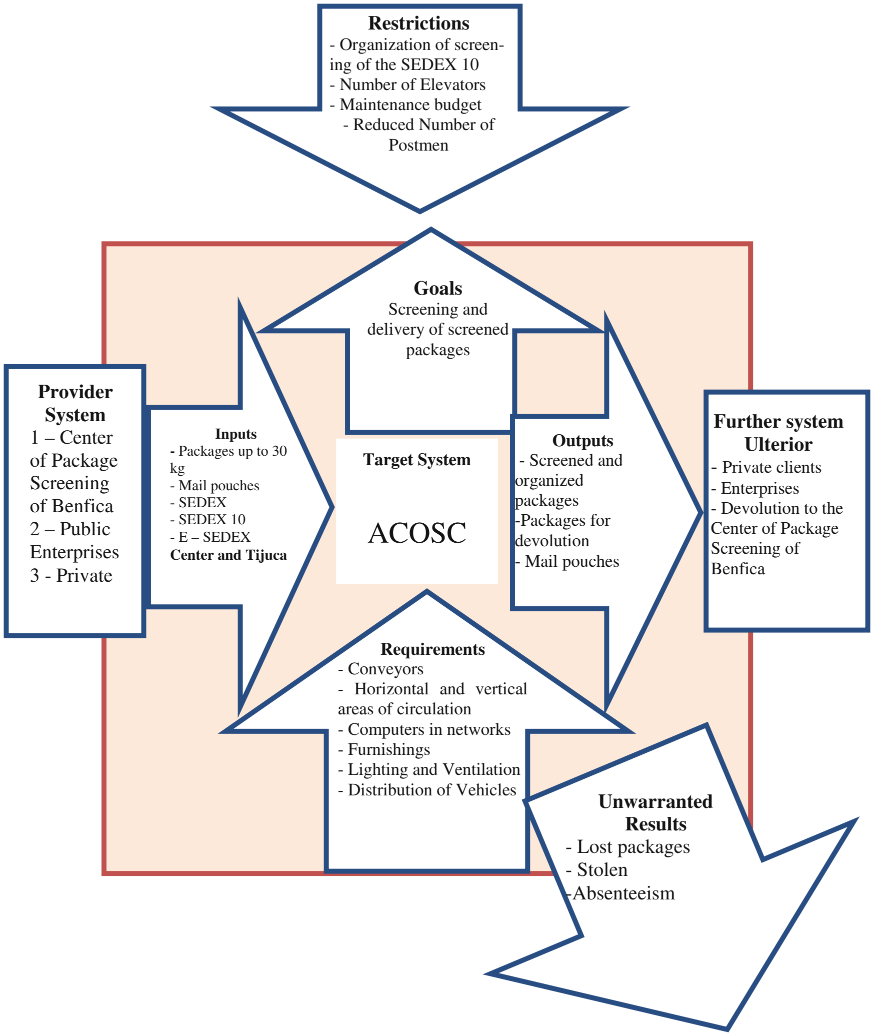

Fig. 1 Characterization and serial position of the CEE Santo Cristo

2 Objective

The objective of this survey was to evaluate the tasks of the postman, workers in the Post Office, in their work place and propose suggestions to eliminate or minimize the risks of accidents, lesions and illness. The survey performed by the multidisciplinary team, with participation of 40 postal clerk, in the period from August of 2013 to December of 2014.

3 Methodology Machine-Man-Task System

The methodology utilized is the approach of machine-man-task system, from the theoretical references of the studies of [3] that defend as stages and phases of the ergonomics intervention through the sequential application of the ergonomics appreciation, ergonomics diagnosis, ergonomics design and validation and or ergonomics tests.

The ergonomics appreciations is the first stage of the method and comprise an exploratory stage that comprehend the recognition and mapping of the ergonomics problems of the enterprise, the presentation of the target system and finish with the ergonomics opinion of which is the basis for the ergonomics diagnosis.

The stages realized in the ergonomics appreciation were:

- Systematization through the studies of: serial position, hierarchical ordering, expansion, modelling communicational of the system and functional flowchart of action-decision
- Problem issue of the machine-man-task system (MMTS)
- Ergonomics opinion.

The ergonomics diagnosis is the second stage of the ergonomic action intervention. In this stage, the problems surveyed in the ergonomics opinion are prioritize through the severity, tendency and urgency for the solution. The multi-professional team do the analysis to elaborate the ergonomics diagnosis that include also the ergonomics recommendations.

The stages realized in the ergonomics diagnosis were:

- Macro-ergonomics analysis with institutional chart
- Analysis of the technological ambience
- Analysis of the physical environment
- Characterization of the task
- Flowchart of the activities
- Table of activities
- Table of postural assumption
- Map flowchart
- Analysis of postures
- Behavior records
- Analysis of the profile and voice of the operators.

The macro-ergonomics is the ergonomics of the interface organization-machine [3, 4]. The ergonomics design, the third stage, based in the ergonomics diagnosis and its recommendations. Through the diagnosis was noticed the needs of alteration in the table of screening of packages called LOEC automatic and the table of the operational performance management system (OPMS) aiming to minimize the problems found in this sector. Utilizing an anthropometric scheme, was designed the stand for the monitor in the LOEC automatic with the use of monitor touch screen and the table of computer in the OPMS, within the standard for the tallest man and shortest woman can use simultaneously, without the needs of adjusting for the personal comfort. Other sectors also were assessed for the recommendations with proposals of improvements in the arrangements of the layout, lighting, effective temperature, noise of the environment and labor gymnastics.

The user population of the OPMS are adult men and women. The percentiles utilized were 2.5 % woman (149 cm) and 97.5 % man (180 cm), comprising 95 % of the user population of the anthropometric survey [5].

The stage performed in the ergonomics design were: LOEC automatic, touch screen monitor, management system of operational performance, the layout and arrangement of the furnishing of the ACOSC, lighting, labor gymnastics, safety of the work. The lighting project assessed attending the requirements of the NBR ISO/CIE 8995-1 [6]. The values of illuminance found were lower of the value pre-established and noticed that the disposition and quantity of lamps was enough, however must change by more powerful lamps, associated to cleaning of the gutters. By the guidance, the measure of illuminance performed based in the Norm 5413/1992 [7].

The Ordinance Norm 3214/78 of the MLE establish in the NR 23.1 [8] that the employers must adopt fire prevention measures by the state legislation and applicable norms. Rio de Janeiro obey the Decree Nº 897 of 21/09/1976 and Decree Nº 35.671 of 09/07/2004. The ACOSC classified as commercial with medium degree of risk. There is the net of sprinklers in all area of common use and operational. It is building with 7 (seven) floors and fireguard doors in operation conditions.

Recommended to do the maintenance with the change of nozzles and test of use by the specialized firm. The ergonomics validation is the phase which postman will express opinion about the test of the new projects to validate or not. Is the greatest phase for implantations or not of the new modifications based in the anthropometric studies, in the answer of questionnaires, in the analysis of videos, photos and record sheets of postural observations, actions, visuals, among others. Phase also based in the experiences of professionals involved in the survey, in the guidance appointed by professors during the studies of specialization in ergonomics as well as in the guidelines received during all period of academic training.

The stages performed for the ergonomics validation were: the LOEC automatic, the table of the OPMS, of the layout, of the labor gymnastics. Authors [3] the ergonomic validation has the objective to prove what proposed in the design. Were chosen 2 places of the ASCOC for the intervention in the portion of the furnishing: table of the LOEC automatic, with the design of the monitor, touch screen, of the computer and the table of OPMS. In this stage were built furnishings to set tests in the work place of the postman, ending with the survey of satisfaction of user regarding to the solution of the problems identified in the appreciation and diagnosis.

4 Problems Found and the Phases of the STHM

4.1 Valuation by the Application of the Table SUT

In the phase of the ergonomics appreciation the table of severity, urgency, tendency (SUT) was built after each of the five elements of the team, assessed the problems and attributed individually, each problem, the values according to the table of the methodology. Individual tables were processed estimating averages as presented in the Table 1, named as Table SUT.

4.2 Advanced Survey in the Stage of Ergonomics Diagnosis

In the phase of ergonomics diagnosis these advanced survey were to guide ergonomics projects. It has noticed the needs of alteration in the table of the LOEC automatic and in the table of the OPMS, aiming to minimize problems found in these sectors.

In this phase applied the equation of the National Institute for Occupational Safety and Health, USA [9] for the estimation of the maximum weight recommended for the manual handling of weights in the provider post of the tagger LOEC automatic table and in the manual handling of the mail pouch of the wired basket to the transporting cart. Were assessed the results obtained of recommended weight limit (RWL) and the value of the lifting index (LI) with the recommendations in the conclusion.

Yet in this phase, the postures adopted by the postman and the necessary rest time for the recuperation of the musculature used during the execution of the activities were evaluated utilizing the *Laboratoire de Economie et Sociologie du Travail* (LEST) method, proposed by [10]. The importance of this method is the physiological approach during the lifting and manual handling of weights (LMH) by workers.

The study performed during the work of the internal service of sorting out packages by districts. It was necessary to decompose the tasks such that characterize the static and dynamic energetic expenditure and then determine the time of rest that the employee must have to minimize the overload of the vertebral column. According [11] the rest time is the time foreseen for the recovery of the organism when the physical effort exceeds the admitted.

To perform the task of the identification of the packages in the LOEC automatic, a position of the monitor much above the track obliges the clerk to do flexural-extension of the cervical column and head successive times. The clerks in the interview stated to bother obliged to make the movement of “to get up and lower” the head during the identification process. In this phase recommends to install the monitor of the LOEC automatic in lower position, reducing the distance monitor/keyboard, that reduce the movements of flexion-extension.

Table 1 Table SUT

Class of the problem	Problem	S	U	T	Total S × U × T
1. Psychosocial	Emotional shock due to assaults	5.00	5.00	5.00	125.00
2. Operational	Intense pace to attend delivery date	5.00	5.00	5.00	125.00
3. Interfacial	Flexion and rotation of the column to reach the packages in wired basket	4.75	4.50	4.50	96.19
4. Psycho-social	Embarrassment in the Federal Police	4.75	4.50	4.50	96.19
5. Urbanistic	Lack of parking in the street	4.00	4.75	4.75	90.25
6. HypSlash>Architectural/spatial	Number of elevators	3.75	4.25	4.25	75.70
7. Movement	Push and pull cart with packages	4.50	4.00	4.00	72.00
8. Accident	Floor irregularity	3.75	4.25	4.25	67.73
9. Informational	Visualization of information in the tag of the mail pouches	3.75	3.75	4.25	59.77
10. Organizational	Lack of tags	3.,75	3.75	4.00	56.25
11. Organizational	Rework the packages in the cart	3.50	4.00	4.00	56.00
12. Informational	Poor visualization of signals Monitor	3.75	3.75	3.75	52.73
13. Interfacial	Flexion-extension of the column in the LOEC automatic	3.50	3.75	4.00	52.50
14. Accident	Packages above the maximum limit in the cart of internal transport	4.00	3.50	3.75	52.50
15. Interfacial	Squat to tag the package	3.75	3.50	3.75	49.22
16. Interfacial	Flexion of the column to use the OPMS computer terminal	4.25	3.50	3.25	48.34
17. Natural	Exposure to rain, wind and sun	3.50	3.25	3.50	39.81
18. Interfacial	Elevation of arms above the shoulders to reach the bar to push the cart	3.75	3.25	3.25	39.61
19. Interfacial	Elevation of the arms to access the bin	3.00	2.75	3.25	26.81
20. Displacement (external)	Postman walks long distances to deliver the packages	3.00	2.75	3.00	24.75
21. Interactional	Use of smartphone	2.75	2.75	2.75	20.80

(continued)

Table 1 (continued)

Class of the problem	Problem	S	U	T	Total S × U × T
22. Movement	Drive manually the shelf with packages	3.00	2.50	2.75	20.63
23. Actional	Lack of grip of packages	2.50	2.75	2.75	18.91
24. Displacement (internal)	Internal walking during the screening	2.25	2.25	2.25	11.39

Source Survey team

Identification of the Orders in the LOEC Automatic Table. The identification of the activities performed, in the utilization of the LOEC automatic, to transport, supply, identify, confer information, tag, re-localize internally the ordered packages, found described in the order of execution:

- 1st Pull the light disassemble container (CDL) till the LOEC automatic table;
- 2nd Lay the packages on track of LOEC automatic table
- 3rd Pass the packages in the bar code reader—track of LOEC automatic table
- 4th Confer information of the monitor with information of the addresses of the packages—track of LOEC automatic table
- 5th Put the tag in the package—track LOEC automatic table
- 6th Lay the package in the corresponding cart.

Flexion of the Column to Use Computer Terminal OPMS. Yet in an ergonomic diagnosis, in the register of exit of the orders in the OPMS, the postman remain standing, and do flexion of the column in the use of computer terminal, can cause pain and/or lesion in the vertebral column. In the interview stated that do not sit to brisk the service. The recommendation is to rise the table of the computer. Each postman must register in the computer terminal:

- The vehicle that is exiting;
- The mileage and exit/return hour;
- Confirm the list of packages that already is in his name and conferred along with supervisor;
- Registering the exit of the OPMS and the return, with or without occurrences, after the delivery done;
- Make all the process of route.

4.3 Utilizations of the Anthropometric Scheme in the Stage of the Ergonomic Design

In this phase were designed, utilizing the anthropometric scheme, stand for the monitor in the LOEC automatic table with the utilization of monitor touch screen.

Also designed, built and set in the place, the computer table in the OPMS, within the standard for the tallest men and shortest women can use simultaneously, without the needs the adjustment. The user population of the projects are adult men and women, postman and the percentiles utilized were 2.5 % woman (149 cm) and 97.5 % man (180 cm), comprising 95 % of the user population of the anthropometric survey [5].

According [12] to choose the extreme percentiles is necessary to evaluate the cost-benefit of these percentiles because how much more extreme bigger the difficulty of their compatibility may encumber the cost of the project. For other sectors also assessment were made recommendations with proposals of improvement in the work place layout set ups, lighting effective temperature, noise of the environment and labor gymnastics.

Anthropometric Design. Anthropometric design (Fig. 2) were based in the parameters of the biomechanical of the human body, based in the table of the [13].

The table of the OPMS designed with 1 m height, thus diminishing the flexion of the vertebral column. The monitor stayed with inclination of 80°, keeping the zones of visualization of the task (Fig. 3).

According [14] the ideal height to work standing depends the height of the elbow and the type of task be performed. In general, the surface of the bench must be 5–10 cm bellow the height of the elbow. For the precision works is convenient the surface slightly high, up to 5 cm above the elbow.

The key board of the OPMS stayed in the same level of the monitor to best actuation of the larger percentile of users.

Project of the Stand of the Monitor for LOEC Automatic Table. Surveys performed for similar products in the market, which found several creative and advanced solutions. However, opted do not modify the table of the LOEC automatic, due to the high financial cost. The proposal was the adaptation of the stands for monitor of the LOEC automatic table, with the substitution of the monitor with key board and the mouse by the touch screen, reducing the needs to keep the head in steady movement of flexion-extension (data found in the records of actuation and collect of information in the previous stage).

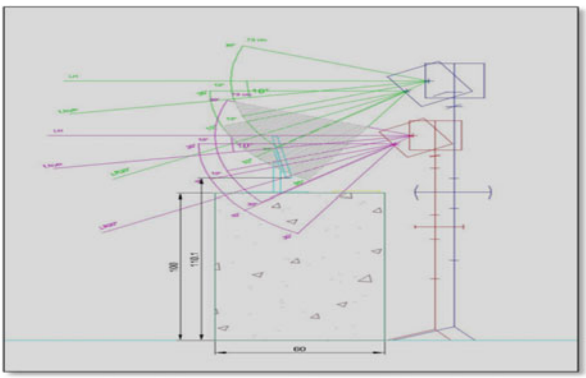

Fig. 2 Anthropometric dummies—visual filed of the OPMS

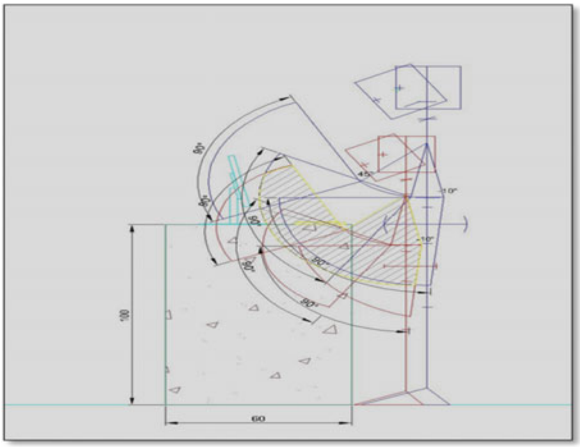

Fig. 3 Anthropometric dummies—action field of the OPMS

Then, to establish alternatives of existing products in the market, used the technique of prioritization called priority matrix, attending the criteria with respective weighs: usability, smaller cost, larger durability, best spatial disposition. Were selected 3 members of the group to determine weight to alternatives. There was 3 alternatives of products and alternative 3, by the better spatial disposal, was the larger result, being adequate to the design and anthropometric scheme.

5 Validations of the Layout

The validation is the phase in which the workers have the effective participation in the surveyors projects and designers of the new organization, disposition of the furnishings and improvement of the place and work environment. Contribution of their experiences is paramount for the survey.

They are who know and experience hotter places, sufficient lighting or deficient, the difficulty in the line of the elevators, the needs of environmental humidification in the summer climate of the Rio de Janeiro, as well as, have important suggestions to make agile the services and better the attendance of clients.

Nobody better than each postman to participate in solutions that intends to implement in their own place of work. In this phase utilized mock ups in drawing on cardboard and tri dimensional schemes, whereby each one can change the position of the set of tables of LOEC, the wire baskets with packages, the table of supervisors to magnify their vision, etc. Also recorded the interviews of satisfaction and suggestions with postmen. The ACOSC has 2310 m^2, there has the great walking of the postman in this sector, during the stowage of the orders.

6 Analysis and Discussion

Regarding to interfacial problems involving lifting of loads and specifics for application of NIOSH methods the studies performed in the diagnosis and solutions as described:

1. For the postman performed the feeding packages in the table LOEC achieved the recommended weight limit, RWL = 9.55 kg, and the value of the lifting index, LI = 1.05. This last value points to moderate increase of risk of low back pain for the weights bigger than 9.55 kg. In the tasks of this type can eliminate the asymmetry angle laying the wire basket or the light collapsible container (LCC) in the same direction continuing towards LOEC and searching in the market lifting apparatus of the wire basket, eliminating the vertical lift of the load by postman.
   With this measures the new RWL = 15.50 kg and for the weight bigger than 15.50 kg up to 30.0 kg the LI will have values bigger than 1 up to 1.93. Still to be continued the increase of risk of lesion in the vertebral column and in the ligament muscle system of the postmen. The best solution will be the mechanization of the system that requires modernization with large amount of investment or increase of effective workers to work in pair for more heavy packages.
2. The equation of NIOSH also applied for the survey of the mail pouches of wire basket that anchor the mail pouches to the carrying cart and achieved RWL = 15.50 kg and the value of the LI = 0.60. This value indicates that the minimum risk of lesion in the column and in the ligament muscle system for the weight up to the limit. In this work conditions the postmen that perform this type of tasks should not have problems.

The equation re-estimated eliminating the angle of symmetry of lifting and achieved RWL = 18.01 kg and for the weight bigger than 18.01 kg up to 30.0 kg the LI will have values bigger than 1 up to 1.66 exposing to risk of low back pain and lesion of the ligament muscle system. As the wire basket that holds the mail pouches is a set of four basket tied together and the time of execution of the task 15–20 min. in the morning and in the afternoon, suggest the work in pair of workers for more heavy packages.

The problems pointed out for medium to easy solution, such as to mend the defective floor, organize the use of elevators in the rush hours of postmen, implant labor gymnastics that already has practiced and presently requested the return in the validation itself. The management of distribution and control tag coils passing to the responsibility of the supervisors, keeping the centralized the purchase to obtain better discounts, are solutions that can immediately adopted or in span of time of 3–6 months.

The solutions of problems that involves the general administration of the enterprise till other organisms as Federal Police regarding to assaults and thefts of loads. Department of transits and prefecture regarding to reorganize exclusive corridors for the bus to transport passengers, ambulances, already exist in the city. However including the transport of the post office and the delimitation of special places for parking of the post office vehicles during the day, requires awareness, determination and involvement of the administration, political will responsible internal team and involved to achieve solutions.

Regarding to the internal idle walking the proposal is the new layout with central positioning of tables LOEC, validation approved by the postmen, however such solution is the high cost of investment.

7 Conclusion

Consider practical character the result of the validation as the table OPMS designed, proposed, provided its execution by the team, obtaining the validation and approval of the postal clerk participants of the survey.

The proposal to set the monitor ergonomically correct for the work standing in the tables LOEC, through the design of adjustable stand for the monitor and install in the front of the table attending 97.5 % of the users, which attended due to the existence of the equipment in the market.

The stand was set in test being the validation achieved effective participation of the postal clerk regarding the position and fixation in the height corresponding to the fields of visual and action intercession, according to the design.

It was tapped the existing monitor and the daily use that become the project accessible to be implanted, once the federal administration and the country is in the situation of investments contention. If not by the purchase of touch monitors suggested could derail this relevant study.

At the end it can said that the Ordinance Norm 3214/78 of the Ministry of Labor and Employment (MLE) governing the labor regime of the postmen and there is the Specialized Services in Safety Engineering and in the Medicine of the Labor (SESML) dimensioned and attending the NR4 of the quoted Ordinance was fulfilled.

Future studies of masters can directed to the extension and application of the methodology to other CEEs in Rio comparing the results and applying statistics pertinent. The application of the methodology can directed to study at doctorate level in the screening of packages of the Center of screening of packages located in Benfica in Rio de Janeiro, Brazil.

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Mobbing as a Psycho-social Risk at Work: A Study in Turkey

Serpil Aytac, Salih Dursun and Ahmet Gokce

Abstract Workplace mobbing can adverse effects on occupational health and safety are termed psycho-social risk factors. Psycho-social risks, compared to other risk groups like physical, biological and chemical risks, the lesser-known area of occupational health and safety in Turkey. Psycho-social risks are identified as social and organizational adversary activities which emerge due to the methods applied and arranged in relation to work life that give rise to psychological and physical harms. Mobbing as psycho-social risk factors can cause many negative effects on employees in today's work life. These negative effects also results some unintended consequences such as low job satisfaction, absenteeism, aggression, anxiety, depression and some health problems. As with all hazards, mobbing (in whatever form) should be treated as a health and safety hazard and risk assessment methods should be used to prevent and control it. This paper objectives to identify the prevalence of reported workplace mobbing among a group of health workers, to evaluate the association between reported mobbing and its effect on workers' health. As a result of this study, we could come to the conclusion that the first of all we have to reduce psycho-social risks. After this achievement, we are able to say that psycho-social risks are the result of harmful effect on individual.

Keywords Mobbing · Health workers · Job satisfaction · Stress · Anxiety and depression

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1 Introduction

Recently it has been speaking about bullying/mobbing and violence at workplace in general. However it is not believed that it is a new pattern of behavior. It was discovered in 1980s by Heinz Leymann, He firstly described a phenomenon mobbing by researching social dynamics of workplace. Leymann defined mobbing as “Psychical terror or mobbing in working life means hostile and unethical communication which is directed in a systematic way by one or a number of persons mainly toward one individual” [1]. According to another definition of mobbing is defined as *typically involves a group of workers ganging up on a target employee and subjecting that person to psychological harassment* [2]. European Commission (2001) mobbing is defined as *negative form of behavior, between colleagues or between hierarchical superiors and subordinates, whereby the person concerned is repeatedly humiliated and attacked directly or indirectly by one or more persons for the purpose and with the effect of alienating him or her* [3].

Mobbing/bullying behavior is seen that to be quite common throughout the world. The European Foundation’s Third European Survey findings indicate that in 2000 around 9 % to intimidation (bullying/mobbing) over the previous 12-month period (ranging from 15 % in Finland to 4 % in Portugal) [4]. A 2011 Monster Global Poll conducted in May, 2011 surveyed workers worldwide, 83 % of European respondents reported that they had been physically or emotionally bullied; 65 % in the Americas; and 55 % in Asia [5].

On the other hand, what types of behavior will be evaluated in the context of mobbing; there is no consensus in the literature. Leymann has classified this mobbing behavior under 5 separate factors and 45 behaviors. According to Leymann, “this behavior; attacks on self-expression and communication (management gives you no possibility to communicate, verbal threats, verbal activities in order to reject you etc.), Attacks on a person’s social relations (colleagues do not talk with you any longer or you are even forbidden to do so by management, you are isolated in a room far away from others etc.), Attacks on a person’s reputation (gossiping about you, others ridicule you, others make fun about your handicap etc.), Attacks on the quality of a victim’s occupational (you are not given any work tasks at all, you are given meaningless work tasks etc.), Direct attacks on a person’s health (you are given dangerous work tasks, others threaten you physically or you are attacked physically etc.)” [6]. Rayner and Hoel [7] defined mobbing behavior into the following five categories: threat to professional status, threat to personal standing, isolation, overwork and destabilization.

This paper objectives to identify the prevalence of reported workplace mobbing among a group of health workers, to evaluate the association between reported mobbing and its effect on workers’ health.

2 Method

2.1 Sample and Procedure

This paper used a cross-sectional questionnaire survey among full-time employees in the health sectors. During a period of 3 months, we visited three hospitals. We distributed printed questionnaires in closed envelopes and collected them back from the participants on a specific day. We distributed a total of 800 questionnaires. 544 were returned giving a response rate of 68 %. As a result of the examination of the questionnaire responses, 69 questionnaires were determined as incomplete or incorrectly marked and thus a final total of 475 questionnaires were evaluated for this study.

2.2 Measures

Our main outcome measures were the following and Reliability analyses for these instruments were made by using the Cronbach Alpha coefficient and were as follows:

1. A 20-item inventory of bullying developed by Quine [8]. The scale's alpha reliability is 0.83.
2. A 7-item Job Induces Stress Scale developed by House and Rizzo [9]. The scale's alpha reliability is 0.83.
3. A 5-item Job Satisfaction Scale developed by Quinn and Staines [10]. The scale's alpha reliability is 0.86.
4. A 14-item The Hospital Anxiety and Depression (HAD) Scale developed by Zigmond and Snaith [11] and translated by Aydemir et al. [12]. The alpha reliability for Anxiety is 0.81; and for Depression is 0.73 respectively.

The Cronbach alpha coefficients of all the scales ranged between 0.73 and 0.86, and all the coefficients were at acceptable limits.

3 Results

Of the 475 participants, 254 (54 %) were doctor, 196 (41 %) were other health professionals (nurse etc.) and 25 (5 %) were officer and secretary; 46.1 % were male and 76.1 % were married. Respondents reported age range of 18–40 (75 %), and work experience range 1–5 years (47.5 %).

During the last year, 55.1 % of the participants had been exposed to mobbing behavior at work, 44.9 % said that not exposure. Some 47.4 % said that they had witnessed others being mobbed. Those exposed to mobbing and not exposure

Table 1 Distribution of participants of mobbing exposure status and characteristics

	Exposure mobbing %	Not exposure mobbing %
Profession		
Doctor (n = 254)	52.4	47.6
Other health professionals (n = 196)	74.7	25.3
Officer and secretary (n = 25)	64.0	36.0
Age		
18–30	63.1	36.9
31–40	51.8	48.2
41–50	51.5	48.5
>51	45.8	54.2
Administrative tasks		
Yes	62.4	37.6
No	53.8	46.2
Work experience		
1–5 years	55.6	44.4
6–10 years	53.2	46.8
11–15 years	57.1	42.9
16–20 years	50.7	49.3
>20	60.6	39.4

mobbing behaviors are given in Table 1 and having distribution according to various characteristics.

As seen from Table 1, 52.4 % of physicians, 74 % of healthcare workers, 64 % of civil servants and secretaries have been exposed to mobbing. With respect to the age range of 18–30 age range are most exposed to mobbing (63.1 %). In addition, 62 % of those exposed to mobbing, which consists of administrative tasks. In terms of the work year, it seems in over 20 years, who were exposed to more mobbing (60.6 %).

Indicate the types of mobbing suffered by participants are shown in Table 2.

Doctors and other health personnel are most exposed to mobbing that kind of work load (37.4 and 60.7 % respectively). Officer and secretary are most exposed to destabilization and workload categories of mobbing (36 %).

Table 2 Report mobbing types that participant

Profession	Threat to professional status		Threat to personal standing		Isolation		Overwork		Destabili-zation	
	N	%	N	%	N	%	N	%	N	%
Doctor (n = 254)	55	*21.6*	35	*13.8*	32	*1.6*	95	*37.4*	74	*29.1*
Other health professionals (n = 196)	61	*31.1*	71	*36.2*	28	*14.3*	119	*60.7*	88	*44.9*
Officer and secretary (n = 25)	7	*28.0*	5	*20.0*	6	*24.0*	9	*36.0*	9	*36.0*

Table 3 T tests

	Exposure mobbing		Not exposure mobbing		t-test	p
	Mean	S.D	Mean	S.D.		
Job stress	21.63	6.460	18.43	6.02	7.398	0.000
Anxiety	8.44	3.75	6.44	3.29	8.242	0.000
Depression	7.22	3.76	5.54	3.72	6.820	0.000
Job satisfaction	11.21	2.84	9.16	2.94	10.459	0.000

The relationship between mobbing and occupational health outcomes were examined by t test.

As it is clear on the Table 3 above, job stress, anxiety and depression are highly seen on the experimental who are exposed to mobbing attitude than the others and the statistically is significant ($p < 0.05$). Health workers who had experienced mobbing in the past year reported significantly lower levels of job satisfaction than others. Additionally, they had significantly higher levels of job-stress. They were significantly more likely to have higher levels of anxiety scores and depression scores ($p < 0.05$).

4 Discussion

In recent years the significant changes in working professional life has led to new risk factors. Psychosocial risks, compared to other risk groups, the lesser-known area of occupational health and safety in Turkey. Increasing workload, working hours and the pace of work, cause many negative effects on employees including particularly distress and burnout in today's work life. These negative effects also results some unintended consequences such as low job satisfaction, anxiety, depression and some health problems.

Psychosocial risks are identified as social and organizational adversary activities which emerge due to the methods applied and arranged in relation to work life that give rise to psychological and physical harms. Psychological harassment at work place and mobbing are the prominent psychosocial risk components that are deal with in this context.

Mobbing is one of the important psychosocial risk factors at work. Mobbing leads to many problems on employees. According to researches, mobbing exposure to increased work stress [13–15], post-traumatic stress disorder [16], depression [17]. Also mobbing cause problems to sleeping problems, headache, overall fatigue [18], burnout [19], decrease of work satisfaction [20, 21], and organizational commitment [22].

Many studies in the health sector suggest a high prevalence of mobbing among health care providers, especially among nurses [23–25]. In this study, we aimed to identify the prevalence of reported workplace mobbing among a group of health workers and effect on health outcomes. In a study, we found that the rate of exposure to mobbing were quite high as 55.1 %. In another study conducted in Turkey it seems to be quite common in mobbing. By Bilgel et al. [26] conducted study, 75 % of health personnel (except physicians), 64 % of secretarial and administrative staff, 56 % of police officers, 56 % of physicians and 39 % of teachers reported that they had been bullied at their workplaces within the last year [26]. Gok [27] in his study, 56 % of the participants reported exposure to one or more types of mobbing behavior during their entire working life [27]. Yıldırım and Yıldırım [13] in their study, the overwhelming majority (86.5 %) of the nurses participating in the research reported facing mobbing behavior in the workplace in the last 12 months. Sahin et al. [28] reported that total of 87.7 % of physicians' experienced mobbing behavior.

In this study, doctors and other health personnel are most exposed to mobbing that kind of work load (37.4 and 60.7 % respectively). Officer and secretary are most exposed to destabilization and workload categories of mobbing (36 %). Similar to our study, other studies have found workload, destabilization and threats to professional status to be the most frequent categories of mobbing [29–32].

In our study, we found that staff that had experienced mobbing reported higher levels of job-induced stress scores and their anxiety and depression scores was higher than those not being mobbed. On the other hand, employees reporting mobbing were significantly more likely to report low job satisfaction. These situations could be explained by the effects of mobbing behavior on the mental health and attitudes towards work of the victims.

Mobbing is psychological risk with devastating consequences. According to the Turkish law (OSHA 6331), employer is responsible for good atmosphere at workplace. New Labor code forbids any discrimination, pestering, harassment and persecution. However, reaching one's rights is often very difficult. Occupational safety laws are not clear for psychological risk and do not cover emotional well-being issues, and protective and proactive measures have been neglected. Furthermore, there are no scientific studies concerning emotional well-being and mobbing issues as psychological risk in Occupational Health and Safety in Turkey [33].

Managing psychosocial risks (e.g. stress and common mental health problems such as anxiety and depression) in the workplace is important as such risks are associated with poor individual health and well-being and subsequent losses in productivity and economic activity. For that reasons, we have to reduce psychosocial risks.

Mobbing and other workplace-related mental health issues should not considered a luxury but a necessity, and should not be further ignored like physical, biological and chemical risks, even in developing countries.

4.1 Limitations of the Study

The participants in this study were health workers. Due to time constraints and busy schedules of the health workers it was difficult to interact with them completely so data were only collected through a questionnaire. The sample size was limited to only tree hospital in Turkey and responses may have been influenced by personal bias.

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Ergonomic Hazards Mapping System (EHMS) for Musculoskeletal Disorders Detection

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Abstract The identification of ergonomic risk and it physical location in production areas is the proposal method called ergonomic hazards mapping system (EHMS). It aim is find the interaction between process conditions that enhance development of musculoskeletal disorders and the work system elements that need to be changed using ergonomic point of view. The EHMS was developed considering the analogy between a mapping quality process that shows a general picture of production activities and it layout and an ergonomic system focused on identify existing hazards at workstations. For it validation, a study case was implemented in a corrugated cardboard production process, the result is an schematic representation of ergonomic risk factors and the identification of body parts of workers that could be damaged if their work conditions do not be improved.

Keywords Schematic models · Human-systems integration · Ergonomics · Safety and health

1 Introduction

A process map is a schematic model, that is, a pictorial relationship between variables, it is composed by legends, symbols and scales organized by explaining the interactions between each other [1], it aim is to identify the activities that add any value to the process. A system is a collection of interacting components that get together for a common purpose [2]. According to Smart [3] a system is limited by

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few (or a single) variables at any moment in time and is subject to cause effect mechanism. Alternatively, the ergonomics is a scientific discipline that studies the system effects in which persons interact [4]. The components of ergonomic system at work are: workplace and it environment, performing tasks, tools manipulation, products and materials, and the work organization [5]. When one ergonomic system component is poorly designed or does not function properly, it becomes an ergonomic risk factor that leads to musculoskeletal disorders and occupational diseases. Axelsson [6], represented the work systems, ergonomics and quality as process map mixed the concept *"fitness for use"* developed by Juran [7] and the concepts contained in the book *"fitting the task to the man"* developed by Grandjean [8], establishing that this kind of tools are useful for ergonomic purposes. On the other hand, in México, the government in order to abate musculoskeletal disorders caused by ergonomic risk factor issued a mandatory rule, called Federal Rule for Safety and Occupational Health [9]. It includes a new employer obligation for identifying; reporting and reducing the ergonomic risks occurred inside facilities. Thus, preventing damage in health and safety of workers became a business obligation and this activity required specialized tools, unfortunately, in México there is not enough information in Spanish about evaluation risks and ergonomic interventions.

The identification of ergonomic risk and its physical location at production areas is the proposal method in this paper; it is called Ergonomic Hazards Mapping System (EHMS) developed by the Autonomous University of State of Morelos. It aim is find process conditions that enhance the development of musculoskeletal disorders and the interactions of the work system that need to be changed using ergonomic point of view. The EHMS was developed considering the analogy between a mapping quality process and an ergonomic system focused on find hazards at workstations. This ergonomic hazards mapping system considers the interaction of three major elements; first the input, which involves the human factor and the workspace, second the process for determining any indication of risk in the environment, and the third consist in identify the potential causes for diseases, in back, neck and upper and lower extremities.

2 Study Case

The study case was developed in a corrugated cardboard process. The work system consisted of four workplaces. Each one was composed by an old semi-automated line without feeding and discharge system. An example of two activities developed is showed in Figs. 1 and 2. Feeding task and discharged task respectively.

Fig. 1 Feeding task: take from the pallet a group of cardboard and place in the feeder mechanism repeated times until the material stocked is finished

Fig. 2 Downloading task: take a packet of cardboard from the rolled conveyor and put over pallet repeated times until the pallet is completed

There was another task like feeding, receiving, picking, moving, and stowing, additional to operators, and assistant operators. The production time was divided in three shifts of 8 h each one; there were 20 operators by shift in each semi-automated line, all of them work on standing posture the complete shift without recovery time. At the final of each line was settled the downloading activity where the worker lift, push and pull packages of cardboard in order to fill a pallet. The rest of workers developed other activities like preparing cardboard for feeding and packing. As result to exceed permissible exposure limits by operators, the department of occupational health from the company reported: 94 cases between accidents and diseases occurred during 2014 and, 142 events occurred during 2015. That represented an increase of 51 % only in one year. Highlighting contusions, back pain, joint pain, knee osteoarthritis, chondromalacia, sprains, strains and bone fractures among others.

3 Methodology

3.1 *Delineation of the Ergonomic Mapping System*

In the first place, ergonomics considerations in machine tool design [10] were defined as ergonomic system variables. Special abbreviations and definitions for ergonomic purposes were established (see Table 1).

These abbreviations were used for identification of Ergonomic Rick Factors (ERF) on the EHMS. Secondly, the definition of the EHMS was done. A comparative analogy between process mapping and ergonomic mapping was developed; the results are showed in Table 2. The input system was defined as human factors and work space, the process was established as ERF considering the ergonomic definition purpose finally the product was the EHMS.

In third place, the identification of the body parts involved in potential disease or exposed to a hazard was represented schematically. The results are showed in Table 3.

3.2 *EHMS Phases of Construction*

- *Step 1*. Generate a list of events and classify about incidents, accidents and illnesses that had occurred most frequently during at least 1 year using company information.

Table 1 Abbreviations and definitions for ergonomic rick factor (ERF)

Component	Abbreviations	ERF definition
Hardware	HDW[a]	Ergonomic design for workstation, machinery and tool considering operability and safety
Software	SFW	Knowledge about error and consequences of risk exposure during performing tasks and its diseases symptomatology. It should include psychosocial factors if it is possible
Physical environment	PHE	Hazards in the Hardware related with ERF that cause diseases like vibration, noise, high temperature and illumination
Job organization	JOR	Job content and working method that involve physical risks like external loads associated with long periods of exposure which involves awkward postures, manual loads incorrectly performed, repetitive motion, and force exerted during the task that impact on the health and well-being of workers
Individual factors of workers	IFW	Worker functional skills, habits, medical record and physical characteristics

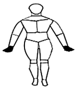
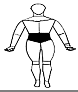
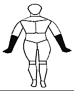
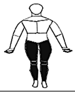
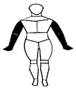
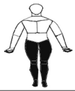
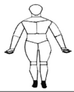
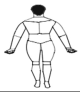
[a]The Abbreviations for Hardware and Software were defined different as its usual context in Computation Science HD and SW

Table 2 Comparative analogy between the process and ergonomic mappings

Process components	Process mapping	Ergonomic hazards mapping system
Input	Materials	Human factor and work space
Process	Transformation process	Ergonomic rick factor (HDW,SFW, PHE, JOR, IFW)
Output	Final product	Ergonomic hazards mapping system

- *Step 2.* From the list of events identify and classify the workplaces most problematic.
- *Step 3.* From the list of events identify and classify the body parts most injured.
- *Step 4.* Identify the current ERF at the workplaces most problematic.
- *Step 5.* If there are awkward postures, manual loads incorrectly performed, repetitive motion, and force exerted during the task performance a risk evaluation shall be implemented as preventive action using methodologies like PLIBEL [11], REBA [12], NIOSH equation [13] among others or implement evaluations proposed by ISO 11228 [14].
- *Step 6.* EHMS construction: over a layout map draw the schematic representation and the abbreviations related with the ERF.

Table 3 Identification of the body parts involved in potential disease

Schematic representation	Body parts affected	Schematic representation	Body parts affected
	Hands and wrist		Lower back
	Forearms, wrist and hands		lower limbs without feet
	Arm, elbow, forearms and hands		lower limbs including feet
	Shoulders, arm, elbow, forearms and hands		Feet
	Neck, shoulders, arm, elbow, forearms and hands		Trunk and upper limbs, feet, knees and hips
	Neck, shoulders, and Chest (thoracic cage)		Body
	Trunk		Head
	Trunk and upper limbs	–	Others not included in this article

4 Results and Discussion

The study case was developed in a corrugated cardboard process. There were three workplaces composed each one by an old semi-automated line. The Pareto chart in Fig. 3 shows the results from the list of events about incidents, accidents and illnesses occurred during 2015, using information provided by the department of occupational health.

The main problem was multiple contusions followed by sprain and lumbar pain caused by numerous accidents, occurred during the performing of the task; due the bad conditions of the machinery and lack maintenance. The three semi-automated lines had any security guards turned on, causing unsafe workstations and its environment. As a result of this the three workstations were considered in the layout map for the schematic representation. With regard to results expected, was easier organized the information from the list of events in a Pareto charts, that allowed classify the information accordingly their frequency.

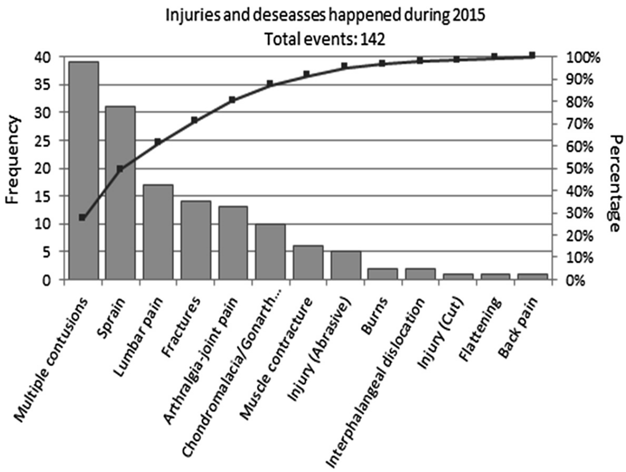


Fig. 3 The Pareto chart about incidents, accidents and illnesses occurred during 2015

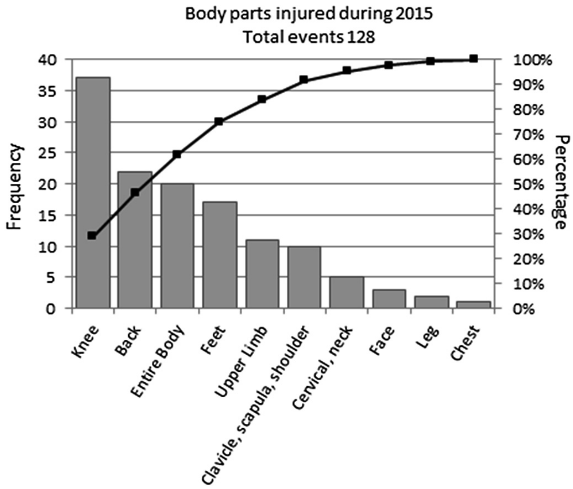


Fig. 4 The Pareto chart about body parts injured during the events occurred during 2015

The body parts most injured as a result of the events are showed in Fig. 4, where the body part most injured were the knees followed by the back and entire body.

The results were not consistent whit respect the incidents, accidents and illnesses defined as most frequent. For that reason a PLIBEL evaluation was implemented in order to verify if those results were correct. The PLIBEL defined there were different body parts involved in potential diseases associated with each workstation, moreover identified the risk by performed task and it physical location (see Table 4).

Table 4 Results from PLIBEL evaluation by workstation and by task

Body part	PLIBEL by workstation	PLIBEL by task					
	Machine 1	Feeding	Receiving	Picking	Moving	Packing	Stowing
Trunk	x	x	–	–	–	–	–
Neck	x	–	–	–	–	–	–
Shoulder	x	x	–	–	–	–	–
Elbow	–	x	–	–	–	–	–
Arms	x	x	–	–	–	x	x
Hands	x	x	–	–	–	x	–
Wrist			–	–	–	x	–
Back	x	x	–	x	x	x	x
Legs	x		–	–	x	–	x
Knees	x		–	–	x	–	x
	Machine 2	Feeding	Receiving	Picking	Moving	Packing	stowing
Trunk	x	x	–	x	–	–	–
Neck	x	–	–	x	–	–	–
Shoulder	x	x	–	x	–	–	–
Arms	x	x	–	x	–	–	x
Hands	–	x	–	–	–	–	–
Back	x	x	–	–	–	–	x
Legs	x	–	–	–	–	–	x
Knees	x	–	–	–	–	–	x
	Machine 3	Feeding	Receiving	Picking	Moving	Packing	Stowing
Trunk	x	x	x	–	–	–	–
Neck	x	–	x	–	–	–	–
Shoulder	x	x	x	–	–	–	–
Arms	x	x	x	–	–	–	x
Hands	x	x	–	–	–	–	–
Back	x	x	–	–	–	–	x
Legs	x	–	–	–	–	–	x
Knees	x	–	–	–	–	–	x
	Machine 3	Feeding	Receiving	Picking	Moving	Packing	Stowing
Trunk	x	x	–	x	–	–	–
Neck	x	–	–	x	–	–	–
Shoulder	x	x	–	x	–	–	–
Arms	x	x	–	x	–	–	x
Hands	–	x	–	–	–	–	–
Back	x	x	–	–	–	–	x
Legs	x	–	–	–	–	–	x
Knees	x	–	–	–	–	–	x

The results were quite different from company information. The discrepancy between body parts most injured as a result of the events and the PLIBEL evaluation was caused by the poorly tracking of the events from department of occupational health. At the same time the identification of the ERF in the layout from the area was done.

Finally, the information required for build the EHMS for cardboard production process was ready. The schematic representation (Fig. 5) consisted of: the layout map from the production area, the location of each Ergonomic Risk Factor (ERF) abbreviations in the areas where they had been identified, the schematic representation of body parts affected by the ERF and inside of a circle the task identified as the most dangerous.

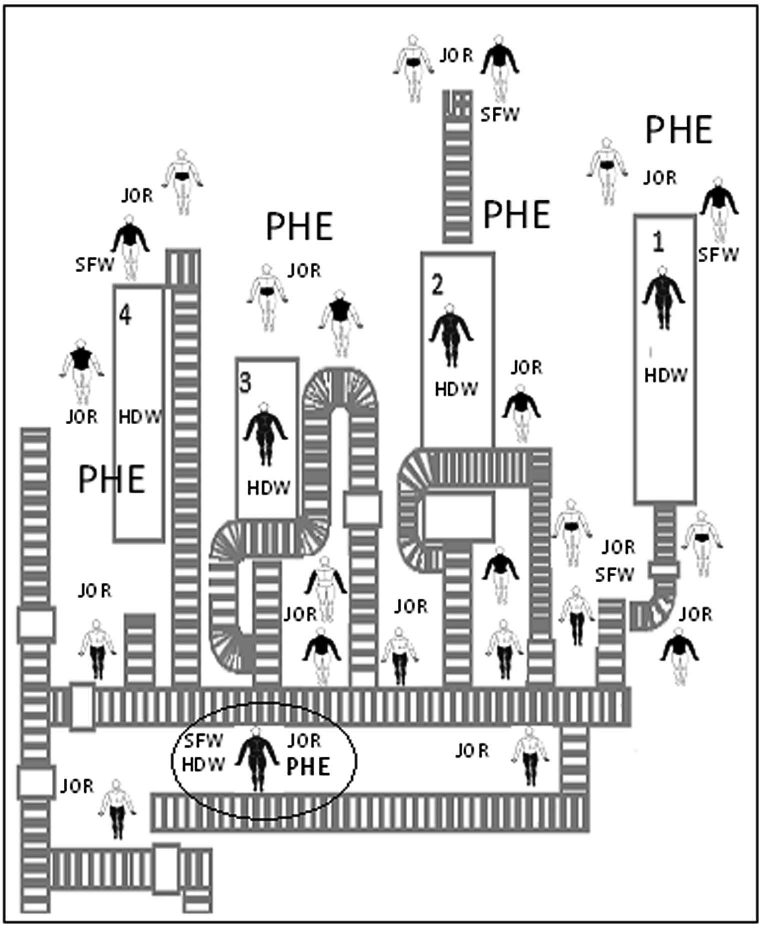


Fig. 5 Ergonomic hazards mapping system for cardboard production process

As a result of this work, the company known the location of its ergonomic problems, the body parts affected and it relationship with the occupational accidents and illness. Additionally, the EHMS allowed to the company established improvement objectives accordingly with the hazards in the areas.

5 Conclusions

The identification of ergonomic risk and it physical location in production areas is the proposed method called ergonomic hazards mapping system (EHMS). We obtained an schematic ergonomic mapping, that shown a general plot of hazards presents in workstations, as well as, body parts injured or affected when the worker performs a task. The result obtained provides the best scene for identifying where and why the risks are presents. Now, It is responsibility of the company take the necessary actions to prevent and reduce the ergonomics risk factors that affect the workers.

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Redesign of Workstation to Reduce the Risk of Wrist Lesion to Improve Work Conditions in an Industry Focused on the Assembly of Spark Plug Wire

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Abstract The present research was done with the aim to evaluate and improve a workstation focused in the assembly of spark plug wire which are composed by boot, terminals and wire. A pneumatic double acting controller with a lockable food pedal was employed as the mechanism for join the parts. Rula and Ocra analyses were done for identify the principal body part compromised by the task and for stablished the presence of a risk for the worker for the omission of an ergonomic right design.

Keywords Workstation · OCRA · RULA · Ergonomics

1 Introduction

Different kind of work stations have been developed around the world with the aim of assembly different parts of components which are necessary for assure the right working of a product. In country with low economic capacity as Mexico, the most of the machines is purchased in other countries like Germany or USA, which were designed for other worker adult population with different anthropometrics characteristics [1], Das and Sengupta [2] made a research focused in the development of workstation design since point of view of ergonomic approach, where they said that few considerations are done about the abilities of the operator with the task requirements, coming as consequence poor design of machines in the industry.

Is important to say that a workstation is a place, which, may integrate several physical components with the aim to develop a specific task, furthermore, it involve working and control elements with a specific sequence that keep the right working

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of the machine and its interaction with the human part. In this way, when these equipments are working in other countries with different anthropometrics characteristic, concepts such as ergonomic design, which play an important role on this topic have been omitted [3].

Base on tridimensional design is possible analyzed and simulate the workstation area where the worker develops his activities. A good design could minimize the injuries done over body parts that are in contact with the machine and reduce the risk of developing work diseases or lesions. The present research is the reproducibility of a work station with pneumatic work elements for the assembly of spark plugs wires, where the principal body part in close contact with the working elements are the wrists and hands of the worker. The latter are exposed to impacts around 8 bar of pressure, a protection again the crash is missing. Ergonomics analysis such as OCRA [4] and RULA [5] were done with the aim to identify and evaluate if the working posture could help in the prevention of lesion or disease and suggest some design adjustment.

2 Experimental Elements

2.1 Work Station Materials

Workstation design were done in Solidworks with simulations in work condition, high, width and depth of the work station were stablished base on the original work station 100 $\times$ 125 $\times$ 100 cm respectively. Aluminum structural components were cut for the structure assembly.

2.2 Pneumatic Components

A pneumatic double acting cylinder with 200 mm of race with a piston with an area of 5 cm^2 was used as work element for the assembly of the spark plugs wires. A barometer with a pressure regulator were used to control the work pressure on the pipe, non-returned check valve where employed like velocity control. A pneumatic 5 port valve, pilot operated and spring returned, was used as control element in combination with a 3/2 lockable food pedal valve. The pneumatic circuit was design using software Fluidsim from FESTO.

2.3 Ergonomic Techniques

Ergonomic techniques such as RULA is proposed to provide a quick assessment of the loading musculoskeletal system due to postures when the worker is in interaction with the workstation. Moreover, with the aim to estimate the repetitiveness degree of the worker OCRA ("Occupational Repetitive Action") technique is proposed following the methodologic describe by ISO11228-3.

3 Results and Discussions

The industry under study have more than 13 types of terminals with 20 types of components for the assembly of spark plug wire, which currently may generate occupational diseases as result of the continues exposition to repetitive actions. Some diseases that could appear based on the near miss report (Fig. 1) made by the industrial safety and health department in 2012 are: tendinitis, carpal tunnel syndrome and Tenosynovitis.

Based on the latter, a study using the REBA technique was done for identify the wrong posture that could appear when the worker interacted with the workstation. The worker begins the activity, taking with his hands the boots and terminals (Fig. 2), greasing them, to help the joint with the wire, after this, active the pedal foot valve to power the work element such as showed in the Fig. 3 where is evident

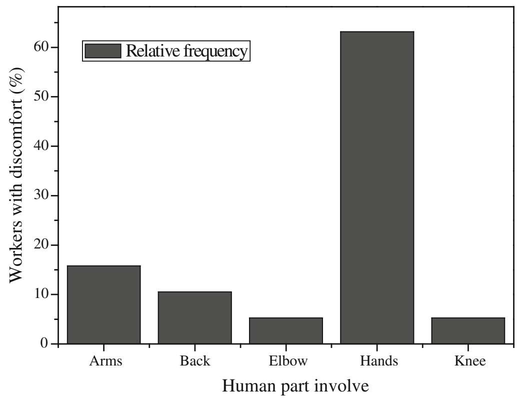


Fig. 1 Near miss report made by the industrial safety and health department in 2012

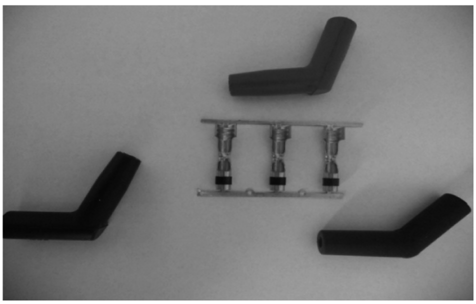


Fig. 2 Components employed in the assembly of spark plug wires

Fig. 3 Wrong posture in the assembly of spark plug wires

Table 1 Score to upper body parts compromised obtained through RULA analysis

Posture of body part	Left	Right
Upper arm	2	4
Lower arm	2	3
Wrist	2	4
Rotation if wrist	1	2
Neck		3
Torso		2

the wrong posture that the worker does to make the task, the back is displaced around 7.32 ° with respect the Y axis, the neck and head is move 59.10 ° against Y axis when the assembly task has been done.

The principal postures to evaluate were the upper body parts, such as upper and lower arm, wrist, neck, and torso. The metrics are showed in the Table 1.

The RULA analysis showed (Table 1) that a redesign of the workstation could be a solution to reduce the damage or discomfort that appear when the worker is direct contact with the workstation. The current design of the station is showed in the Fig. 4, where is possible observe the mechanisms that compound the machine which contain in its structure a pneumatic double acting (C1) that was used as work element for the assembly of the spark plugs wire, non-returned check valve (A1) employed like velocity control. A pneumatic 5 port valve, pilot operated and spring returned (A2), was used as control element in combination with a 3/2 lockable food pedal valve (A3) using a compressor (A4) as energy supply. The pneumatic circuit and displacement step diagrams are showed in the Fig. 5 and 6.

OCRA Checklist was applied with the aim of clarify if a redesign of the workstation is necessary, the methodologic was carried out following the steps of the ISO 11228-3 which are: Repetitive Work, recovery time factor, and additional

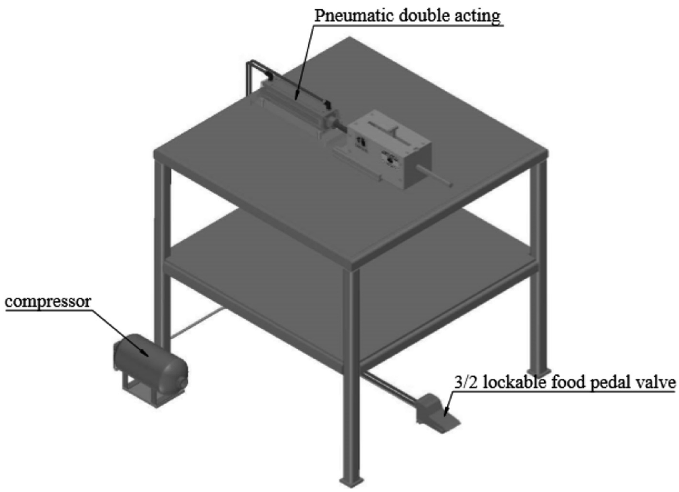
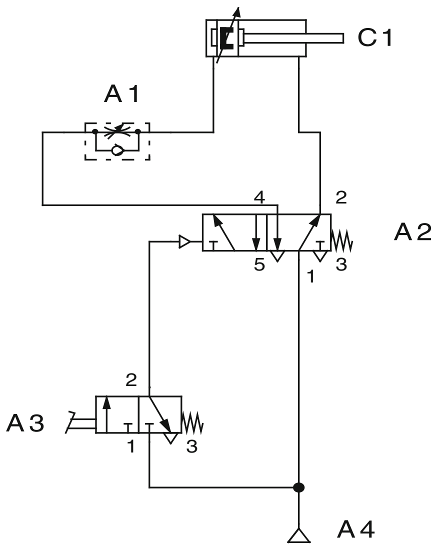


Fig. 4 3d design of the current workstation

Fig. 5 Pneumatic arrangement of the current workstation



risk factor. The results of the evaluation are showed in the Table 2. For the Step 1 the most of the answers were positive, which mean that exist a risk due to repetitive movements, this behavior is evident, since the worker take with his hands 8 wire and its respective components in each cycle during the shift (7.5 h) taking just 30 min to take lunch. Consequently, for the step 2 more than 1 answer was positive, such as was demonstrated through RULA analysis where the wrist, upper and lower arm, back and neck are seriously compromised taken awkward posture. The

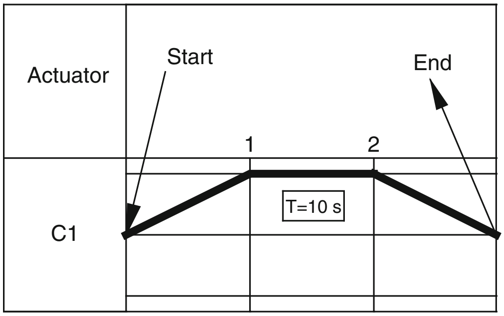


Fig. 6 Displacement step diagrams

Table 2 Risk evaluation with OCRA analysis

Evaluation	Step	Answer		Green	Yellow	Red
		Yes	No			
Repetitive work	1	4	0	–	–	x
Awkward posture	2	4	1	–	–	x
Recovery time factor	4	3	0	–	–	x
Additional risk factor (physical)	5	6	5	–	–	x
Additional risk factor (Psychosocial)	5	0	7	x	–	–

recovery time factor is omitted in the shift, generated a risk for worker´s health. Psychosocial additional risk factor was evaluated give negative answer for all questions, which suggest that this factor is not a representative risk. However, for the physical risk, more that of 50 % are positive, consistent with the other result in the OCRA evaluation. Therefore, a redesigned of the workstation is necessary.

Concerning to the workstation, the introduction of two capacitive proximity sensing is proposed in combination with a hold device. One of the sensor is localized on the ground, while, the other is in the hold device. The first, help to reduce the force that the worker perform when switch on the work element. The second is localized in the hold device in which the terminal and wire will be assembled with the boot, avoiding the crash of the work element with the hand, reducing the wrong position on wrist that the worker adopter when the task is being done (Fig. 7).

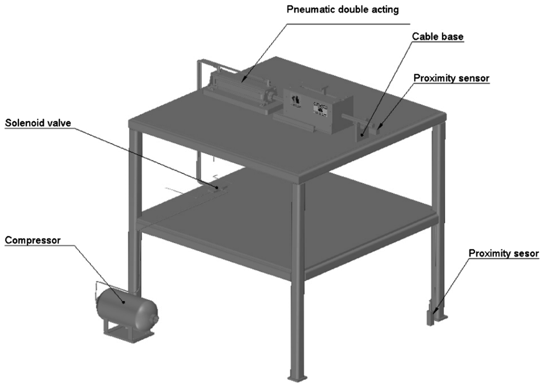


Fig. 7 3d Redesign of the workstation

4 Conclusions

The RULA and OCRA technique was helpful to determinate the body parts compromising in the task, as well as, the risk that is exposed the worker. The RULA analysis showed that wrist, upper and lower arm as well as neck and head, taken posture that may generate a lesion, with the aim to minimized the effect, an OCRA analysis was done to identify if repetitive work, recovery time were considerate during the shift. With the results obtained, a redesign of the current workstation is proposed with the addition of sensors and hold device, contributing to reduce the damage or lesion that can appear if continue the exposition during the Shift.

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Part VI
Social and Organizational Factors in Industry

The Relationship Between Sustained Attention and Mindfulness Among U.S. Active Duty Service Members and Veterans

Valerie J. Rice and Baoxia Liu

Abstract Sustained attention is critical for military service members in operational environments. This study explored the relationship between sustained attention and mindfulness among military personnel and veterans (n = 247). Volunteers completed a sustained attention task (Integrated Visual and Auditory Continuous Performance Test), and two mindfulness surveys (Mindful Awareness and Attention Scale [MAAS] and the Five Facet Mindfulness Questionnaire [FFMQ]). Results revealed positive correlations between the MAAS and Full Scale Response Control Quotient (FSRCQ) and Full Scale Attention Quotient (FSAQ) scores. For the FFMQ, *Acting with Awareness* was positively correlated with the FSRCQ and FSAQ; *Describing* was correlated with FSRCQ; and *Non-judging* was correlated with FSAQ. Thus, increases in mindfulness were associated with increases in sustained visual and auditory attention, and certain facets of mindfulness were more closely aligned with sustained performance than others. These results suggest mindfulness training may assist with improving sustained attention, and that research in this area is warranted.

Keywords Mindfulness · Military · MAAS · FFMQ · Sustained attention · Mindfulness training

1 Introduction

Sustained attention refers to the ability to attend and maintain consistent performance over time. Sustained attention tasks may also be referred to as vigilance tasks, and such tasks often require detecting low level signals over extended monitoring time-periods. Vigilance tasks in a military operational environment can include

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detection (in person or via technology) of life-threatening targets. Non-detection of a threat can mean life or death for the individual warrior and his team, while false alarms could lead to equally serious mishaps, such as responding to threats that are not present. Sustained attention tasks can be demanding and stressful, and cannot always be assisted through automation. While maintaining focused attention may be desirable for a multitude of jobs, it is fundamental to combat.

Mindfulness refers to the conscious awareness of one's present experience without judgment. As described by Kabat-Zinn [1], it is "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally". When learning mindful meditation, participants are taught to focus on present experiences, including thoughts, feelings, or sensations as they change from moment-to-moment [2, 3]. When a person is being mindful, their attention will be intentionally administered and purposefully managed.

Since mindfulness meditation training incorporates training in 'paying attention', it might be expected that such training would have an impact on sustained attention and sustained performance. Research on the effects of mindfulness training show promising results in this regard. Early research found increases in attention were correlated with how long a meditator had been practicing [4]. Valentine and Sweet [5] found that both mindfulness meditators and concentrative meditators performed better than a control group on a sustained attention task, and that long-term meditators performance was superior to short-term meditators. They also found that mindfulness meditators surpassed concentrative meditators when an unexpected stimuli was shown during a sustained task, but performed no differently when expected stimuli were shown. More recently, mindfulness training was found to reduce attentional lapses through mind wandering (thinking of other things) among military participants pre-deployment [6]. Mindfulness training is being offered in a variety of work settings, as well as in homes, to increase individuals' attention and self-control and to decrease anxiety, stress, and emotional deregulation [7].

While these few studies on mindfulness and sustained attention are encouraging, additional studies are needed to gain knowledge about the relationship between mindfulness and sustained attention. The goal of this study is to explore this relationship among military active-duty personnel and veterans, and to investigate how individual components of mindfulness (as defined by the Five Facet Mindfulness) may be related to sustained attention.

2 Methods

2.1 Participants

Research volunteers (n = 247) were recruited from U.S. military active service members and veterans at Joint Base San Antonio and the surrounding vicinity. Volunteers agreed to participate in a larger study on Mindfulness-Based Stress

Reduction taught in-person and via a virtual world, approved by a military Institutional Review Board. Full explanations of the study were given to all potential volunteers. Interested individuals read and signed an informed consent form. Participation was voluntary and volunteers were permitted to terminate their participation at any time during the study. Volunteers were not compensated for their participation. Volunteers completed pre- and post-training evaluations as part of the study. This paper uses data collected during the initial baseline assessment, prior to intervention training.

2.2 Questionnaires

Volunteers completed three questionnaires. One questionnaire addressed demographics and two questionnaires focused on mindfulness.

Demographics. The demographic questionnaire included questions on age, gender, race, marital status, education level, and military status.

Mindful Awareness and Attention Scale (MAAS). The MAAS was developed to measure self-reported frequency of enhanced attention to, and awareness of, present experiences over time, that is, trait mindfulness [8, 9]. The 15-item unidimensional scale uses statements such as, "I break or spill things because of carelessness, not paying attention, or thinking of something else". Respondents rate how often they have experienced such instances of acting on automatic pilot, being preoccupied, or not paying attention. Items are scored on a 6-point Likert scale (1 = almost always, 2 = very frequently, 3 = somewhat frequently, 4 = somewhat infrequently, 5 = very infrequently, and 6 = almost never). A single average score can be generated from the questionnaire. The questionnaire has been shown to be a reliable and valid instrument [8]. A test-retest reliability of 0.81 and internal consistency of 0.82 were reported [8], and the assessment has been positively correlated with other measures of mindfulness [10]. The mean score on the MAAS for community adults was 4.20 ± 0.69 (4 independent samples, n = 436), while the mean score for college students was 3.83 ± 0.70 (14 independent samples, n = 2277) [9].

Five Facet Mindfulness Questionnaire (FFMQ). The FFMQ is a 39 item self-report questionnaire, developed to measure five facets of mindfulness: *observing* (8 items), *describing* (8 items), *acting with awareness* (8 items), *non-judging of inner experience* (8 items), and *non-reactivity to inner experience* (7 items) [10]. An overall score is also assessed. Observing, describing and acting with awareness reflect mindful actions, while non-judging and one-reactivity show individual responses to internal experiences. A five-point Likert scale (1 = never or very rarely true, to 5 = very often or always true) is used, with responses chosen according to how well the statement describes an individual's opinion or what is generally true for them. The FFMQ has adequate to good internal consistency [10] and construct validity [11]. The reliability and validity of each of the five facets of FFMQ was shown to be acceptable [12].

2.3 Integrated Visual and Auditory Continuous Performance Test (IVA+Plus CPT)

The IVA+Plus CPT measures sustained continuous auditory and visual performance, assessing response control and attention on a computerized assessment [13]. Following warm-up and practice trials, the main assessment includes 500 trials of “1”s and “2”s presented in a pseudo-random order. The volunteer is instructed to click the mouse only when he sees or hears a “1” and inhibit his response when seeing or hearing a “2”. During some segments, the “1”s are more common than “2”s, which tends to cause errors of commission or impulsivity. During other segments, the “1”s occur infrequently, typically yielding more errors of omission or inattention. Scores are normed for children and adults (ages 6–96). Two global quotient scores are used to indicate one’s attention, the Full Scale Response Control Quotient (FSRCQ) and the Full Scale Attention Quotient (FSAQ). The FSRCQ is based on the corresponding auditory and visual quotients: Auditory Response Control Quotient (ARCQ) and Visual Response Control Quotient (VRCQ). Each response control quotient has three components: *prudence*, *stamina* and *consistency*. *Prudence* measures response inhibition, as indicated by commission errors. *Stamina* measures the ability to sustain effort over time, and *consistency* measures the volunteer’s consistency of responses across trials. The FSAQ is based on its corresponding auditory and visual quotients: Auditory Attention Quotient (AAQ) and Visual Attention Quotient (VAQ). The attention quotients also have three components: *attention* (indicated by omission errors), *focus-of-attention* (indicated by variability of response speed), and *processing speed* (time between stimulus presentation and response). All quotient scores are normalized based on participants’ age and the scores are similar to an IQ score in that the mean is 100 and a score of 115 means the individual scored 15 above the mean for the same age group and one standard deviation from the mean. Higher scores indicate better performance.

2.4 Statistics

Descriptive analyses included frequencies, means and standard deviations. Pearson-Product Moment correlations were used to examine the relationships between mindfulness scores (MAAS and FFMQ) with quotient scores from IVA+Plus CPT. Data analyses were conducted using IBM SPSS Statistics for Windows (Version 22, Armonk, NY: IBM Corp, Released 2013) using a significance level of 0.05.

3 Results

3.1 Demographics

Volunteers' demographic data are shown in Table 1. Volunteers ranged in age from 24 to 74 (M = 48.19, SD = 11.97) and were predominately veterans (66.0 %). The majority of volunteers were Caucasian (53.8 %), married (57.9 %), and most had attained a college or professional degree (61.5 %).

Table 1 Demographic information for volunteers*

	N	(%)
Gender		
Male	131	(53.0)
Female	116	(47.0)
Education		
GED/High school	16	(6.5)
Some college/Associate's	79	(32.0)
Bachelors	61	(24.7)
Masters/Doctorate	75	(30.4)
Other professional degrees	16	(6.5)
Race		
African American	61	(24.7)
Native American	4	(1.6)
Caucasian	133	(53.8)
Hispanic	42	(17.0)
Asian	5	(2.0)
Other	2	(0.8)
Marital status		
Married	143	(57.9)
Divorced	49	(19.8)
Widowed	3	(1.2)
Single/separated	42	(17.0)
Living with significant other	10	(4.0)
Military status		
Active duty	75	(30.4)
Reserve	5	(2.0)
Guard	4	(1.6)
Veteran	163	(66.0)

*The total percentage may not be exactly 100 due to rounding

3.2 Mindfulness and Sustained Performance

Descriptive data from the mindfulness questionnaires and quotient scores from IVA+Plus CPT are shown in Table 2. The MAAS score for this population was lower than the norms seen for community adults (4.20 ± 0.69) and for college students (3.83 ± 0.70) [9]. FFMQ scores for *observing*, *describing*, *acting with awareness*, *non-judging*, and *non-reactivity* for this population were slightly lower than those for college students (college student scores, respectively 27.11 ± 5.38, 29.76 ± 5.45, 26.95 ± 5.63, 28.77 ± 6.51, 22.14 ± 4.57) [14]. The overall FFMQ score for this population was also slightly lower compared with a college students (134.73 ± 19.41) [14], and a little higher compared with 92 veterans seen at a veterans hospital (108.0 ± 25.3) [15].

Sustained attention scores on the IVA+CPT Quotient scores were lower than normalized scores based on age. For the Full Scale Response Control Quotient (FSRCQ) score and the Auditory Response Control Quotient (ARCQ) score, the scores fell approximately one standard deviation below the mean.

3.3 Correlations

The correlation coefficients between the IVA+Plus CPT quotient scores and the MAAS and FFMQ scores are listed in Table 3.

Table 2 Scores and standard deviations for the mindfulness questionnaires and the sustained performance assessments, for all volunteers

Measures	Mean	SD
MAAS	3.74	1.04
FFMQ		
Total FFMQ	123.49	23.86
Observe	25.11	6.18
Describe	26.35	7.38
Acting with awareness	25.10	7.43
Non-judging of inner experience	26.31	7.34
Non-reactivity to inner experience	20.62	5.28
IVA+Plus CPT quotients		
Full scale response control	85.01	21.63
Auditory response control	85.77	21.84
Visual response control	88.49	19.90
Full scale attention	90.39	23.29
Auditory attention	91.73	22.92
Visual attention	90.86	23.65

Table 3 Pearson-product moment correlations between mindfulness scores and sustained performance scores (N = 247)

	Full scale response control (FSRCQ)	Auditory response control (ARCQ)	Visual response control (VRCQ)	Full scale attention (FSAQ)	Auditory attention (AAQ)	Visual attention (VAQ)
MAAS	0.15	0.10	0.17	0.17	0.16	0.13
FFMQ						
Total score	0.15	0.11	0.17	0.16	0.11	0.18
Observe	−0.04	−0.08	0.02	−0.05	−0.06	−0.03
Describe	0.19	0.16	0.18	0.11	0.04	0.16
Acting with awareness	0.21	0.19	0.19	0.23	0.19	0.23
Non-judging	0.04	0.03	0.04	0.13	0.10	0.14
Non-reactivity	0.12	0.06	0.16	0.11	0.10	0.09

4 Discussion

Results showed that mindfulness, as measured by the MAAS, was positively correlated with both global quotient scores that measure one's attention, the FSRCQ and the FSAQ. The FSRCQ measures visual and auditory response inhibition, consistency of responses, and sustainment of effort. Of the two component quotient scores of FSRCQ, only the visual response control quotient (VRCQ) was correlated with mindfulness, the auditory control quotient (ARCQ) was not. This indicates that as mindful awareness increases, visual response inhibition (the ability to voluntarily supress one's own inappropriate actions that might interfere with contextual goal attainment), sustained effort over time (the ability to continue the same level of visual mental effort and attention), and consistency of responses over trials (maintaining the same level of performance over a certain time period) also improve. Mindfulness, as measured by the MAAS, was also positively correlated with both components of the FSAQ, the auditory and visual attention quotient scores (AAQ and VAQ). The FSAQ is an indication of vigilance, focus and speed, which include errors of omission, variability of response times, and reaction times. Thus, as mindfulness improved, both auditory and visual attention improved in terms of not missing important cues, maintaining attention (responding to cues at the same speed), and mentally recognizing and physically responding to cues with a similar processing speed over time.

Similar research with 50 undergraduate college students investigated the relationship between mindfulness (measured by the MAAS) and sustained performance, measured by Conners' Continuous Performance Test II (CPT-II) [16]. The authors found that mindfulness was negatively correlated with the number of target omissions on the CPT-II, but not with reaction time variability. They speculated that the omissions were indicative of exaggerated lapses in attention, which may be related to being unaware of the present experience. Greater mindfulness was found to be associated with fewer lapses of attention. This is similar to our findings, in which we found that both auditory and visual attention quotients, which include omission errors, were related to greater mindfulness. However, we found that greater mindfulness was also associated with greater visual and auditory *focus-of-attention* (indicated by less variability of response speed), while they did not find such a relationship. According to the authors, they felt that reaction time variability was an indication of one's constant awareness of the present, which may be too subtle to be regulated for participants with little meditation training. Our findings contradict that statement, as our volunteers were naive to meditation training and their higher mindfulness was related to their 'constant awareness of the present' as indicated by reaction time variability. The difference between the results of their study and ours may be due to the different populations and also the differences in the sustained attention tasks. Our participants had military experience and the average age was 48, clearly an older population than undergraduate college students. The active serve members and veterans may have more experience with monitoring their attention through military training and experience, which may explain why their mindfulness was correlated with sustained attention since they may be more capable of regulating their attention. However, their mindfulness scores were slightly lower than those of college students. Thus, if our volunteers had greater control over their attention, it was not shown in their mindfulness assessments. Still, our results suggest that the more mindful a person is, the better they are at maintaining their attention over time and reducing lapses of attention. Perhaps the more accurate explanation of a difference in research results is the difference in our sustained attention tasks. Their sustained attention task used visual stimuli only, with 360 trials, while ours included both visual and auditory stimuli for 500 trials (a more extended period of time).

Positive correlations between FFMQ scores and sustained attention performance scores showed that certain facets of mindfulness were correlated with sustained performance, while other facets were not. *Acting with Awareness* is paying attention to ones actions, which stands in contrast to acting mindlessly, such as one does when on 'automatic pilot'. Higher scores on *Acting with Awareness* were associated with higher scores on all measures of visual and auditory sustained attention, in terms of *prudence*, *stamina* and *consistency*, as well as *attention*, *focus-of-attention*, and *processing speed*. That is, those whose scores indicated they act with awareness also inhibited incorrect responses, sustained their efforts over time, were consistent across trials, and also sustained their attention, demonstrated fewer lapses of attention (fewer omission errors), maintained their focus, and responded to stimuli in a consistent fashion (less variability in response and processing speed).

Describing is the ability to identify internal experiences with appropriate verbiage. The higher self-reported ratings of *Describing*, the better the scores were on all aspects of sustained performance, with the exception of FSAQ and its' sub-quotient AAQ score. It may be, however, that even this type of attention may be improved by mindfulness meditation training, given that part of the training teaches participants to focus on hearing, as well as physical sensations, thoughts, and emotions. This supposition would need to be substantiated through additional research. Interestingly, two of the three facets considered to represent mindful actions were associated with greater sustained attention; *Describing* and *Acting with Awareness* were associated with sustained attention, while *Observing* was not. *Observing* refers to one's noticing internal and external sensations, cognitions, emotions, sights, sounds, and smells [11].

Finally, of the two facets showing individual reactions to internal experiences, only three associations were identified. *Non-judging* is when an individual does not evaluate his or her own inner experiences of thoughts or feelings. *Non-judging* was associated with the FSAQ and VAQ, but not with AAQ or any measures of Response Control. *Non-reactivity* is related to *Non-judging*, but differs in that one recognizes thoughts and emotions, but does not so closely identify with them that they become ensconced in them. *Non-reactivity* was associated with VRC (visual inhibition of errors of commission) only.

Greater mindfulness is clearly associated with greater sustained attention and sustained performance, as shown in these results. In addition, keeping ones consciousness attuned to one's present actions and being able to identify one's internal sensations (*Acting with Awareness* and *Describing*) are the most closely aligned with sustained attention and performance, of the five facets of mindfulness.

5 Limitations

The data collected in this study were from a cross-section of a population at a particular point in time, which did not provide evidence about the causal relationship between mindfulness and sustained attention. Empirical study that involves mindfulness training could provide more insight about the relationship between mindfulness and sustained attention. The results in this study are from military participants and veterans, under non-deployment conditions. Caution should be used in applying these results to other populations.

6 Conclusions

This study demonstrated that higher scores on two mindfulness assessments were associated with higher performance on a sustained attention task, and on both visual and auditory components of the task. In addition, maintaining a conscious awareness (mindfulness) of one's present actions and being able to detect and identify one's internal sensations (interoceptive awareness) are more closely aligned with sustained visual and auditory performance than are other facets of mindfulness. These findings hint at the possibility of further improving individual performance on sustained attention and vigilance tasks through training in mindfulness-based interventions, such as Mindfulness-based Stress Reduction (meditation) training. For those whose jobs require such careful, continued watchfulness for danger over prolonged periods of time, this research is certainly warranted. Should such training be effective, lives might be saved among military, police, and firefighters, as well as among those they protect.

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Human and Economic Factors of Long-Distance Commuting Technology: Analysis of Arctic Practices

A. Kozlov, S. Gutman, E. Rytova and I. Zaychenko

Abstract The important problem of Arctic zone of Russia development is the development technology choice, because of some specific features of this territory. One of the possible alternatives is long-distance commuting technology. This type of work organization becomes more and more actual for extractive industry, for construction and services all over the world. It is especially important for remote regions, like Arctic, and for regions where the qualified labor force is not accessible. Long-distance commuting technology (fly in/fly out, shift work) has some advantages and disadvantages. Advantages are connected with economic indicators of work, and disadvantages—with social aspects of this technology. Productivity evaluation shows long-distance commuting technology is efficient for development of new areas and industries in remote regions. But it is also efficient to maintain existing industries and settlements with existing infrastructure permanently. So the development technology depends on the regional conditions.

Keywords Long-distance commuting technology · Arctic region · Russia · Human and economic factors

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1 Introduction

Arctic area of the Russian Federation takes 9 million km^2 (6.8 million km^2 is water space and 2.2 million km^2 of land), representing over 50 % of the total area of the country. It is necessary to take into account some specific feature of Arctic zone of Russia because of some limits they do to develop these northern territories:

- Extremely unfavorable climate (including ice cover and drifting ice in Arctic Ocean);
- Focal socio-economic and industrial development and low population density;
- Remoteness from main industrial areas, great resource use, high industry and population dependence from delivery of fuel, food and other essentials from other Russian regions
- Low stability of ecological system, which forms biological balance and Earth climate, its high dependence from anthropogenic influence.

So there are four main elements of Arctic environment: nature, economy, population and social sphere. All elements are interacted and correlated.

Arctic territory of the Russian Federation are involved in an intense economic activity. Extractive industries plays the main role in Arctic economy nowadays. [1].

Labor potential together with the natural resources there is also an essential and important element of economic development. Due to the natural features of the region it is especially important to preserve and increase the Arctic human capital. Moreover, human resources can be considered as one of the strategic resources of the Russian Arctic, along with oil, gas, marine and air routes. The permanent Arctic population number is relatively small: in the extreme conditions of high Arctic resides less than one percent (0.88 %) of the 517 million people in 8 Arctic countries. In Russia, the number of Arctic population, twice as many (1.7 %) than the average in the Arctic. 2.5 million of people or more than 54 % live In the Russian Arctic [2, 3], and only 2.1 million people live in all the other seven Arctic countries.

Thus there is an advantage in population number in Russian Arctic in comparison with other Nordic countries, and by this indicator North Russia even can be called is excessively populated. But the analysis of the demographic situation in the Russian Arctic [4] shows negative trend to a reduction of small arctic population, and as a consequence the reduction of the employment potential of the region.

Considering the labor potential of the Arctic is important to pay attention to issues that seem a priority to ensure sustainable development of the labor market: the impact of poor living conditions on the labor potential development, quality of human capital (stock of knowledge, health, professional competencies), public solidarity (welfare all members of society, overcoming inequality, jobs, education system, the prevention of social conflicts, the preservation of culture and indigenous peoples traditions).

Cash income is the basic indicator for the assessment of the standard of living of the population in the region. The low level of cash income is accompanied by a large number of social problems. For the north of Russia, including the Arctic zone, such negative social phenomena are common as poor infrastructure, alcoholism, poor health system.

Alcoholism and crime are consequences of other important problem of the Arctic territories—the unemployment problem. The lack of employment opportunities in the areas of residence makes limits for the working-age population. In many small settlements only temporary or part-time work is available. As a result, working-age people who could and would work full time, have a lot of free time for drunkenness and crime. In turn, labor mobility of Arctic inhabitants is low because of the isolation and inaccessibility of Arctic settlements and underdeveloped transport infrastructure.

There is an apprehension that the population of the Russian Arctic cannot become a modernization factor in economic and social development, and also is unable to maintain the current very low level of economy infrastructure of the Russian Arctic.

Development—a very important quality of the territory. Developed territory is characterized by economic potential, undeveloped area has only resource potential available for further use in various ways. During Soviet period, the economic development of the North was widespread and complex, including large number of residents were moved to the north, according to so-called sedentary development technology. Sedentary technology means the organization of permanent residence of people, and has the number of economic, social and medical problems. In addition, the need to create socio-cultural and domestic infrastructure requires significant one-time and ongoing costs which are comparable with the cost of production infrastructure.

The exhaustion of mineral resources there is also one of the main problems for the existence of populated northern regions. Regions are focused on the mineral extraction industries and it could cause recession after resource deposits exhaustion. It makes the problem of development technology choice actual: is the sedentary (traditional) forms of development of the Arctic territories efficient or it is necessary to use alternative development technology, taking into account the experience of other Arctic countries.

Further development of the Arctic territories of the Russian Federation is a strategic resource of the country's economic development and an important factor of comprehensive state security.

The aim of this study is to offer proposals for the selection of development technology for Arctic territory, taking into account social aspects.

2 Existing Literature

Existing literature on the development technology shows three main aspect of this problem: the first aspect—the notion of development and developed territory in relation to the Far North; the second one—the concept and content of development process; and the third—positions on the development technology of the northern territories.

Speaking about the "developed areas" and "areas development", Zuev proposes a definition of "developed areas", and declares that one should not confuse the concept of affiliation and development of the territory. The development of the territory—"a process in which the population comes to the territory and try to build an autonomous and self-sufficient economic system, designed to meet people's needs" [5]. Alaev [6] determines the development of the territory as a form of dissemination of the productive forces, or inclusion in the national economy of the territories previously had a natural, unchanging landscape. According to Nikul'nikov [7] "Development of the territory is a process of involving new natural resources in social production".

The development process is classified into types and kinds. Kosmachev [8] identified three types of development: (1) Pioneer (creation of the first layer of development); (2) Reconstructive (more intensive types of economic development); (3) High intensity (associated with the creation of "new territory", creation of artificial environment to increase the efficiency of the development process).

In a study of the development process, there are different approaches that complement each other. Some scientists focus on the geography factors of development (territorial differences in the availability of natural resources), others on the geography of the process (settlement, natural resources, infrastructure saturation area).

The first approach of Kultashev is based on the study of the development factors. In his opinion, "the development of territories is the complex of socially organized human activities aimed at use of resources and environment, and their transformation to meet the needs of territory inhabitants …" [9]. Thus, when he speak about the development of the territory the author had in mind the development of natural resources.

The second approach—the study of economic geography of the development process (settlement, natural resources, infrastructure saturation area). This approach is common of the work of Alaev [6] and Kosmachev [8].

Development technologies include sedentary and long-distance commuting (shift) methods of development of the territory. Sedentary method is a way of development associated with permanent living and economic activity of the population at the same place in the settlements of various types. Urban settlements accumulate industrial, organizational, economic, administrative, cultural, entertainment and other functions. Geography of population studies the production and consumption of the settlement and is a part of economic geography.

Under sedentary technology refers permanent settlements near the main work sites where population forms communities for various purposes and specialization [10].

Thus, sedentary technology of development of can be interpreted as the traditional form of the labor process organization in the place of residence of the workers, when it is possible to provide them with a daily return to their place of residence. Since workers are permanent residents and work in the same region, employers do not participate directly in the process of providing workers with housing and other social services. Company is located inside or in the immediate vicinity of the settlement, transport costs to move to work place is minimal.

Long-distance commuting technology (shift work) is mobile organization design, when workers permanently live in one region, but temporary live and work in another region and regularly commute between these two points. Usually working place is situated far enough from constant habitation and is isolated from others settlements, so residence and social services have to be organized by employer. This type of work organization becomes more and more actual for extractive industry, for construction and services all over the world. It is especially important for remote regions, like Arctic, and for regions where the qualified labor force is not accessible. But there are just a few researches about long-distance commuting technology in spite of using this technique by employers in different countries, like USA, Canada, Norway and Australia.

In Russian legal documents the “shift method” concept was first used in the “The Regulations of work in shifts organization of 11 April 1974” and then in “The Regulations of rotational harvesting organization” in 1976 [11]. There long-distance commuting (shift method) was understood as a method, involving the work of teams in remote camps—temporary settlements for living workers without families. The most important part of the shift method infrastructure is a shift camp—a complex of residential, sanitary and economic, cultural and community buildings, which are intended for accommodation of employees, providing their rest time also, and for the maintaining transport and construction machinery and storage of material values [12].

Methods of selecting of development technology in the literature are generally reduced to the justification of the effectiveness of the shift method for specific sectors, such as road construction [13], agricultural production [14], oil and gas companies [13], or to analysis of the motivation problems of shift employees [11]. Gertrude Eilmsteiner-Saxinger mentiones to the social problems of shift technology in the Arctic regions of Western Siberia, but analyzes them only in terms of values and lifestyles of commuting workers using ethnographic methodology in the works [15–17]. Similar studies were carried out in [18]. Öfner [19] analyzes the social factors influencing the choice of shift work and attributes this to the general instability of the labor market in the Russian Federation and a more favorable situation in the oil and gas sector, as the main user of mobile resources.

There are also some papers discus different aspects of the shift technology, such as, for example, statistical studies of shift workers migration [20], the impact of shift workers on the livelihoods of indigenous people of the northern regions [21], the effectiveness of the shift method for the development of natural resources [22, 23], staff turnover among shift workers [24].

But the social aspects are not taken into account practically in the studies devoted to the choice of development technology for Arctic zone of Russia. The selection of people, who by their business, personal and physiological qualities are the most appropriated to conditions of shift work in the North; adaptation of newcomers to the shift teams; the choice of timetable for work and rest; labor motivation system; social benefits and guarantees; comfortable living conditions, also during transportation and recreation, and so on—all of this must be considered in the evaluation and selection of development technology for the northern territories.

Thus, the problem of selecting of effective technology of development for Arctic territories, taking into account the social aspect, is a poor investigated area, which confirms the relevance of the research problem.

3 Methodology

Main research methods are assembling and analyzing the information, particularly, statistics, comparative analysis and synthesis, analogies when choosing basis to compare, as well as measuring socio-economic efficiency and secondary analysis of sociological research of domain experts.

4 Findings and Results

There are some features of each of the development method which have a significant impact on the staff livelihoods. Long distance commuting method has a number of advantages and disadvantages. The benefits relate mainly to the economic performance, and the shortcomings are connected with the social characteristics of this method. In particular shift method requires less investment, as does not involve the development of infrastructure; camps are mobile, allowing you to move them as needed at a low cost. Comparison of the main parameters of the development methods shown in Table 1.

Based on the previous studies, it is possible to state that both, sedentary and long-distance commuting technologies, in Arctic conditions have their advantages and disadvantages. Comparative analysis of these technologies submitted in Table 2.

In particular shift work is required less investments, because infrastructure development is not necessary; shift camps are mobile and can be moved with low costs. Also it is possible to increase employment; shift workers have high salary, because of 35–75 % bonus for working conditions. On the other part unfavorable climate lead to increasing of morbidity of workers. Long work cycle and tearing off usual social environment are the cause physical and moral exhaustion. Isolation and lack of usual life conditions lead to frequent breach of the law by shift workers. It also makes threats for culture and traditions of native population. All these disadvantages have different effects on staff and require different actions from the companies' management.

Vorkuta city (currently municipal district Vorkuta), founded in 1943, is one of five cities in the world which are located beyond the Polar Circle. It is situated in

Table 1 Comparison of sedentary and long-distance commuting (shift) technologies

Indicators	Sedentary technology	Long-distance commuting (fly in\fly out) technology
1. *Work and leisure*		
The duration of the operating cycle	1 week	From 2 weeks up to several months
Timesheet	Per day, weekly	Summarized
Working hours	8 h	Up to 10 h, continuous 8 × 8 h, 12 × 12 h
Weekends during the operating cycle	According to the schedule	Not provided
Order of collectives replacing	–	Regularly taking into account the production cycle
2. *Moving to the workplace*		
Transport type	City transport, automobile	Air transport, rail transport, helicopter
Travel time	Up 2 h	from 12 h to several days
3. *Social aspects*		
Settlement type	Cities and rural settlement	Shift camps
Social service	Formed in the settlement	Provides employer
Social environment	Developed, diverse	Limited
Application period	Unlimited	Up to 10 years
Application sector	Any sector	In construction, exploration, extractive industries
Labor usage	Intraregional	Interregional

Table 2 Advantages and disadvantages of sedentary and long-distance commuting technologies

	Sedentary technology	Long-distance technology
«+»	1. A positive impact on the geopolitical situation 2. City development 3. The economic development of the territory 4. Employment increasing 5. Creation of the city-forming enterprises	1. Less investments 2. High wages 3. Creation jobs 4. Shift camps mobility 5. Increase of wage up to 30–75 %, which increases the motivation of workers
«−»	1. Higher investments 2. The threat of depopulation 3. Violation of cultural and traditional values of the indigenous population 4. Insufficient social infrastructure 5. The emergence of “dead cities”	1. High incidence threshold 2. Prolonged labor cycles 3. Violation of cultural and traditional values of the indigenous population 4. Violation of the law by shift workers who are isolated from the usual social environment

the Arctic zone of Russia, in its European part, on the far North West of the Komi republic. City economy is mainly mono profiled [25]. Coal industry is city-forming and provides 80 % of industrial manufacturing and about 60 % of the gross city product. The foundation of the city was coupled with coal mining. "Vorkutaugol" company was founded in 1931, because there was discovered coking coal in Pechora Basin for metallurgical sector of Russia. Vorkuta geological region has high production potentials and has coal inventory above 4 billion tons.

The sedentary method is the main and actually the only development method used for Varkuta Basin. This follows from the dominant doctrine in the Soviet times, the practice of the development of the Soviet North by "broad and lasting settlement development" is a more cost-effective than the Western experience of using rotational technology [26]. The result of this approach, and was the creation and development of the Vorkuta city on base of coal city-forming enterprise.

Spitsbergen or Svalbard is a vast polar archipelago located in the Arctic Ocean and the most northern part of Norway.

Russia played an important role of developing the Svalbard, and is currently working on the archipelago trust "Arcticugol", organized in 1931. On Svalbard has one active Russian mine "Barentsburg," and 2 closed—"Pyramid" (conserved at the end 1998) and "Grumant" (work stopped in 1961).

Number of Norwegian population of Spitsbergen has a positive trend since 1990. Norwegian population has increased for 1000 people (90 %) in 1990–2015. Population of Norwegian communities considerably changes within a season. So 150 people leave Spitsbergen in the first half of the year and 250–300 people in the second half of the year. Russian population was the largest on Spitsbergen in 1990–1997. According to the statistical data of the year 2015, the number of Russian population is about 471 people (decreasing from 2000 people i.e. in 5 times from 1990 to 2015). This situation came from the fact the Russian coalmines were suspended and the whole coal industry became non-profitable.

Since Vorkuta city has been developed by the sedentary method, there were founded and currently function several other industries apart of the main (coal) one, such as cement industry, brickyards and ferroconcrete items manufacturing.

Spitsbergen developing was only focused on mining and population was brought as a temporary labor force, i.e. the shift method (Table 3).

Difference in productivity is even more serious according to the 2014 statistics. Productivity of the company SNSK (per worker accounted 5068 tons of coal) is 4 times higher than in the company of "Vorkutaugol" (per worker accounted 1602 tons of coal). Coal mining of "Vorkutaugol" company 5 times higher the

Table 3 Main production indicators of SNSK and Vorcutaugol enterprises (2012)

Indicators	Store Norske	«Vorcutaugol»
Coal production (million tons)	1.229	11.6
Number of stuff (person)	396	7091
Turnover (million dollar)	120.4	
Productivity tons/person	3208	1636

Sources of statistics: [27–29]

Table 4 Long-distance commuting technology social effectiveness factors

Personal	Social	Management
Business, personal and medico-physiological merit and specifics of personnel	Used routines for work and rest	Management work efficiency
Motivation to productive work	Social satisfaction of shift workers by their job and family situation	Everyday life and spare time organization
	Socio-psychological climate in shift teams	Staff logistics efficiency
		Interaction with authorities

production of company SNSK, while the number of employees in SNSK 336 people, and in “Vorkutaugol”—7116 people. For comparison, on 336 people working in “Vorkutaugol” company falls 566 thousand tons of coal that 3.27 times lower than the SNSK company.

It can be concluded that the involvement of shift staff makes SNSK labor productivity higher, but also should bear in mind the differences in coal mining technology.

All the factors that determine the social effectiveness of shift technology can be divided into three main groups (Table 4): personal, social and management. In this case it seems clear that management factors largely affect the social ones, and social factors determine to a large extent the person adaptation of person to the shift conditions.

Evaluation of social efficiency of the long-distance technology is quite difficult due to a variety of factors which are mainly qualitative. Nowadays, the most commonly used are the sociological methods to assess the social efficiency, based on interviews and questionnaires of shift workers. According to a study [30] on the basis of shift workers polls were defined the main problems in shift-production organization. Most of these problems can be solved by social management methods (Table 5).

Table 5 Management technologies suitable for solving long-distance commuting problems

Problems	Range	Management technologies
Dissatisfaction with wages	1	1. Stuff attestation system 2. Wage monitoring and correspondence of wage with level of labor market 3. Extension of social benefits and guarantees for rotational staff
Inefficient production management	2	Determination of required number of shift personnel, taking into account labor market conditions and company development trends

(continued)

Table 5 (continued)

Problems	Range	Management technologies
Poor working conditions	3	1. Certification of workplaces 2. Improving the sanitary and hygienic working conditions (lighting, temperature, noise, fumes, etc.)
Poor care for employee	4	1. Support in treatment and rehabilitation of the worker and his family members 2. Perspective shift workers study 3. The using of non-financial incentives 4. Shift team adaptation mechanism
Poor living conditions	5	Improving the living conditions: changing of organization the food; maximum availability of the gym
Dissatisfaction logistics	6	1. Optimization of the traffic scheme in order to provide workers with necessary equipment and materials 2. Modernization of production
The lack of information about the affairs of the organization	7	Improving awareness of employees about the affairs and events in the organization, about current and future work plans
Dissatisfaction with the organization of traffic shift	8	1. Optimization of work and rest, taking into account travel time of each shift workers 2. The organization the change of teams with maximum binding to the base city 3. Optimizing the delivery from permanent residence, reducing the number of collection points of shift personnel and transport

It is also necessary move from occasional sociological studies to permanent socio-economic assessments of the long distance commuting technology consequences, based on built-in shift work management monitoring system.

5 Conclusions

Therefore, according to the implemented analysis it can be concluded that shift method being used by SNSK on Spitsbergen provides higher productivity. At the same time, transferring existing coalfields developed by the sedentary method to the shift method implies high costs, which will not be covered within an acceptable timeframe by saving current costs of maintaining social infrastructure required by the sedentary method. However, the shift method might be economically expedient for developing new coalfields by "Vorkutaugol" company in Vorkuta region. Additionally it is worth mentioning that the process of selecting a development technology for arctic regions should consider not just economical expedient of an option but also social consequences of the option and technological capabilities of each option applied within the given region.

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Analysis of Organizational and Human Factors in the Local Production Arrangement of the Hotel Chain to Avoid Social and Environmental Impacts, Case Study of Maragogi, Alagoas, Brazil

Eduardo Menezes, Salvador Filho and Edmara Drigo

Abstract This study evaluates the environmental and social impacts of the hotel industry in the local community and its influence on the environment, through a case study in the city of Maragogi, State of Alagoas. The surveys were conducted by sampling, where four projects of different categories were observed. This analysis identifies the organizational and human factors to reduce these impacts and the role of leaders and stakeholders in the model of the decision-making process in maintaining the hotel chain. Through semi-structured questionnaires to the hotel, its staff and representative bodies presents the perception of organizational factors, human and important environmental involved. The results suggest a regionalized model of environmental management for the hotel industry that can contribute to mitigate environmental and social impacts observed in the use of natural resources, contributing to an effective sustainable development, and prevent this activity can derail tourism in other municipalities that have similar tourism.

Keywords Human and social factors · Hotel industry · Environmental sustainability · Sustainable development

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1 Introduction

1.1 International Tourist Panorama

When speaking of tourism, we are talking about the increased activity of international trade, which employs millions of people, directly or indirectly, in 01 of its approximately 56 segments of the economy, ranging from hotels, airlines, car rental companies, dry cleaners, travel agencies, souvenir shops, restaurants, farms, arts and crafts, among others. It adds that contributes to the active preservation of historical heritage in the world and is therefore an activity that promotes between sectors development, due to the multiplier effect of investments [1].

Currently, there is consensus on the potential for international tourism in promoting the growth of socio-economic development by increasing the GDP (Gross Domestic Product), the activity responsible for the generation of 1 every 11 jobs worldwide [1]. International economic data shows a strong relationship between economic environment and the growth of tourism around the world. In the period 1975–2000 tourism grew at an average rate of 4.6 % annually, while the average world economic growth, as measured by GDP, was 3.5 % per year [2].

1.2 National Tourist Panorama

The share of tourism in the Brazilian economy already represents 3.7 % of Gross Domestic Product (GDP) of our country. From 2003 to 2009, the tourism sector grew 32.4 %, while Brazil's economy grew by 24.6 % (MTUR 2012a). For the World Travel and Tourism Council (WTTC), in 2011, about 2.74 million direct jobs were generated by tourism and with estimated growth of 7.7 % for the year 2012, totaling 2.95 million jobs (World Travel and Tourism Council, 2013th). It is estimated that even for the year 2022 tourism is responsible for 3.63 million jobs. They are included as generating direct jobs activities related to hotels, travel agencies, airlines, other types of passenger transport, restaurant and leisure [3].

Regarding the potential for job creation is one of the economic activities that require the lowest investment to create each job vacancy, which provides a faster return on initial investments. A good example is the branch of Brazilian hospitality:

Moreover, it is one of the economic activities that require the lowest investment for creating each job vacancy, which provides a faster return on initial investments. A good example is the branch of Brazilian hospitality: "intensive sector in hand-to-work and important role in tourism, demand around US$9.115,70[1] activity of production value required to generate a unit of jobs, a figure less well than that

[1]The original amounts in R$ have been converted to US Dollar exchange rate of the reference year in the text (R$1777).

demanded by other economic sectors, such as textiles (US$15,439.05), construction (US$15,775.46) and steel (US$38,382.61)" [2].

This set of factors has attracted the attention of governments and other authorities responsible for public policy planning, such as the creation of government plans as PNMT—Municipalization National Program of Tourism, PNT—National Tourism Plan and the numerous investments that has been made in the sector through programs like PRODETUR I, established in 1991 which is focused on the development of tourism in the Northeast and the PRODETUR II.

1.3 State Tourist Panorama

Specifically in the case of Alagoas state that always appears in the worst placements in various social indicators rankings: last place in MHDI—Municipal Human Development Index (0.633), according to the last census of the IBGE,[2] worse life expectancy (66.8 years), higher infant mortality (50 per 1000); 70 % of Alagoas households without basic sanitation (5th worst position of the country) and 25 % have garbage collection [4], tourism emerges as an important alternative development.

In this promising scenario, with respect to tourism in Brazil travel for leisure reason in sun and beach environments (SSS—Sun, sand and sea) are those with the greatest degree of attraction for foreign tourists: 64.2 % [2]. These data confirm the great potential for tourism, especially along the northeast coast, dominated lush landscapes and well preserved with mangroves, beach ridges, dunes, cliffs, river mouths, warm waters and sunshine for most of the year.

Identified with this vocation, as the activity development strategy, created the "Polo Coral Coast" which is formed by the municipalities of Maragogi (2 county in the state with greater tourist activity), Japaratinga, Porto de Pedras, Porto Calvo, São Miguel dos Milagres, Matriz de Camaragibe, Barra de Santo Antônio and Paripueira, which has been met with government resources through PRODETUR, as is the case of Maragogi city center where there was the implementation of water and sewage systems simultaneously investments provided an increase in tax revenues of around 33.0 % per year [5].

However, it is known that as the mass tourism—which is the used model the object Municipality this work—will develop, the socio-environmental problems of all kinds will manifesting the tourist territory, from pollution noise, air and water, to slums due to gentrification, waste, deforestation, ground mangroves, collapsing hillsides by irregular occupation, besides the social problems (violence, drug trafficking, prostitution etc.).

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[2]Brazilian Institute of Geography and Statistics.

1.4 Hypothesis

Other municipalities whose tourism is its main economic activity and that are geographically close to Maragogi, such as Porto de Galinhas, had the development of tourism started many years before, which somehow anticipates some problems that may happen (and that may already be happening) if there is no proper planning of the activity [6].

As concerns Maragogi municipality that leads one pole, the growth in tax revenue seems satisfactory growth have not provided your MHDI,[3] that despite being the second largest tourist destination, display only a twentieth position in that index. Therefore, in order to make a socio-environmental diagnosis to later propose solutions, it conducted a case study with the hotel chain that municipality.

2 Tourist Activity and Sustainable Development

When it comes to sun tourism, sand and beach, environmental resources are the raw material of tourism. So keep practicing these resources if sustainable development is to guarantee the survival of the activity itself. Including the absence of environmental management in its processes was determining the future status of low environmental quality, and consequent decline in local tourism demand [7].

The tourist-hotel business can generate income and employment for millions of people around the world, use of hand labor site, show their culture and art, increased income, generating new sources of income, environmental education, preservation current for use by future generations [8].

On the other hand, currently, there is consensus that the uncontrolled growth of tourism can cause numerous problems such as disorderly economic growth, lack of infrastructure, environmental degradation, pollution, unordered occupation of spaces (slums), import leakage income and property speculation [9].

To encourage entrepreneurs of the sector to adopt environmental initiatives in their endeavors, a good alternative is to use the economic bias to facilitate the adoption of sustainable attitudes [10, 11]. This becomes easier from the fact that the guest prioritizes hotels that perform environmental actions [12].

However, this is not a simple process, since "in the process of confrontation between opposing interests, socio-environmental conflicts are configured, and the confrontation relationship—negotiation between stakeholders, result the coordination mechanisms for the regulation of these conflicts" [5].

[3]The MHDI is a suitable index HDI—Human Development Index created by the United Nations used to quantify the level of development of cities.

2.1 The Participation of the Native Community

Another aspect that really draws attention is that community participation at all stages of the development of tourist and hotel enterprises is crucial, even before its implementation [4]. It happens that such participation seems utopian. Numerous authors cite the importance; however, they do not realize in their work any consultation with this community [12, 13].

The interesting thing is to realize that the term participation appears in all methodologies, although the prominence given to it is higher or lower in each case, but the vision that has the participation is still passive and bureaucratic, as public consultation and data collection not advanced towards offering co-authorship of decisions to the supposed "participants" and still far from able to be called "active citizenship" [14].

The solution to this issue is the design of a sustainable development model based on the concepts of equity and social justice under a capitalist society that is focused on the accumulation of capital [7].

3 Methodology

Preliminarily, there was a bibliographical research on the socio-environmental aspects in the hotel. The research techniques used in the research were the questionnaire and field observation. From the literature, were prepared forms 03:

- Form 01: Characterization of the hotel
- Form 02: Diagnosis of the qualitative aspects of the employees of the enterprises.
- Form 03: For field observation of socio-environmental practices.

After the literature review and the preparation of forms, they were selected 04 hotel enterprises to carry out sampling, each of a different category.

In the days 3:04 of March 2016 a personal visit was made to the municipality, where there was the application forms. The technical visit was composed of interviews with each of the managers of the hotels, another interview with 19 employees chosen at random and in various sectors. Then it was held in the enterprise in company of an employee appointed by management, a field observation, for comparison with the answers given by the project manager.

There was also an interview with the agency that organizes the local tourism industry (Costa dos Corais Convention & Visitors) and a cooperative (Coopeagro), which brings together some 130 settlers who are farmers.

After only selected the answers obtained to score 5 were tabulated the answers and prepared the constant Fig. 1.

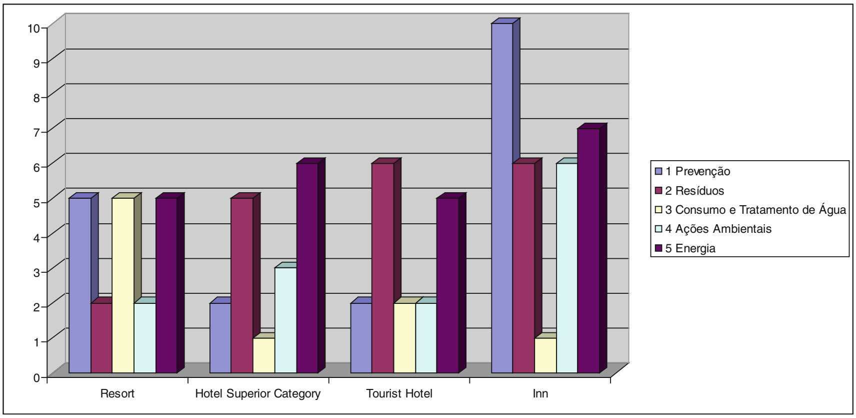

Fig. 1 Social and environmental performance chart observed in field observation

4 Materials and Results

The results of the Form 1 replies (Table 2) confirm that the greatest environmental problem facing today is the public infrastructure of electricity supply, where the constant cuts in supply, adversely affect the entire community. Regarding the Internet connection, the problem was perceived in the most remote areas of the center, directly affecting the development of the category Inn (Tables 1, 3 and 4).

Data obtained by completing the Form 3 served to prepare Fig. 1. In it, there were only the items that obtained in response: 5—Very practiced.

5 Discussion

This point was emphasized by all hotel managers interviewed in this study, and observed in the field record. The existing sewerage network is limited to the central area of that municipality. Thus, the hotel enterprises located in the center, are benefited, as stated by the manager of the Hotel Areias Belas. It happens that these developments are just the smaller. the bigger ones: Resorts and 04 stars, are not benefited by the public sewage network. The greater geographical proximity (about 5 km), in an interview, the manager of the hotel Golden Beach (04 stars), Mr. John Bosco said there is a project to extend the sewer system to the facilities of that hotel. Still regarding the lack of sanitation in the peripheral regions of that municipality, it was observed that in Rio Maragogi that runs through the facilities of the Resort object of this work, some households dump their sewage directly at the river, which causes inconvenience to the activity of that hotel, with imminent risk health of guests that solve bathe in its waters, in addition to their local community.

Table 1 Form 1 structure

Q1 - INTERVIEW FORM - ACCOMMODATION MANAGERS
Hotel Characterization
Company name, CGC, Location, UH's amount (rooms, apartments and suites).
Internal organization: (mark with an "x")
Commercial, Administrative, Accommodation, A & B, General Services, Others.
Category: Market Segment (mark with an "x")
Super Luxury☆☆☆☆☆ SL, Luxury ☆☆☆☆☆, Superior ☆☆☆☆, Tourist☆☆☆, Economic ☆☆, Simple ☆.
Type: (mark an "x")
Local, State, Regional. National, International
Purpose of Customers (%)
% Business, % Recreation, % Others
How many employees in the season? (Qty)
Low, Average, High
Main problem (Tick x xx as the importance)
Supplier selection / purchase of inputs, Hiring outsourced service providers, Selection and hiring of qualified employees, Public infrastructure - electricity supply, Public infrastructure - water supply, Public infrastructure - lack of sanitation, Others.

Analyzing the results obtained through the form filling 3, unambiguously, were found numerous problems which negatively interfere with the tourism. They could be numbered according to their responsibility: One of the most serious problems is the selective collect garbage which is the local government's responsibility, where only in the enterprise 1 in the table above, about 2–3 tons of trash (about 6 kilos of waste per guest, according to the manager) are released daily in the existing dumpsite in its countryside. In this case, the average waste/very high guest (up to 2 kg/person, so almost three times the acceptable value) reflects the status of "all inclusive" resort, where people culturally consume more foods that normally consume. It should be noted that some environmental actions are performed by private entities, such as oil collection used in the kitchen, which is collected by a company for the manufacture of soaps.

It was also noted that thousands of lamps are being released directly into the trash with the ultimate destination, the municipal dump.

Also selective collection has been carried out by a private company, highlighting the lack of vision by the municipal government.

Another serious aspect and that is government responsibility is the partial sewage disposal system that only meets part of the city, leaving part of the hotel

Table 2 Results of the Form 1

Interviewed	Resort	Hotel superior category	Tourist hotel	Inn
Classification	Resort	4 stars	3 stars	Inn
Accommodation units	236	132	34	29
Number of employees	360	100	26	36
Network type	State	Local	Local	Local
Purpose of guests -%	Leisure - 100 %	Leisure - 85 %	Leisure - 95 %	Leisure - 95 %
Main problems				
Supplier selection/purchase of inputs	X			
Hiring outsourced service providers				
Selection and hiring of qualified employees	X			
Public infrastructure—electricity supply	X	X	X	X
Public infrastructure—water supply				
Public infrastructure—lack of sanitation				X
Others	Courses for the community given by Senac			Internet connection

without this essential service. In this case, the cost of separating the produced drain is reflected in high costs of hotels not benefit the public sewer.

Finally and also the responsibility of government, the constant cuts in electricity supply is hindering greatly all the activity, in addition to the local population. In January of this year, there was a cut that lasted more than 24 h. Enterprises lost their perishable food supplies, ice cream etc. Guests requested reimbursement of the amounts paid to the daily and others canceled their reservations, in a significant loss to all activity and consequently the native population. Confirming the persistence of this serious problem, on the application of interviews, there was also a cut that lasted in some locations, about 09 h.

Other environmental actions that have not been committed are due to the lack of will of their owners, such as: failure to collect rain water for cleaning and irrigation of plants from their gardens. In this case, as they are using artesian wells, they believe that this practice is not interesting at the time.

Table 3 Form 2 structure

Q2 – INTERVIEW FORM – OFFICIAL CHARACTERIZATION
Sex, Age, Resides in that city, Time working in hospitality, service time in the hotel, function wich currently holds. Then there was the record of their rate of pay: 01) Up to 01 minimum wage (US $ 233.98). 02) From 1 to 1.5 minimum wages (US $ 233.99 to US $ 351.23). 03) Between 1.5 and 2 times the minimum wage (US $ 351.23 to US $ 467.96). 04) Between 2 and 5 minimum wages (US $ 467,97 to US $ 1,169.90). 05) Between 5 and 10 times the minimum wage (US $ 1,169.91 to US $ 2,339.80). 06) Above 10 minimum wages (over US $ 2,339.81). Obs.: The original amounts in R$ have been converted to US Dollar exchange rate of the reference date in the text (R$ 3,761).
Educational qualification – Professional
He did a course of qualification for the position he holds? It is fluent in a foreign language? What? English, Spanish, Another language:
Level of Education: (Mark with an "x" the highest level attained)
Not Literate Full; Elementary school Incomplete; Traditional High School; High School College; Higher education; Postgraduate (specialization); Postgraduate (Master); Post-graduate (doctoral)
Stage (Mark with “x”) Complete or Incomplete
Qualify professionally? mark with an "x" the desired option.
1) Technical Course in Tourism Guide; 2) Technical Course in Hosting; 03) Technical Course in Gastronomy; 04) Advanced Course in Tourism Management; 05) Higher Course in Hospitality Other: English language; Spanish language; Another language:
Support Company
Receive a financial incentive from the employer to qualify? Has reduced load-time to qualify?
The company provides some kind of financial support
1) Health care; 2) Dental care; 3) Scholarship; 4) Bonus for performance
Professional satisfaction
Feels valued personally and professionally? Intends to pursue a career in the hotel business?
Difficulties / Suggestions

As for the aspect of compensation of employees in general, most receive up to 1.5 minimum wage (US$348.39[4]) representing a low attractiveness for more qualified professionals. In this case, it was also observed to import skilled workers from other regions to assume managerial positions.

On the positive side there is the work of the Coral Coast Convention & Visitors that adds dozens of enterprises linked to tourism-activity, which has been organizing, representing and discussing the demands of the sector with the various government agencies and support (Senac, Sebrae, APL, state government etc.).

[4]The original amounts in R$ have been converted to US Dollar exchange rate of the reference on March 07 (R$3,83).

Table 4 Form 3 structure

Q3—Field observation form	
No	To check
Prevention	
1	Has program environmental risks prevention—PPRA
2	There is an environmental awareness program established
3	There is information for guests on protection measures of the environment
4	There is a periodic cleaning of the ducts plan of ap. central air-conditioning
5	There is concern in the shopping area, as the products acquired, in relation to its potential for environmental degradation
6	There are qualification criteria for suppliers taking into account the environmental actions carried out by them
7	There is a regular program of cleaning of grease traps
8	The level of noise generated is controlled
9	The level of odor generated is controlled
10	Avoids the use of disposable products where there is no reuse of items
11	It requires tour operators who work in the hotel (owners of nautical vessels, vehicles etc.) some environmental certification
Waste	
12	Organizes the selective collection of cardboard, paper, newspapers and magazines for recycling
13	Organizes the selective collection of glass for recycling
14	Organizes the selective collection of aluminum cans and batteries for recycling
15	Organizes the selective collection of used oil in the kitchen for recycling
16	Recycles ink cartridges for printers and photocopiers
17	Fluorescent lamps are forwarded to the co-processing
18	The generated organic material is used as a fertilizer (compost)
19	Prioritize the use of recycled paper
20	Use biodegradable chemicals
Consumption and water treatment	
21	You have control of water consumed with water meters on the main points
22	Use the local public sewage system with treatment
23	Proceed any treatment of sewage prior to discharge
24	It uses organic tanks (if there is no sewage system)
25	It adopts rainwater collection system for irrigation and/or other purposes
26	Uses automatic controllers such as timers and/or photocells in the taps of sinks
27	Carry out some kind of reuse of water (s) pool (s)
28	Effects the change of bed linen and bath towel only on request
29	The showers and faucets have flow reducers
30	The toilets have low discharge volume
Environmental actions	
31	There is involvement with the surrounding community in the environmental aspect
32	There is an identification and cataloging of fauna species in the hotel location

(continued)

Table 4 (continued)

Q3—Field observation form	
No	To check
33	There is an identification and cataloging of flora species in the hotel location
34	The hotel takes care properly for its gardens and green areas
35	All employees participate in at least once a year, an awareness meeting on environmental policy adopted
36	Extends to tour operators who work in the hotel (owners of nautical vessels, vehicles etc.) awareness meeting on environmental policy
37	Extends to members of the local community awareness meeting on environmental policy
38	It is a member of an association or community, within an action for the environment
39	There is awareness of environmental issues for the future of the region where it is installed
40	Prioritizes local input suppliers valuing APLs
Energy	
41	Use key card to control the electricity in U.H
42	There are replacing conventional bulbs for low consumption
43	There is the use of alternative energy generators, natural gas (non-renewable)
44	There is the alternative use of renewable energy
45	Uses conventional electric heaters
46	There is the use of automated lighting controllers, such as timers, photocells and presence sensors
47	There is control of gas consumption (LPG or natural)
48	Prioritizes renewable fuels in its fleet of vehicles
49	There are criteria for the acquisition and use of equipment that have low power consumption
50	Avoids the use of pesticides replacing them with natural control mechanisms
Subtitle (Evaluation): 1. Not applicable, 2. Do not practiced, 3. Little practiced, 4. Regularly practiced, 5. Very practiced	
Drawn from the environmental action module that is used to determine the Matrix Rating of Embratur authorship Hotel and the Brazilian Association of the Hotel Industry—Abih [15]	

Another important initiative is the Coopeagro that adds about 130 settlers (former landless) with production being marketed in the region and prioritized by most enterprises, including this research. Despite its local character, the target resort this research, usually do surveys of prices, leaving several times to purchase local products to acquire them from other state suppliers, in this case, failing to promote local sustainable development.

Another positive side there was the observation that some courses offered by IFAL—Federal Institute of Alagoas and the Senac—National Commercial Training Service, has provided good service the hotel activity, qualifying hand labor to meet the demand of hotel local. This aspect can minimize the tendency that has been observed in other locations, such as Itacaré, state of Bahia, Brazil, the natives are excluded from the labor market, the lack of qualification, losing a job for people from other locations with a higher educational level [9]. Still with respect to these services, the Manager of the hotel category resort complained, claiming that facing financial contribution is intended that organ (Senac), the return is very slow and wicked.

6 Conclusions

Environmental initiatives in the tourist-hotel activity Maragogi municipality has been carried out in some organized way, most of the time with occasional and spontaneous actions, the private network, and the best results were observed in a small enterprise, where practices environmental are another result of the social responsibility of its owner and manager, than compliance with rules and environmental laws. One such practice is to stipulate targets to be met by its employees, which has provided the hostel win awards for his performance (TripAdvisor) with financial compensation to these employees. In this particular case, the staff showed great satisfaction in working at that company.

On the other hand, the large project studied in this work, fails to carry out numerous environmental actions, which will surely increase your sales and recognition of guests. Simple actions such as the development of rainwater utilization projects for use in the cleaning of facilities and irrigation of the gardens could be quickly implemented.

As for the action of government, add to the fact that the tourism-activity has suffered negative impacts due largely to infrastructural problems under its responsibility: sanitation, electricity, personnel qualification, facing problems already provided for in the work done in Porto de Galinhas city which is in relatively close region and also plays the same kind of tourism (Sun, Salt and Sea) [6]. In this case, the strengthening of the body representing the tourism and hotel industry in the region (Coast Convention & Visitors Reef) by its members.

Include in the work on the tourist-hotel business research involving the local community to learn how the social and environmental impacts is affecting it.

Include participatory monitoring of the native community that is not contemplated in any of the methods, which involves inserting the actors only in the initial data collection without compromising them with the proceedings and the long-term results, as would be required for ensure sustainability [14].

Stimulate the creation of an environmental seal or an Environmental Management Model facing the sun tourism, sand and sea with local characteristics, respecting the size of each hotel project.

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The Way to Use the Guidelines for Supporting Resilience Enhancement: From Verifying Effectiveness Using Before-After Comparison Test Design of Two Fitness Centers

Naoto Shoji, Takumi Iwaasa, Yutaka Nakajima and Motoki Mizuno

Abstract The purpose of this study was to verifying effectiveness of the guidelines for supporting resilience enhancement. Moreover, we aimed to discuss the effective way to use the guidelines based statistical data. The two fitness centers of the Metropolitan area joined this research in Japan. The fitness clubs approached to enhance resilience using the guidelines for a month or three months. The samples were 18 employees (Center A: 10, Center B: 8) completing the before-and-after evaluation using a questionnaire about resilience. The effect size (r) of result for paired t-test was pointed as the evaluate index for effectiveness of the activities to enhance resilience with the guidelines. As the result, center A's resilience increased ($r = 0.15 - 0.64$), center B's resilience decreased ($r = 0.23 - 0.80$). The organizational improvement activities including the improvement organizational process and interaction cause more effective resilience enhancement rather than the activities aiming to individual ability development to strengthen individual weakness.

Keyword Resilience enhancement · Fitness center · Before-After comparison test design

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1 Introduction

Recently, occupational stress is treated widely as a big issue. One of the stressor is difficulty or adversity larking the daily operations. However, if you want to make successful career, you are needed to overcome many hardships on your career. That is much alike as Japanese fitness centers' employees. They are required resilience to overcome hardships like a difficulty and an adversity on their career, resilience is the key factor to overcoming adversities for positive career design [1]. The most of hardships is on the work career [2].

Many resilience training is developed and focused in industry [3]. The resilience trainings like a Master resilience training and Penn resiliency program is mostly collective corporate training [2– 7]. Those are having a high threshold for small enterprises and small workplaces, because those need a kinds of very high cost. In such situation, the guidelines was developed which support approaches to enhance resilience using daily operations and self-help effort without in expert's interventions [8]. However, effectiveness of the guidelines were not verified. Therefore, we tried approaches for resilience enhancement using the guidelines at two fitness centers in Japan. The purpose of this paper was to verify statistically effectiveness using before-after comparison test design of two fitness centers. Moreover, we aimed to gain the knowledge about the way to use the guidelines for supporting resilience enhancement.

2 Methods

2.1 Participants

The two fitness centers joined this study. They were major companies in Japanese metropolitan area. We targeted a branch of them. There are resemblance between two fitness centers on the number of employees, business condition, and provided programs. Additionally, the both fitness centers positioned in the shopping mall.

In this study, 49 employees (Center A: 25, Center B: 24) working at the two fitness centers answered questionnaire. 18 employees (Center A: 10, Center B: 8) completed both before-test and after-test, they extracted as samples of this study (Fig. 1). Employees were excluded who did not join each test and did not connect before-test to after-test.

Average age was 31.7 years (SD = ±9.4). Average business career was 5.4 years (SD = ±4.6). They resembled numerical value of all 49 participants responded validly. They consisted of 8 instructors, 7 receptionist, and 3 generalist. They consisted of 6 full-time, 3 contract or temporary employee, and 9 part-time (Table 1).

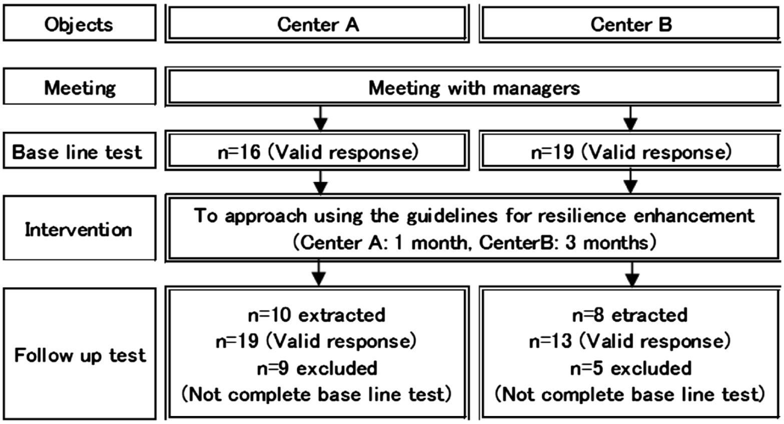

Fig. 1 Flow of extracting the samples

Table 1 Samples of this study

	Center A (n = 10)	Center B (n = 8)	Total
Gender			
Male	5	3	8
Female	5	5	10
Age (years ± SD)	32.1 ± 8.5	31.1 ± 10.4	31.7 ± 9.4
Cateeer (years ± SD)	5.4 ± 4.1	5.0 ± 5.2	5.4 ± 4.6
Job category			
Instructor	4	4	8
Reception	4	3	7
General	2	1	3
Employment status			
Regular	2	4	6
Contract	1	2	3
Part-time	7	2	9

2.2 Intervention

Intervention was conducted to the two fitness centers for resilience enhancement. We showed only how to approach for resilience enhancement using guidelines for supporting to enhance resilience. Managers and employees conducted activities for resilience enhancement using the guidelines which focused on promoting "stretched challenge", "supportive relationship", and "collecting and using client's feedbacks [8]". The three improving areas were led referring the pilot research. It showed the viewpoints to support the cycle of resilience enhancement using daily operations [9].

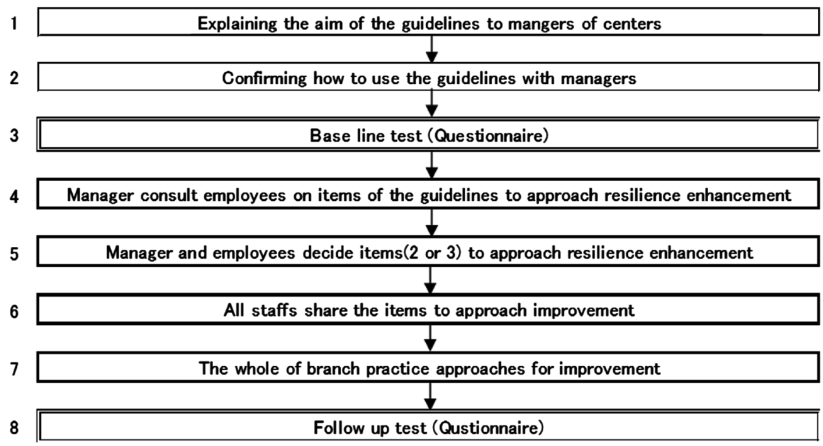

Fig. 2 Flowchart of this study including the process of the approaches toward resilience enhancement

Firstly, meeting was carried out with mangers of each fitness centers. The content and the aim of the guidelines for supporting to enhance resilience were explained in the meetings. Secondly, the way to use the guidelines was explained and confirmed. These process were only intervene we conducted.

The managers and employees of two fitness centers conducted activities for resilience enhancement as self-help effort basing the guidelines for supporting to enhance resilience through improvement organizational process. The specific process toward resilience enhancement was shown in the Fig. 2.

Each fitness center decided 2 or 3 items included the guidelines, conducted the challenge toward resilience enhancement following the guidelines. 2 or 3 items for the challenge to enhance resilience were selected throughout discussion by manager and employees. The challenge was kept on for a month or three months. The reason for why different span for challenges was defined that we were required to establish the appropriate way for using the guidelines. The appropriate span for producing some positive results had not been clarified. We aimed to examine the appropriate span for using easy the guidelines.

2.3 Measurements

Questionnaire survey was conducted to assess resilience. The Bidimensional Resilience Scale (BRS) [10] was used to assess resilience. BRS consists of innate factors and acquired factors of resilience. The innate factors include optimism, control, sociability, and vitality; acquired factors include attempting to solve a problem, self-understanding, and understanding others. Resilience measured with BRS was defined as outcome of challenge toward resilience enhancement.

Questionnaire of BRS was answered on a five-point Likert scale from 1 (very poorly) to 5 (very well). Each factors consists of 3 items, they were assessed by a total score of the 3 items.

2.4 Analysis

The data of questionnaire survey was analyzed to show statistical evidence using SPSS ver. 21. The data about resilience gained from targeted two fitness centers was analyzed using paired t-test. The passage of time was independent variable, resilience was dependent variable in the analysis. The sample size was small, it was predicted that p-value did not satisfy standard of less than 5 %. Hence, effect-size (r) was defined as the evaluate index for effectiveness of the challenge for resilience enhancement using the guidelines.

3 Results

The results of analysis using paired t-test, the quantitative data of fitness center A showed the different results from fitness center B. The results of the total of both centers were showed (Table 2). However, the total data was not reference material, because each center's data showed opposite results. The data of center A generally showed positive effect, resilience factors showed positive effect were vitality ($r = 0.31$), sociability ($r = 0.64$), self-understanding ($r = 0.40$), and understanding others ($r = 0.49$) (Table 3 and Fig. 3). While, The data of center B generally showed negative effect, resilience factors showed negative effect were control ($r = 0.64$), vitality ($r = 0.31$), sociability ($r = 0.80$), attempting to solve problem ($r = 0.55$), self-understanding ($r = 0.59$), and understanding others ($r = 0.23$) (Table 4 and Fig. 4).

4 Discussion

In this study, the guidelines to support for resilience enhancement was used at onsite for the first time. Center A brought the positive result statistically. It was estimated that good practice toward improving organizational process contributing to resilience at center A. It was clarified through an interview after this research that there was a clear difference between center A and center B. The difference was the way to use the guidelines approaching resilience enhancement.

Center A approached the challenge for resilience enhancement using the guidelines as the whole of the branch. For example, the manager and the employees of center A confirmed items and its contents of the guidelines, they had tackled on

Table 2 Resilience of total number

			Mean				*t*	*df*	*p-value*	95 %CI		*r*
			Baseline	(*SD*)	Follow-up	(*SD*)				Lower	Upper	
Resilience	Innate factor	Optimism	12.6	1.8	12.3	1.9	0.544	17	0.954	−0.64	1.08	0.13
		Control	12.4	1.9	12.1	1.6	1.065	17	0.302	−0.33	0.99	0.25
		Vitality	11.7	2.4	11.8	2.0	−0.12	17	0.907	−1.04	0.93	0.03
		Sociality	11.4	2.4	11.4	2.5	−0.12	17	0.909	−1.07	0.96	0.03
	Acquired factor	Attempting to solve a problem	12.5	1.5	11.4	2.1	2.162	17	0.045	0.03	2.09	0.46
		Self-under standing	11.2	2.3	11.4	2.2	−0.544	17	0.594	−1.08	0.64	0.13
		Under standing others	11.8	2.0	12.3	1.7	−0.987	17	0.337	−1.57	0.57	0.23

Table 3 Resilience of center A

			Mean				*t*	*df*	*p-value*	95 %CI		*r*
			Baseline	(*SD*)	Follow-up	(*SD*)				Lower	Upper	
Resilience	Innate factor	Optimism	12.7	1.6	12.5	1.8	0.476	10	0.64	−1.01	1.55	0.15
		Control	12.5	2.1	12.5	1.8	−0.232	10	0.82	−0.96	0.78	0.07
		Vitality	11.5	2.8	12.1	2.3	−1.032	10	0.33	−1.72	0.63	0.31
		Sociality	11.0	2.6	12.3	2.5	−2.609	10	0.03	−2.36	−0.19	0.64
	Acquired factor	Attempting to solve a problem	12.8	1.8	11.8	2.4	1.658	10	0.13	−0.34	2.34	0.46
		SeIf-under standing	11.3	2.3	12.1	2.0	−1.399	10	0.19	−2.12	0.49	0.40
		Under standing others	11.4	2.2	12.5	1.8	−1.796	10	0.10	−2.65	0.28	0.49

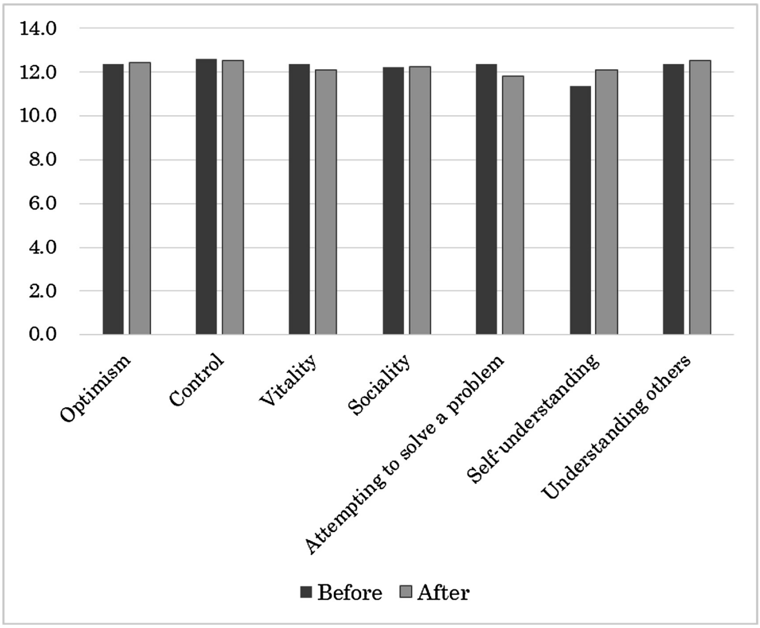

Fig. 3 Mean of center A's resilience

daily operations. Additionally, they posted the tool (leaflet of the guidelines including checkmark space for tackling items) on the wall of office. They considered the challenge for resilience enhancement as the whole of the organization.

On the other hand, the challenge for resilience enhancement was considered as the opportunity to develop individual skills and abilities in the center B. Especially, it was emphasized that the challenge for resilience enhancement was the activities to strengthen individual weakness.

The above showed the probability the organizational approach effect resilience enhancement using the guidelines. Participatory improvement toward occupational risk measure was clarified what organizational approach was important [11, 12]. In occupational health, the focus is on organizational interventions rather than individual interventions to make healthy people and healthy organizations [13, 14]. The results of this study reinforced these previous studies, showed the probability what organizational approach using the guidelines made more effective resilience enhancement. The guidelines might display the effect when the guidelines was used organizational approaches as like other tools for workplace improvement (cf, Mental Health Action Check List [15]; Stress prevention at work checkpoints [16]).

Finally, in this study, two fitness centers showed a significant difference about the process for activities using the guidelines toward resilience enhancement. The aim of the guidelines was to enable to make resilience enhancement as self-help effort without an expert like a facilitator. Hence, the importance was to install a manual about how to use the guidelines.

Table 4 Resilience of center B

			Mean				*t*	*df*	*p-value*	*95 %CI*		*r*
			Baseline	(*SD*)	Follow-up	(*SD*)				Lower	Upper	
Resilience	Innate factor	Optimism	12.4	2.4	12.4	2.1	0	7	1	−1.26	1.26	0.00
		Control	12.6	2.9	11.8	1.4	2.198	7	0.06	−0.07	1.82	0.64
		Vitality	12.4	2.1	11.8	1.8	0.856	7	0.42	−1.10	2.35	0.31
		Sociality	12.3	2.1	10.8	2.5	3.550	7	0.01	0.50	2.50	0.80
	Acquired factor	Attempting to solve a problem	12.4	1.3	10.4	3.2	1.740	7	0.13	−0.72	4.72	0.55
		SeIf-under standing	11.4	2.3	10.0	3.4	1.949	7	0.09	−0.29	3.04	0.59
		Under standing others	12.4	1.7	12.0	1.4	0.629	7	0.55	−1.03	1.78	0.23

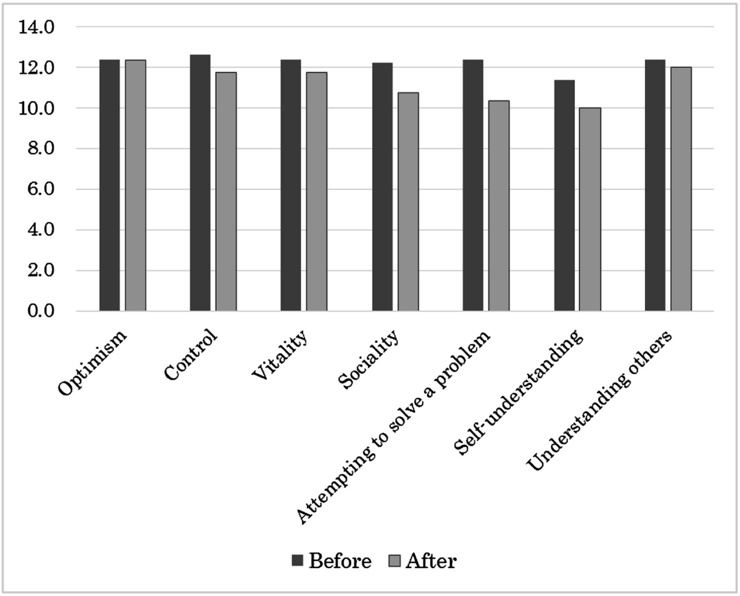

Fig. 4 Mean of center B's resilience

5 Conclusion

The guidelines for supporting resilience enhancement might influence positively resilience. Especially, an approach as the whole of the organization might bring the positive effectiveness. Organizational approach is important for good results as like other improvement tools showed the previous studies.

6 Limitations

The design of this study did not show right the evidence of the guidelines. It was needed robust research design like a RCT. In future, next research is required with more robust research design.

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The Effects of a Trust Violation and Trust Repair in a Distributed Team Decision-Making Task: Exploring the Affective Component of Trust

Corey K. Fallon, April Rose Panganiban, Peter Chiu and Gerald Matthews

Abstract The researchers investigated trust in a distributed work team. We explored the extent to which increased negative affective implicit and explicit attitudes are associated with loss of trust after a trust violation. We also investigated the effects of an attempt at trust repair after this violation. Participants performed a remote team task with two teammates. One of the teammates exploited the participant and then attempted to repair trust. Implicit and explicit affective attitudes and trust were measured. Increased negative explicit attitude toward the violator was associated with loss of trust in this teammate. Also, the attempt to repair trust significantly increased trust, but was still significantly lower than baseline. Results highlight the importance of explicit affective attitude as a trust predictor. Also, loss of trust resulting from exploitation may be increased by attempts at trust repair, but complete restoration of trust may be challenging after exploitation has occurred.

Keywords Trust · Affect · Trust repair · Exploitation

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1 Introduction

1.1 The Importance of Trust in the Workplace

Technological advances have led to an increased reliance on distributed teams in many work environments including complex task domains such as Command and Control [1]. Distributed teams offer the advantage of coordination and sharing of expertise without the cost associated with being co-located. However, the lack of face to face interaction in distributed teams does appear to weaken trust among team members [2]. This presents a challenge for distributed teams because the impact of trust on behavior in work team environments is powerful [3, 4]. Cuadrado and Tabernero [5] found that trust in a small work team moderated the impact of positive affect on prosocial behavior within the team. Positive affect was a stronger predictor of prosocial behavior when employees trusted their fellow team members. In an investigation of the relationships between employer leadership and both employee emotional exhaustion and work engagement, Chughtai, Byrne and Flood [6] found that employee trust in the supervisor mediated the relationship between ethical leadership and employee engagement and emotional exhaustion. Emotional exhaustion and work engagement are known to be associated with work performance [7, 8], thus trust in one's supervisor can indirectly impact work performance. Trust can also lead to cooperative behavior [9]. Trust in coworkers has also been associated with increased reliance without direct supervision. Serva et al. [10] found that management teams during an information systems design project were significantly more likely to delegate important tasks to the design team when they trusted the team. Research is needed to better understand the development of trust in a work team including both, the impact of abuse of power, attempts at trust repair, and the role of affect in trust development. This research is particularly needed for distributed teams where trust may be especially fragile.

1.2 Trust Violations and Repair

The dynamic nature of trust implies that it can increase and decrease with changes in trustee behavior and perception of their trustworthiness. Researchers have identified several behaviors that may damage perception of trustworthiness and result in a trust violation that can be either temporary or permanent. A qualitative analysis by Groveret al. [11] of actual trust violations in the workplace suggests many trust violations do not lead to a permanent loss of trust. Employer trust violations which resulted in recovered trust included poor performance, ambiguous expectations, unpredictability, lack of support and interference [11]. Steps can be taken to increase trust in the wake of these violations. Other trust violations appear to result in irrecoverable damage to trust. According to Grover et al.'s [11] study, some of these violations include loss of trust due to unfair favoritism and denigration.

Exploitation [11, 12] has also been found to violate trust. However, empirical evidence is mixed over whether this violation can be repaired. Like unfair favoritism and denigration, Grover et al. [11] also identifies exploitation as resulting in an irrecoverable loss of trust. However, laboratory research suggests a trust violation due to exploitation can be repaired. King-Casas et al. [12] assessed the impact of exploitation during a multi-round financial exchange game. In this study exploitation caused investors to lose trust in their trustee, which was reflected by a decrease in the amount of money given to the trustee on subsequent rounds of the game. However, King-Casas et al. [12] found trust could be repaired if the trustee reversed their behavior by sharing a generous amount of money on subsequent financial exchanges. The researchers concluded that this behavior signaled trustworthiness to the investors and worked to restore trust.

1.3 Affective Component of Trust

The workers recruited in Grover et al.'s [11] study, whose trust was irrecoverably violated, experienced deep negative emotions in response to the violations, suggesting a connection between emotion and trust. Evidence from experimentation also appears to support this connection. In Mislin, Williams and Shaughnessy's [13] experiment trust behavior was measured from participants after receiving a positive mood induction. These researchers found that participants who experienced a happy mood were more likely to engage in trusting behavior with an anonymous teammate compared to a control group who received a neutral mood induction. Schoorman, Mayer and Davis [14] suggest affect may influence trust indirectly by influencing the cognitive predictors of trust. Lee and See [3] agree that both affective and cognitive processes influence trust. In fact, these researchers argue that trust may be influenced by Analytic and Analogic (i.e. heuristic based) systems but '… Ultimately trust is an affective response' (p. 61).

Attitude researcher Giner-Sorolla [15] provides additional insight into affect's role in trust development. The affective component of an attitude includes both immediate evaluation and emotional response. The immediate evaluation is expressed as simple preference of like or dislike for the attitude object and is generated automatically with little cognitive effort. After the immediate evaluation takes place, a more deliberative, cognitively effortful process is involved that generates discrete emotions. Giner-Sorolla [15] concludes that the immediate evaluation often informs the emotional response, but not in all circumstances. In some situations the emotions experienced during deliberation conflict with the immediate evaluation.

1.4 Explicit Attitude

In order to get a complete understanding of affect's influence on trust, researchers must be able to effectively measure the affective component of an attitude. Traditional techniques for measuring the affective component of attitudes focused on a variety of self-report measures [16]. There is some debate over whether or not self-report measures capture all of the variance associated with the affective attitude component. Giner-Sorolla [15] argues that self-report measures capture only the deliberative portion of affect. However, Slovic et al. [17] contend that some self-report measures, such as those that are recognition-based, are similar to implicit memory tasks and therefore may capture some of the immediate evaluation component. Although recognition self-report measures may capture some of the immediate evaluation component, it is difficult to assess how much of this component is captured with self-report measures. In addition, it is challenging to tease apart the separate influences of immediate evaluation and deliberation on self-report measures of affect.

1.5 Implicit Attitude

One way to capture the immediate evaluation's impact on the affective component of trust may be to employ implicit measures. According to Giner-Sorolla [15], an implicit attitude measure may be less contaminated by deliberation, making it a more valid measure of the immediate aspect of an affective attitude. The ability of implicit attitude measures to capture immediate affect was also emphasized by Gawronski and Bodenhausen [17]. These researchers referred to implicit attitudes as 'automatic affective reactions' (p. 693) triggered by associations built over time. It is believed that implicit attitudes are not formed by reason or logic [17]. These measures rely on an automatic process known as response activation to uncover both the strength and direction (i.e. positive or negative valence) of the implicit attitude [18, 19; see 20 for review].

Some evidence suggests implicit attitude may predict trust. Merritt et al. [21] measured individual differences in implicit attitude toward automation and found this attitude predicted trust in an automated tool during periods of uncertainty. Stanley et al. [22] found that racial implicit attitude significantly predicted explicit evaluations of a person's trustworthiness as well as reliance on that person during an economic decision game. Perhaps one's implicit attitude toward a person reflects the immediate affective component of their trust in that person. If this relationship exists, implicit attitude should be associated with trust.

1.6 Current Study

In the current study, participants worked with two remote teammates on a financial team decision-making task to earn money over the course of two sessions. In the first session teammate behavior was manipulated to create a trust violation. One teammate exploited the participant by taking more than his or her share of the money during most of the trials in the session. The other teammate remained fair throughout session one. Consistent with Grover et al. [11], teammate exploitation can be characterized as an abuse of power that violates trust. We measured the impact of teammate exploitation on the participant's trust and affective attitude toward the teammate. Affective attitude was measured both explicitly and implicitly.

We investigated two research questions related to trust in a distributed work team environments. First, we investigated the effects of an attempt at trust repair after a serious trust violation (i.e. exploitation). Previous research is mixed on whether trust can be repaired after an individual has been exploited [11, 12]. In addition, we explored the extent to which an increased negative affective attitude is associated with loss of trust after this violation.

2 Method

2.1 Participants

The sample consisted of undergraduate participants (N = 59) from the University of Cincinnati. All participants participated in Session One of the experiment. A subset of the sample (N = 27) was randomly selected for a follow-on trust repair condition.

2.2 Materials

Implicit Attitude Test. Implicit attitudes were assessed using an adapted version of the IAT developed by Meade [23] using Visual Basic Express 2008 and administered using a windows PC. For this study the IAT was used to measure the change in implicit attitude toward an unfair teammate relative to a fair teammate. This measure presents participants with pictures of their two computer teammates in the center of the computer screen and the participant presses separate computer keys to match each picture with the teammate's name at the top of the screen. The IAT presents words that have either a positive or negative valence and uses the same keys to indicate if the words belong with labels 'Positive Words' or 'Negative Words' presented at the top of the screen. The computer keys used are the 'e' and 'i' key. Four pictures of each teammate are used along with four words with

Table 1 Options presented in round 17 of work with the unfair teammate

	Chance of success (%)	Return on investment
Option A	95	$80
Option B	35	$170
Option C	80	$120
Option D	30	$180
Option E	99	$40

positive valence and four words with negative valance. This version of the IAT displays the positive words ‘Good’, ‘Pleasant’, ‘Likable’ and ‘Enjoyable’ and the negative words ‘Dislikable’, ‘Bad’ ‘Unpleasant’ and ‘Displeasing’.

The IAT requires participants to complete a series of trial blocks for each condition. For the Congruent Blocks, Positive Words are assigned to the same key as the Fair Teammate and Negative words are assigned to the same key as the Unfair Teammate. For the Incongruent Condition the assignment is switched such that Positive Words are assigned to the same key as the Unfair Teammate and Negative words are assigned to the same key as the Fair Teammate. Tables 1 and 2 present the Trial Block sequence for both condition orders.

Trial blocks 1 and 2 are practice blocks designed to familiarize the participant with key assignment. Block 3 is the first Test block. In this block both teammate photos and words are displayed and assigned to the same keys as in the first two blocks. Block 4 reversed Teammate Picture assignment to Key ‘e’ and Key ‘i’. For example, if the Unfair Teammate photos were assigned to key ‘e’ in blocks 1 through 3, they were now assigned to key ‘i’. Block 4 is a practice block to get participants accustomed to the reversed assignment. Block 5 is the second test block. Similar to block 3, in this block both teammate photos and words were displayed and assigned to the same keys as in block 4. The reaction time difference between blocks 3 and 5 is then measured as an indirect measure of association strength between the teammate and positive or negative valence. If reaction time is faster when the teammate is paired with a positive valence word than when paired with a negative valence word, it is concluded that the participant’s implicit attitude toward the concept is more positive than negative [24].

Financial Decision-Making Conditioning Task. The evaluative conditioning task is a remote team financial decision-making task programmed in E-prime and presented on a windows PC. The team consists of the participant and the teammate. Although participants were told that this teammate is another remote located participant in the study, the teammate is actually part of the computer program. The

Table 2 Correlation between affective attitude shift and trust (i.e. economic offer)

Difference	Change in trust fair teammate	Change trust unfair teammate
Implicit attitude shift 0.23	0.23	−0.11
Explicit attitude shift 0.59	0.41	−0.44

team is given $5 of virtual money to invest in stocks. The participant is presented with 24 trials where they are tasked with choosing the best stock option from 5 choices. Both the probability of success and the monetary return on investment is provided for each option. The teammate begins each round by selecting two of the five options in order to narrow the five options to the best two. The participant will then decide between the two remaining options which is the best stock. If participants choose the correct stock their team earns the return on investment for that stock. The task is designed such that the team chooses the correct stock 22 out of 24 rounds. However, both the participant and teammate each have individual financial goals for the task. They are expected to each earn $700 across the 24 rounds of investment. Therefore, the return on investment for each correct choice must be divided between the participant and teammate. The teammate decides how much money to allocate to the participant and how much to keep. This component of the task is consistent with the dictator game originally developed by Kahneman et al. [25] to investigate the role of fairness in economic exchanges.

Following each trial, the participant is presented with feedback relating to whether or not they choose the best option, how much they earned for that round as a team and how much of the earning their teammate decided to give to them. The team's earnings accumulate across trials with every correct choice, but the amount allotted to the participant is determined by the teammate. We used teammate generosity in this conditioning task to manipulate exploitation. In the fair teammate condition, teammates consistently split the earnings 50/50 with the participant. In the unfair condition teammates gradually take increasingly more of the earnings on every correct round. The teammate is visible on the screen throughout both conditions. The constant presence of the teammate's picture is designed to strengthen the association between the teammate (i.e. neutral stimulus) and the money allocation decisions (i.e. unconditioned stimuli).

To further illustrate the conditioning task Table 1 reflects the 5 stock options presented in round 17 of the task when working with the unfair teammate. At this point in the task the teammate is taking all of the earnings awarded to the team. The participants are presented with only the percent chance of success and return on investment for all five options. They have no other information to base their decision on. Before participants can make their selection, their teammate (i.e. the computer program) narrows down the five to Option A and Option E. The participant must then decide between Option C and Option D. Regardless of which option the participant chooses he or she is informed by the program that he or she chose the correct option and the team receives the return on investment for the selected stock; either $120 for option C or $180 for option D. Next, the teammate decides to keep the entire return on investment leaving nothing for the participant.

Training Materials. Participants were provided with several power point slides explaining the expected value formula and how it could be used to make stock selection decisions. In addition to the tutorial, a short version of the financial-decision making task was developed to familiarize participants with the task. In this practice session participants complete three rounds of investment and are told they are working with the computer instead of an actual teammate.

Questionnaires. Participants were asked to perform a picture rating task. Participants rated 10 possible teammates based on their overall first impression of how much they would like to have each teammate as a co-worker. Ratings were based on a photo of the teammate and the teammate's name. The photos were taken of undergraduate students with the student's consent and names were randomly assigned to these photos. Participant ratings were recorded on a scale from −100 (dislike a lot) to +100 (like a lot). This rating scale is adapted from one described by De Houwer et al. [26]. Participants also completed an explicit attitude questionnaire adapted from De Houwer [18]. This explicit attitude scale consists of 200 points ranging from −100 (Dislike a lot) to +100 (Like a lot). Similar to other explicit attitude measures [16, 27], the attitude questionnaire simply asks the question "How much do you like your teammate?"

Economic Offers. Participants also played a modified Trust Game which was designed to be a more ecologically valid measure of trust [12, 22]. The participant is presented with a scenario where they are given a sum of $10 and must choose how much of the sum to give to the trustee. The amount given to the teammate will be quadrupled and in this scenario the teammate then decides how much of the quadrupled sum to return to the participant. In this scenario, participants must make a decision about how much money to risk a financial exchange with the teammate. This measure is not an explicit assessment of trust, but reflects participant's trust in their teammate.

2.3 Procedure

This study consists of two sessions. In Session One teammate behavior will be manipulated in an attempt to violate trust. In the second session the unfair teammate attempts to repair trust. In this session the unfair teammate gradually shares more of the earnings on each round and the fair teammate remains fair.

Initially, participants were asked to rate pictures of people in order to select the stimuli for the evaluative conditioning task. Male participants rated pictures of 10 male teammates and female participants will rated pictures of 10 female teammates. If the participant recognized one of the pictures, the rating for that picture was excluded from the analysis. Once the ratings were complete the researcher used the ratings to select teammates that did not carry a preexisting explicit positive or negative bias relative to each other.

After completing the ratings participants were informed that they would be working on a financial decision-making task with two remote teammates and that their teammates were two of the individuals they rated. The experimenter explained that initial ratings were gathered to assess a first impression of their teammates relative to others. Next, participants provided a rating of their explicit affective attitude toward each teammate, made economic offers to each teammate and performed the IAT to assess baseline explicit and implicit attitudes and trust. After the baseline measures, participants were trained on how to perform the financial decision making task.

Participants began Session One by performing the team financial decision-making task with each teammate, both explicit and implicit attitude measures were administered to assess attitude toward the teammate and the participant made an economic offer. Next, a subset of the original sample began Session Two. The procedure in Session Two was exactly the same as in Session One except both teammates exhibited fair behavior and the participant reached his or her financial goal with both teammates.

3 Results

The IAT effect was computed using Greenwald et al. [28] improved scoring algorithm for measuring the IAT effects called *D*. *D* is an effect size measure similar to Cohen's d and is used to assess the attitude of the unfair teammate compared to the fair teammate. The algorithm involves eliminating reaction time outliers < 300 and > 10,000 ms. Next reaction time in blocks 3 and 5 are subtracted to generate a within-groups difference score. This difference score is then divided by the pooled standard deviation for both blocks. *D* was calculated for both pre and post-test IAT measures and pretest *D* was subtracted from post-test to compute the impact of the new evaluative conditioning task on implicit attitude.

3.1 Affective Attitude and Economic Offer Correlations

Pre-test D was subtracted from post-test to compute the impact of the financial decision-making task on implicit attitude. Explicit attitude toward the unfair teammate was subtracted from the explicit attitude rating toward the fair teammate at both the pre and post financial decision-making time points. This was to create a relative explicit measure comparable to D. Next, the relative explicit attitude measure was subtracted from the post-test measure to compute the impact of the task on participant's explicit affective attitude. Change scores for the economic offers given to both the fair and unfair teammate were also computed by subtracting the baseline offer from the offer made after Session 1. Correlations were computed to determine if a change in affective attitude was correlated with economic offers. Correlations revealed significant associations between Trust in both teammates and explicit attitude shift. In addition the magnitude of the difference between trust in the fair teammate and trust in the unfair teammate was also correlated with explicit attitude shift (see Table 2). Lower trust in the unfair teammate was associated with a shift in negative explicit attitude toward this teammate. Higher trust in the fair teammate was associated with a shift in positive explicit attitude toward this

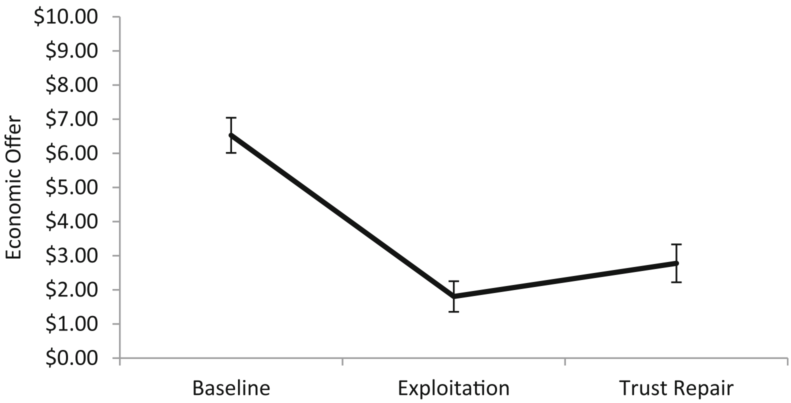

Fig. 1 Economic offer as a function of time

teammate and large shift in explicit attitude was associated with a large relative difference between trust in the fair teammate and trust in the unfair teammate.

3.2 *Trust Repair*

We investigated the impact of an attempt at trust repair on economic offers. The researchers computed a repeated measures One-way ANOVA to examine the effects of time on economic offer. The independent variable time had three levels; baseline, after exploitation, after trust repair attempt. The ANOVA revealed a main effect for time, $F(2, 52) = 42.86$, $p < 0.001$, $\eta_p^2 = 0.62$ (see Fig. 1). LSD pairwise comparisons revealed that the economic offer given to the unfair teammate was significantly lower after the teammate's exploitation (M = \$1.80, $SD = 2.33$) compared to baseline (M = \$6.53, $SD = 2.67$) ($p < 0.001$). In addition, although the economic offer significantly increased after the teammate's attempt at trust repair (M = \$2.78, $SD = 2.88$) ($p = 0.02$), this offer was still significantly lower than the baseline offer ($p < 0.001$).

4 Discussion

Explicit affective attitude shift was significantly associated with shifts in economic offers for both the fair and unfair teammate as well as the relative difference between the two teammates. These correlations suggest that affect plays a role in trust development and decision-making. In the context of decision-making research these findings are consistent with research exploring the impact of affect on decision-making. Slovic et al. [29] refer to this emotional influence on decision-making as the affect heuristic. Individuals guided by the affect heuristic base their decisions and choices on a basic emotional response on a continuum from like to hate [29].

In reference to trust the findings suggest an affective attitude toward a teammate has an influential impact on trust in this teammate. The findings provide empirical evidence to support the need to include affect in theoretical models of trust. One possibility for the lack of association between implicit attitude and trust is perhaps 15 min of work with each teammate was not enough to build implicit associations for all participants. However, even participants that did not develop an implicit bias favoring the fair teammate could still generate an explicit attitude consistent with their economic offer by relying on Type 2 process. Future research should be conducted to explore if an affective attitude can predict trust after controlling for cognitive predictors of trust such as perceived ability, benevolence and integrity (ABI) [9]. It is unclear if affects impact on trust development is direct as suggested by Lee and See [3] or mediated by cognitive predictors in the ABI model as suggested by Schoorman, Mayer and Davis [14].

The researchers found that the unfair participant's attempt at trust repair was influential enough to significantly increase economic offers. However, this increase in trust was far from comparable to baseline levels of trust. Consistent with King-Casas [12], the results suggest increasing generosity may increase trust after a trust violation due to exploitation. Perhaps teammate exploitation does not result in an irrecoverable loss of trust as suggested by Grover et al. [11]. However, the results also suggest that it may be challenging to completely restore trust to pre-exploitation levels. It is possible that the trust repair manipulation was not strong enough in this study to completely restore trust. Although the unfair teammate in Session Two was more generous, he or she did not split the earnings evenly on all trials. In fact, the teammate did not start splitting the earnings evenly until trial 15 of Session Two. Perhaps the teammate's generosity was too little too late to completely restore trust. Future research should manipulate the magnitude and consistency of teammate's generosity after a trust violation to explore their effects on trust. These findings can be used to inform strategies for improving trust in distributed teams.

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Applying Triangulation Method to Strengthen Validity of Integrated Balanced Scorecard's Performance Measurement Model for Supply Chain's Actors and Regulators

Elisa Kusrini, Subagyo and Nur Aini Masruroh

Abstract This study describes the application of triangulation method to strengthen validity of the integrated Balanced scorecard (BSC) performance measurement models for actor and regulator. This integrated BSC model has been developed by author in the previous research by combining Balanced Scorecard-Supply Chain Operation Reference-Regulator contribution model. This model referred as B-S-Rc-model. This model has been tested using Structural Equation Model (SEM) in leather craft industry in Yogyakarta (Indonesia) and valid to measure the performance of the regulator and supply chain's actor. The model is further validated using a triangulation approach to strengthen the validity of model using a combination of method (Quantitative and Qualitative) and data source. It can be concluded that generally the B-S-Rc model is valid. Nevertheless, there is relationship between two variables and two indicators that detected inappropriate with the model, but still can be justified due to acceptable certain conditional factor. This study concluded that the method of triangulation can enhance the validity of the model because it combines multiple data sources and methods.

Keywords Triangulation method · Performance measurement · Supply chain's · Actors and regulator · Balanced · Scorecard · SCOR · Regulator contribution

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1 Introduction

Many organizations conduct performance measurement because it can provide information about the objectives, strategies and performance improvement in the future [1, 2]. Performance measurement not only need to be done by the company, but also needs to be done on the supply chain network. This is because at the present time the company's competitive advantage lies not only in its internal capabilities, but also on the ability to manage supply chain network [3, 4]. Furthermore, the measurement of supply chain performance improvement becomes main concern not only by the company's member of supply chain (actors) but also by regulator/government. This is because the regulator/government has responsibility to formulate regulation and facilitate the economic growth of supply chain.

All this time, performance measurements by supply chain actors and regulator/government are conducted separately. It causes inefficiency, as well as obstructs both parties in understanding the effectiveness of each respective performance Therefore, an efficient and effective integrated model of performance measurement by supply chain actors and regulator is required, because this far the model of performance measurement by supply chain actors and regulator is still separately developed [5]. Kusrini et al. [6] proposed a model of integrated measurement between actors and regulators by combining Balanced Scorecard—Supply Chain Operation Reference—Regulator Contribution model. This model referred as B-S-Rc model. This model has been tested using Structural Equation Model (SEM) by distributing 162 questionnaires to supply chain actors and regulator in innovative product (i.e. leather craft) industry in Yogyakarta (Indonesia) and valid to measure the performance of the regulator and supply chain's actor. This paper aims to improve the level of validity of the model using triangulation approach, which is the integration of triangulation method and data source. Triangulation method is carried out by combining the quantitative analysis (SEM) with interview and document/archive study. Data source triangulation is conducted by comparing existed documents with different source of data.

2 Development of Integrated B-S-Rc Model

This integrated BSC model has been developed by author in the previous research. The following is a brief explanation of developing integrated B-S-Rc model [6]. The basic model employed is Balance Scorecard (BSC) model [7]. In this stage, basic model is improved, from BSC (corporate) model to BSC's supply chain model (BSC-SC). Later, process activity measurement that conducted based on SCOR (Plan-Source-Make-Deliver-Return) is integrated into the perspective of internal process business originated from BSC-SC. Furthermore, integration is continued by involving performance measurement on regulator contribution towards supply chain actors on each BSC-SC perspective. Then, this model is

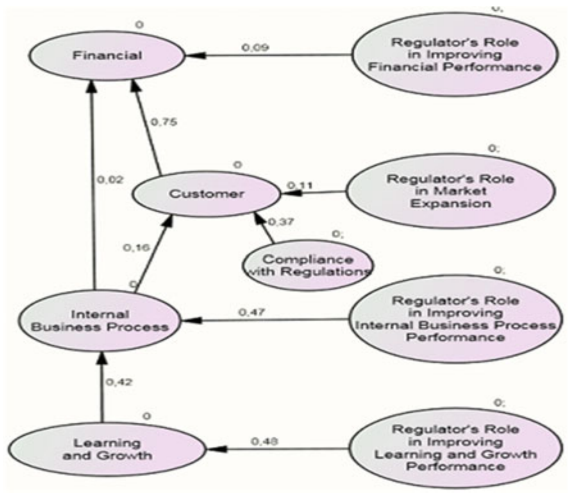

Fig. 1 Final model of correlation among performance of B-S-Rc model [6]

known as BSC-SCOR-Regulator Contribution integration model. Later on, it is abbreviated as B-S-Rc. The proposed model is tested by distributing 162 questionnaires to supply chain actors and regulator in leather craft industry in Yogyakarta. Then, the data are processed with Structural Equation Modeling (SEM) model. From the SEM analysis using Confirmatory Factor Analysis (CFA) and composite indicator, resulted fit model based on Maximum likelihood estimation with index goodness of fit, as follows: x^2-chi-square = 11.65; Significance probability = 0.17; CMIN/DF = 1.46; RMSEA = 0.05; TLI = 0.96; CFI = 0.99. This indicates that causal relationship of proposed model in accordance with the conditions of empirical field. From the testing results, 31 valid key indicators are found consisted of 19 indicators to measure performance of supply chain actors and 12 indicators to measure the regulator's performance. Final model of correlation among performance of B-S-Rc-S model depicted in Fig. 1.

3 Literature Review on Triangulation Method

Triangulation is a combination of several methods to study the same phenomenon. According to Denzin (1970) in [8], triangulation is defined as a combination of various methods used to study the interrelated phenomena from different angles and different perspectives. Triangulation includes four things: (1) triangulation method, which is done by comparing the information or data by different methods. For example a combination of interviews, observation and surveys. (2) inter-researcher triangulation, which is done by using more than one person in the collection and analysis of data. (3) Triangulation of data sources, i.e. getting the truth of information through a variety of methods and sources of data acquisition. For example, in addition to interviews and observation, researchers could use participant observation (participant observation), written documents (records, official records, or personal writing), image or photograph. (4) Triangulation theory, comparing the findings with existing theories.

Some researchers called the term triangulation with different terms, such as multi method or mix method/mix of research. Freling et al. [9] using a triangulation method that combines some qualitative methods of focus groups, depth interviews and document analysis in building brand personality and call it a multi method qualitative study. Titko and Lace [10] using multi method that combine questionnaires, interviews and content analysis to know the concept of value the role of the bank. While Jogulu and Pansiri [11] called triangulation method mix that combines quantitative and qualitative methods in management research. Almajali and Dahalin [12] using a triangulation method which is mixed method research among methods of quantitative (statistical analysis by SEM) and qualitative (interview) to test the effect of various constructs alignment IT strategic business to business performance.

4 Result and Discussion

In this research, triangulation approach using combination of triangulation method and data source. Triangulation method is carried out by combining the quantitative analysis (SEM) with interview and document/archive study. Data source triangulation is conducted by comparing existed documents with different source of data, which is from SME actors on different innovative products and location. Interviews are conducted with regulators from three local industrial and trade office (Local Government of Bantul distric, Sleman distric and Yogyakarta distric) and one province's industrial and trade office. Interviews are also conducted with 6 Small Medium Enterprise (SME's actors) from different products and location (Bantul, Kulonprogo, Gunung Kidul, Sleman and Yogyakarta distric). Respondents are classified as the owners as well as management of community/cooperative for innovative craft products of leather, bamboo, agel, teakwood, and handmade batik. All those products are innovative products. Interview conducted by asking about the relationship between variables and indicators of the B-S-Rc model. Interview result show that generally the proposed model is valid. However there are two variables relationship and two indicators are not in accordance with the proposed model. The influence of the regulator's role in the development of new markets on the performance of customers, from the results of SEM analysis showed that it has positive relationship but no significant impact (b coefficient = 0.11; P value = 0.27). However from the interviews, it conclude that this influence has positive relationship and significant impact. This is possibly due to some SME's actor realize that they get enough support from the government, but the impact of the support/aids depends on the internal capabilities of SME.

SEM results indicate that adherence to regulatory positive and significant effect on the performance of the customer (b coefficient = 0.37; P value = 0.00). But from the interviews showed that compliance regulations are not positive and no significant effect on the performance of the customer. This is because in real conditions, there is the lack of awareness of the actors (SME) to comply with the regulation, especially in the field of occupational safety and health. On the other hand, consumers are also not so concerned about occupational safety and health, environmental and regulatory conformity. This condition cause discrepancy between the model SEM with the interviews. However it still can be justified due to acceptable certain conditional factor, therefore the proposed model is valid.

5 Conclusion

Triangulation method can be used to increase the level of validity of proposed model by combining various methods used to study the interrelated phenomena from different angles and different perspectives. In this research, triangulation approach using combination of triangulation method and data source. It can be concluded from validation test that proposed model is valid. Nevertheless, there is relationship between two variables and two indicators that detected inappropriate with the proposed model, but still can be justified due to acceptable certain conditional factor. The limitations of this study are interviews conducted by the researchers themselves so the results might be biased. Further research opportunity is to validate the inter-researcher triangulation, which is done by using more than one person in the collection and analysis of data to reduce the bias.

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