Culture and Neural Frames of Cognition and Communication

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Preface

The present volume of the book series *On Thinking* is organized based on the seventh Sino-German workshop on cognitive neurosciences in Beijing in October 2008. This workshop is one of the series conferences that are organized by the Department of Psychology at Peking University, Beijing, China, and the Human Science Center of Munich University, Germany, and attended by psychologists, cognitive neuroscientists, linguistics, anthropologists, psychiatrists, computer scientists, philosophers, economics, sociologists, and researchers in other related fields from China, Germany, Japan, Poland, the USA, the Netherlands, Hungary, and Russia. The goal of the series workshops is to promote the communication and cooperation in cognitive neuroscience between researchers from different disciplines and different countries.

The workshop in 2008 focused on the relationship between culture and cognition because there has been accumulating evidence during the last few years that sociocultural contexts generate strong influences on human cognitions and the underlying neural substrates. Since then, there has been increasing interest in studies of the interaction between sociocultural factors and multiple levels (e.g., gene, neuron, neural circuit) of the biological basis of human cognitive processes. Researchers have also started to examine neurocognitve processes in specific sociocultural contexts from the evolutionary point of view in order to understand the mutual interactions between environments and the human brain.

The present volume contains presentations from the workshop and some invited chapters. Two chapters give general views of the relationship between biological evolution and cultural evolution and recent cultural neuroscience studies of social cognition. Other chapters focus on several aspects of human cognition that have been shown to be strongly influenced by sociocultural factors such as self-concept representation, language processes, emotion, time perception, and decision making. The main goal of this volume is to address how thinking is conducted and how the underlying neural mechanisms are affected by culture and identity – a frame in which human cognition develops and evolves.

We very much appreciate the contributions of the distinguished authors from different disciplines who contribute greatly to both the series workshop and the present volume of the series *On Thinking*. We are also grateful to Anette Lindqvist from Springer Science+Businesses Media and Susanne Piccone from the Human Science Center of Munich University for their constant support which makes the series Sino-German workshop and the series book possible.

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Munich, Germany Ernst Pöppel
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Neuroplasticity: Biological Evolution's Contribution to Cultural Evolution

Bruce E. Wexler

Abstract The increase in brain size in humans relative to other primates is due to an increase in the number of cells and their interconnections. These increases exponentially increase the number of possible combinations of cells. Brain functions, including behavior and cognition, are based on functional systems that integrate widely distributed brain areas and millions of individual cells. The connections among neurons that constitute these functional systems are shaped by neuronal activity induced by stimulation from the environment. The powerful postnatal shaping of brain structure and function by environmental input during childhood continues much longer in humans than in other animals. Moreover, humans are the only animal that shapes the environment that shapes its brain. Today, most children are raised in largely human-made environments. This process of creating different neural structures through transgenerational alterations in the rearing environment is cultural evolution. By young adulthood, established neurocognitive structures are self-maintaining and the biological processes that support change in neuronal connections become less powerful. As a result, the homology between internal neurocognitive structures and the external environment achieved in childhood by the brain shaping itself to the environment is maintained in adulthood by acting on the environment to make it match established internal structures.

Keywords Cultural evolution · Evolution · Epigenetic · Neuroplasticity · Parenting · Rearing environment

1 Introduction

The human brain differs from the brains of other mammals most fundamentally in the greater extent to which development of its structure and function are influenced

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by sensory input. This sensitivity to the environment rests on three features shared throughout the mammalian line and one unique to human beings. First, cognitive functions such as perception, memory and thinking arise from the integrated activity of dynamic neural systems distributed over multiple brain areas rather than being properties of a specific anatomical location or of groups of nerve cells each "dedicated" to different specific cognitive operations. Second, neurocognitive capacity increases across the phylogenetic hierarchy primarily through increases in the overall number of brain cells and their interactions. Third, cell viability and growth depend upon cells being activated by input from the environment. Fourth, human beings alone shape the environments that in turn shape their brains.

Neuroplasticity is the quality of neural structures to change, primarily through change in the interconnections of the nerve cells that constitute the structures. Neuroplasticity is evident on different time scales. Functional connectivity can change moment to moment as neural subunits associate themselves in changing ways to dynamically constitute functional systems of perception, cognition and motor activity. More enduring aspects of neuronal structure can also change as a result of recurring activation of some cells and pathways more than others; "neurons that fire together wire together." Change at both time scales is largely a function of the individual's interaction with the environment, and although the boundaries of this categorical distinction may not always be clear, it points to different mechanisms of plasticity as well as different types of interactions with the environment. It also appears that the neural mechanisms of plasticity within the second category of more enduring changes as a result of similar and repeated environmental input may be different in children than in adults. It is this second type of neuroplasticity that is the focus of the discussion that follows, with a further emphasis on the neuroplasticity of childhood.

The first part of the thesis of this chapter is that biological evolution, as described by Darwin and based on random mutations in DNA and selection for those mutations that provide adaptive advantages in the organism's particular environment, led to changes in two parameter settings in pre- and post-natal neurodevelopment. One is the number of neurons, while the second is the length of time after birth that the brain is easily shaped, and reshaped, by environmental input. These two changes are greater in human beings than in other animals and make it possible for environmental input to create more elaborate and powerful neural functional structures in human beings. The second part of the thesis is that people began to change the environment that provided the brain-shaping sensory input for their children. While the time and manner of this development in human prehistory is unclear, it is clear that it was at first a very gradual change, and that in recent millennia it has greatly accelerated. Today, most of the world's children are raised in largely human-made environments. This process of creating different neural structures through transgenerational alterations in the rearing environment is cultural evolution.

Cultural evolution is much faster that of Darwinian biological evolution. Like Darwinian evolution, it creates population variability by mixing traits of the parental generation in their offspring. However, cultural evolution much more rapidly creates variability, and the variability is more incremental and extensive in distribution across the population. In terms of human development over the last 100,000 to 150,000 years, it is as if cultural evolution said to biological evolution: "thank you for creating the opportunity for me to contribute to human development. I will take over from here because I am much faster than you." Of course, cultural evolution also differs from biological evolution in the way information is stored so as to provide continuing influence on function. In biological evolution, the information is stored in the base sequence of DNA molecules. In cultural evolution, the information is stored in the minds and behavior of adult members of society, in cultural artifacts such as books, architecture and works of art, and in social institutions including laws, customs and schools. In biological evolution, the information is stored in identical and complete form in many individuals. In cultural evolution, the information is distributed in different and incomplete form across many individuals and artifacts.

This chapter will review the neuroscience basis for cultural evolution. It begins by presenting a contemporary neural systems view of brain functional organization. It will then review the evidence that neuronal viability depends upon sensory input, and that the nature of that input influences structural and functional organization in the brains of other mammals. This will include demonstration of the remarkable extent of the plastic potential. The chapter will next describe the work of Harlow and Mears demonstrating the centrality of parental stimulation of infants in the parent–infant interaction, summarize more recent work identifying the epigenetic changes in DNA structure responsible for life long effects of early maternal behaviors, and briefly review the remarkably similar work of the Russian developmental psychologist Vygotsky and the early twentieth century psychoanalytic ego-psychologists on the role of interpersonal interactions in creating internal mental structures. The next section will present brain imaging studies that have demonstrated the effects of environmentally induced activity on human brain structure and function. The chapter concludes with a brief summary and discussion, including comments on changes in neuroplasticity over the life span and social implications of these changes.

2 Part One: Cognitive Functions such as Perception, Memory and Thinking Arise from the Integrated Activity of Dynamic Neural Systems Distributed over Multiple Brain Areas

Each of the 100 billion neurons in the human brain receives input from approximately 1,000 other cells. The interconnections among neurons that create functional ensembles and neural systems are heavily influenced by post-natal environmental input, as reviewed below. Consistent with this massive interconnectivity, learning even simple associations between two stimuli leads to altered response characteristics in millions of cells distributed across wide expanses of cortical territory (John et al. 1986). Brain imaging studies in human beings show that, in order to perform simple cognitive operations, multiple brain areas in both cerebral hemispheres become more active, and others decrease their activity (e.g., D'Esposito 2007). Moreover, when even simple tasks are repeated minutes or hours later, the pattern of regional activations is different, with (e.g., Poldrack et al. 1999) or without (e.g., Loubinoux et al. 2001; Kelly et al. 2006) deliberate efforts to teach or learn the tasks. Of course, in real life, most of the things we do we have done before, so that the brain activations associated with them have been different at different times. As people get older, there are also common changes across individuals, so that the same tasks are done by different combinations of brain areas at different ages (e.g., Gaillard et al. 2000; Stebbins et al. 2002). Furthermore, if the same component cognitive operation is performed as part of different overall cognitive functions, the pattern of regional brain activation associated with the cognitive operation is different (e.g., Friston et al. 1996; Wexler 2004).

These relatively recent observations are all consistent with the notion of cerebral functional systems defined so succinctly by the early twentieth century Russian neuropsychologist A.R. Luria (Luria 1973; see also Vygotsky 1978). Luria worked with many soldiers who had suffered highly localized brain injuries. He noted that localized injuries rarely affected only one cognitive operation, but usually affected multiple operations. He also noted that individual cognitive operations were affected by injuries at multiple different locations. Luria concluded, as had Pavlov earlier, that while groups of cells in a specific anatomic location might work together and have some "elementary tissue function," such functions do not correspond to mental functions like perception, memory or cognition. Mental operations are instead properties of multi-component cerebral functional systems. Like other systems, cerebral functional systems perform a constant function through means or components that vary from instance to instance. The function is localized in, or is a property of, the system and not of a specific anatomic location in the brain. This systems thinking characterizes most contemporary views of the functional organization of the human brain.

This modern view contrasts with nineteenth century concepts of phrenology and the related mid- to late twentieth century concepts of modularity (see Wexler 2004, 2006). Phrenology and modularity posit that specific cognitive operations are performed at specific localized anatomic sites, and that the function of these sites is the specific cognitive operation. In contrast, the twenty-first century systems view posits that groups of cells at different locations have different characteristics like different letters in an alphabet, and that cognitive functions emerge from the combination of different local units into functional systems just as words emerge from the combination of letters. In actuality, there may be some localized units in the systems model that actually are also "stand alone" modules for simple cognitive operations that may have evolved prior to the primate, or even the mammalian, line, and been conserved since. These elementary modules would still serve as components but, like the single letter words "a" and "I," can most likely serve both as free-standing cognitive modules and as components of larger systems.

When one hemisphere of the brain must be surgically removed in very young infants, their subsequent cognitive development is largely normal and all cognitive operations are performed with the remaining hemisphere (Ogden 1996; Werth 2006). This is even true when the left or language hemisphere is removed; in these cases, language is supported by the right hemisphere. As with the many other examples of developmental neuroplasticity discussed in the next section, such relocations and reconfigurations of brain functional architecture are more easily understood in the systems/emergent property view than in the phrenology/modularity view.

3 Part Two: Sensory Stimulation and the Viability and Growth of Brain Cells

The brain's dependence upon environmental input starts with the requirement of sensory stimulation to maintain structural integrity. Information processing structures along the entire information input pathway, from peripheral sensory receptors to cortical processing centers, atrophy when deprived of sensory input. For example: the number of ganglion cells in the retina, which carry excitation from the photoreceptor cells of the eye to the first relay station in the brain, is decreased to 10% of normal in dark-reared chimpanzees (Rasch et al. 1961); cats and rats have smaller than normal ganglion cells after dark rearing (Rasch et al. 1961); and the rod and cone photoreceptor cells themselves in the eyes of chicks reared for 4 weeks with opaque coverings of the eye are morphologically abnormal (Liang et al. 1995). Similar sensory dependence is seen in the first relay station for visual information in the brainstem, the lateral geniculate body, and in the area of the cortex that receives input directly from the lateral geniculate. Both the number and size of cells are reduced by as much as 30–40% in the lateral geniculate of cats and monkeys deprived of visual input during the initial weeks of life (e.g., Wiesel and Hubel 1963; Kupfer and Palmer 1964; Hubel and Wiesel 1970; Sherman et al. 1972; Sherman and Sanderson 1972; Hubel 1988; Tigges and Tigges 1993). The effects continue along the information input pathway to the visual cortex where cell number, cell size and the density of connections among cells are decreased and the organization of cells is altered (e.g., Aghajanian and Bloom 1967; Cragg 1970; Fifková 1970; Rakic et al. 1991; Kumar and Schliebs 1992, 1993; Robner et al. 1993). Studies of olfactory deprivation have yielded a similar picture (e.g., Benson et al. 1984; Skeen et al. 1986; Najbauer and Leon 1995). Effects of sensory deprivation on structural integrity can be decreased by injection of nerve growth factor into the cerebral spinal fluid within the brain during the period of deprivation (Berardi et al. 1992, 1993; Carmignoto et al. 1993; Domenici et al. 1993; Pizzorusso et al. 1994). This naturally occurring substance is produced and released by cells stimulated by sensory input, thus providing further evidence of the association between neuronal activity and neuronal viability and growth (Domenici et al. 1993).

Effects of sensory deprivation on development of brain functional organization follow from these effects on cell viability and growth. Neurons at each stage of processing compete for connections with neurons at each subsequent stage, with neurons that fire more often gaining territory. These effects were investigated systematically in Hubel and Wiesel's Nobel prize-winning studies of kittens and monkeys (Hubel 1988). Recording electrical activity from hundreds of cells in the area of the brain that receives visual information, they determined that in animals raised under normal conditions most cells respond to inputs from both eyes (approximately 85% in the kitten, 65% in the monkey). Many of these responded somewhat more frequently to input from one eye, with such eye preferences divided evenly between the eyes. Similarly, of the monocularly responsive cells, half responded exclusively to the right eye and half to the left. However, when an eye was sutured closed shortly after birth and then reopened 10 weeks later, 85% or more of cells responded preferentially to the previously non-deprived eye, and few if any cells responded exclusively to the previously deprived eye. Responses to stimulation of the previously deprived eye were slow to start, decreased in amplitude, and easily fatigued when present at all.

Hubel and Wiesel also demonstrated two additional features of the effects of sensory-induced neuronal activity on the development of brain structure and function that are of particular relevance to cultural evolution. When visual input to the deprived eye is restored, the altered pattern of cortical cell sensitivities persists despite the fact that both eyes are now receiving unobstructed visual input. As long as neurons from the previously non-deprived eye remain active, they are able to maintain their abnormally acquired hegemony. If, however, the previously non-deprived eye is occluded while the animal is still young enough, the abnormal response pattern can be normalized or reversed in favor of the previously deprived eye (Hubel 1988). The first conclusion of particular interest in relation to cultural evolution is that socially generated activity can create unusual structures that alter the interaction with the environment so as to maintain themselves. In this case, when the eye was occluded, cortical structure changed so as to be unusually responsive to input from only one eye. When the occlusion was removed and input was available to both eyes, the brain still registered input almost exclusively from only one eye. The neural resources necessary to process input now available from the previously occluded eye were absent. They had been appropriated by the active eye during the period of unilateral occlusion, and the active eye maintained the extra resources because it kept those resources actively engaged in processing input within the systems that had appropriated them. This situation could be reversed by occluding the previously open eye, demonstrating that the plastic potential remained, that the brain could be shaped or normalized by corrective intervention, and that without such active intervention the "normal" pattern could not reassert itself even in a "normal" situation. The second conclusion of particular interest is that active intervention to normalize or reverse the effects of the initial unilateral occlusion was only effective in young animals. After a certain stage in development, often referred to as the critical period, there is a higher degree of stability in established neural structures, in part because neurochemical mechanisms that support neuroplasticity are less powerful in older individuals.

In further work, Hubel and Wiesel demonstrated that altering the nature or content of the visual stimuli changes the functional organization of the visual cortex even when the stimuli are viewed normally by both eyes. For example, some cells in the visual cortex respond selectively to moving objects, with each cell having maximum sensitivity to movement in a particular direction. Other cells respond selectively to lines (i.e., object edges), with each of these cells having maximum sensitivity to lines of a particular orientation. Kittens raised in strobe light that prevents appreciation of movement have decreased numbers of motion-sensitive cells (Cynader et al. 1973; Cynader and Chernenko 1976). Presumably cells that would have been "specialized" for movement detection became selectively responsive to some other aspect of visual information instead. Kittens raised in the dark except for exposure to stripes moving from left to right have a marked increase in the proportion of cells selectively responsive to left/right rather than right/left movement (Tretter et al. 1975). Similarly, kittens exposed to vertical black and white stripes for a few hours each day, but otherwise reared in darkness, have cortical cells with vertical line orientation preferences, but none with preferences for other orientations (Blakemore and Cooper 1970). Kittens raised wearing goggles that allowed them to see only vertical lines in one eye and horizontal lines in the other have fewer than the normal number of cells that respond to oblique lines. Moreover, cells responsive to vertical lines are active only with stimulation of the eye that had been exposed to vertical lines, and cells responsive to horizontal lines are active only with stimulation of the eye that had been exposed to horizontal lines (Hirsch and Spinelli 1970).

The extent of neuroplastic potential in the developing mammalian brain is remarkable. In adult rats that had an eye removed at birth, stimulation of their whiskers led to electrophysiological and metabolic activity within the visual cortex (Toldi et al. 1994). Apparently, neurons in what is normally a visual processing area came instead to respond to input from the whiskers when deprived of input from the eye. In perhaps the most dramatic demonstration of plasticity, the optic nerve in 1-day-old ferrets was rerouted to provide visual rather than auditory input to what is normally the auditory cortex. The "auditory" cortex developed a functional organization of ocular dominance columns highly similar to the normal visual cortex rather than its usual tonotopic structure, and the ferrets saw with what would normally have been the auditory regions of the brain (Sharma et al. 2000).

The studies summarized in this section provide evidence that mammalian brains (and minds) develop concrete perceptual structures, capabilities and sensitivities based on prominent features of the rearing environment, and then are more able and more likely to see those features in the sensory mix of new environments encountered subsequently. Or to turn it around, mammals have limited ability to see even prominent features of a new environment if those features were absent from their rearing environment.

4 Part Three: Social Interactions as the Source of Early Environmental Stimulation

The class mammalia is named on the basis of the presence of mammary glands. It is defined on the basis of nourishing young with milk and a series of physical features including a chain of small ear bones, four optic lobes in the brain, a particular mandibular structure, a muscular diaphragm separating the lungs and heart from the abdomen, only a left aortic arch, warm blood with red blood cells lacking nuclei and viviparous reproduction. In studies of infant monkeys and wire mesh "surrogate" mothers, Harlow and Mears provided a radical correction to this definition, adding another central feature that in many ways is more important than all the others. Infant monkeys were separated from their mothers and raised in cages with access to both a wire mesh and a cloth "surrogate" mother. Both surrogate mothers were kept at the same temperature as normal monkey mothers. One-half of the monkeys received milk from the wire mesh mother and one-half from the cloth mother. Both groups spent much more time on the cloth than the wire mesh mother. The differential was greater by only a small amount when the cloth mother was the source of milk. The preference for the cloth mother became greater over time in both groups, the opposite of what would be expected from a food/hunger reduction conditioning model which would predict increasing preference over time for the food-providing surrogate mother. Harlow and Mears concluded that "the disparity [in favor of selecting the cloth mother independent of which mother provides milk] is so great as to suggest that the primary function of nursing as an affectional variable is that of ensuring frequent and intimate body contact of the infant with the mother (Harlow and Mears 1979, p. 108)." In other words, instead of the provision of milk being the end goal of mother–infant interaction in and of itself, it is a means of ensuring contact between the mother and the infant because this contact is essential for provision of sensory stimulation necessary for brain development, and for production of population variability through variability in that stimulation.

Real living mothers and other parenting figures vary in the ways they stimulate their infants and children. Naturally occurring differences in these parenting behaviors have life-long and specific effects on the brains and behavior of their offspring, and changes in DNA structure that mediate these effects have been identified in studies of rats (Weaver et al. 2004a, b). Mother rats differ in the amount of time they spend licking and grooming their pups, and in the ways they position themselves for nursing. Michael Meaney and colleagues found that adult rats which had been licked more as pups had decreased behavioral and hormonal responses to stress, and greater spatial learning abilities – a capacity in which areas of the hippocampus play an important role (Weaver et al. 2004b). Examining brain chemistry and structure, they found greater levels of specific types of messenger RNA that carry the information from the DNA to parts of the cells that synthesize the glucocorticoid receptors important in regulating stress responses. Similar changes were noted in the RNA associated with producing the NMDA receptors important in promoting neuroplasticity and learning. Direct examination of the hippocampus revealed that offspring of high-licking mothers had longer neurons with more branches and interconnections (Fig. 1; Champagne et al. 2008). Direct examination of the DNA identified actual changes in the genes associated with stress response as a result of the degree of maternal licking. Shortly after birth, the surface of DNA is largely covered by small chemical complexes called methyl groups. These methyl groups limit access to the DNA and thereby limit activation or expression of genes. Experiences during the first weeks of life can lead to

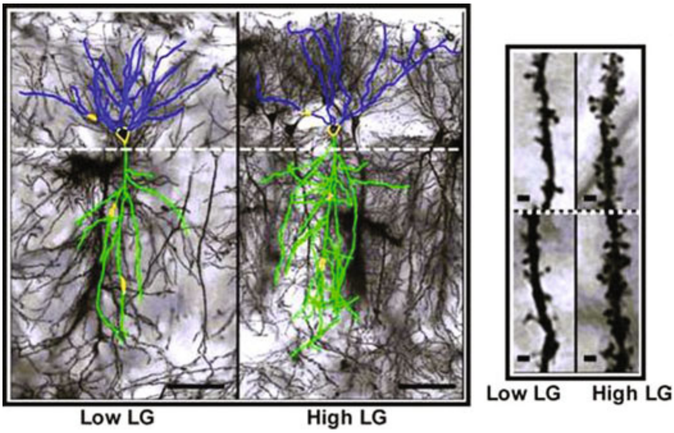


Fig. 1 Increased dendritic branching on hippocampal neurons in adult rats which had high-licking and -grooming mothers (*high LG*) as compared to adult rats which had low-licking and -grooming mothers (*low LG*). The *right-hand panel* shows photographs of dendritic connections along the length of axons. The increased branching in rats raised by high LG mothers is again evident (from Champagne et al. 2008)

selective removal of these methyl groups, making some genes more active. The effects of experience on methylation are much greater during the first 3 weeks of a rat's life than thereafter, and changes induced by experience during this "critical" period usually remain relatively unchanged throughout the rat's adult life. Maternal licking initiates a series of neurochemical processes that selectively demethylate genes that produce the glucocorticoid receptors in the hippocampus and frontal lobes that turn off the stress response.

To ensure that these observations were due to the differences in maternal behavior, and not to genes that high-licking mothers passed on to their offspring, Meaney and colleagues had pups born to low-licking mothers raised from birth by high-licking mothers, and vice versa (Weaver et al. 2004a, b). When these rats became adults, their stress responses and the methylation of their DNA (see Fig. 2; Weaver et al. 2004a) were both consistent with the type of mother that reared them and not with the type of their biological mother.

Two other aspects of this work are also of relevance to cultural evolution. First, when given learning tests in high stress environments, adult rats raised by low-licking mothers out-performed rats raised by high-licking mothers. This demonstrates the adaptive value of the population variability induced by cultural evolution. Second, some of the persistent neurochemical and behavioral effects of maternal care of female infants affect the way the infant functions as a mother herself when she becomes an adult. Females that had been separated from their mothers when they were infants showed lower than normal gene expression in areas of the brain associated with maternal behaviors when they themselves became mothers (Fleming et al. 2002). They also licked and crouched over their pups less often than other mothers (Gonzalez et al. 2001), and their generally decreased ability to

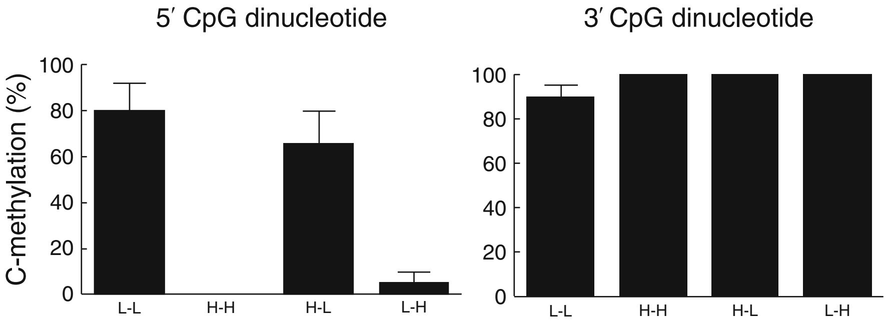


Fig. 2 Cross-fostering study of maternal effects on DNA methylation. Percent of the DNA surface covered by methyl groups in the region of DNA which codes for production of glucocorticoid receptors important in regulating stress response (*left figure*), as a function of biological and rearing mother. *L-L* Offspring of low-licking and -grooming mothers raised by low-licking -grooming mothers. *H-H* Offspring of high-licking mothers raised by high-licking mothers. *L-H* Offspring of low-licking and -grooming mothers raised by high-licking -grooming mothers. *H-L* Offspring of high-licking mothers raised by low-licking mothers (Weaver et al. 2004a)

maintain attention and increased response to stress have been hypothesized to further compromise their maternal competence (Fleming et al. 2002). Such inter-generational effects are potentially self-propagating and even self-amplifying. Moreover, since litter size (Jans and Woodside 1987; Fleming et al. 2002) and food availability (Lyons et al. 2002) can influence the amount of licking and other behavioral interactions between mother and infant, a variety of environmental factors can influence maternal behaviors and their impact, across generations, on a range of individual and group behaviors. All this depends on the post-natal sensitivity of the mammalian brain to sensory stimulation, and the proximity of mammalian infants and mothers ensured by nursing.

5 Part Four: The Human Rearing Environment

Human rearing behaviors are more complex and more varied than those of other mammals, and include massive social components and influences from extended families, communities and nation states. The extra-familial influences include schools, mass media, arts, laws and customs. The human social and economic environments also affect the states of mind, time and energy of the parents, thus affecting their interactions with their offspring in a manner analogous to the effects of food supply on rat maternal behavior. And although beyond the scope of this chapter to discuss, the huge role of language – spoken and written – in facilitating the influence of the human-made environment on the development of children must be noted, along with the fact the latter is itself clearly a product of cultural evolution, and it seems increasingly probable that the former is in large part as well.

At birth, human infants can distinguish their mother's language from other languages based on stimulation received in utero (Mehler et al. 1988). Within hours of birth, they show a selective interest in looking at the human face, with the interest greatest for the full face as experienced in social interactions rather than for the face in profile. Within days, they prefer their mother's face and voice to those of others (Spitz and Wolf 1946; Carpenter 1974; Mills and Melhursh 1974; Goren et al. 1975; MacFarlane 1978; Mehler et al. 1988; Fifer and Moon 1994). Within this context, parents provide objects of play and structure interactions and activities. As Kenneth Kaye has remarked, "social interference in the object-directed activities of babies is such a commonplace occurrence that few authors have remarked on its absolute uniqueness to our own species (Kaye 1982a, p. 193)." The brains and minds of human infants and children develop while closely linked to the minds and brains of their biobehaviorally mature caregivers. The characteristics of the adults shape the stimulation that shapes the growing brains of the children through the small details and general rhythms of the child's experiences. The child integrates input from progressively larger circles of direct interaction, beginning with primary caregivers and growing to include extended family members and then members of the community and society more broadly.

While some of the social input is actively shaped and provided by others, much is just "absorbed" through essentially constant imitation. Within 2 days of birth, infants will stick out their tongues and move their heads in imitation of an adult doing so (Meltzoff and Moore 1977, 1989). From infancy on, children learn how to do things simply by watching them done. They imitate the goals of action even by different means and imitate a parent's affective response to new stimuli (Kaye 1982b; Klinnet et al. 1986). "Mirror neurons" fire when people (and monkeys) watch an act being done, and many times these same neurons are then active when the individual performs the action previously observed (Rizzolatti et al. 1996; Iacoboni et al. 1999; Umilta et al. 2001). Similarly, looking at someone else in pain activates the same regions of the brain as are active when the observer experiences pain him or herself (Singer et al. 2004; Jackson et al. 2005; Gu and Han 2007). The earlier cited work of Hubel and Wiesel demonstrated that environmentally induced neuronal activity shaped the development of cerebral functional structures through the process of neurons that fire together wire together. In human development, active parental and community interventions and nearly constant imitation of what is seen and heard produce intensive and repetitive firing of neuronal ensembles and circuits. This environment-induced neural activation shapes brain development to be consistent with the largely human-made rearing environment.

Well before the relevant neuroscience research, psychologists were aware of the role of the social environment in shaping mental development, describing the processes in language remarkably similar to what would be suggested by the subsequent work of Hubel, Wiesel, Meaney and others. Writing in 1926, Fenichel states that "changes in the ego, in which characteristics which were previously perceived in an object [usually an important person] are acquired by the perceiver of them, have long since been familiar to psychoanalysis (Fenichel 1926)."

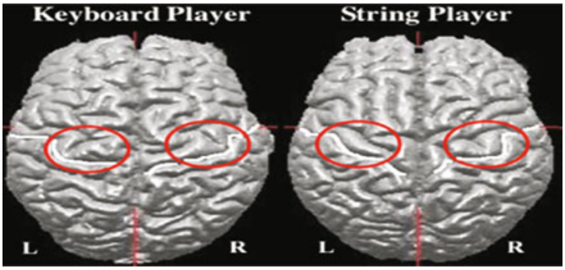
Freud described identification as "the assimilation of one ego to another one, as a result of which the first ego behaves like the second in certain respects, imitates it and in a sense takes it up into itself (Freud 1933)." Greenson stated that "identification with an object means that. . .a transformation of the self has occurred whereby the self has become similar to the external object. . .one can observe behavior, attitudes, feelings, posture, etc., which are now identical to those characteristics belonging to the external object," and that at early stages of development "perception implies transformation of the self (Greenson 1954)." Reich explained that "the child simply imitates whatever attracts his attention momentarily in the object. . .normally these passing identifications develop slowly into permanent ones, into real assimilation of the object's qualities (Reich 1954)." Writing from a different cultural and intellectual context, the Russian psychologist Lev Vygotsky described the process: "In the early stages of development the complex psychological function *was shared between two persons*: the adult *triggered* the psychological process by naming the object or by pointing to it; the child *responded* to this signal and picked out the named object either by fixing it with his eye or by holding it with his hand. In the subsequent stages of development. . .The function which hitherto was shared between two people now becomes a method of *internal organization of the psychological process*. From an external, socially organized attention develops the *child's voluntary attention*, which in this stage is an internal, self-regulating process (Vygotsky 1978)."

6 Part Five: Brain Imaging Demonstrations of Environment Induced Brain Organization in Human Beings

Brain imaging studies have now demonstrated changes in brain structure and function that result from unusual motor activity or sensory input during childhood and persist into adulthood. One set of studies has examined differences in brain structure and function as a result of practicing a musical instrument during childhood. A socially and culturally created and induced activity on multiple levels, intensive practice of string instruments leads to selective increase in volume of the right somatosensory and motor areas associated with the rapid, fine motor movements of the fingers of the right hand. The changes in the brain are greater in adults who practiced more hours and began practicing at younger ages (Schlaug 2001). Figure 3 shows this "bulked up" motor cortex in the right hemisphere of string players (the increase in volume is actually visible to the naked eye!) and bilaterally in piano players who practice with both hands (Bangert and Schlaug 2006).

The second set of studies looked at brain activations in the normal visual areas of the brain in adults who were blind at birth or shortly thereafter, or the normal auditory areas of the brain in adults who were deaf at or shortly after birth. Directly analogous to the selective sensory deprivation experiments of Hubel and Wiesel, the findings were also analogous. In early blind subjects, the area of the brain that is

Fig. 3 Expansion of motor cortex unilaterally *(right side)* in long-time players of string instruments and bilaterally in long-time piano players (Bangert and Schlaug 2006)



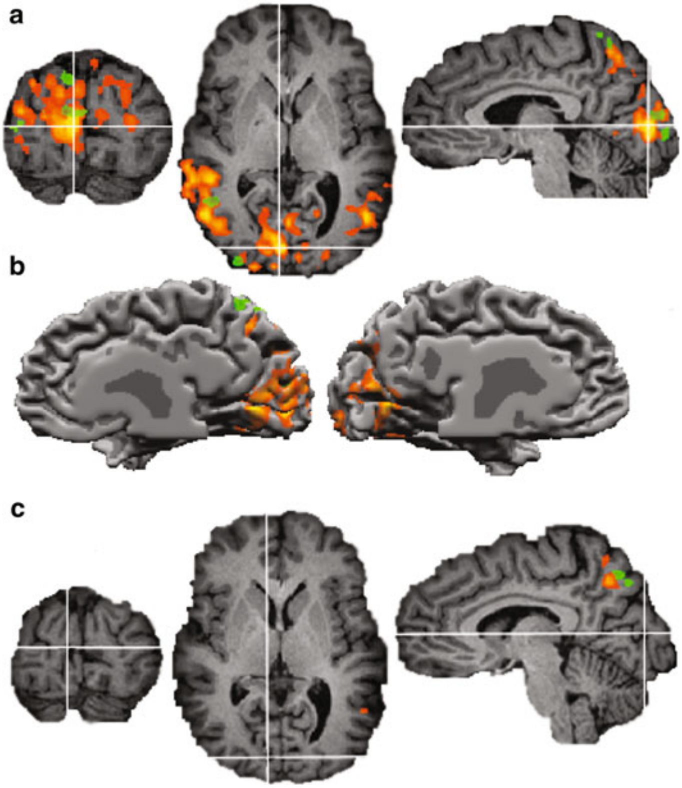


Fig. 4 In individuals blind since early childhood, auditory (*white*) and somatosensory (*black*) stimuli activate areas of the brain that normally respond to visual stimulation (Amedi et al. 2003)

normally the site of early visual processing is activated instead by auditory and tactile stimulation (Fig. 4), and is also more active during language processing tasks than is the case in sighted people (Amedi et al. 2003). Apparently, when the normal sensory input to the area was absent, other sensory input and cognitive operations moved into the territory.

7 Summary and Conclusions

Individual neurons in the human brain have few if any functional differences from individual neurons in the brains of other primates. Other things therefore must account for the large differences in function between the human brain and other primate brains. One is the increased number of cells and interconnections among them. Second is an extended period after birth during which the brain is highly susceptible to shaping by environmentally induced neuronal activity. Third is the fact that humans alone alter the environment that produces the neuronal activity that shapes the brains of their off spring. Together these factors constitute neuroplasticity and cultural evolution.

Cultural evolution appears to have produced much greater changes in human life and experience during the more recent history of our species than during its early history. Cave paintings, acknowledged to reflect mastery of craft and complexity of aesthetic, are equally remarkable for having changed little or at all in style and content for over 25,000 years. Change in technology was similarly slow for many thousands of years in comparison to the rate of change in the last several hundred. The facts that our brains and minds are shaped by sensory input from our human-made environments, and that different communities of humans have developed different cultures over thousands of years, provide a scientific foundation for the possibility that cultural evolution has produced brains and minds that differ from culture to culture. Recent research, as richly represented in other chapters of this volume, has now demonstrated a number of such differences. The neuroplasticity that underlies these processes itself changes during the life span: the underlying neurochemistry becomes less powerful and established structures maintain themselves in multiple ways. This provides a conservative counterbalance to the social-cultural change made possible by developmental neuroplasticity. It also contributes to conflict between generations common to all or most cultures, and to conflict and misunderstanding between cultures. These matters are discussed at length elsewhere (Wexler 2006).

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Cultural Neuroscience of Social Cognition

Joan Y. Chiao and Genna M. Bebko

Abstract A contemporary mystery for both social neuroscientists and social cognitive neuroscientists has been to distill the core mechanisms in the human brain that facilitate complex social behavior. The purpose of this chapter is to examine this mystery from a cultural neuroscience perspective. Opening with a description of the social brain hypothesis, the chapter first describes research on the neurobiological basis of human social behavior, as well as an account of the culture–gene coevolutionary theory. In the next section, the chapter examines the theory and methods used by cultural neuroscientists to investigate the development of the social brain over the course of culture–gene coevolution. This section reviews recent evidence for cultural influences on social cognitive brain function across a range of domains from self-knowledge and interpersonal perception to empathy and theory of mind. Finally, the chapter ends with questions open to future research endeavors using cultural neuroscience methods to examine social cognition.

Keywords Culture-gene coevolution · Cultural neuroscience · Social cognition

1 The Social Brain Hypothesis

Humans, like non-human primates, live in incredibly complex social groups of varying size from small-scale hunter-gatherer tribes, ranging from a few to a few hundred people, to large-scale settled horticultural tribes, ranging from a few hundred to a few thousand people. According to the social brain hypothesis, such versatility in social living

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arrangements is possible due to increased growth in brain size, particularly in the neocortex (Brothers 2001; Dunbar 1998). That is, humans, like other primates, have evolved an unusually large brain with increased cognitive capacities in order to meet the demands of living in unusually complex social structures. Supporting this view, a number of quantitative studies have shown that, among primates, the relative volume of the neocortex is positively correlated with a range of markers of social group complexity, including the average size of a social group, number of females in the group, grooming group size, frequency of coalitions, prevalence of social play, prevalence of deception, and frequency of social learning (Dunbar and Shultz 2007). These findings provide initial support for the notion that the human brain has evolved for social group living. A contemporary mystery for social neuroscientists and social cognitive neuroscientists alike has been to distill the core mechanisms in human brain that facilitate complex social behavior, by mapping networks of brain structures to complex social functions.

Over the past decade, social neuroscientists have been unraveling the structure and function of the social brain with remarkable success (Adolphs 2009; Decety and Cacioppo 2010; Hein and Singer 2008; Ochsner and Lieberman 2001; Ochsner 2007). Convergent evidence from functional neuroimaging and patient studies indicates that a network of brain regions subserve a range of processes that enable humans to infer the thoughts, feelings and desires of others and themselves, including the medial prefrontal cortex (MPFC), anterior cingulate cortex (ACC), anterior insula (AI), secondary somatosensory cortex (SII), temporal poles (TP), superior temporal sulcus (STS), and temporo-parietal junction (TPJ) (see Fig. 1). Seemingly complex

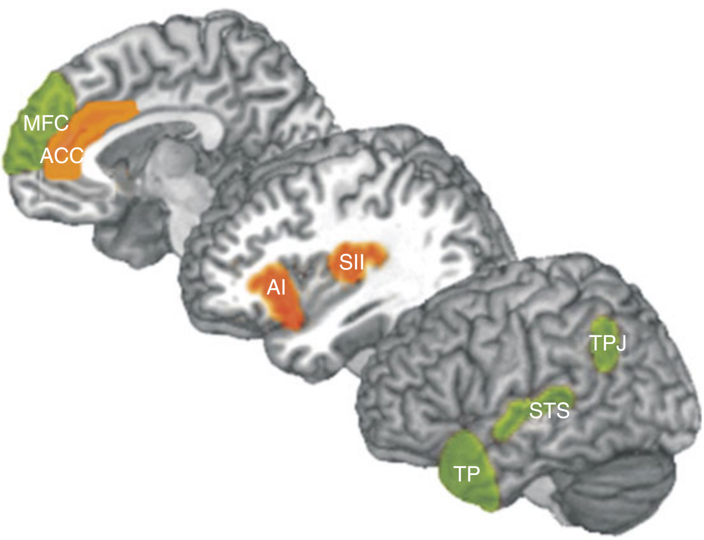

Fig. 1 Illustration of network of brain regions involved in understanding the mental states of self and others (adapted from Hein and Singer 2008). *MFC* medial prefrontal cortex, *ACC* anterior cingulate cortex, *AI* anterior insula, *SII* secondary somatosensory cortex, *TP* temporal poles, *STS* superior temporal sulcus, *TPJ* temporo-parietal junction

social skills such as inferring another's desires or beliefs in the absence of sensory input are supported by neural activity within the right TPJ (Saxe and Kanwisher 2003), while sharing the emotional pain of a close other is facilitated by neural activity within the ACC and bilateral insula (Singer et al. 2004). The ability to think about one's self and distinguish it from another is supported by neuronal activity within cortical midline structures such as the MPFC and posterior cingulate cortex (PCC) (Northoff et al. 2006), while the ability to recognize fear in another's face relies on ensembles of neuronal activity within the human amygdala (Adolphs 2009).

In addition to identifying reliable mappings between brain structure and function, social neuroscientists have also begun uncovering the genetic mechanisms that have evolved to regulate social brain functioning. In particular, the serotonin transporter gene (SLC6A4) has been implicated in emotional and social processing (Canli and Lesch 2007). The serotonin transporter gene (SLC6A4) contains a polymorphic region, known as 5-HTTLPR, comprised of a short (S) allele and a long (L) allele version that result in differential 5-HTT expression and function (Lesch et al. 1996). Individuals carrying the S allele of the 5-HTTLPR produce significantly less 5-HTT mRNA and protein, resulting in higher concentrations of serotonin in the synaptic cleft relative to individuals carrying the L allele (Lesch et al. 1996). Evidence from behavioral genetics indicates that the S allele of the serotonin transporter gene (5-HTTLPR) is associated with increased negative emotion, including heightened anxiety (Munafò et al. 2005; Sen et al. 2004), harm avoidance (Munafò et al. 2005), fear conditioning (Lonsdorf et al. 2009), attentional bias to negative information (Beevers et al. 2007), as well as increased risk for depression in the presence of environmental risk factors (Caspi et al. 2003; Taylor et al. 2006; Uher and McGuffin 2008; see also Munafo et al. 2009). By contrast, people who carry the L allele are thought to have higher degrees of agreeableness (Lesch et al. 1996). Convergent evidence indicates that activity in brain regions that are regulated by serotonergic neurotransmission and are critical to emotional behavior, such as the amygdala, varies as a function of 5-HTT. Specifically, individuals carrying the S allele show greater amygdala response (Hariri et al. 2002; Munafò et al. 2008), which is likely due to increased amygdala resting activation (Canli et al. 2005) and decreased functional coupling between the amygdala and subgenul cingulated gyrus (Pezawas et al. 2005), relative to those carrying the L allele. Comparative primate studies indicate that macaque societies that are more hierarchical and less tolerant are polymorphic for the 5-HTTLPR relative to those who are more egalitarian and conciliatory (Thierry et al. 2000). Hence, the serotonin transporter gene plays a key role in regulating neural mechanisms underlying emotional and social behavior in humans and other primates.

While great progress has been made over the past decade in understanding the neurobiological basis of human social behavior, an important puzzle remains. Prior research in social neuroscience to date has focused largely on the role of natural selection in shaping adaptive mechanisms in the human mind and brain that facilitate social group living and are largely shared across cultures. For instance, a central goal of social neuroscience research to date has been seeking evidence for social brain modules or cortical regions specialized for social cognitive functions (Adolphs 2009). One of the most compelling cases for social brain modules is the fusiform face area (FFA), a region within extrastriate cortex that responds preferentially to faces relative to other kinds of complex visual stimuli (Kanwisher et al. 1997).

However, more recently, culture–gene coevolutionary theory has emerged as a complementary process by which adaptive mechanisms in the human mind and brain may have evolved to facilitate social group living through both cultural and genetic selection. In particular, culture–gene coevolutionary theory posits that cultural traits are adaptive, evolve, and influence the social and physical environments under which genetic selection operates (Boyd and Richerson 1985). A prominent example of dual inheritance theory across species is the culture–gene coevolution between cattle milk protein genes and human lactase genes (Beja-Pereira et al. 2003) whereby the cultural propensity for milk consumption in humans has led to genetic selection for milk protein genes in cattle and gene encoding lactase in humans.

Recently, Chiao and Blizinsky (2010) uncovered novel evidence for culture–gene coevolution in humans. Specifically, they found that cultural values of individualism and collectivism are associated with the serotonin transporter gene (*5-HTTLPR*) across nations (Fig. 2). Collectivistic cultures were significantly more likely to be comprised of individuals carrying the S allele of the 5-HTTLPR across 29 nations.

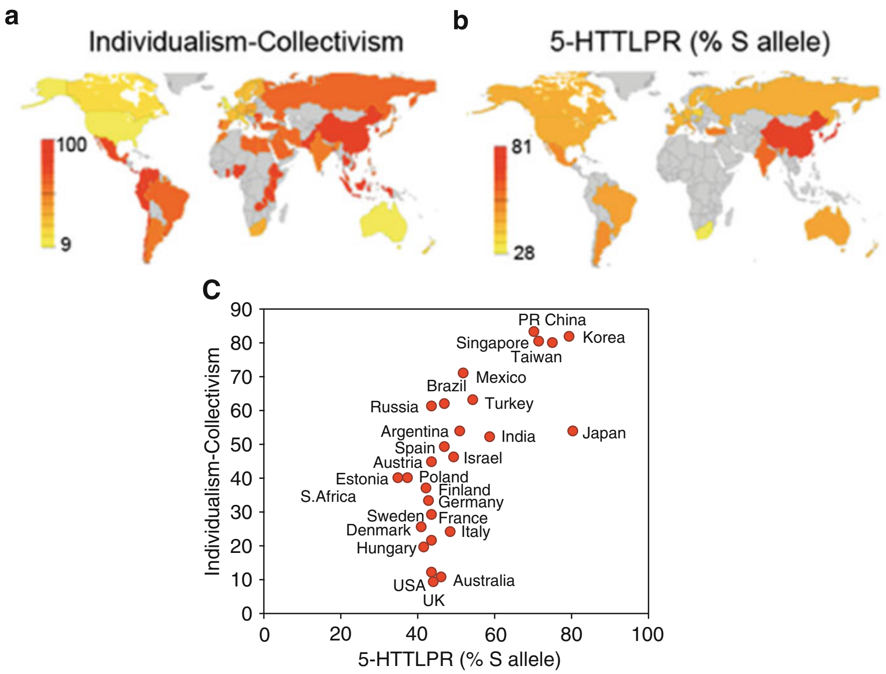

Fig. 2 Culture–gene coevolution of individualism–collectivism and the serotonin transporter gene (5-HTTLPR) (adapted from Chiao and Blizinsky 2010). (**a**) Color map of frequency distribution of IND-COL from Hofstede (2001). (**b**) Color map of frequency distribution of S alleles of 5-HTTLPR. (**c**) Collectivistic nations showed higher prevalence of S allele carriers

Additionally, cultural values and frequency of S allele carriers negatively predicted global prevalence of anxiety and mood disorder. Mediation analyses further indicate that increased frequency of S allele carriers predicted decreased anxiety and mood disorder prevalence due to increased collectivistic cultural values. These findings support the notion that cultural values buffer genetically susceptible populations from increased prevalence of affective disorders and suggest culture–gene coevolution between allelic frequency of 5-HTTLPR and cultural values of individualism–collectivism. A central claim of culture–gene coevolutionary theory is that, once cultural traits are adaptive, it is likely that genetic selection causes refinement of the cognitive and neural architecture responsible for the storage and transmission of those cultural capacities (Boyd and Richerson 1985). An important puzzle for future neuroscience research is to understand how culture–gene coevolution may have shaped mechanisms in the social mind and brain differently across cultural contexts, due to diversity of selection pressures across geographical regions.

2 What Is Cultural Neuroscience?

Here, we examine how theory and methods in cultural neuroscience may prove valuable for investigating how the social brain may have unfolded over the course of culture–gene coevolution. Cultural neuroscience is an emerging research discipline that investigates cultural variation in psychological, neural and genomic processes as a means of articulating the bidirectional relationship of these processes and their emergent properties (Fig. 3) (Chiao and Ambady 2007). Research in cultural neuroscience is motivated by two intriguing questions of human nature:

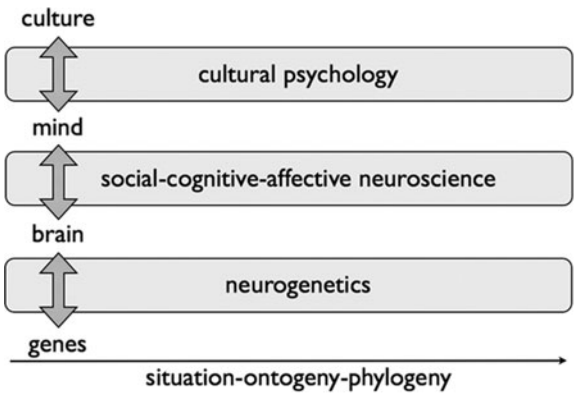

Fig. 3 Illustration of the cultural neuroscience framework, integrating theory from cultural psychology, social/cognitive/affective neuroscience and neurogenetics (adapted from Chiao 2009a, b)

how do cultural traits (e.g., values, beliefs, practices) shape neurobiology (e.g., genetic and neural processes) and behavior, and how do neurobiological mechanisms (e.g., genetic and neural processes) facilitate the emergence and transmission of cultural traits? To address these questions, cultural neuroscientists integrate theory and methods across cultural psychology, neuroscience and neurogenetics (Chiao 2009a, b).

There are at least three reasons why understanding cultural and genetic influences on brain function likely holds the key to articulating better psychological theory. First, a plethora of evidence from cultural psychology demonstrates that culture influences psychological processes and behavior (Kitayama and Cohen 2007). To the extent that human behavior results from neural activity, cultural variation in behavior likely emerges from cultural variation in neural mechanisms underlying these behaviors. Second, cultural variation in neural mechanisms may exist even in the absence of cultural variation at the behavioral or genetic level. That is, people living in different cultural environments may develop distinct neural mechanisms that underlie the same observable behavior or recruit the same neural mechanism to varying extents during a given task. Third, population variation in the genome exists, albeit on a much smaller scale relative to individual variation, and 70% of genes express themselves in the brain. This population variation in allelic frequency in functional polymorphisms, such as those that regulate neural activity, may exert influence on subsequent mental processes and behavior. To the extent that behavior arises from neural events and both cultural and genetic factors influence neural events, a comprehensive understanding of the nature of the human mind and behavior is impoverished without a theoretical and empirical approach that incorporates these multiple levels of analyses.

Until recently, most behavioral and neuroscience research sampled predominantly from Western, industrialized nations (Henrich et al. 2010; Chiao and Cheon 2010; Fig. 4). Several factors have contributed to the current sampling bias in human neuroscience research. First, human neuroscience research programs typically build either on empirical questions inspired by animal models and case studies of brain damaged patients or on theories from evolutionary psychology. Each of these three starting points for neuroscience research carries implicit assumptions of minimal variability across human populations. Second, human neuroimaging methods have become available only within the past three decades, and are still not available in many non-Western regions of the world. The use of neuroimaging is often prohibitively expensive, making it easier for wealthy, politically stable countries, such as Western industrialized nations, to create the powerful societal infrastructures necessary for novel and timely neuroscientific discovery. Hence, our current state of knowledge of mind–brain mappings to date has largely been restricted to scientific observations made from people living within Western, industrialized nations, leaving a large empirical gap in our understanding of how diverse cultures affect mind, brain and behavior.

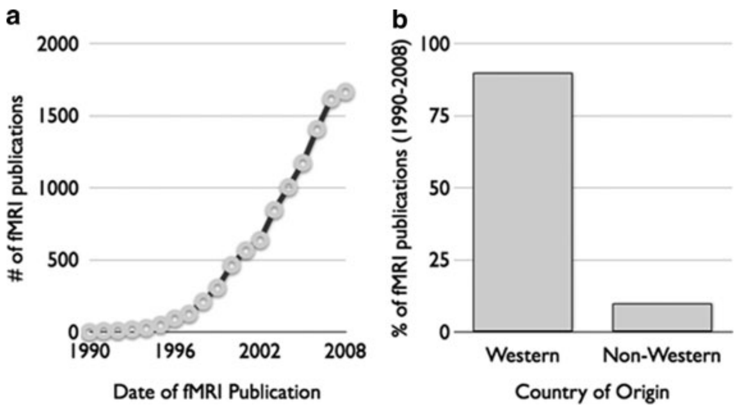

Fig. 4 Growth trends and publication bias in peer-reviewed human neuroimaging literature. (**a**) Graph illustrating the growth in peer-reviewed human neuroimaging studies from 1990 to 2008. (**b**) Graph illustrating the publication bias within the human neuroimaging literature whereby the vast majority (~90%) of publications to date originate from a Western country (adapted from Chiao 2009a, b)

3 Cultural Neuroscience of Social Cognition: A Review of the Current Literature

Nevertheless, early efforts by cultural neuroscientists to address the question of how culture influences brain function have proven fruitful, particularly for understanding differences in social cognitive brain processing between Westerners and East Asians (Chiao 2009a). Here, we review recent evidence for cultural influences on social cognitive brain function across a range of domains from self-knowledge and interpersonal perception to empathy and theory of mind (Table 1).

3.1 Self- and Other Knowledge

Cultural values, practices and beliefs shape social behavior in profound ways. One of the most robust ways that values, such as individualism and collectivism, influence human behavior is in self-construal, or how people think about themselves in relation to others. Individualists think of themselves as autonomous from others, while collectivists think of themselves as highly interconnected with others (Markus and Kitayama 1991; Triandis 1995). Recent evidence from social neuroscience indicates that specific brain regions, such as the MPFC and PCC, are involved in self-evaluation and self-knowledge (Amodio and Frith 2006).

Recent cultural neuroscience evidence indicates that neural substrates of self-evaluation are modulated by cultural values of individualism and collectivism. In one study, Caucasians, but not Chinese, showed greater neural activity within the

Table 1 Summary of current evidence for cultural modulation in the neural substrates underlying social cognition

Social cognitive process	Sample	Brain region or waveform	Task	References
Self and others	13 CH 13 EU	MPFC	Explicit self–other trait judgment	Zhu et al. (2007)
	20 CA 20 AA	P3	Oddball detection task	Lewis et al. (2008)
	14 NR 14 CHR	VMPFC, DMPFC	Explicit self–other trait judgment	Han et al. (2008)
	12 CA 12 JP	MPFC	Explicit general-contextual self-judgment	Chiao et al. (2009)
	30 AA	MPFC, PCC	Explicit general-contextual self-judgment	Chiao et al. (2010)
	16 NR 16 CHR	DMPFC, VMPFC, PCC	Explicit self–other trait judgment	Ge et al. (2009)
	14 BUD	DMPFC, VMPFC, ACC	Explicit self–other trait judgment	Han et al. (2008)
	18 US	MPFC, PCC	Explicit self–other trait judgment	Ray et al. (2010)
	47 JP	N400	Word–voice incongruity task	Ishii et al. (2010)
	16 CH 16 TB	MPFC, ACC	Explicit self–other trait judgment	Wu et al. (2010)
	18 AA	DMPFC, VMPFC	Implicit self–other-trait judgment	Harada et al. (2010)
Interpersonal perception	14 CA 14 JP	STS	Reading the mind in the eyes test	Adams et al. (2010)
	17 CA 17 JP	Caudate, MPFC	Passive viewing of bodies	Freeman et al. (2009)
	18 CA 16 JP	Amygdala	Passive viewing of faces	Adams et al. (2010)
Emotion recognition	16 CA 16 JP	Amygdala	Passive viewing of emotional faces	Moriguchi et al. (2005)
	10 CA 10 JP	Amygdala	Explicit emotion recognition	Chiao et al. (2008)
	24 EA 24 EU	Amygdala	Explicit emotion recognition	Dertnl et al. (2009)
Empathy	17 CH 16 CA	ACC	Explicit pain rating	Xu et al. (2009)
Theory-of-mind	16 US 16 JP	IFG	False belief task	Kobayashi et al. (2006)
	12 US 12 JP	IFG, TPJ	False belief task	Kobayashi et al. (2006)

ACC anterior cingulate cortex, *MPFC* medial prefrontal cortex, *TPJ* temporoparietal junction, *P3* late positive potential, *VMPFC* ventromedial prefrontal cortex, *DMPFC* dorsomedial prefrontal cortex, *PCC* posterior cingulate cortex, *STS* superior temporal sulcus, *IFG* inferior frontal gyrus, *CA* Caucasian-American, *JP* Japanese, *EA* East Asian, *EU* European, *KO* Korean, *CH* Chinese, *NR* non-religious, *CHR* Christian, *BUD* Buddhist, *US* American, *AA* Asian-American, *TB* Tibetan

MPFC during evaluation of personality traits of one's self relative to a close other (i.e., mother), suggesting cultural variation in MPFC response during self-evaluation (Zhu et al. 2007; Fig. 5). More recent evidence has demonstrated that cultural values (i.e., individualism–collectivism), rather than cultural affiliation (i.e., East Asian–Westerners) per se, modulate neural response during self-evaluation. In another cross-cultural neuroimaging study, people in both Japan and the USA who endorsed individualistic values show greater MPFC activity for general relative to contextual self-descriptions, whereas people who endorsed collectivistic values show greater MPFC for contextual relative to general self-descriptions (Chiao 2009a). Supporting this view, another study using cultural priming (Hong et al. 2000) showed that even temporarily heightening awareness of individualistic and collectivistic values in bicultural individuals (i.e., bicultural Asian-Americans) modulates MPFC and PCC in a similar manner (Chiao 2009b; Fig. 6). In addition to cultural values modulating neural responses during explicit self processing, a recent neuroimaging study shows that dorsal, but not ventral, regions of MPFC are modulated by cultural priming of individualism and collectivism when thinking about one's self in an implicit manner (Harada et al. 2010). Such findings suggest that cultural values dynamically shape neural representations during the evaluation,

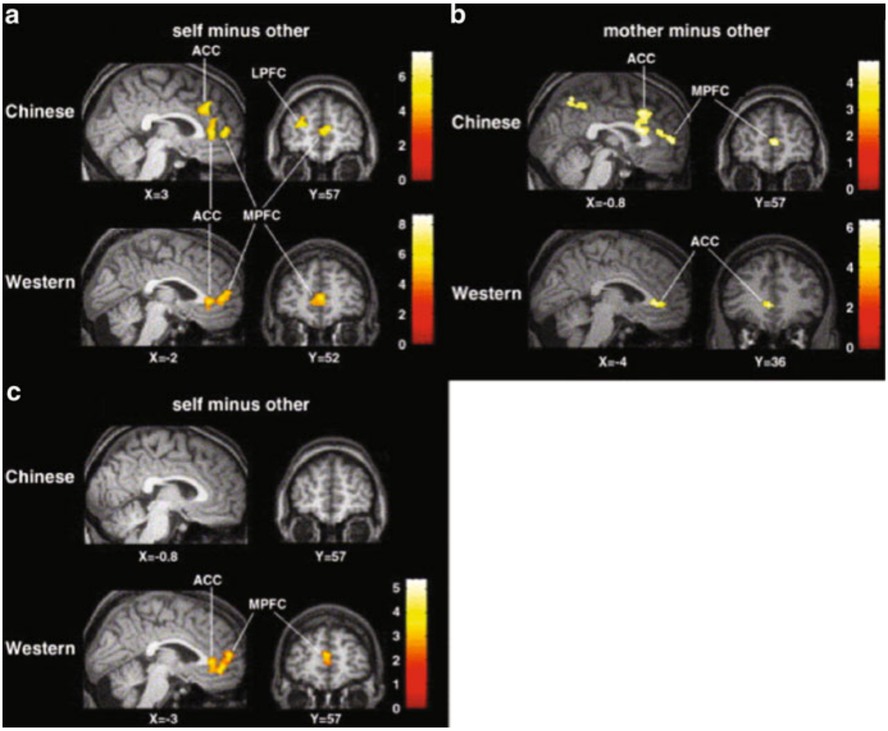

Fig. 5 Brain activations revealed in the contrast between different trait adjective judgment tasks. (**a**) Self minus other; (**b**) mother minus other; (**c**) self minus mother (adapted from Zhu et al. 2007)

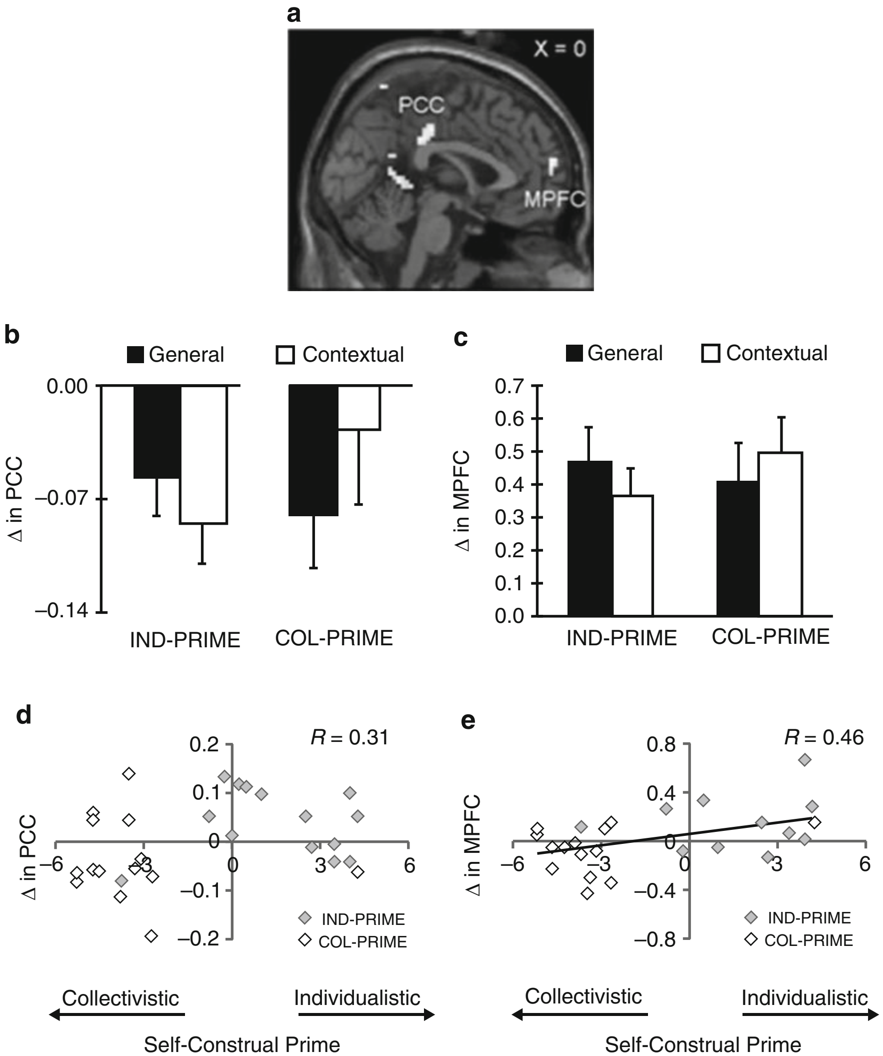

Fig. 6 Dynamic cultural influences on neural representations of self (adapted from Chiao et al. 2010). (**a**) Modulation of neural activity within cortical midline structures, including the posterior cingulate cortex (PCC) and medial prefrontal cortex (MPFC) as a function of cultural priming. Bicultural participants primed with individualistic cultural values show greater PCC (**b**) and MPFC (**c**) to general relative to contextual self descriptions. Bicultural participants primed with collectivistic cultural values show greater PCC (**b**) and MPFC (**c**) response to contextual relative to general self-descriptions. The degree to which a person is primed with individualistic or collectivistic values is positively correlated with neural activity within PCC (**d**) and MPFC (**e**) to general relative to contextual self-descriptions, respectively

rather than the detection, of self-relevant information. Taken together, these studies provide convergent evidence that cultural values of individualism–collectivism shape neural representations of both implicit and explicit self-knowledge.

In addition to cultural values of individualism–collectivism, religious beliefs may also play an important role in modulating neural responses underlying social cognition. One set of neuroimaging studies examining the neural substrates of religiosity found activity within theory-of-mind regions, including left precuneus, left TPJ and left middle frontal gyrus, was correlated with the degree of one's religiosity (Kapogiannis et al. 2009). Additionally, religious practices, such as praying, also modulate neural responses within theory-of-mind regions. For instance, compared to formalized prayer and secular cognition, improvised praying activated the temporopolar region, MPFC, TPJ and precuneus (Schjoedt et al. 2009). Finally, religious beliefs affect neural representations of the self. Whereas atheists typically recruit ventral MPFC during self-evaluation, religious individuals show greater response within dorsal MPFC, suggesting that religious beliefs promote greater evaluation, rather than representation, of one's self (Han et al. 2008). Hence, the human ability to possess religious beliefs and exercise religious practices relies on theory-of-mind and mentalizing brain regions that facilitate the representation and evaluation of one's own and others' (e.g., human, God) mental states.

Although the lion's share of cultural neuroscience research on knowledge of self and other has been conducted with human neuroimaging methodology, a couple of recent studies have examined the effect of culture on electrophysiological indices of social cognition. In one study, Lewis et al. (2008) measured event-related potentials while participants completed the oddball task, where they are shown visual stimuli in either a frequent or infrequent (i.e., oddball stimulus) manner. Results demonstrated that European-American participants showed greater novelty P3, or late positive potential, amplitude for target events, whereas East Asians showed greater P3 amplitude to oddball events. Another study by Ishii et al. (2010) found that amplitude of the N400, a late negative potential, was significantly larger when individuals perceived incongruent relative to congruent information, and degree of late negativity activity was reliably predicted by chronic social orientation (e.g., interdependence) for females. Both electrophysiological studies demonstrate the effect of cultural values of individualism–collectivism on how people respond to information that is either congruent or incongruent to one another. Hence, cultural values of individualism–collectivism not only affect how people represent knowledge about self and others, but also respond to congruent or incongruent informational cues in the environment.

3.2 Interpersonal Perception

Minimal perceptual cues from the body, such as the eye region of the face, convey a wealth of information about what people are thinking and feeling. Recent neuroimaging evidence indicates cultural variation in neural responses when inferring the internal states of others, particularly from the eye region (Adams et al. 2010). Native Japanese and US Caucasian participants performed the "reading the mind in the eyes" (RME) test, a measure of mental state decoding from visual stimuli only depicting an individual's eyes (Baron-Cohen et al. 2001). Behaviorally, people were more accurate at decoding the mental state of members of their own culture relative to members of another culture. Neurally, culture was found to also modulate neural activity underlying mental state decoding such that activity in the pSTS increased during the same culture mental state decoding relative to other culture mental state decoding (Fig. 7). This intracultural effect was consistent between the native Japanese and US Caucasian participants, thus excluding any intercultural variation in neural activity. Additionally, the intracultural advantage was significantly negatively correlated with pSTS activity during other culture mental state decoding such that, as pSTS activity increased, the intracultural advantage decreased. This correlation was not significant for same culture mental state decoding from the eyes, suggesting that the intracultural advantage may be due to less pSTS recruitment during other culture mental state decoding. These findings support the universal recruitment of pSTS in ToM, while at the same time revealing culturally modulated pSTS recruitment underlying the intracultural advantage in ToM. Another recent

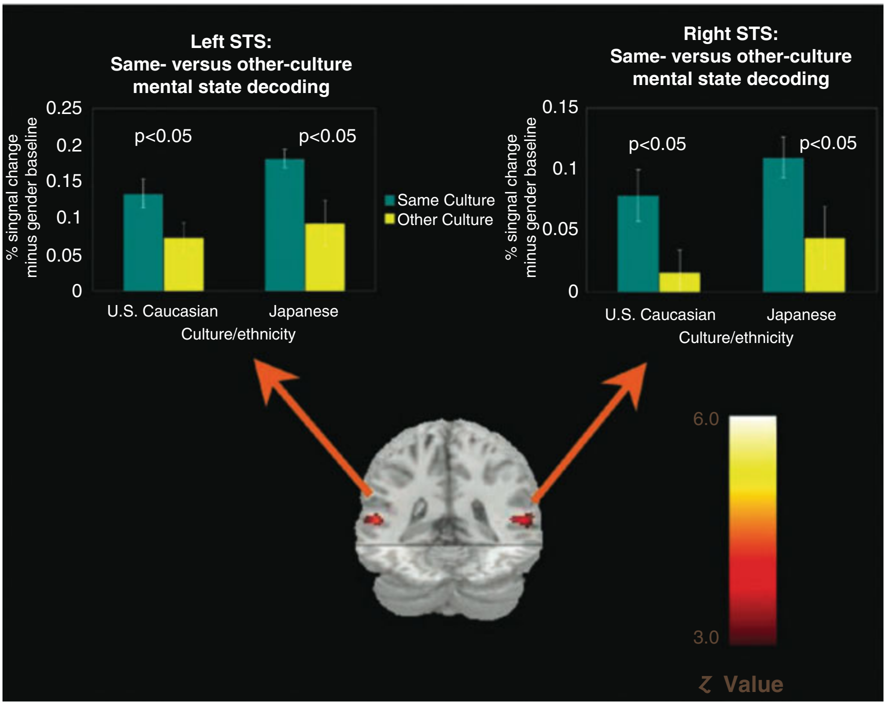

Fig. 7 Graphs depict regions of left and right pSTS activation for same- versus other-culture mental state decoding (RME GD). Results show significantly greater same- versus other-culture activation in both cultural groups for both the left and the right STS (from Adams et al. 2010)

study found that activity within the mesolimbic system responds more to culturally-congruent dominant and submissive facial cues (Freeman et al. 2009). Individuals from egalitarian cultures, such as the USA, show greater mesolimbic response to dominant facial cues whereas individuals from hierarchical cultures, such as Japan, show greater mesolimbic response to submissive facial cues. Taken together, these studies highlight how cultural variation in attribution styles may modulate neural activity underlying processes related to interpersonal perception.

3.3 Emotion Recognition

Culture affects how people prefer to experience, express, recognize and regulate their emotions (Mesquita and Leu 2007). East Asian prefer to experience low arousal relative to high arousal positive emotions (Tsai 2007), and are more likely to suppress their emotions relative to Westerners (Butler et al. 2007). Additionally, both East Asians and Westerners demonstrate cultural specificity in emotion recognition, whereby they show greater recognition for emotions expressed by their own cultural group members relative to members of other cultural groups (Elfenbein and Ambady 2002). Recent cultural neuroscience of emotion research has shown cultural specificity effects within a number of brain regions involved in emotion recognition. Moriguchi et al. (2005) found greater activation in the posterior cingulated, supplementary motor cortex and amygdala in Caucasians, relative to Japanese, who showed greater activity within the right inferior frontal, premotor cortex and left insula when participants were asked to explicit recognize emotions from the face. Chiao et al. (2008) examined neural responses in adults living in either the USA or Japan and found that, across cultures, people exhibit greater bilateral amygdala response to fear faces expressed by their own relative to other culture members (Chiao et al. 2008; Fig. 8). Another recent neuroimaging study comparing neural responses during emotion recognition in Asians and Europeans found a significant negative correlation between duration of stay and amygdala response such that amygdala response during emotion recognition was higher in individuals who were recent immigrants to the region, suggesting that experience alters neural responses to emotional expressions (Dertnl et al. 2009). Taken together, this research indicates that activity within the human amygdala is modulated by cultural group membership. An important question for future research will be to determine whether neural mechanisms that support other facets of emotion, such as experience and regulation, are affected by culture.

3.4 Empathy

Empathy is the capacity to share the emotional states of others (Batson et al. 1981; Preston and de Waal 2002). The perception–action model of empathy indicates that empathy is a key motivator (Decety and Grezes 2006) and the proximate

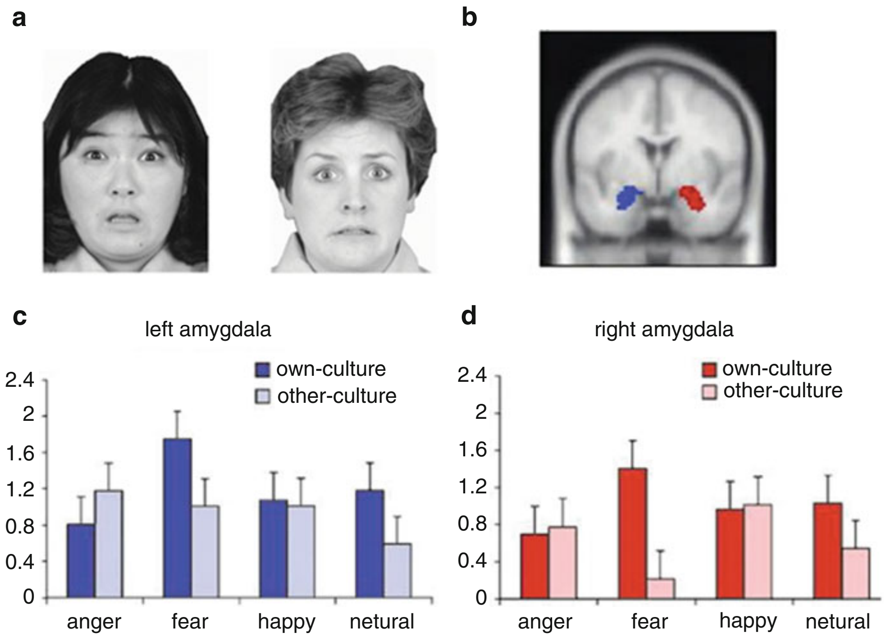

Fig. 8 Cultural specificity in bilateral amygdala response to fear faces (adapted from Chiao et al. 2008). (**a**) Examples of Japanese and Caucasian-American fear faces. (**b**) Illustration of bilateral amygdala. Participants show greater left (**c**) and right (**d**) amygdala response to fear expressed by members of their own cultural group

mechanism (de Waal 2008) of altruistic behavior, whereby an individual perceives and shares in the distress of another person, and acts to reduce his or her suffering (Preston and de Waal 2002). Prior social neuroscience research indicates that empathy is a multi-component process that includes affect sharing, cognitive perspective taking, and cognitive appraisal (Decety and Jackson 2004; Hein and Singer 2008; Lamm et al. 2007; Olsson and Ochsner 2008). Empathy for pain is supported by neuroanatomical circuits underlying both affective and cognitive processes (Decety and Jackson 2004; Hein and Singer 2008; Lamm et al. 2007; Olsson and Ochsner 2008). A distinct neural matrix, including bilateral AI and ACC (Decety and Jackson 2004; Hein and Singer 2008; Olsson and Ochsner 2008), is thought to underlie the affective components of empathy. AI and ACC code the autonomic and affective dimension of pain and, in particular, the subjective experience of empathy when perceiving pain or distress in others (Decety and Jackson 2004; Hein and Singer 2008; Olsson and Ochsner 2008). A recent neuroimaging study by Xu et al. (2009) examined whether or not cultural group membership modulates neural response during the perception of pain in others. Chinese and Caucasian participants were scanned while observing Chinese and Caucasian targets either in physically painful (e.g., needle stick) or neutral (e.g., Q-tip probe) scenes. All participants showed greater ACC and AI response to painful relative to neutral scenes; however, they also showed greater ACC response to ingroup relative to outgroup members. These findings demonstrate that cultural group membership affects neural responses to perceived physical pain of others and suggest a neural precursor to group selection in altruistic behavior (Wilson 2006).

3.5 Theory of Mind

Another key social cognitive process is theory of mind (ToM), or the ability to understand and represent the psychological state of others (Wellman et al. 2001). Normally developing children demonstrate ToM starting at 4 years of age, while younger children and children with autism typically fail to demonstrate ToM (Baron-Cohen et al. 1985). Such developmental findings provide evidence for ToM as a universal developmental process (Fodor 1983; Scholl and Leslie 1999; Leslie et al. 2004) with an underlying biological basis (Frith and Frith 1999; Scholl and Leslie 1999). While some cross-cultural studies support the universality of ToM, other studies suggest ToM may be culturally and linguistically dependent (for review, see Kobayashi et al. 2006). For example, variation in cultural attribution styles may influence ToM performance in Asian children (Naito 2003) who are raised in a culture that attributes behavior to external and contextual causes rather than to internal causes, as in American/European cultures (Masuda and Nisbett 2001; Nisbett 2003). Similarly, speaking a non-English language with few mental state verbs may negatively influence children's performance on ToM tasks (Vinden 1996).

Neuroimaging evidence provides further evidence for both the universal aspects of (Saxe and Kanwisher 2003; Saxe 2006) and culturally specific influences on ToM processes (Kobayashi et al. 2006). A number of prior neuroimaging studies of theory of mind conducted on individuals from Western populations have found greater activity within the right temporoparietal junction (rTPJ) specifically when participants read stories about another person's thoughts (Saxe and Kanwisher 2003; Saxe 2006). Recently, Kobayashi et al. (2006) used fMRI to examine cultural and linguistic influences on neural activity underlying ToM in American English-speaking monolinguals and Japanese–English late bilinguals. Neural activity was recorded using fMRI while participants completed second-order false-belief ToM stories in both English and Japanese languages. Universally recruited brain regions associated with ToM processing included the right MPFC, right ACC, right MFG/DLPFC, and TPJ. In the American English-speaking monolinguals, culturally modulated neural activity underlying ToM was observed in the right insula, bilateral temporal poles, and right MPFC relative to the Japanese–English bilinguals, while the Japanese–English late bilinguals showed culturally modulated neural activity in the right OFG and right inferior frontal gyrus (IFG) associated with ToM processing relative to the American English-speaking monolinguals. Greater insular and TP activity in the American English-speaking monolinguals suggest that ToM in American culture emphasizes integrating sensory modalities with limbic input, while greater OFG and IFG activity in the Japanese–English late bilinguals suggest ToM in Japanese culture may rely more on emotional mentalizing. Taken together, these findings demonstrate universality and cultural diversity in neural mechanisms underlying theory of mind.

4 Open Questions for Research on Cultural Neuroscience of Social Cognition

As our review shows, considerable progress has been made in understanding how cultural values, practices and beliefs shape social brain functioning. A network of brain regions, including the amygdala, STS, MPFC, and ACC, display evidence of cultural specificity, whereby neuronal response is heightened when perceiving information or thinking about one's self or others in a culturally-congruent fashion in young adults. However, a number of fundamental questions remain.

One open question for future research is uncovering the trajectory by which cultural specificity in social brain functioning occurs. Are these demonstrations of cortical specialization towards a culturally familiar social percept or cognition are akin to evidence for cortical specialization in language or face perception, whereby neural mechanisms tune to familiar kinds of percepts during development? Akin to language development, do brain structures underlying social cognition tune to culturally specified percepts during certain critical periods early in lifespan? Or does cultural specificity in brain responses occur readily in the absence of developmental input due to cultural and genetic selection of culturally specific neural mechanisms over generations? How does malleability in social brain function in response to cultural context change as a function of aging into late adulthood? Future research is needed to disentangle the malleability of social neural processing as a function of cultural and genetic constraints throughout the lifespan.

Remarkably, cultural neuroscience evidence indicates that the social brain shows sensitivity to cultural frame switching as a function of situational forces. That is, biculturals, who are adept at multiple cultural value systems, can be primed to think of themselves as more individualists or collectivists within a given situation, and such momentary variability in cultural values is reflected in variability in neuronal processing with the social brain. Hence, the process by which cultural and biological mechanisms interact in monocultural and multicultural individuals likely unfolds across macro (e.g., lifespan) and micro (e.g., situation) time scales.

Additionally, future research is needed to better understand the scope of cultural and genetic selection on the human social brain. For instance, in addition to cultural values of individualism–collectivism, what other kinds of cultural values may have been selected for throughout the course of culture–gene coevolution? Cultural psychologist Hofstede (2001) identified four other kinds of cultural value systems that reliably shape human social behavior, including power distance, long-term/short-term orientation, masculinity/femininity and uncertainty avoidance. To the extent that these cultural values, or a subset of them, may have coevolved with a specific gene or family of genes, it is plausible that neural variation in the social mind and brain may exist due to cultural variation in values and subsequent social behavior.

Perhaps one of the most elusive, yet provocative, avenues for future research in cultural neuroscience of social cognition is acquiring a deeper understanding of the evolutionary function of cultural variation in social brain functioning. That is, uncovering how and when culture shapes social brain function is a laudable and necessary empirical goal as a stepping stone to a larger project of understanding how and why culture–gene coevolution forces shape the human social brain. What kinds of evolutionary selection pressures have led to diversity in cultural value and neurobiological systems? What kinds of evolutionary advantages are afforded to the human species with increased cultural and neural diversity? How might changes in cultural values systems due to immigration and globalization affect the human social brain? How might the human brain construct and constrain human cultural value systems?

The answers to these intriguing questions are finally within our empirical grasp, and there is perhaps no better time for us to learn the answers. As the world becomes increasingly globalized and modern technology facilitates human migration to places and distances with ease and efficiency like never before, deepening our knowledge of how the human brain enables people to adopt and adapt to multiple cultural value systems is critical. Promoting our understanding of how our brains give rise to cultural value systems and vice versa, we gain leverage on what is at stake when we make decisions about how best to achieve optimal co-existence amongst diverse cultural groups. By using the cultural neuroscience framework to identify and investigate candidate phenomena using the multiple levels of analysis approach, we will enhance our chances of understanding how the social brain works across diverse cultural contexts as well as find potential ways to direct this knowledge towards a range of timely public policy issues, such as interethnic ideology and population health, that arise due to our increasingly globalized social interaction.

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The Brain and Its Self: Concepts of Self and the Cortical Midline Structures

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Abstract The self is a complex concept that has long been investigated in philosophy and most recently in neuroscience. The present paper discusses some conceptual issues revolving around the self and how that match with the current empirical data. It becomes clear that we need to abandon the traditional Cartesian-based concept of the self as entity or substance and replace it by more process-based concept of the self in which medial cortical regions seem to play a central role.

Keywords Cortical Midline Structures · Entity versus Processes · Self

1 Introduction

The question of the self has been one of the most salient problems throughout the history of philosophy and more recently also in psychology (Gallagher 2000; Gallagher and Frith 2003; Metzinger and Gallese 2003). For example, William James distinguished between a physical self, a mental self, and a spiritual self. These distinctions seem to reappear in recent concepts of self as discussed in neuroscience (Panksepp 1998a, b, 2003; Damasio 1999, 2003a, b; Gallagher 2000; Stuss et al. 2001; Churchland 2002; Kelley et al. 2002; Lambie and Marcel 2002; LeDoux 2002; Turk et al. 2002, 2003; Gallagher and Frith 2003; Keenan et al. 2003; David and Kircher 2003; Vogeley and Fink 2003; Dalgleish 2004; Marcel and Lambie 2004; Northoff and Bermpohl 2004). Damasio (1999) and

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Panksepp (1998a, b, 2003) suggest a "proto-self" in the sensory and motor domains, respectively, which resembles William James' description of the physical self. Similarly, what has been described as "minimal self" (Gallagher 2000; Gallagher and Frith 2003) or "core or mental self" (Damasio 1999) might correspond more or less to James' concept of mental self. Finally, Damasio's (Damasio 1999) "autobiographical self" and Gallagher's (Gallagher 2000; Gallagher and Frith 2003) "narrative self" strongly rely on linking past, present, and future events with some resemblances to James' spiritual self.

These distinct selves are now related to distinct brain regions. For instance, the "proto-self," outlining one's body in strongly affective and sensory-motor terms, is associated with subcortical regions like the PAG, the colliculi and the tectum (Panksepp 2007). The "core or mental self" building upon the "proto-self" in mental terms is associated more with the thalamus and cortical regions such as the ventromedial prefrontal cortex (see, for example, Damasio 1999, 2003a, b). Finally, the "autobiographical or extended self" that allows one to reflect upon one's "proto-self" and "core or mental self" is associated with cortical regions like the hippocampus and the cingulated cortex.

What is the difference between this brain-based concept of the self in current neuroscience and the mind-based account by Descartes? Ontologically, Descartes assumed a special substance which he assumed to underlie the self and, due to his famous insight "I think, therefore I am," he characterized this substance as non-physical and hence as mental. Current neuroscience diverges from this in two aspects. First, the concept of self is multiplied with, for example, "proto-self," "core self" and "autobiographical or extended self" describing distinct aspects. Hence, the concept of self is no longer unified and homogeneous as in Descartes but diverge and heterogenous. Second, the assumption of a mind as underlying substance is replaced by the brain implying physical ontology, and hence possible naturalization, rather than mental ontology making any neuroscientific approach to the self impossible. This, however, points out a crucial underlying similarity. Current neuroscientific approaches to the self are still very much in the ontological tradition of Descartes in assuming a substance or "special addition" to underlie the self. In both approaches, the self is considered ontologically to be a substance or "special addition," be it physical or mental and homogenous or heterogenous. And such substance or "special addition" is characterized by a contents, i.e., mental or physical/neuronal, entity, i.e., as distinguished from other entities, and innateness, i.e., as inborn and intrinsic.

The question is whether this concept of the self and the features it attributes to the self are compatible and plausible with empirical data as obtained in recent imaging studies on the self. If so, we can maintain the concept of self. If not, we may need to develop an alternative concept of self as, for example, developed in immunology. My aim here is to present both the neuroscientific-based concept of self and the concept of self as presupposed in immunology. This will then serve as starting point to compare both concepts of self with the current empirical data about the self as obtained in imaging studies and thus to test for empirical plausibility.

2 Concepts of the Self I: Characterization of the Self in Neuroscience

2.1 Self-Specific Contents

The self can be characterized by specific contents, self-specific contents, which distinguishes it from other contents that are not specific for the self, i.e., non-self-specific contents. Such self-specific contents can concern, for example, the body, i.e., my face, my limb, etc., or some mental and reflective characteristics like my thoughts, my self, my will, my action, etc. (see, for example, Gillihan and Farah 2005). The self can then be characterized by specific physical, mental or reflective contents mirroring the distinct concepts of self outlined above. These self-specific contents are considered objective characteristics of the self which are the objects of our perception, attention, etc., and can hence be apprehended in third-person perspective (see Legrand 2007: 589). This opens the door for neuroscientific investigation in that the brain activations associated with the occurrence of these self-specific contents are assumed to be distinct from the ones underlying non-self-specific ones. This is, for example, mirrored in activation tasks that distinguish words that are closely related to oneself like one's own or one's spouse's name or face from those that bear no relation to oneself like names or faces of strangers (see Kelley et al. 2002; Northoff et al. 2006 for review).

2.2 Self as Entity

Another characterization of the concept of self in neuroscience is the assumption of an entity. This entity may be physical as one's body or mental as one's mind, and the self is characterized by representation with consecutive awareness that this particular entity, i.e., the body or the mind, is mine, i.e., my body and my mind. Extending its characterization by contents, the self concerns a specific object, be it one's body or one's mind, and this description by a specific content is possible only if one presupposes the self as entity with specific contents rather than, for example, as a relationship that describes a specific form rather than a content. The self as entity is well reflected in the often made assumption of a "core or mental self" which on a physical or neuronal level must be considered more or less analogous to Descartes' assumption of the self as a specific mental entity, although, unlike in the case of Descartes, the entity underlying the self is no longer determined as a mind being non-physical but rather the physical brain (and the body). The neuroscientists may want to argue that this comparison is unfair since the "core or mental self" has both predecessors and extensions in the gestalt of the "proto-self" and the "extended or autobiographical self." However, adding appendices in either direction does not make the "core or mental self" less of an entity than without those appendices since the assumption of a "core" remains which accounts for its characterization as entity. Only if the assumption of such "core" is abolished, the entity character will vanish, which, however, implies the giving up of the concept of self completely and the regarding of it as mere illusion (see, for example, Metzinger 2003).

2.3 Self as Innate

Finally, the concept of self in current neuroscience may be characterized by what may be called innateness, the intrinsic and inborn character. Our body is our body and our mental states are our mental states which are inborn and intrinsic, and hence the entity underlying our self is innate and so distinguished from any extrinsically acquired and constructed content and entity. This innateness is supposed to be reflected on the neuronal level in intrinsic characteristics of our brain as, for example, in high resting state in the brain's default-mode network that largely encompasses medial cortical regions like the ventromedial and dorsomedial prefrontal cortex, the anterior and posterior cingulate, and the superior temporal gyrus and the hippocampus. High resting state activity in this so-called default-mode network is associated with introspection of one's self-specific contents as attention towards internal contents, e.g., physical or mental, so that the self is characterized by a higher-order cognitive function, e.g., by attention, and meta-representation of one's self-specific contents in awareness (Wicker et al. 2003).

2.4 Self as "Special Addition"

The characterization of the self by content, entity, and innateness presupposes that the self is considered something specific and distinct from everything else, i.e., from all other functions. The self may then be regarded as what I call a "special addition" that may be necessary to integrate and coordinate neural activity across the brain – hence, the concept of self as "special addition" may be regarded as neurophilosophical answer[1] to what I will later call the "basic coordination problem." Churchland (2002), for example, considers the self is as some "special addition" that is needed to organize and coordinate the various functions: "Rather, the self is something like a squadron of capacities flying in loose formation. Depending on context, it is one or another of these capacities, or their exercise, to which we refer when we speak of the self. Some of these capacities involve explicit memory, some involve detection of

[1]A detailed discussion of the various concepts of self discussed in neurophilosophy is beyond the scope of this book; I therefore indicate only two authors, Churchland and Searle, and even this only very briefly.

changes in glucose or CO_2 levels, others involve imagery in diverse modalities or emotions of diverse valence. The fundamental capacity, however, probably consists in coordinating needs, goals, perception, and memory with motor control." (Churchland 2002: 63). Churchland assumes that, for this to be possible, there must be what she calls "self-representational capacities" that operate on all levels including "representing the internal milieu and viscera via chemical and neural pathways aimed largely at the brainstem and hypothalamus, representing musculoskeletal structures via the somatic sensory system, representing autobiographical events via medial temporal lobe structures, deferring gratification and controlling impulses via prefrontal lobe and limbic structures, and representing the sequence of actions to take next, as well as representing where one is in space–time and the social order." (Churchland 2002: 309). The most characteristic feature of these self-representational capacities is that they represent the brain's activity during these various processes: "A brain can also have models of its own processes. If some neuronal activity represents a motor command to reach for an apple, other neuronal activity represents the fact that a specific command ahs been issued. If some neuronal activity represents a light touch on the left ear, higher-order neuronal activity may represent the integration of many lower-order representations (light touch on the left ear and buzzing sound to left, which means that there is a mosquito, etc.). The brain not only represents the sensations of one's limbs: it specifically represents the sight and feel of that limb as belonging to oneself (there is a mosquito on my left ear). Yet further neuronal activity may represent that representation as a mental states (I know I feel a mosquito on my left ear)." (Churchland 2002: 64). According to Churchland (2002: 77, 2005), these inner models of one's body and experience may be mediated by what she, in orientation on Grush, calls emulators.

Interestingly, Searle, in his recent writings (Searle 2002: 93–95; 2004: 200–206) characterizes the self as form or mode when he describes, as "purely formal notion": "The self as I am describing it is a purely formal notion; it does not involve having a particular type of reason or a particular type of perception. Rather, it is a formal notion involving the capacity to organize its intentionality under constraints of rationality in such a way as to undertake voluntary actions, intentional actions, where the reasons are not causally sufficient to fix the action." (Searle 2004: 204). The self is devoid of any content and is rather some organizational principle that allows the constitution of the relationship to the environment, e.g., what Searle calls intentionality. As such the self must be considered a "special addition" to all other functions: "nonetheless there is a formal or logical requirement that we postulate a self as something in addition to the experiences in order that we can make sense of the character of our experiences." (Searle 2004: 205). Searle thus shares with Churchland the characterization of the self as "special addition" while they depart from each other with regard to its specific features. Churchland assumes specific contents, self-specific contents, while Searle, based on Kant, assumes a specific form or organisation, i.e., unity, to characterize the self. Without going deeper into the details of their concepts of self, the characterization of self as a "special addition" can probably be traced back to Descartes and his distinction of mental ontology from physical ontology mirroring its dualism. While Churchland continues Descartes' mental approach by translating it onto the neural level when she assumes specific neuronal self-contents, Searle attempts to soften the Cartesian heritage by introducing some Kantian elements in the gestalt of form and organisation.

In sum, though neuroscience (and neurophilosophy) diverges from Descartes in assuming a heterogeneous and brain-based concept of self rather than a homogenous and mind-based one, it still adheres to the underlying ontological assumption of the self as substance or as a "special addition." Such substance can in turn be characterized by self-specific contents, the assumption of an entity in the gestalt of a "core self," and the presupposition of innateness with intrinsic and given properties. It is this ontological characterization of the self by content, entity and innateness that is debated and denied in immunological concepts of the self and which consequently allow neuroscientific and immunological accounts to differ principally from each other.

3 Concepts of the Self II: Characterization of the Self in Immunology

In the 1940 and 1950, Burnet sought a firm definition of the immunological self as distinguished from others as foreign. He introduced the self/non-self distinction by holding a purging function of self-reactive lymphocytes (the cells responsible for synthesizing reactive antibodies and mediating so-called cellular reactions) so that all antigens (substances that initiate immune responses) from the own organism would be ignored by the immune system. The hypothesis was later developed into the clonal selection theory which maintains that lymphocytes with reactivity against host constituents are destroyed during development, and only those lymphocytes that are non-reactive would be left to engage the antigens of the foreign universe. These potentially deleterious substances would select lymphocytes with a high affinity for them, and through clonal amplification a population of lymphocytes would differentiate and expand to combat the offending agent.

3.1 Specific Contents

Such a distinction between self and non-self went along with genetic or molecular definition of the self whose constitutive agents see that the foreign and immune reactivity arises from this polarization with the attack directed only against non-self (Tauber 2006). Genetically, the immunological self was then considered to be based upon the major histocompatibility complex (MHC) which describes a set of antigens to which the own immune system remains silent without attacking them as in the case of foreign or non-self antigens. Antibodies are thus directed only against other organisms, non-selves, but not against the own self, precluding "normal" autoimmunity. Besides the genetically-based definition, the immunological self has also been defined by cell surface and soluble molecules, a set of bodily proteins, peptides complexed with the MHC, or antigen-presenting cells (see Tauber 1998 for an overview). This presupposes an entity view of the immune self which is defined by specific materials (DNA, RNA, proteins) and specific localization (genes, cells).

3.2 Emergence of Self

This entity concept of the immune self presupposes that the immunological functions are organized according to the self/non-self distinction. Lymphocytes, phagocytes, cytokines, and antibodies are not directed against the own organism, the self, while rejecting other organisms, non-selves. This implies an All-or-Nothing distinction with no continuum between self and non-self. Either the respective antigen belongs to the own organism, the self, causing no immunological rejection, or the antigen is recognized as non-self with the immune system reacting and responding with attack and defence resulting in rejection. The purpose of the immune self is to maintain control over itself and to preserve its contents by defending, attacking, and rejecting non-selves. Other organisms with other contents, i.e., genes, proteins, lymphocytes, etc., are then considered only as dangerous and possible invaders and intruders which need to be destroyed in order to preserve the organism's integrity and identity and thus its immunological self. The non-self is thus considered only as foreign and dangerous in immunological terms.

3.3 Self and Zero Resting State

Immunological activity occurs only when an invader or intruder, a non-self, attacks the self. The resting state of the immunological self is consequently defined by the absence of any foreign intruder or invader and thus by absence of non-selves, and of immunological activity because the immunological self does not need to defend itself against non-selves. The active state of the immunological self is then best described by recognition, attack and rejection of non-selves. Taken together, the immunological self is either resting, showing zero immunological activity, or defending itself, showing some immunological activity – immunological activity is thus switched off, as in the baseline resting state, or switched on, as in the active defence state.

3.4 Self/Non-Self Continuum

The concept of the entity view of the immunological self was challenged by Jerne (1974) who proposed a novel conception of immune regulation. His idiopathic network hypothesis proposed that antibodies formed a highly complex interwoven system, where the various specificities referred to each other. Under the general rubric of cognition, Jerne characterized the immune system as self-regulating, where the antibody not only recognizes foreign antigens, but is capable of recognizing self constituents as antigens (so-called idiotypes). Immune regulation is here based on the reactivity of the antibody (and later lymphocytes) with its own repertoire, forming a set of self-reactive, self-reflective, self-defining immune reactivities. There is no principal distinction between self and non-self anymore for the immune system. According to Jerne's theory, the immune system is complete unto itself, consisting of a network of interlocking recognizing units where each component reacts with other constituents to form a complex network of lattice structure. If this network encounters a substance that is recognized, i.e., the substance reacts with a member of the network, immune responsiveness is initiated. Thus, foreignness or a non-self per se does not exist in this network theory since the system reacts only to the disturbance or perturbation but not to foreignness per se. In this case, there is no circumscribed self with a specific localization anymore. If one still wants to speak of a self, the whole immune network must be considered the self: "If there is a 'self' in Jerne's theory, it is the entire immune system as it 'sense' itself. Jerne's theory thus appears radically different from the dominant theories of immune function built from Burnet's self/non-self dichotomy." (Tauber 1998: 463–464).

3.5 Dynamic Network

Such self can no longer be described by specific contents, be they genes or proteins. Instead, the patterns and dynamic processes that constitute the organism's immune network reactivity are central by allowing to maintain an equilibrium in encountering internal and external substances. If, however, there no specific contents anymore but processes, while localization of the self also remains impossible. The immune self no longer has firm genetic, cellular or protein-defined boundaries: "It must be stressed that the self is in no way a well-defined (neither predefined) repertoire, a list of authorized molecules, but rather a set of viable states, of mutually compatible groupings, of dynamical patterns. In effect, a molecule is neither self nor antiself, as a musical note does not belong more to a composer than to another one. The self is not just a static border in the shape space, delineating friend from foe. Moreover, the self is not a genetic constant. It bears the genetic make up of the individual and of its past history, while shaping itself along an unforeseen path." (Varela et al. 1988: 363). Simply, any kind of content- and material-defined self as entity no longer exists in the relational approach where the self is considered a dynamic network aiming at maintaining equilibrium between its various contents and materials.

3.6 Inherence of Self

One central problem in immunology is the problem of autoimmunity, i.e., immune reactions directed towards the own organism. Autoimmunity is considered merely a pathological phenomenon in the context of the entity view of the immune self since immune reactivity towards the organism's own substances would violate the self/non-self boundaries and thus the definition of the immune self as material- and content-defined localized entity. However, empirical findings demonstrated that autoimmunity does not only occur in pathological cases but also in the normal healthy organism which raises serious doubt about the All-or-Nothing distinction between self and non-self. In contrast, the relational concept of the immune self can readily accommodate autoimmunity in normal healthy organisms. The relational immune self does not primarily target the distinction between self and non-self, own and foreign antigens, but rather aims to maintain its equilibrium. Everything which disrupts this equilibrium, be it of internal or external origin, induces immune reactivity. If, for example, internally originating substances disrupt the organism's equilibrium, an immune response, and thus autoimmunity occurs. The All-or-Nothing distinction thus becomes replaced by a More-or-Less continuum between self and non-self where the self/non-self distinction is only of secondary importance compared to the one between equilibrium and non-equilibrium, implying that the immune system only knows itself: "Second, the immune system is self-definitional; it is designed to 'know' itself. In this sense, antigenicity is only a question of degree, where 'self' evokes one kind of response, and the 'foreign' another, based not on its foreignness but, rather, because the immune system sees the foreign antigen in the context of invasion or degeneracy. These precepts then merge in the idiotypic 'hall of mirrors': there is no foreignness per se because if a substance were truly foreign, it would not be recognized, there would be no image by which the immune system might engage it. The immune systems knows only itself" (Tauber 1997: 424–425).

To put it metaphorically: the entity view presupposes an immune system that is structured like an army which recognizes, defends and destroys any other foreign army simply because it is, based on its foreignness, considered an enemy while not recognizing the deserters within its own ranks and the supporters within the other army. The relational view of the immune self, in contrast, allows the recognition of both deserters within its own ranks and supporters within the foreign army simply by constantly adjusting its own equilibrium according to the respective context. What is defended and destroyed is thus not the foreign army as a whole but all deserters within the own army and all opponents within the other army.

3.7 Equilibrium and Active Resting State

The main organizational principle is not the self/non-self distinction but the maintenance of the organism's equilibrium. The resting state can no longer be defined by the mere absence of non-self, as in the entity approach, but rather by the presence of an equilibrium with continuous assessment or self-identification. The organism continuously encounters internally and externally originating substances and must maintain its equilibrium in face of them. There must thus be continuously ongoing activity within the immune system so that the resting state must be defined by a rather high level of immune activity and reactivity: "I see the immune system as continuously seeking a dynamic equilibrium – and by dynamic I mean a vast number of immune responses are going on all the time, even in the absence of foreign antigen. The old term 'immune response' suggests that the immune system is 'at rest,' waiting to 'respond' whereas I think it is continuously active, interacting with self-antigen, idiotypes, factors, etc." (Jerne, personal communication, quoted by Tauber 1997: 436). The immune system is thus continuously active and displays a high level of baseline immunological activity, and what is falsely called resting state reflects nothing but an equilibrium with a stable state being tolerable to internally or externally originating challenges. The active state may then be defined by disequilibrium with an unstable or viable state being highly vulnerable to encounters by either internally or externally originating substances. In terms of immunological activity, the active state may then be characterized simply by deviation from the immune system's stable state and equilibrium. The principal distinction between resting and active state fades and is no longer of primary importance for the organism itself. What from the observer's perspective appears as resting and active states must be considered stable and unstable states from the host's perspective.

4 Empirical Plausibility I: Self as Content or Structure

4.1 Subcortical–Cortical Midline Structures and the Self: Empirical Data

Recent imaging studies in humans show various cortical regions, predominantly the so-called cortical midline structures (CMS), to be involved in what is called self-related processing (SRP) (see Northoff and Bermpohl 2004; Northoff et al. 2006; Uddin et al. 2007) that are integrated with subcortical SELF processes to yield an integrated subcortical–cortical midline system (SCMS). Although some authors, like Gillihan and Farah (2005), do not yet see supporting evidence for localizing the self in particular brain regions, that may be because the concept covers so much territory and needs to be parsed into more specific variants. In our estimation, as supported by a mass of empirical evidence (Northoff et al. 2006), there are specific brain regions most critically important for constituting the higher reaches of a core-nomothetic self-referential network. The question arises whether the very same higher medial frontal brain regions are present and also implicated in self-relatedness in animals. The stream of evidence runs thinner here than in respect to the deeper, subcortical midline SELF systems (Holstege and Saper 2005; Panksepp 1998a, b). Thus, even if the higher cortical midline regions are structurally homologous across some species, this does not yet confirm that there is functional homology, e.g., that they mediate SRP in animals as well as humans.

The lowest regions of this distributed SCMS network include the periaqueductal grey (PAG), the superior colliculi (SC), and the adjacent mesencephalic locomotor region (MLR) as well as preoptic areas, the hypothalamus, and dorsomedial thalamus (DMT) (Holstege et al. 1996; Panksepp 1998a, b). For example, the colliculi and the PAG are among the most richly connected areas of the brain (Strehler 1991); both receive afferents from several exteroceptive sensory regions (occipital, auditory, somatosensory, gustatory, and olfactory cortex) and, at the same time, afferents from other interoceptive subcortical regions (Holstege et al. 1996). In addition, the PAG and the colliculi are connected with the cortical midline structures (CMS) (Dujardin and Jurgens 2005). Since the same is true for the other subcortical midline regions mentioned, it is important to conceptualize the self-integrative lower brain systems to have intimate relationships with the higher CMS structures, which is anatomically the case (see Strehler 1991, for overview), thus yielding a highly integrated SCMS in normal organisms and providing a complex infrastructure for self-referential processing of external information. Functionally, higher cortical regions might represent the functions that are primarily represented subcortically in a more detailed and specific way. Examples of this are sensory and motor functions. Though both sensory and motor functions are already represented in subcortical regions like the PAG, basal ganglia, mesencephalic locomotor system, they are again represented in cortical regions (somatosensory and motor cortices). This may allow these functions to be elaborated in more detail than is possible on the subcortical level.

Such an analysis is consistent with various lines of research showing that core self-related functioning involves both cortical and subcortical regions (Panksepp 1998a; Phan et al. 2004). Many imaging studies in humans have focused on cortical regions, in part because of the involvement of strong cognitive components such as evaluative judgments in the respective tasks (see Northoff et al. 2006). A recent human imaging study on SRP pursuing a less cognitive approach (i.e., without an evaluative judgment in the task) observed involvement of various subcortical regions like the hypothalamus, the DMT, the PAG, and the superior colliculi in addition to the higher cortical midline structures during evaluative SRP (Heinzel et al. 2005). Interestingly, these subcortical regions are enriched in the pre-eminent anatomies of basic emotional systems in all mammals (MacLean 1990; Panksepp 1998a). This provides empirical support for the trans-species involvement of a SCMS in SRP in humans as well as in other vertebrates. In further support, Mobbs et al. (2007) recently imaged the cascade of brain arousal in these regions from the higher cognitive structures when a threat was far away to the most basic animal instinctual–emotional integrative systems when it was nearby, using a predatory imminence task during human brain imaging.

The assumption of the SCMS as common across species implies that it should be independent of particular sensory modalities and other domains. This has indeed been demonstrated in a recent meta-analysis that compared all imaging studies on self-relatedness conducted in different sensory modalities (e.g., auditory, visual, olfactory) and different domains such as verbal/vocal, emotional, social, facial, spatial, and memory (Northoff et al. 2006). These results support the idea of domain-independence of self-relatedness, reflecting a common process whose coordinated functioning comprises the basic sense of self.

4.2 Subcortical–Cortical Midline Structures: Self as Content or Structure

The imaging data show involvement of a large brain system in the self, the subcortical–cortical midline structures. Moreover, the data indicate domain-independence, e.g., occurrence of self-relatedness in different domains (verbal, spatial, etc.) with regard to the SCMS. Are these results more compatible with the concept of the self as content or as structure? In the case of a content-based concept of self, one would expect the involvement of specific brain regions in self-specific contents as distinguished from others that are then associated with other contents that do not involve the self, i.e., non-self-specific contents. However, in the case of a structure-based concept of self, one would expect that self-relatedness implicates many brain regions if not the whole brain, since when considered an overarching structure the self should be processed in various brain regions. And most importantly, the self as structure should impact or, even better, structure all psychological functions which ultimately results in what we called domain-independence.

Rather than being an interaction between specific brain regions, which would still be perfectly compatible with a content-based view of the self, the SCMS must be considered a functional unit that predetermines and predisposes the brain's neural activity to process incoming stimuli in a certain way (see below for details, and also Northoff et al. 2006). This is especially true given that the SCMS's high resting activity may impact the neural activity in other regions like sensory regions and their predisposition to be activated by incoming sensory stimuli. Accordingly, the SCMS are not so much an executive brain system but rather an enabling brain system. An "enabling system" provides the neural ground for specific kinds of neural processing by, for example, setting the appropriate level of resting state activity that may be necessary to process specific goal-orientations. This distinguishes an "enabling system" from "executive systems" that carry out and realize the actual process by itself as, for example, an actual goal-orientation. The SCMS may indeed be an "enabling system" rather than an "executive system." The SCMS may then predispose and predetermine the neural activity of other brain regions including their constitution of contents. In other terms, the SCMS as "enabling system" may provide the structure and organization by means of which the brain may be able to process self-specific contents and to distinguish them from non-self-specific contents. If this holds, it implies, however, that the observed association of self-relatedness with the SCMS in functional imaging studies does not argue in favor of a content-based concept of the self but is more compatible with the concept of the self as structure.

Defined by organization, the concept of structure implies that different kinds of contents can be organized along the same organizational principle – different contents are united by the same organization. If the concept of self is indeed structure-based, one would expect that first, different types of contents (sensory, verbal, motor, affective, etc.) should show self-relatedness, and second, that high self-relatedness across different types of contents leads to neural activation in the same neural network as, for example, the SCMS. This means that neurally one would expect recruitment of these regions during any instance of self-relatedness regardless of whether it concerns verbal, spatial, facial, etc. contents what has been called domain-independence (see Northoff et al. 2006; Walter et al. 2009). Interestingly, a recent meta-analysis by our group (Northoff et al. 2006) showed exactly this: the activation of SCMS during self-relatedness of different contents (see above for description). Thus, it is not so much a specific content that activates the SCMS but rather the degree of self-relatedness that proves crucial in recruiting these regions. This lends strong and positive empirical support to the concept of self as structure-based rather than content-based.[2]

What are the functional mechanisms that may possibly underlie such a structure-based concept of self? Relying on our own studies (see Northoff et al. 2004, 2006), I speak of what I call self-related processing (SRP)[3] (Northoff and Bermpohl 2004;

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[2]If the self is considered an organizational principle (a structure), one would expect that any function with its specific contents, motor, sensory, verbal, facial, etc., should be modulated, even pre-determined, by that structure and hence by self-relatedness. This may correspond, at least in part, to what empirically is described as priming. Priming describes the modulation of a particular function like visual perception by another stimulus that may be presented so briefly that it can be perceived only unconsciously. If the concept of self is indeed structure-based, one would expect that unconscious perception of high self-related stimuli modulates neural activity in visual cortices during visual perception (and other functions) in a different way than unconsciously presented low self-related stimuli. Furthermore, effects of self-related primes should be observed in all sensory and non-sensory functions, visual, auditory, affective, cognitive, etc. If self-relatedness primes primary sensory (and also motor) functions, one would expect some direct interaction and modulation of the sensory (and motor) regions by the SCMS. Unfortunately, such priming experiments with self-relatedness have not yet been reported. Conceptually, self-relatedness would then need to be regarded as some kind of matrix or grid and hence a structure underlying the different functions and their specific contents rather than being a specific content by itself.

[3]However, considered from a purely logical point of view, the concept of SRP may be regarded problematic. If SRP is supposed to be the empirical mechanisms that underlies, and is necessary to constitute, structure and hence a structure-based self, then SRP by itself already presupposes for what it is to be a necessary condition. The concept of SRP includes the term self which, on the basis of SRP, is supposed to be related to the environment. If SRP is a necessary condition of a structure-based self, SRP already implies and presupposes a self which, however, following my account here, should only be the result of SRP but not presupposed and implied by it. There is thus logical circularity in the concept of SRP. How can we avoid such logical circularity? One may for instance replace the term self by the one organism so that then one may speak of organism-related

Northoff and Panksepp 2008). Self-related processing (SRP) describes the coordination of various basic emotional processes and bodily interoceptive stimuli (e.g., emotional, motivational, homeostatic, bodily need states) with exteroceptive stimuli (e.g., sensory stimuli) in relation to the organism's goal-directed activities (Alcaro et al. 2007; Ikemoto and Panksepp 1999; Kelley et al. 2002; Northoff et al. 2006). This relationship is strongly affectively colored as it allows external events to be linked to the organism's basic needs (Panksepp 1998a; Northoff and Panksepp 2008). Neuoroimaging studies in humans have demonstrated that precisely those words and pictures that are highly related to the respective individual's self are considered to be more emotional than those that showed rather low degrees of self-relatedness (Northoff and Bermpohl 2004; Northoff et al. 2006). The affective "coloring" of the world may yield phenomenal experiences of survival-relevant objects and events experienced as "mine" or as "belonging to me," i.e., my picture rather than your picture, reflecting what has been called "belongingness" or "mineness" (Lambie and Marcel 2002). As such, SRP is supposed to underlie the following empirical processes: (1) development of sensorimotor coordination by relating both sensory and motor functions to actual goal-orientations, (2) processes of relating different kinds of stimuli to each other such as intero- and exteroceptive stimuli; (3) intero-exteroceptive linking in relation to actual goal-orientation, and, (4) a strong affective coloring of such stimulus linkage thereby enabling phenomenal experience of the self in relation to the world. Empirically, SRP is consequently not a higher-order cognitive function by itself but rather a very basic one that is primarily the intrinsic linkage and the common coding of sensory, motor and affective with regard to their importance and meaning for the respective organism within its actual environment, i.e., its relatedness.[4] However, conceptually, SRP in this sense cannot be equated with any kind of

processing rather than self-related processing. Or, alternatively, one may very simply speak of relational processing. What, however, is important is to note that the way SRP is understood here does not presuppose any kind of self in the gestalt of some entity with specific contents as, for example, physical or mental contents but rather a living organism.

[4]What does the assumption of SRP imply in empirical regard? SRP implies what may be called valuing of (sensory, motor, affective, etc.) stimuli with regard to their importance and meaning to the organism. Valuing of stimuli has been associated empirically with reward where stimuli are valued with regard to their potential positive effects. If true, one would expect close relationship between SRP and reward. A recent study by our group (de Greck et al. 2008) tested this hypothesis by investigating how high and low self-related stimuli recruit neural activity in reward circuitry as determined by a typical reward task. Interestingly, reward circuitry including the ventral striatum, the ventral tegmental area and the ventromedial prefrontal cortex did not only show neural activity during the reward task but also during self-relatedness. This provides first evidence that SRP as sketched here does indeed implicate the process of valuing as in reward. However, one should be careful. Despite the similarities between reward and self-relatedness, the results also revealed prolonged neural activity in self-relatedness but not in reward (de Greck et al. 2008). This is further underlined by studies in both alcoholic patients and pathological gamblers, both of which showed abnormalities during self-relatedness in reward circuitry that differed from those during the reward task in the same regions. Conceptually, this implies that self-relatedness may be based upon valuing and reward but is not identical to it. Hence, further studies are necessary to better understand the exact functional process by means of which SRP makes it possible to relate and value stimuli with regard to the organism.

contents like self-specific contents as distinguished from non-self-specific ones. Instead, SRP may conceptually be determined rather as process that first and foremost makes the distinction between different degrees of self-relatedness including high and low self-relatedness (with the latter being what we, as external observers, call other) possible.[5]

In sum, the findings in the SCMS are more compatible with the concept of the self as structure rather than as content because of: (1) domain-independence of self-relatedness in SCMS; (2) possible yet to be demonstrated priming effects of self-relatedness on primary sensory-motor functions with the SCMS predisposing sensory-motor regions' neural activity to process incoming or outgoing stimuli; and (3) overlap of self-related processing with valuative processes in reward that is crucial for any kind of stimulus to be relevant for a person. Taken together, this implies that the SCMS may be characterized by what I called self-related processing or relational processing which, if true, designates the SCMS as an "enabling system" rather than as an "executing system."

5 Empirical Plausibility II: Self as Innate or Constructed

5.1 Subcortical–Cortical Midline Structures and High Resting State Activity: Empirical Data

A unifying characteristic of the subcortical–cortical midline structures is the high resting state activity with spontaneous fluctuations in these regions, the so-called default-mode network, which has been observed in both humans (Damoiseaux et al. 2006; Fox and Raichle 2007; Fransson 2005; Raichle et al. 2001) and chimpanzee/macaques (Rilling et al. 2007; Vincent et al. 2007). However, one has to say that high resting state activity in these studies focuses especially on the cortical midline structures while subcortical midline regions seem to be spared. Another limitation

[5]Once the self can no longer be characterized by specific contents, the self can also no longer be considered a mere object at all including even specific ones, as Legrand (2007: 589) described it nicely with the term "self-as-object." However, the rejection of the "self-as-object" does not entail the assumption of the "self-as-subject" that characterizes the self as subject (rather than object) with first-person perspective as distinguished from third-person perspective, as, for example, phenomenological accounts assume (see, for example, Legrand 2007). SRP, as presupposed here, can neither be associated with the "self-as-object" nor the "self-as-subject"; instead, it makes this distinction first and foremost possible in that it allows the distinction between subject and object and hence between both concepts of the self. SRP must consequently be regarded as more basic and fundamental than both subjective, i.e., phenomenological, and objective, i.e., neuroscientific, concepts of the self. As we will see further on, characterization of SRP as basic and fundamental to both subjectivity and objectivity is also central in developing a neuropsychodynamic concepts of self, self objects and objects.

is that high resting state activity does not seem to be specific for the subcortical–cortical midline system since to some extent it occurs, indeed must occur, throughout the brain (see Fox and Raichle 2007). What seems to be specific, however, especially for the cortical midline structures (the default-mode network) is that they show predominant deactivation, i.e., negative signal changes, in functional magnetic resonance imaging (fMRI) (see Fox and Raichle 2007; Raichle et al. 2001). As observed in a recent study in humans, the degree of self-relatedness engendered by different emotional pictures modulated predominantly negative signal changes in a variety of subcortical and cortical midline regions. This indicates that the resting state activity in these regions might be rather high and can no longer be elevated by external stimuli, thus resulting in predominantly negative rather than positive signal changes. Based on our own (Schneider et al. 2008) and others' (D'Argembeau et al. 2005; McKiernan et al. 2006) research, we assume that such high resting state activity in the subcortical–cortical midline network may reflect what we have identified as self-related processing, the continuous process of coding the relation between interoceptive, affective, motor and, if present, exteroceptive stimuli. Such continuously ongoing processing of self-relatedness even in the absence of new streams of exteroceptive stimuli might allow us to maintain a continuous and temporally extended "sense of relatedness" and thus a "core-self" which conceptually may also be described as embeddedness.

The continuous high resting state activity may be crucial in maintaining our relatedness to others and the environment and thus what we describe as embeddedness. While high resting state activity may be regarded as a "physiological baseline," continuous SRP even in the absence of exteroceptive stimuli may be described as a "psychological baseline" (see Northoff and Bermpohl 2004; Northoff et al. 2006). If this is true, exteroceptive stimuli might only modulate the already existing high resting state neural activity and the corresponding degree of self-relatedness (see Schneider et al. 2008, for empirical support in humans). What is then coded in neural activity is the relationship between the pre-existing degree of self-relatedness, as reflected in the level of resting state neural activity, and the exteroceptive stimulus' degree of self-relatedness. Future investigations in both animals and humans might then focus predominantly on the modulation of high resting activity by exteroceptive stimuli with different degrees of self-relatedness, which might reveal what we call the subcortical–cortical midline systems neural reactivity. A recent study by our group (Schneider et al. 2008) investigated whether the degree of resting state activity in the SCMS may be modulated by the level of self-relatedness by the prior stimulus. Interestingly, we observed that resting activity in various cortical midline regions (VMPFC, DMPFC, PCC) was significantly higher when the prior-presented stimulus showed a higher degree of self-relatedness when compared to one with low self-relatedness.[6]

[6]Thereby, the temporal profile of neuronal activity differed between cortical and subcortical midline regions. While cortical regions reacted to stimulus-associated changes in self-relatedness in the subsequent resting state, subcortical regions showed differential activity during different degrees of self-relatedness during the stimulus period itself. Though tentatively and preliminary,

While in healthy subjects, the importance of the high resting state activity has often been investigated, this has so far remained unclear in depression. Given the above-described increased self-focus in depression, one would expect resting state changes in these regions as well as their implication in abnormal self-relatedness. In a recent study during emotion perception and judgment (see also Greicius et al. 2007, who investigated the resting state; Grimm et al. 2008), we were able to demonstrate reduced deactivation or so-called negative BOLD responses (NBRs) in core subcortical and cortical midline regions of the default-mode network in depression. Since reduced NBRs also correlated with subjective measures of emotional valence and depressive symptoms, our results lend evidence to the assumption that reduced subcortical–cortical midline NBRs are crucially implicated in abnormal negative emotional processing in MDD. In another study, we were able to show abnormal signal changes in subcortical–cortical midline regions in depression during a task requiring self-relatedness (Grimm et al. 2008). Interestingly, these abnormal subcortical–cortical signal changes also correlated with behavioral indices of self-relatedness that were significantly higher in depressed patients when compared to healthy subjects, thus reflecting the behavioral correlate of the increased self-focus. Taken both studies together, these empirical data provide first evidence that (1) the subcortical–cortical midline structures resting state activity may be altered in depression, and (2) that these subcortical–cortical resting state changes may be related to the increased self-focus in these patients.

5.2 High Resting State Activity in Subcortical–Cortical Midline Structures: Self as Innate or Constructed

The concept of an innate self implies prediction of an innate or inborn self-specific neural activity that remains (more or less) independent of either bodily, cognitive-mental or environmental stimuli and hence of non-self-specific contents. Such neural activity that underlies an innate self must be distinguished from the neural activity that may be crucial in representing such innate self in the gestalt of self-representation. One may consequently assume neural distinction between the innate self and the representation of that innate self. The construction-based concept of self, in contrast, would assume some neural activity that is necessary to construct the self in relation to the environment. Due to its essential relational character, this neural activity should be modulated by stimuli from both one's body and the environment. Since in this case construction replaces representation, no essential difference is assumed between self and self-representation or, to be more precise, between self and self-construction; the self is nothing but construction and this

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these results suggest different temporal coding of self-relatedness in subcortical and cortical midline structures thereby integrating stimulus-induced and resting state-related neural activity in the SCMS.

construction does not need to be represented to be accessible to the subject or person itself.

The high resting state activity and the predominant modulation of negative BOLD responses (NBRs) is a hallmark of the SCMS. The proponent of the innate-based concept of self may argue that this proves his point, e.g., that this neural activity is innate since otherwise it could not occur in the resting state. Since the neural activity must be regarded innate, one cannot do other than to assume an innate self given the association of the SCMS with self-relatedness. This, however, is to neglect a crucial point. If the high resting state activity in SCMS is indeed innate, it should not be possible to modulate it by actual exteroceptive stimuli and their degree of self-relatedness. This, however, is exactly the case as the study by Schneider et al. (2008) shows. The high resting state activity in the SCMS can be modulated by the preceding exteroceptive stimulus' degree of self-relatedness even in the resting state. This means that the resting state's degree of neural activity is not fixed and static but is rather changeable and dynamic. If the degree of high resting state activity in SCMS can be changed in accordance with the degree of self-relatedness of the prior stimulus, high resting state activity in SCMS can no longer be regarded as innate but as constructional; it modulates and thereby constructs the actual relation between organism and environment in orientation on self-relatedness. Hence, high resting state activity in SCMS is not as isolated from the world (and thus purely intrinsic) as is often presupposed. Though preliminary, these results demonstrate that, rather than being intrinsic in the sense of being limited to the brain itself, it is intrinsically related to the environment, thus making possible what phenomenological accounts call "being in the world" (see, for example, Legrand 2007: 590). This is turn makes it possible that "self-experience and world-experience are two sides of the same coin" (see Legrand 2007: 590). And it is the SCMS's high resting state activity that I suppose to be essential in constructing the organism–environment relationship as self-related by employing a relational code on it.

What is innate then is no longer the high resting state activity itself in the SCMS but the process of constructing. Due to the high resting state and its modulation and subsequent adaptation to the environmental stimuli and their degree of self-relatedness, the SCMS may prove crucial in constructing a self. And it is this construction of the self using high resting state activity and its modulation of the organism–environment relationship as its tool that is innate. High resting state activity may thus signal that your brain is predisposed and hence doomed to relate to the environment which it cannot avoid given its current design. This implies conceptually that the brain cannot do otherwise than to relate and to generate self-relatedness with the subsequent construction of a self.[7]

[7]To assume, in contrast, high resting state and the self as innate is to confuse process and result. Construction with SRP and high resting state activity in SCMS is the process, and it is this process that is unavoidable (and hence innate) since we cannot do otherwise than to relate to the environment and to construct some kind of self. It is this process of construction that may be considered innate. High resting state activity and the self may be considered the results of this

The results in depression confirm the central role of the high resting state activity in the SCMS in modulating the organism–environment relationship. Phenomenologically, the organism–environment relationship can be characterized as shift from the environment to the own self in depression as discussed above. Our results indicate that this shift may be reflected in the apparently increased resting state activity in the SCMS in depression which, however, makes further studies necessary that specifically focus on investigating the interaction and relationship between self and environment focus in depression. What the case of depression points out is that neural activity and even high resting state neural activity in SCMS may be directly dependent upon the environment and its relationship to the organism. The environment may thus exert not only mere modulatory influence on SCMS resting state activity by modulating some pre-existing a priori neural activity, but, instead, the level of resting state activity in the SCMS may be directly determined and constituted by the organism–environment relationship including both evolutionary and actual relationships. In contrast to mere modulatory dependence of neural activity on the environment, one may better speak of constitutional dependence. Needless to say, it is clear that such constitutional dependence of high resting state activity in the SCMS upon the organism–environment relationship needs to be demonstrated in further detail in future studies which at this point remains a rather speculative hypothesis.[8]

In sum, the resting state findings in the SCMS support the concept of the self as construction rather than one of the self as innate because of (1) possible modulation of continuous high resting state activity in the SCMS by exteroceptive stimuli implies continuous construction and adaptation of a self rather than representation of some kind of mysterious pre-existing self, i.e., self-representation; (2) high resting state activity in SCMS may be characterized by innate relational coding

process. If the process itself changes, the result becomes a different one. This clearly indicates that it would be wrong to characterize the results, the high resting state activity and the self, as innate by themselves. One may consequently claim that an innate-based concept of the self confuses process and results when it considers the results as given, i.e., as innate, thereby neglecting the process that leads to these results.

[8]The high resting state activity in SCMS points out another ambiguity in the concept of SRP particularly in the term "processing." If associated with high resting state in SCMS, the term "processing" may point out that there is constant change or flux; this meaning is perfectly compatible with what has been called process-based accounts of the self in the tradition of James ("stream of consciousness"), Whitehead and more recently Rescher. Alternatively, the term "processing" may indicate the opposite of change, fixation, which may be maintained only by continuous processing. Continuous processing in the latter sense is, for example, necessary to maintain a continuous relationship to the environment with the relationship itself, as such, reflecting stability, i.e., dynamic balance between change and fixation. The continuous processing in this second sense may be necessary to allow for continuous construction which in turn is necessary to maintain some kind of stable self in the sense of a construction-based concept of the self. Change and fixation may then no longer be regarded as opposite and mutually exclusive but rather as complementary, describing different aspects in the process of constructing the organism's relationship to the environment and hence its self. Change describes the process, e.g., SRP, while fixation concerns the outcome or result of that very same process, the constructed self.

and may hence be crucial in enabling self-related processing as relational processing; and (3) high resting state activity and its possible modulation imply dynamic balance and hence stability in the organism–environment relationship. Taken together, this implies relational coding may be implemented by high resting state activity in SCMS, which in turn enables the brain and its organism to continuously relate to the environment while at the same time maintaining stability of its self as dynamic balance between self and environment.

Taken together, the empirical data seem to be much more compatible with the immunological concepts of the self than the neuroscientific one that it is based on and derived from the Cartesian conception. This implies that the brain-based concepts of the self as employed and presupposed in current cognitive neuroscience may need to be altered and modified to better fit the data, and hence to develop an empirically more plausible concept of the self. One may consequently diagnose a mismatch between concepts and facts with the latter not corresponding to the former. In other terms, the neuroscientific concepts of the self may be more related to the observer himself than the brain and its actual neural organisation, so that they may be regarded as what I will later call observer-dependent concepts. I have sketched an alternative concept of the self that is oriented more on the immunological concepts of the self than the neuroscientific/neurophilosophical ones. Such an alternative concept hallmarks the self as a relational self and I hypothesize that such a relational self is possible only on the basis of a specific neural organisation and neural coding, i.e., relational coding. The concept of a relational self is thus perfectly compatible with my theory of brain function developed here, namely, relational coding. This makes it clear that the self is an ideal window into the way how our brain organizes and codes its neural activity. Looking through the window of the self to the brain reveals that a future theory of brain function should be based on form and organization, i.e., form- and organization-based, rather than on specific contents be they mental or neural, i.e., content-based. The hypothesis of relational coding developed here must be considered a first step in the future development of such form- or organization-based theory of brain function.

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Self Identity in Sociocultural Contexts: Implications from Studies of Self-face Recognition

Shihui Han, Yina Ma, and Jie Sui

Abstract One's own face is an index of personal identity, and recognition of one's own face reflects how an individual processes self identity in a perceptual task. Recent studies have uncovered cognitive and neural mechanisms underlying self-face recognition, which are characterized by faster behavioral responses to self-face than to familiar faces and enhanced activity in a fronto-parietal neural circuit. In addition, the processes of self-face are modulated by sociocultural contexts. The neurocognitive processes of self-face recognition are significantly different between participants from East Asian and Western cultures. In addition, the neurocognitive processes of self-face recognition are modulated by priming procedures that temporally activate specific cultural values or schemas. The findings of neurocognitive processes involved in self-face recognition provide empirical evidence that sociocultural contexts strongly modulate human self identity.

Keywords Brain imaging · Culture · Self identity · Self-face recognition

What is the self? Is the self special? What is the nature of mental representation of the self? How is self representation realized in the human brain? These questions have been central to the history of human thoughts and have been stimulating ample research in philosophy, sociology, psychology, and neuroscience. To answer these questions is critical for us to understand the self as a status of a person, and is highly related to each individual's well-being.

It has been well documented since William James that the self can be divided into different constituents that emphasize the material, social, and spiritual aspects of the self. In addition, "a man has as many social selves as there are individuals who recognize him" (James 1890/1950, vol I, p. 294). In other words, self identity may vary tremendously according to how the self is recognized by others in

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different social contexts. However, it has been unclear whether and how the neurocognitive processes of the self are modulated by sociocultural contexts.

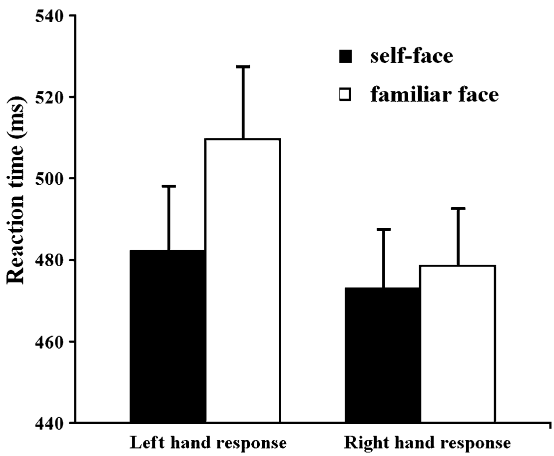
Recently, psychologists and neuroscientists have turned to brain imaging techniques to explore the neurocognitive processes involved in self-consciousness and self-reflective thoughts. In addition, the studies have shown evidence that the neurocognitive processes of self representation and self reflective thoughts are strongly influenced by sociocultural contexts in which an individual is brought up. This chapter aims to outline the relationship between neurocognitive processes in association with self identity and sociocultural contexts. Specifically, we employed behavioral and brain imaging studies of self-face recognition as an approach to the understanding of how sociocultural contexts affect the neurocognitive processes in association with self identity. We start with the introduction of recent behavioral and brain imaging studies that uncovered neurocognitive processes involved in self-face recognition. We then review recent investigations that compare behavioral and neural responses to self-face from participants in Western and East Asian cultures. We also introduce a paradigm of self-construal priming that may help to explore the cause–effect relationship between sociocultural contexts and the neurocognitive processes of self-face recognition. These findings together highlight the influence of sociocultural contexts on self identify in the perceptual domain.

1 Neurocognitive Mechanisms Underlying Self-face Recognition

The "self," as a delimited individual that represents an entity of subjectivity, is different from others in many aspects. The distinctiveness of the self can be observed in both perception of and responses to the self and this has been studied extensively by comparing behavioral and neural responses to one's own face and faces of familiar/unfamiliar persons. The ability of self-face recognition has been suggested to be an important component of self-awareness (Keenan et al. 2000). The competence of recognizing one's own face has been confirmed at an early age of human development. Children in their second year of life show self-oriented actions in front of a mirror (Amsterdam 1972; Asendorpf et al. 1996), suggesting early development of the ability of self-face recognition in humans.

Self-face recognition in human adults is characterized by faster behavioral responses to self-face than to faces of familiar/unfamiliar others. Such self-face advantage in behavioral performances has been observed in different tasks. For example, Tong and Nakayama (1999) found faster responses when participants searched for self-face than a stranger's face among distractor faces. The self-face advantage is also observed over familiar others in a face recognition task and has been observed across participants from different cultures. For instance, Keenan et al. (1999) had a group of American participants identify self-face versus familiar faces and found shorter reaction times (RTs) to self-face than to familiar faces.

Fig. 1 Reaction times in an explicit face identification task. Left hand and right hand responses are shown separately. The left hand responses show a more salient self-face advantage compared to the right hand responses



Similarly, Ma and Han (unpublished data) asked a group of Chinese participants to identity self-face versus familiar faces using the left index and middle fingers in one block of trials but the right index and middle fingers in another block. They also found shorter RTs to self-face compared to familiar faces (Fig. 1). Interestingly, both studies found that the self-face advantage was significant with the left hand responses but not with the right hand responses (Keenan et al. 1999; Ma and Han unpublished data).

The self-advantage in face recognition has been observed not only in tasks that required explicit self recognition (as those used in Tong and Nakayama 1999 and Keenan et al. 1999) but also in tasks that required implicit self-face recognition. Sui et al. (2006) took photos with neutral facial expressions for each participant and a personally familiar other that matched for gender and age. Participants' heads were oriented to the left in some photos but to the right in other photos. They asked participants to discriminate orientations of faces but to ignore the face identity. Again, they observed faster responses to self-face than to familiar faces, similar to the study using explicit self-face identification task.

Multiple perceptual and cognitive mechanisms may contribute to the self-face advantage in behavioral performances. Tong and Nakayama (1999) observed shorter search time to self-face than to stranger's face when the faces were presented in front, three-quarter or profile views, upright or upside-down, and with or without hair. They interpreted this view-invariant self-advantage in face recognition as evidence for robust representations for highly over-learned faces. However, such a perceptual mechanism may not account for the self-face advantage over highly familiar faces. Ma and Han (2010) proposed a social cognitive mechanism that may contribute to the self-face advantage. They hypothesized that self-face recognition and the concomitant self-awareness activate positive attributes in self-concept, which facilitates behavioral responses to self-face and thus results in self-advantage in face recognition. To test this implicit positive association theory of self-face recognition, Ma and Han (2010) examined whether self-concept threat priming, which asked

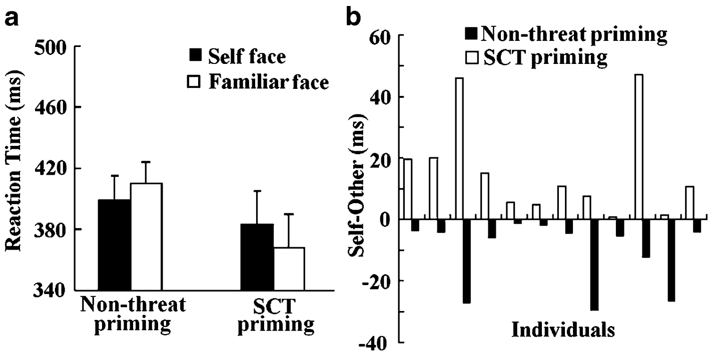


Fig. 2 (**a**) Mean reaction times to self-face and familiar faces in the self-concept threat (SCT) priming and non-threat priming conditions. (**b**) Reaction time differences between self and familiar faces from each individual subject in SCT and non-threat priming conditions. The *Y*-axis represents the difference in reaction times between self and familiar faces (i.e., self minus familiar faces). The negative values index faster responses to the self than to familiar faces (i.e., the self-face advantage)

participants to judge if a number of negative personal traits were appropriate to describe themselves and reduced the implicit positive association with the self, may reduce the self-face advantage in behavioral performances. They showed that, while RTs were shorter to the identification of orientations of self-face compared to familiar faces in a control priming condition, the self-concept threat priming reduced the self-face advantage greatly, even leading to faster responses to familiar faces than self-face (Fig. 2). This finding supports the idea that high-level social cognitive mechanisms contribute at least partially to the self-face advance in behavioral performances.

Another important issue regarding self-face recognition is when and where self-recognition is realized in the human brain. To address the neural processes involved in self-face recognition helps to understand the neural mechanisms underlying self-awareness and self identity. The observations that self-face advantage is much more salient with the left hand responses than with the right hand responses in both explicit (Keenan et al. 1999; Ma and Han unpublished data) and implicit (Ma and Han 2010) face recognition tasks suggest that the right hemisphere dominates the left hemisphere in self-face recognition, as each hand is predominantly controlled by the motor cortex in the contralateral cerebral hemisphere. In accordance with the behavioral results, Keenan et al. (2001) found that patients failed to recognize images of their own faces morphed with a famous face when their right hemispheres were anesthetized. Others observed failure of recognizing self reflected images in a patient with a cortical infarct in the right frontal lobe (Breen et al. 2001).

Recent brain imaging studies have shown that a complicated neural circuit engages in self-face recognition in human adults. In an early positron emission tomography (PET) study that measured regional cerebral blood flow, Sugiura et al. (2000) found that, relative to viewing unfamiliar faces, passively viewing one's own face or performing an explicit self-face recognition task induced increased activations in the fusiform gyrus in the left hemisphere and in the supramarginal gyrus and hypothalamus in the right hemisphere. The explicit self-face recognition task was characterized with activations in the right middle and inferior frontal cortex, the right anterior cingulate gyrus, the left middle frontal gyrus, and the left anterior insula. Direct comparison between neural activities elicited by self and unfamiliar faces, measured using functional magnetic resonance imaging (fMRI), also identified activation in the right frontal cortex, the right occipito-temporo-parietal junction, and the left fusiform gyrus (Sugiura et al. 2005). Contrast between recognition of self-face and a familiar famous face provided further evidence for the involvement of the right frontal lobe in self-face recognition (Platek et al. 2004). To better control for face familiarity, researchers directly compared neural activities linked to the self and personally familiar faces (Sugiura et al. 2005; Platek et al. 2006). This revealed increased activation in the right frontal and parietal lobe and the left middle temporal gyrus (Platek et al. 2006). Similar right frontal and parietal activation was identified in contrast between morphed images containing more self than those containing more personally familiar others (Uddin et al. 2005). These neuroimaging results are further supported by a recent transcranial magnetic stimulation (TMS) study (Uddin et al. 2006), which reported that inhibition of the activity in the right (but not the left) inferior parietal cortex by TMS disrupted the performance on self–other discrimination of morphed images. However, while these fMRI findings indicate the involvement of several brain areas in self-face recognition, the precise functional roles of the brain areas have not been defined.

The time course of self-face recognition has been examined by recording event-related brain potentials (ERPs) to self-face and familiar/unfamiliar faces. For example, Sui et al. (2006) recorded ERPs from participants who were asked to discriminate orientations of faces of the self, familiar or unfamiliar others. The ERP results showed that the early face-specific ERP component, i.e., the N170 recorded over lateral occipito-temporal brain regions that has been demonstrated to be engaged in structural encoding of face stimuli (Eimer 2000; Rossion et al. 1999), did not differ between self-face and familiar faces. However, relative to familiar faces, self-face generated an increased positive activity over the fronto-central brain area at 220–700 ms after stimulus delivery, suggesting differential processes of cognitive evaluation of self and familiar faces in this time window. A recent ERP study that monitored a sequence of images of self-face, a friend's faces and a stranger's faces found evidence that self-face can be distinguished from familiar faces even at an earlier time window. Keyes et al. (2010) recorded ERPs to self-face, familiar faces, and strangers' faces that articulated different speech sounds. They found differences in early ERP waveforms with increased N170 and VPP amplitude to self relative to both friend and stranger measured over posterior and fronto-central sites, respectively. In contrast, differences between familiar faces and strangers' faces did not emerge until 250 ms and beyond. Taken together, the behavioral and brain imaging findings suggest that self-face recognition is characterized by distinct neural mechanisms at multiple levels of face processing and in multiple brain areas.

2 Social Contexts and Self-face Recognition

It has been noticed since William James that self-concept may vary as a function of social contexts in which the self interacts with others. As Ma and Han (2010) have shown that temporal self-concept threat priming implemented in a laboratory reduces self-face advantage, we (Ma and Han 2009) further considered whether and how social threat in real social situations may influence self-face recognition that reflects the process of self-concept in the perceptual domain.

Given that reducing the implicit positive association with the self by self-concept threat priming weakened self-face advantage, it may be proposed that social threats confronted in naturalistic social situations to one's positive associations may also weaken self-advantage during face recognition. To test this hypothesis, Ma and Han (2009) asked a group of Chinese graduate students to identify orientations of self-face that were intermixed with either their faculty advisor's face (high threat condition) or with the face of another faculty member who was not within their own laboratory (low threat condition). As negative evaluations from advisors constitute higher threats to self-esteem compared to those from other faculty members, one may expect that the self-face advantage would be reduced in the high compared to the low threat conditions. Interestingly, the results showed a self-face advantage in the low threat context (i.e., faster responses to self-face than to the faculty member's face) but a self-face disadvantage in the high threat context (i.e., slower responses to self-face compared to the advisor's face). We further quantified the relationship between subjective evaluations of social threats and RTs to self-face and found that differential responses to self-face and advisor's face correlated with individuals' subjective ratings of fear of negative evaluations from the advisor. These findings provide the first evidence that social contexts strongly influence behavioral performances in association with self-face recognition. In addition, the findings implicate that the presence of influential superiors modulates self-face recognition by shaping self-concept and gives rise to multiple social self identities.

3 Cultural Differences in Self-face Recognition

Social psychological studies have shown accumulating evidence that people from Western and East Asian cultures possess different self-concepts. A well-documented theory of the cultural difference in self-concept argues that Western (North American in particular) cultures with the emphasis on self identity lead to the independent self who is inclined to pay much more attention to the self than to others. In contrast, the emphasis of fundamental social connection in East Asian cultures results in the interdependent self who is generally sensitive to information related to significant others and who attends to intimate others as much as to the self (Markus and Kitayama 1991).

Such viewpoint of cultural differences in self-construals has origins from Western and East Asian philosophies and has boosted recent brain imaging studies that aim to find neural consequences of the cultural difference in self-construals on the processing of the self (Zhu and Han 2008; Han and Northoff 2008, 2009). The distinction of independent/interdependent self-construals predicts that the Western independent self may assign greater social salience or stronger positive association with one's own face than to others' faces. This may in turn lead to stronger attention to one's own face when presented among others' faces and induce enhanced processing of self-face. In contrast, as the East Asian interdependent self emphasizes the significance of others in social interactions, enhanced processing of self-face in East Asians may not be as strong as that observed in Westerners.

To assess the possible cultural difference in neurocognitive processes involved in self-face recognition, Sui et al. (2009) conducted the first experiment that recorded both behavioral responses and ERPs from two cultural groups using similar stimuli and the same paradigm. They recruited British participants at the University of Hull, UK, and Chinese participants at Peking University, China. Both cultural groups were presented with self-face and a friend's face and had to judge head orientations of the face stimuli. Interestingly, while both cultural groups responded faster to self-face than friends' faces, the self-face advantage was much greater in British than in Chinese participants (Fig. 3). Moreover, the cultural

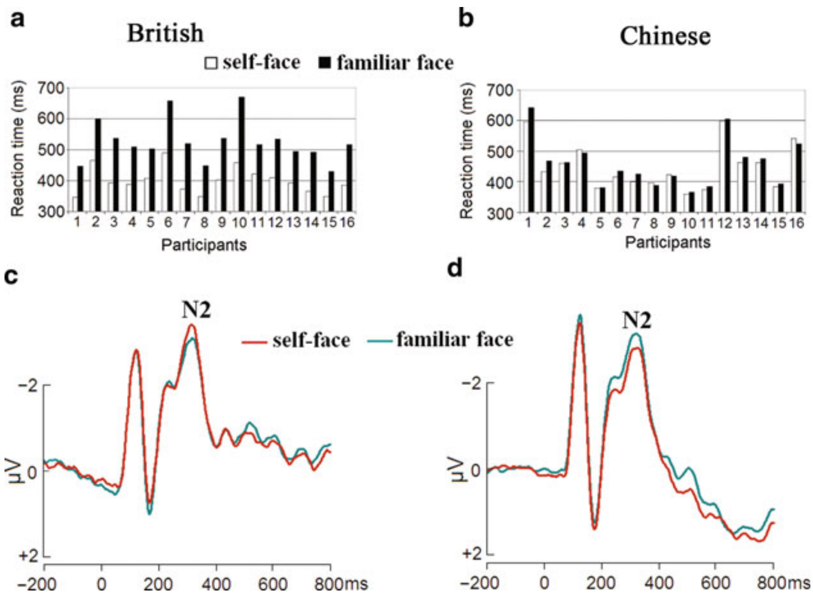


Fig. 3 (**a**) Mean reaction times to self-face and familiar faces recorded from each individual British participant. (**b**) Mean reaction times to self-face and familiar faces recorded from each individual Chinese participant. (**c**) Event-related potentials to self-face and familiar faces recorded from British participants. (**d**) Event-related potentials to self-face and familiar faces recorded from Chinese participants

difference in behavioral performances was associated with distinct underlying neural mechanisms between the two cultural groups. Specifically, ERPs to self-face in British participants showed a larger negative activity at 280–340 ms over the frontal-central area (N2) relative to the familiar face. Nevertheless, a reverse effect was observed in Chinese participants, i.e., self-face elicited an anterior N2 with smaller amplitude compared to friends' faces (Fig. 3). The ERP results suggest that the independent self-construals may give rise to enhanced social salience of self-face over faces of familiar others and in turn result in dissociation between self and others in behavioral performances and the underlying neural mechanisms in Western participants. In contrast, the interdependent self-construals in East Asian cultures may evolve the neurocognitive processes that assign the faces of familiar others (particularly of superior others) with greater social salience over self-face.

In our recent study, we also recorded behavioral responses from two cultural groups (i.e., Chinese and American participants) in an implicit face recognition task requiring judgments of face orientations (Ma and Han 2010). We first observed self-face advantage in RTs in both cultural groups and found that the self-face advantage was comparable between the two cultural groups. In addition, we found that the self-concept threat priming reduced the self-face advantage in both Chinese and American participants. These results suggest that self-face advantage and the underlying mechanism of positive association with the self may be culturally universal. However, the effect of self-concept threat priming on self-face advantage was greater in Chinese than in American participants. The self-concept threat priming reduced the self-face advantage in American participants to the degree that participants responded equally faster to self-face and to friends' faces. The effect of self-concept threat priming on self-face processing in Chinese participants was so large that participants even responded significantly slower to self-face than to friends' faces. These results indicate that self-face processing is much more easily affected by a context that weakened the positive association with the self for Chinese than for American participants.

Taken together, both behavioral and ERP results suggest cultural differences in neurocognitive processes involved in self-face recognition. These findings are consistent with the idea that the interdependent self of East Asian cultures is more sensitive to social contexts and social connections between the self and others relative to the independent self of Western cultures.

4 Self-construal Priming and Self-face Recognition

While previous behavioral and ERP results showed cultural differences in neurocognitive processes involved in self-face recognition, the findings, in a strict sense, have not demonstrated a cause–effect relationship between cultures and the different patterns of neurocognitive processes involved in self-face recognition. Recent research has tried to use psychological priming procedures that may activate specific cultural knowledge in individuals in one culture group to clarify the contribution of a specific aspect of cultures to culture-specific neural mechanisms of cognitive processes. This approach is grounded in the theory that “an individual can acquire the shared knowledge of two cultures and either set of shared knowledge can become activated in the mind of the bicultural individual by certain contextual cues, and the activated knowledge set will affect the individual’s subsequent cognition, affect, and behavior” (Hong 2009, p 4). According to this theory, a priming procedure with different cultural symbols may temporarily activate the knowledge of one or another cultures in participants’ minds and this may cause a shift between different cultural styles of self-concept and lead to corresponding changes of the neurocognitive processes of self-face.

To test this hypothesis, we (Sui and Han 2007) employed a self-construal priming procedure that has demonstrated that one’s self-construal formed chronically in one sociocultural context can be shifted by tasks of searching for independent or interdependent pronouns (e.g., “I” or “We”) in essays (Gardner et al. 1999). We examined whether the independent self-construal priming would result in neurocognitive processes of self-face recognition similar to those observed in Western cultures (e.g., large self-face advantage in behavioral performances), whereas the interdependent self-construal priming would lead to neurocognitive processes of self-face recognition similar to those observed in East Asian cultures (e.g., weak self-face advantage in behavioral performances). In addition, we scanned participants using fMRI while they judged head orientations of self-face or a personally familiar face, after different self-construal priming procedures, to assess the possibility that self-construal priming may result in modulations of neurocognitive processes of self-face recognition.

We first found a significant effect of self-construal priming on behavioral performances to self-face and familiar faces. Participants responded faster to self-face compared to familiar faces after the independent self-construal priming. However, they responded slower to self-face than to familiar faces after the interdependent self-construal priming (Fig. 4). These results are consistent with the idea that the independent self intends to pay more attention to the self than to others and the interdependent self is sensitive to information related to significant others (Markus and Kitayama 1991). Surprisingly, we also found that the self-construal priming modulated the neural activity in association with self-face recognition in a comparatively short time (e.g., 3 min in this study). The contrast of self-face versus familiar faces showed stronger activation in the right middle and inferior frontal cortex after the independent self-construal priming. However, the right frontal activity was significantly reduced after the interdependent self-construal priming. A whole-brain interaction analysis confirmed that self-specific activity was larger after the independent than the interdependent self-construal priming. The brain imaging results provide strong evidence for a cause–effect relationship between cultural specific self-construals and cultural specific styles of neurocognitive processes involved in self-face recognition. Self-awareness induced during face perception was augmented by independent relative to interdependent self-construal priming. While cultural psychologists find that shifts between the independent and interdependent self-construal influence social behaviors

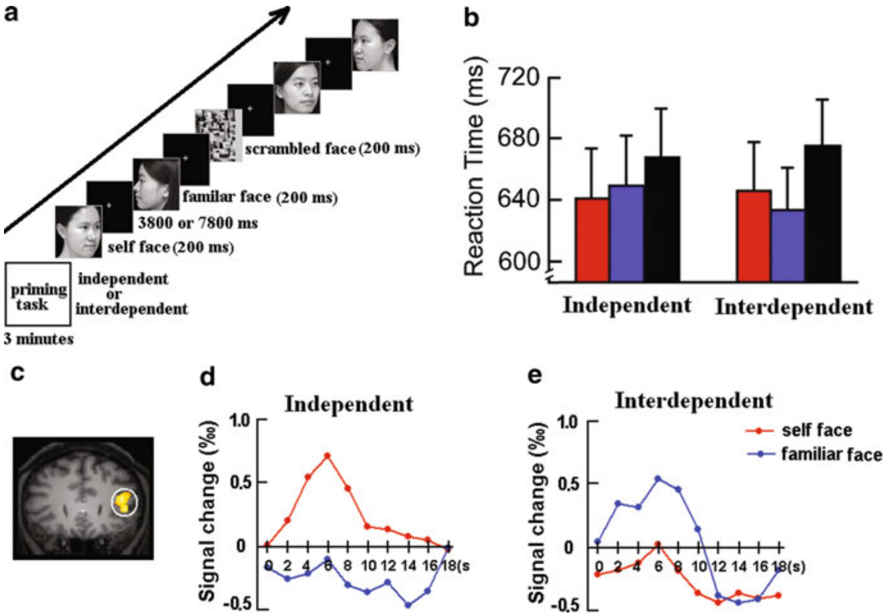


Fig. 4 (**a**) Illustration of the self-construal priming procedure and the implicit face recognition task. After the self-construal priming task, participants were scanned while being presented with their own face, a familiar face, and scrambled faces, and had to indicate the head orientation of the intact faces and the location of the gray bar next to the scrambled faces by pressing a button with the right index or middle finger. (**b**) Mean reaction times to self-face, familiar faces, and scrambled faces. (**c**) Illustration of the right frontal activation in association with self-face. (**d**) The time courses of the blood-oxygenation-level-dependent (BOLD) signals in the right middle frontal cortex after the independent self-construal priming. (**e**) BOLD signal in the right middle frontal cortex after the interdependent self-construal priming

and social judgments (Gardner et al. 1999), our brain imaging findings indicate that emphasizing the independence of the self enhances the self-other distinction in perception.

5 Conclusion

There has recently been increasing interest in behavioral and brain imaging studies of self-face recognition as self-face recognition is an index of self-awareness and self-concept in the perceptual domain. These studies have uncovered behavioral performances and neural activity that distinguish between the processes of self-face and familiar/unfamiliar faces. More interestingly, a number of studies have shown evidence that the neurocognitive processes of self-face are strongly influenced by social contexts and are different between participants from Western and East Asian cultures. Self-face recognition in participants from Western cultures is characterized by faster behavioral responses and enlarged neural responses to self-face compared to familiar faces. The self-face advantage in behavioral performances is weaker, and stronger neural responses are observed to familiar faces than to self-face, in participants from East Asian relative cultures compared to participants from the Western cultures. In agreement with the studies of Western and East Asian cultural groups, the research employing self-construal priming shows further evidence for a cause–effect relationship between culture-specific self-concept and neurocognitive processes of self-face. Specifically, relative to the interdependent self-construal priming, the independent self-construal priming leads to a greater distinction between self-face and familiar faces in both behavioral performances and the underlying neural activity. These findings can be interpreted in the framework that Western cultures encourage attention to self-related information and assign high social salience to the self than to others, whereas East Asian cultures emphasize the importance of social connections and the significance of close others in one's own life.

The behavioral and brain imaging studies of self-face recognition inaugurate a new approach to investigate cultural difference in self-concept and self-related neurocognitive processes. However, it should be noted that cultural influences on self-related processing have been observed in other domains. For example, we have shown evidence for differences in neural mechanisms underlying trait judgments of the self and close others between Western and Chinese cultures (Zhu et al. 2007). We demonstrate that Chinese participants used the medial prefrontal cortex to represent both the self and a close other (i.e., mother), whereas English-speaking Westerners used the same brain area to represent only the self. Although different stimuli and tasks were used in the studies of self-face recognition and self-trait judgment, the findings of these studies are coherent, and consistently reflect the difference in self-concept between Western and East Asian cultures. Taken together, these findings indicate that self-concept and self-related processing can be understood correctly only if one takes into account the sociocultural contexts in which human individuals are fostered.

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The Relation Between the Self and Others: A Transcultural Neuroimaging Approach

Li Zhang, Ying Zhu, and Shihui Han

Abstract Cultural differences in the relationship between self and others induce different self-concepts. Chinese define the self in terms of connectedness with in-group members in an interdependent manner whereas Westerners view the self as a unique and autonomous entity that is separated from others in an independent manner. This chapter reviews recent neuroimaging studies that investigated the neural basis of representations of the self and close others by comparing brain imaging results obtained from Chinese and Westerners. We suggest that cultural specific neural representations of the self constitute the basis for Chinese–Western cultural differences in most cognitive processes.

Keywords Close other · Culture · Self · Transcultural neuroimaging

An anthropologist, Lutz (1992), posited that "although self-awareness is universal, cultures differ in how the self is conceptualized and experienced." Another anthropologist, Francis Hsu, observed cultural differences between Chinese homes and American homes. The majority of American houses have neither hedges nor outside walls which prevent a passerby from watching through windows. In contrast, the majority of traditional Chinese houses are surrounded by high outside walls so that only the roofs are visible from the outside. Inside the home, the contrast between China and American is reversed, where Americans emphasize that space and possessions are individualized whereas in Chinese homes privacy hardly exists at all. The differences between American and Chinese homes reflect the discrepancy in self-concept between American and Chinese cultures (Chiu and Hong 2006).

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Cultural psychological studies of self-concept (e.g., Triandis 1989; Markus and Kitayama 1991) promoted great searching after cultural variant rather than cultural universal self-concepts. A wealth of research on the cultural differences in self-concept has been conducted since the ideas of forerunners of anthropology and social psychology were proposed. Based on these studies, Heine (2001) concluded that "In general, across a wide variety of paradigms, there is converging evidence that East Asians view in-group members as an extension of their selves while maintaining distance from out-group members. North Americans show a tendency to view themselves as distinct from all other selves, regardless of their relationships to the individual." Chiu and Hong (2006) also suggested that "findings from recent research comparing East–West differences in the conceptions of the self-other relation agree with Hsu's observations: In American culture, the boundary between the in-group and out-group is soft and thin, but the boundary between individuals is sharp and impermeable. In Chinese culture, the walls separating the in-group from out-groups are solid and thick. Inside the walls, the boundary between in-group members is fuzzy." Evidence supporting these propositions comes from both studies of cultural psychology and brain imaging studies of self-concept and self-referential processing.

This chapter first summarizes the results of behavioral studies of self-referential processing that show cultural differences in the processing of self-related information between Chinese and Westerners. We then review recent neuroimaging studies of self-referential processing that examined to what extent neural representations of others are incorporated with or distinct from the neural presentation of the self. We discuss how a transcultural neuroimaging approach (Han and Northoff 2008), which integrates designs with both culture-sensitive (e.g., mother/father/friend reference) and culture-invariant (self-reference) cognitive tasks (Zhu and Han 2008), may help to uncover cultural difference in neurocognitive processes of the self. Finally, we discuss what are the appropriate designs of brain imaging studies for investigation of neurocognitive processes of the self and close others.

1 Cultural Differences in Self-referential Processing

Cultural psychological studies have shown ample evidence that East Asians and Westerners perceive the world and think about it in different ways (Nisbett and Masuda 2003). Specifically, East Asians process information in a more holistic and contextualized manner, whereas Westerners process information in a more analytic and feature-based style. Cultural psychological findings implicate that similar cognitive tasks may be processed rather differently by individuals in different cultural contexts (Li 2003). Indeed, research during the last two decades has shown increasing evidence that cultures influence memory processing of information related to the self and to others (Klein et al. 1989, 2002; Zhang 2005; Zhu and Zhang 2002; Qi and Zhu 2002; Yang and Zhu 2003; Sui et al. 2007; Zhang et al. 2006; Zhu et al. 2007; Heatherton et al. 2006; Gutchess and Indeck 2009).

The self-reference effect (SRE) is a classical finding in memory research and has been widely used in brain imaging studies to examine neural representations of the self (Rogers et al. 1977). In a self-reference encoding task, participants are presented with trait adjectives. In one condition, participants are required to judge whether an adjective describes the self so that they encode the adjective with reference to the self. In other conditions, participants make trait judgments on mother/best friend/partner or a public figure so that the encoding of trait adjectives is referenced to others. After the encoding task, participants are given a surprise recognition test in which participants are presented with old and new adjectives and have to make old/new judgment on each adjective. It has been shown that the adjectives with reference to the self are remembered better relative to the adjectives with reference to others. This SRE has been suggested to reflect the fact that a trait summary about the self is well established and is employed during the encoding of self-related information (Klein et al. 2002).

Klein et al. (1989) summed up 14 SRE studies and their own experiments and found that "with a few exceptions the use of descriptive tasks for making judgments about well-known others (e.g., 'Does this trait describe your mother?') has produced recall inferior to that found with self-reference." Consistent with Klein et al. (1989), Heatherton et al. (2006) observed significant better memory performance in the self-reference task than in a best friend-reference task that required trait judgments. Conway (2000) also found that answering the question "Does this trait describe your mother?" produced inferior recognition than the question "Does this trait describe you?" in a pilot SRE experiment (in private letter; the results are shown in Table 1). Zhu et al. (2007) replicated Conway's results by showing higher recognition scores of trait adjectives used during self-judgments than those used during mother-judgments in Western participants. Thus, Klein et al. (1989), Conway (2000), Heatherton et al. (2006) and Zhu et al. (2007) consistently showed that, in Westerners, reference with a well-known other (e.g., mother or best friend) produced inferior memory performance than reference with the self.

Interestingly, research has shown that cultures significantly influence the SRE. Studies of Westerners have shown that recognition accuracy tended to be higher for trait adjectives that were encoded with reference to the self relative to those were encoded with reference to a celebrity or a close other such as mother (Klein et al. 1989). However, Zhu and colleagues (Zhu and Zhang 2002; Qi and Zhu 2002; Yang and Zhu 2003) found that, while Chinese participants similarly showed the SRE,

Table 1 Mean number of words recognition as a function of encoding task

	Old words			
	R	K	F	G
Self-reference ($n = 16$)	0.50	0.23	0.18	0.07
Mother-reference ($n = 9$)	0.28	0.36	0.27	0.05
B. Clinton-reference ($n = 16$)	0.26	0.23	0.27	0.12

Data come from Conway (2000). In a recognition test, subjects required to choose the old words first, then to continue to answer whether the word chosen was recalled (R), or was known (K), or felt familiar (F), and was guessed (G)

Chinese participants also showed memory performance equally well on trait adjectives that were encoded with reference to mother and the self. The size of the SRE was comparable with that of the mother-reference effect. Zhang et al. (2006) and Zhu et al. (2007) replicated these results by showing that the recognition scores were comparable between the self- and mother-trait judgments in Chinese participants.

Cultural differences in SRE stems from cultural differences in self-construal. That is, an independent self in Western cultures is inclined to attend to self-focused information and attends to the self more than others, including intimate others such as mother, which leads better memory of information about the self than that about others (e.g., mother/best friend). In contrast, an interdependent self is sensitive to information related to significant others and attends to intimate others as much as to the self, which leads equally well to memory of information both about the self and mother/best friend (Markus and Kitayama 1991, 2003; Conway et al. 2005; Zhu and Han 2008).

2 Cultural Difference in Self-reference Effect and the Scope Hypothesis

How are personality trait adjectives stored in memory? How are personality trait judgments made? To answer these questions, Klein et al. (2001) proposed that trait judgments draw on two kinds of memory: (1) trait summaries, which provide information in the form of a generalization, and (2) memories of episodes in which a person behaved in ways that are relevant to the trait. A trait summary is most useful when its scope is delimited (i.e., when it is accompanied by information specifying those situations in which it does not apply). Episodic memories that are inconsistent with a trait summary can serve this function because episodic memories encode specific situations in which the generalization fails to predict the outcome. The *scope hypothesis* proposes that, to render judgments that are both fast and accurate, judgment and decision procedures should be designed to search for summary information in semantic memory and, upon retrieving it, also search for episodic memories that are inconsistent with that summary, ones that place boundary conditions on the summary's scope. This prediction has been tested by Klein et al. (2001, 2002).

In their first study, Klein et al. (2001) examined whether accessing a trait summary about the self would prime trait-inconsistent episodes but not trait-consistent ones. Subjects were presented with a list of trait adjectives and had to perform tasks to decide whether the stimulus trait described themselves (e.g., "Does this describe you: Stubborn?"). The recall task asked subjects to retrieve a specific instance in which they manifested the stimulus trait. A control task required subjects to generate a definition for the stimulus trait (e.g., "Think of the definition of the word 'stubborn'"). Each trial consisted of performing two of these tasks – an initial task and a target task – in succession on either the same trait word or on a trait and its antonym (e.g., rude and polite) (Klein et al. 2001). The scope hypothesis predicts that the described task activates episodes that are inconsistent with the trait adjective for judgments and result in faster reaction times in remembering the episodes than in remembering the same episodes after the control task. The described task accesses both trait summary and trait-inconsistent episodes as a delimitation of trait summary and thus triat-inconsistent episodes are primed. In other words, when trait summary is retrieved, trait-inconsistent behavioral episodes are retrieved along with it. Klein et al.'s findings are illustrated in Fig. 1. Regardless of the level of trait-descriptiveness, subjects were significantly faster performing the recall task when the initial task was described than when it was defined. The results provided strong evidence that trait judgment activated trait-inconsistent episodes but not trait-consistent episodes.

Klein et al. (2001) also tested whether trait judgments about a well-known other (e.g., mother) generate results that are consistent with the predictions of the scope hypothesis. The procedure was the same as the self-judgment except that the target of the judgment was mother. The results of mother judgments are shown in Fig. 2. For traits highly descriptive of one's mother, whose trait summary exists, inconsistent episodes were primed (subjects were significantly faster performing the recall task when the initial task was described than when it was defined) whereas trait-consistent episodes were not. An opposite pattern of performances was found for traits that were only moderately descriptive of one's mother. Trait-consistent ones were primed whereas trait-inconsistent episodes were not. Thus, Fig. 2 confirms the prediction that retrieving a trait summary (if it exists) primed trait-inconsistent episodes but not trait-consistent ones.

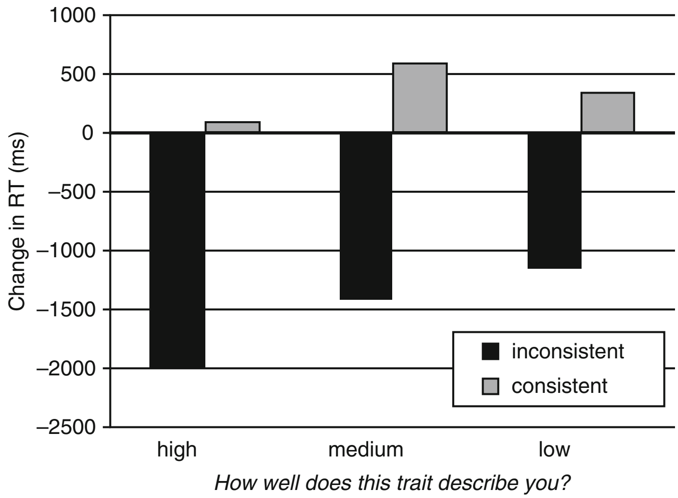

Fig. 1 Activating a trait summary about the self can prime episodic memory: self-study. Deciding whether a trait describes one's self activates episodes that are inconsistent with the trait asked about. Trait-consistent episodes are not primed. This holds whether the subject views the trait as highly descriptive or not. Negative numbers indicate that the episode was recalled faster than in a control condition. *RT* reaction time (from Fig. 1 in Klein et al. 2002)

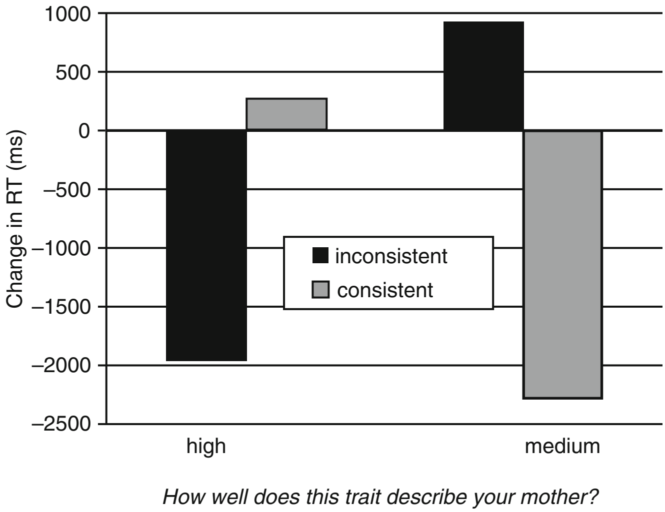

Fig. 2 Activating a trait summary about another person primes inconsistent episodes: mother study. Deciding whether a trait describes one's mother activates episodes that are inconsistent with the trait asked about only when the trait is highly descriptive of one's mother. When it is only moderately descriptive, trait-consistent episodes are primed. This is consistent with the notion that subjects have formed summaries only for traits they consider highly descriptive of their mothers. Negative numbers indicate that the episode was recalled faster than in a control condition. *RT* reaction time (from Fig. 2 in Klein et al. 2002)

The results shown in Figs. 1 and 2 indicate that Westerners form a trait summary of highly descriptive, medium descriptive and low descriptive traits about the self. However, Westerners form a trait summary of only highly descriptive traits about mother. It appears that the role of mother is different from the role of the self during encoding of trait adjectives for Westerners. As mentioned early in this chapter, while the SRE is larger than the mother-reference effect in Westerners, self- and mother-reference effects are comparable in Chinese. To further examine the mother-reference effect in Chinese, Zhang (2005) conducted two experiments on Chinese subjects. The experimental procedure was the same as Klein et al. (2001) except that the Chinese subjects were recruited. However, Zhang found that the processing of trait adjectives was similar for Chinese self and mother, as illustrated in Fig. 3. The results suggest that Chinese may form a trait summary of high/medium/low descriptive traits both for the self and mother. Consistent with this, reaction times to both self and mother in remembering the episodes that were trait-inconsistent were faster when the initial task was the described task than when the initial task was the defined task. The contrast of the results from Westerners and Chinese suggests that Western self is different from their mother in terms of their functional roles in encoding trait adjectives whereas traits about the self and mother are similarly encoded in Chinese. Taken together, these findings indicate that culture shapes memory processes of close others and are consistent with the proposition that "Chinese position the self and the mother in the same social

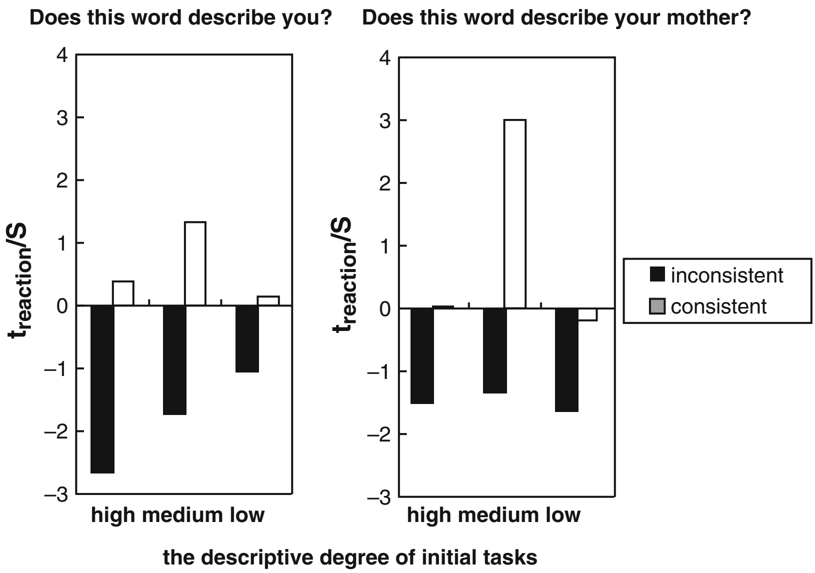

Fig. 3 Activating a trait summary about both self and mother can prime inconsistent episodic memory. Negative numbers indicate that the episode was recalled faster than in a control condition (from Fig. 2 in Zhang 2005)

psychological space and the public figure in a different one. Contrariwise, Americans position the self and others (including the mother) in different social psychological space" (Chiu and Hong 2006).

3 Neural Basis of the Cultural Difference in Self-referential Processing

The aforementioned behavioral studies show evidence for cultural differences in self-construals (e.g., the independent self in Western cultures and the interdependent self in East Asian cultures). To investigate the neural basis of cultural difference in self-referential processing, we (Zhu et al. 2007) assessed if cultures influence the neural representation of the self by combining the SRE paradigm and brain imaging. We scanned both English-speaking Westerners (British, American, Australian and Canadian) and Chinese participants using functional magnetic resonance imaging (fMRI). We found that self-trait judgments induced increased activity in the ventral medial prefrontal cortex (VMPFC) relative to judgments of others [i.e., a public figure, the former American president (George W. Bush) for Westerners, and the former Chinese primer (Rongji Zhu) for Chinese] as a control condition. However, interestingly, the mother-trait judgments generated increased

VMPFC activity relative to judgments of a public figure in Chinese ($x, y, z = 2, 55, 3$, BA 10) but not in Westerners. The results suggest that both the self and mother are represented in the VMPFC whereas the vMPFC is exclusively recruited in presentation of the self in Westerners (see Fig. 4).

Consistent with Zhu et al.'s (2007) results, Heatherton et al. (2006) found that, in an event-related fMRI experiment using the SRE paradigm, the contrast between the self and best friend judgments showed activity in the VMPFC in American participants (see Fig. 5), which was consistent with the finding from Zhu et al. (2007) that the contrast between the self and mother judgment showed

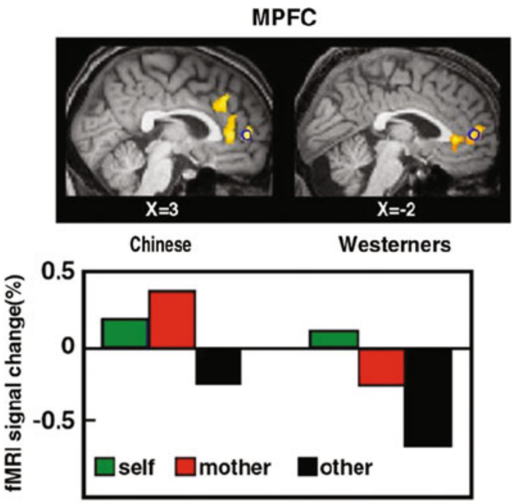

Fig. 4 fMRI results of the ROI analysis. The upper panel illustrates the locus of the MPFC (marked with *blue circles*); the lower panel represents fMRI signal changes in MPFC in the self-, mother- and other-judgment tasks relative to the null condition (from Fig. 4 in Zhu et al. 2007)

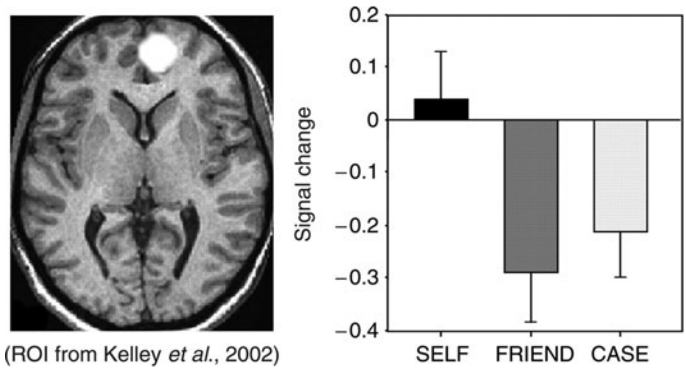

Fig. 5 An a priori region-of-interest (ROI) in MPFC based on Kelley et al. (2002) was used to compute mean signal change during SELF-, FRIEND-, and CASE-judgments. Signal intensities for each condition are plotted relative to a baseline control condition (fixating a crosshair). Similar to the previous work, MPFC activity was uniquely sensitive to self judgments. Case-judgments and judgments about an intimate other produced robust decreases in MPFC activity that did not differ from each other (from Fig. 2 in Heatherton et al. 2006)

activity in the VMPFC in Western participants. In addition, Zhang et al. (2006) and Zhu et al. (2007) found that the contrast between the self and mother judgments did not produce activity in the VMPFC in Chinese, providing further evidence for an overlap of the neural representation of the self and close others in Chinese.

Table 2 summarizes neuroimaging studies that used the SRE paradigm and employed either a public figure or a personally familiar other as the control condition. As can be seen in Table 2, self-trait judgments induced increased activity in VMPFC or DMPFC relative to judgments of both a public figure/semantic processing and mother/best friend in Western participants, whereas self-trait judgments induced increased activity in VMPFC only relative to judgments of a public figure in Chinese. Thus, it may be concluded that neural representations of mother/best friend are different between Westerners and Chinese, in that mother is similar to a public figure in Western participants but mother is similar to self in Chinese.

Table 2 Chinese–Westerner differences in SRE neuroimaging studies

Studies	Designated other	Regions activated in self minus other				
		x	*y*	*z*	BA	Area
A. Using Western participants						
Zhu et al. (2007) (English, American, Australian and Canada)	B. Clinton	0	51	3	10	VMPFC
	Mother	−4	46	−6	10	VMPFC
Heatherton et al. (2006) (American)[a]	G. Bush	10	52	2	10	VMPFC
	Best friend	−9	55	3	10	VMPFC
		6	58	3	10	VMPFC
Schmitz et al. (2004) (American)	Semantic	6	56	4		VMPFC
	Close friend or relative	26	52	16		DMPFC
		−28	46	16		DMPFC
Ochsner et al. (2005) (American)	Teaching assistant	36	42	10	10	DMPFC
		−12	40	42	8	MPFC
	Best friend or partner	26	42	4	10	MPFC
D'Argembeau et al. (2007) (French)	Close friend or relative	−10	46	22	9	DMPFC
		10	44	24	9	DMPFC
		−8	50	−2	10	VMPFC
		12	44	0	10	VMPFC
B. Using Chinese participants						
Zhu et al. (2007)	Rongji Zhu[b]	8	55	6	10	VMPFC
	Mother	No VMPFC activated				
Zhang et al. (2006)	Lu Xun[c]	−6	52	12	10	VMPFC
		−2	46	18	9	MPFC
	Mother	No VMPFC activated				
Wu et al. (2009)	Lu Xun	0	53	5	10	VMPFC
	Mother	No VMPFC activated				
Han et al. (2008)						VMPFC
	Mother	No VMPFC activated				

[a]Heatherton et al. (2006) stated that "The MPFC ROI was defined from an independent data set (Kelley et al. 2002) comparing self-judgments to judgments about a familiar but personally unknown other (George W. Bush). This region was then interrogated for replication in the current data set"

[b]Rongji Zhu was the former Chinese premier

[c]Lu Xun was a famous Chinese writer

The brain imaging results are consistent with the proposition that "across a wide variety of paradigms, there is converging evidence that East Asians view in-group members as an extension of their selves while maintaining distance from out-group members" whereas "North Americans show a tendency to view themselves as distinct from all other selves, regardless of their relationships to the individual" (Heine 2001). Chinese–Westerner differences in neural representations of the self and others also support that "the significance and the exact functional role that the person assigns to other when defining the self depend on the culturally shared assumptions about the separation or connectedness between the self and others" (Markus and Kitayama 1991). Why does the Chinese self overlap with mother in MPFC? Why is the Western self separated from mother in MPFC? Our brain imaging findings suggest that the relatively heavy emphasis on interpersonal connectedness in Chinese culture has led to the development of neural unification of the self and intimate persons such as mother, whereas the relative dominance of an independent self in Western cultures results in neural separation between the self and others (even close others such as mother) (Zhu et al. 2007).

It has been proposed that people in different cultures have strikingly different construals of the self and others, and most people in Western cultures hold an independent self whereas most people in East Asian culture hold an interdependent self (Markus and Kitayama 1991). In addition, all processes that implicate the self may take different forms if the self-construals are different (Markus and Kitayama 2003). The transcultural neuroimaging approach posits that it is possible to distinguish culture-sensitive from culture-invariant neural mechanisms of human cognition based on the results of transcultural neuroimaging studies (Han and Northoff 2008). Our brain imaging results indicate that Western self and Chinese self process information related to self and others differently. The cultural differences in behavioral performances may arise from the cultural differences in neural representations of the self and close others.

4 Cultural Neuroscience Study of the Self: Selection of a Baseline

It is critical for fMRI studies to choose an appropriate baseline condition for identification of neural representations of the self and others. Most of the previous fMRI studies contrasted a self-judgment task with a control task that required judgment of a public person (see review in Northoff et al. 2006). Such a control task is a necessary control for confounds such as perceptual/semantic processing and motor responses that are involved in self-judgments. Using a low-level non-semantic task as a baseline condition may obtain different neural imaging results.

For example, Vanderwal et al. (2008) investigated neural correlates of self- and mother-referential processing by comparing BOLD signal changes in Self, Mother and Letter conditions. In their experiment, each stimulus consisted of a pair of adjectives, and subjects were instructed to "choose the word that best describe you/your mother." This task required self-referential or mother-referential processing, though it is different from the previous studies whereby subjects were shown with a single word on each trail and were asked to judge "Does this word describe you/mother?" However, Vanderwal et al. (2008) used Letter condition ("Choose the word that contained the letter 'a'") as a control condition for identification of neural correlates of self- and mother-referential processing. They found that a conjunction analysis of self and mother conditions relative to Letter condition showed several common areas of significant activation, including the medial aspects of the superior frontal gyri, left inferior frontal gyrus, bilateral temporal poles, left superior temporal sulcus and left precuneus. Based on these results, the authors argued that self and mother rely predominantly on the same neural basis and cognitive processes that are not neurofunctionally unique.

The problem of using a non-semantic control task in this study is that the contrast between self-/mother-judgments and the baseline basically identifies neural substrates involved in semantic processing rather than neural substrates specific to the processing of self and mother. Craik et al. (1999) used SRE tasks including Self, Other (Brian Mulroney, a former Canadian prime minister), General (semantic processing of a word) and Syllable (non-semantic processing of a word) conditions to study the neural correlates of self-referential processing. They found that when Self condition minus Other, General and Syllable conditions medial frontal cortex activity (x, y, $z = -6$, 56, 8 and 30, 60, 20, BA 10; 6, 40, 28, BA 9) was observed (Table 5 of Craik et al. 1999). Moreover, the contrast of semantic conditions (Self, Other, General) versus non-semantic condition (Syllable) showed common areas of relative activation in the three semantic conditions included the medial aspect of the superior frontal gyrus (BA 8/9,10), inferior frontal gyrus (BA 47), superior temporal gyrus (BA 38), middle temporal gyrus (BA 39), and cingulated gyrus (BA 23/32) (Table 3). These brain activities related to semantic processing are similar to those observed in Vanderwal et al. (2008). Craik et al. (1999) suggest that the common areas of Self, Other and General conditions are the areas associated with meaningful processing of individual words in a number of previous studies, as every significant activation in the Self–Syllable contrast was also found in either the Other–Syllable contrast or the General–Syllable contrast. These results suggest that self-concept involves general schematic structures. Thus, the brain areas observed in Vanderwal et al. (2008) may reflect neural structures involved in general schematic structures or semantic knowledge encoding rather than brain areas specifically involved in the representations of the self and mother.

According to Kirmayer (2007), "the person is not synonymous with the self; personhood is more completely a social creation, a category in the classification of events and a juridical concept on which hinge questions of moral agency, responsibility, and blame. We see others as persons and experience our own person as a self. While the person may be a category used implicitly in diverse cultures and the experience of self-awareness a human universal, the concept of the self is a hypostatization given central importance in Western psychological discourse. In contemporary terms, the self is a center of narrative coherence achieved by a cognitive control system that uses consciousness (specifically, self-consciousness)

Table 3 Comparison between Vanderwal et al. (2008) and Craik et al. (1999)

Region	*x*	*y*	*z*	BA
Vanderwal et al. (2008)				
Left DMPFC	–9	44	43	8
Left medial frontal lobe	(–4	46	36)	(8/9)
Bilateral DMPFC	–6	50	31	9/10
Left medial frontal lobe	(–6	52	–4)	(10)
Left lateral orbital gyrus	–45	23	–2	47
Left inferior frontal gyrus	(–32	24	–8)	(47)
Left precuneus	–6	–52	25	23/31
Left posterior cingulate	(–6	–54	16)	(23)
Left temporal pole	–45	23	–23	38
Left superior temporal gyrus	(–38	10	–16)	(38)
Craik et al. (1999)				
Left inferior frontal gyrus	–51	20	16	45
Left superior temporal sulcus	–48	–37	1	21/22
Right DMPFC	15	26	49	8
Right temporal pole	42	14	–23	38
Left cuneus	–15	–55	4	17/18
Right cuneus	12	–70	7	17/18

The data without parentheses refer to the common areas of Self and Mother from Table 2 of Vanderwal et al. (2008) and the data with parentheses refer to the common areas of the three semantic conditions (Self, Other, General) from Table 4 of Craik et al. (1999); Part B include only some data of Table 2 of Vanderwal et al. (2008) which are not much related to self processing

for adaptive purposes." While the self-referential processing involves semantic and motor processes, selection of an improper baseline condition for identification of neural substrates of self- and other-referential processing may lead to inappropriate conclusions and make it difficult to uncover cultural differences in neural mechanisms underlying self- and other-referential processing.

5 Implication of the Brain Imaging Findings

Studies of social psychology, anthropology and psychotherapy suggest that the self is a cultural product or construction (Triandis 1989; Markus and Kitayama 1991; Heine 2001; Lutz 1992; Kirmayer 2007). Recent transcultural neuroimaging approaches allows us to identify culture-invariant and culture-sensitive neural substrates of human cognition including self-related processing (Han and Northoff 2008). We suggest that self-reference is culture-invariant because the self-referential effect in memory performance is observed in subjects from different cultures (e.g., in Western cultures, Rogers et al. 1977; Symons and Johnson 1997; Klein et al. 1989; Kelley et al. 2002; in Chinese culture, Zhu and Zhang 2002; Qi and Zhu 2002; Zhang et al. 2006; Zhu et al. 2007). In addition, the neural substrates underlying self-referential processing in the VMPFC (BA 10 and BA 9) is also similarly observed in Western (Craik et al. 1999; Kelley et al. 2002; Zhu et al. 2007) and Chinese participants (Zhang et al. 2006; Zhu et al. 2007; Han et al. 2008).

The brain imaging findings also indicate that the process of close others (e.g., mother) is culture-sensitive because memory performances related to mother-referenced trait adjectives are inferior to that related to those referenced to the self in Western participants (Klein et al. 1989; Heatherton et al. 2006; Zhu et al. 2007), whereas memory performance are equally well for trait adjectives referenced to the self and mother in Chinese (Zhu and Zhang 2002; Qi and Zhu 2002; Zhang et al. 2006; Zhu et al. 2007). In addition, mother-reference task induced VMPFC activity (x, y, z = 2, 55, 3, BA 10) relative to other-reference (a public figure) for Chinese participants (Zhu et al. 2007), and the contrast between the self and mother did not induced VMPFC activity (Zhang et al. 2006). In contrast, mother-reference task did not induced VMPFC activity relative to other–reference (a public figure) in Western participants (Zhu et al. 2007) and the contrast between the self and best friend induced VMPFC activity in Western participants (Heatherton et al. 2006). Thus, we suggest that the neurocognitive processes of the self and close other (e.g., mother) are respectively culture-invariant and culture-sensitive.

6 Conclusion

The neuroimaging studies of the self and close others showed that Western self is separated from others (even close others such as mother, best friend) in the MPFC, whereas Chinese self overlaps with mother in the MPFC. The cultural differences in neural representations of the self and close others are consistent with the general idea about the relationships between self and others: "Chinese position the self and the mother in the same social psychological space and the public figure in a different one. Contrariwise, American position the self and others (including the mother) in different social psychological space" (Chiu and Hong 2006). The neuroimaging findings provide neural accounts of why "for those with a more autonomous self in Western cultures, the self-nonself boundary is located distinctly between the individual and the other: any other" (Heine 2001) and why self is the self only when it is connected with others and placed in a social field of relationships in East Asians (Markus and Kitayama 2003).

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Unconscious Self-processing: Subconscious, Unintentional or Subliminal?

Haiyan Geng and Shan Xu

Abstract The existing evidence suggested that self-relevant information is processed in an implicit and automatic manner in many situations. Specifically, the present chapter makes a brief review of empirical evidences which suggest the existence of unconscious self-processing in the situations when the self-relevance of stimuli or task is not registered consciously. According to the characteristics of the existing demonstrations of unconscious self-processing, we classified them into three different categories: “subconscious” or “unrecognized” self-processing, “unintentional” self-processing and “subliminal” self-processing. Integrating evidence of all three categories, one can infer thereby the wide existence of self-processing which is not dependent on subjective activation or awareness of self, and the automatic nature of self-related cognitive or social cognitive processing. For such remarkable phenomena, further efforts must be made to reveal the cognitive mechanism, behavioral effect and neural correlates of the consciousness-independent self-processing, the results of which might contribute to the thorough understanding of the nature of human self.

Keywords Consciousness · Continuous flash suppression · Self · Subconscious self-processing · Subliminal self-processing · Unintentional self-processing

1 Instruction

The self is a unique psychological construct that carries great ecological value in one’s everyday life. Convergent evidence indicates that the specialty of self exists widely in various basic modules of human cognition, and that such self-specialty always turns out to be a particular priority that emerges automatically as the self-reference effect in memory (e.g., Rogers et al. 1977; Zhu and Zhang 2002), and as the cocktail party effect in attention (e.g., Wood and Cowan 1995). The goal of this

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chapter is to give a brief review about evidence which has suggested the existence of unconscious self-processing. Here, the term unconscious self-processing is used generally to refer to the self-processing carried out when the self-relevance of stimuli or tasks is not registered consciously, the existence of which highlights the implicit and automatic nature of the unique self-processing.

However, though widely and deeply explored, “self” is difficult to define in any explicit and noncircular way. In a previous review, Gillihan and Farah (2005) mentioned a commonsensical approach to divide the studies of self-related processing into physical and psychological aspects. The studies of physical self-processing examined whether specific body parts, or the whole body and the spatial relationship among body parts, were processed differently in the case of the individual’s own body comparing to others’ bodies. So in this branch, the investigators explored self-face or self-body part recognition (e.g., Gallup 1970; Anderson 1984; for review, see Keenan et al. 2003). On the other hand, the studies of psychological self-processing focused on knowledge of self and the first-person perspective. The most famous instances of the self-knowledge effect can be found in self-reference tasks (e.g., Rogers et al. 1977; Zhu and Zhang 2002) and autobiographical memory tasks (e.g., de Renzi et al. 1987), while in the first-person perspective studies, investigators compared participants’ performance of first- and third-person perspective tasks (e.g., Lane et al. 1997; Vogeley et al. 2001).

Later, we will follow this division as a guideline in organizing our following discussion.

2 Whether Unconscious Self-processing Is Conceptually Feasible?

The link between the concepts of “self” and “consciousness” is tight and complex. Self is believed to be relative to the existence and nature of human consciousness (e.g., levels of consciousness, Morin 2006; the involving of “observing self,” Baars et al. 2003; the egocentric nature of consciousness, Trehub 2007). Especially, the establishment of the concept of “self” and the ability of self-recognition are of great ecological value as they make possible series of high-level cognitive operations (e.g., Turk et al. 2002; Keenan et al. 2000), which include self-consciousness, introspection and theory of mind. Some researchers practically equate the usage of “consciousness” with “self-awareness” (e.g., Gallup 1970; Anderson 1984; Keenan et al. 2003, p. xix). Here, the term “self-awareness” is defined as “the ability to recognize that we think, to be aware, and to reflect on our own thought processes” (Keenan et al. 2003, p. xviii). In fact, this view considers the relationship of self-awareness and consciousness from the perspective of comparative psychology and individual development, and emphasizes the synchronous emergence of consciousness and self-concept. Based on this opinion, the origin of consciousness is usually tested by self-image recognition and tasks involving theory of mind (Keenan et al. 2003). However, we would like to point out that the just-mentioned point of view has only emphasized the close relationship of self-processing and consciousness while ignoring the possible dissociation between self-processing and consciousness. Nevertheless, not all self-processing can be self-aware; that is, self-processing may not necessarily rely on consciousness. In fact, according to the empirical evidence we will discuss in the following paragraphs, before rushing to the easy claim that self-recognition and other self-processing are confined to conscious cognition, we would do better to reexamine the relationship between self-processing and awareness of self.

Our point here is that, as illuminated by some well-established implicit self-processing phenomena, such as IAT-based self-esteem tests, it is probable that self-processing can be carried out automatically, not requiring subjective awareness of "self" or the very sense of self-relatedness. As we will see in following sections of this chapter, although some cognitive processes (for instance, self-recognition) used to be defined as key components of self-awareness, they have been proved not entirely fixed to the subjective awareness of self.

In a later section, we will review the evidence which indicates that self-processing does not necessarily rely on awareness of self; that is, the concept of "self" can function in an implicit or unconscious way during various forms of cognitive or social cognitive processes. Before that, we would like to present some reasons which inspire the investigation of consciousness independent self-processing.

3 What Are the Practical and Theoretical Values of Unconscious Self-processing?

As mentioned, the studies of conscious self-processing have established the specialty of self. Then, why are we here turning our attention away from the well-developed and fruitful field of conscious self-processing to the topic of unconscious self-processing, which is unfamiliar and full of tangled concepts, guesses and arguments? What is the significance of unconscious self-processing? Is there real unconscious self-processing in daily live? What is it for?

There are surely some reasons which make us to believe in the existence of unconscious self-processing. Firstly, from the perspective of evolution, it is possible that unconscious processing of self-related information is more prevailing than conscious processing of the aforesaid information, particularly in the early stages of evolution when fully developed consciousness had not yet taken place. Therefore, unconscious self-processing may have contributed to information selection and processing promotion (e.g., Eastwood and Smilek 2005) and possibly helped these branches of information to be immune from the limitation of cognitive resource in advance.

In addition, some research has demonstrated that information from certain complex but ecologically significant stimuli such as faces can be processed implicitly and without the awareness of such stimuli. Studies on unconscious face processing (in which faces were presented under the participants' threshold of awareness) demonstrated that some information transmitted by faces, for instance, emotion (e.g., Burton et al. 2005; Suslow et al. 2006; Jiang and He 2006; Habel et al. 2007; Eastwood and Smilek 2005, for a review) and familiarity (Stone and Valentine 2004, 2005) could somehow be extracted unconsciously, i.e., producing behavioral or neural effects without becoming accessible enough to be reported. These results make us more confident to expect the existence of physical self-processing and its specialty in the unconscious state. Actually, Stone and Valentine's work (2004, 2005) has already demonstrated that the facial identity information could be extracted and analyzed during unconscious processing, and that attitude played a role in unconscious processing. These results also raise the question as to whether self-related attitude will modulate self-specialty in unconscious processing, which can be considered as an unconscious effect of the psychological component in self-processing in contrast to the physical component involved in self-face recognition.

Even though unconscious self-processing is theoretically possible and practically feasible, what is the value of investigating it? There are so many potential perspectives, such as cognitive psychology, social psychology and philosophy, from which we can address its importance and investigative value. However, in this chapter, we will focus on the perspective of social cognitive neuroscience.

In recent years, social cognitive neuroscience becomes a rising research domain, from where is welling up more and more exciting issues and experimental studies. Unlike the traditional cognitive neuroscience, social cognitive neuroscience takes social psychological topics, e.g., personality and social background, into account when explaining the functional values of cognitive processing, as well as the cognitive and neural mechanism of complicated social cognition (Zhu and Sui 2004). Following the thought path of social cognitive neuroscience, psychologists are integrating questionnaires, behavioral experiments, ERPs and brain-imaging in order to get a deeper understanding of previously confusing social behaviors.

But, in the very case of self, which is one of the hotspots in social cognitive neuroscience, some confusing factors are hard to avoid, and they might thus confound the results and explanations of relevant investigations if the exploration is limited to conscious level, even with aids from all the just-mentioned methods. Such factors include the participants' social desirability and similar matters. These factors might contaminate the behavioral output and neural correlates of conscious self-processing. However, in unconscious processing, researchers might be able to get rid of some of such deliberately performed camouflage and their interaction with personality or attitude, and at last aim at the "pure" measure of self-processing.

In summary, the existing evidence suggests that it is possible to process self and other survival-related information in an implicit and automatic manner. Taking this fact, together with the potential evolutionary value of unconscious self-processing, it is rather natural to hypothesize the existence of unconscious self-processing, which might be a fruitful approach to study the nature of self in the domain of social cognitive neuroscience.

4 Then, What We Know About Unconscious Self-processing?

After all the lengthy discussion, we now finally reach the core topic of this chapter, that is, the exact scope in which self-processing can exist without the awareness of self. What, then, does "without awareness of self" mean? In a typical self-processing task at conscious level, we receive stimuli that are self-related, such as our images in a mirror or notions in our brains like "Am I pretty today?," and we make specified responses because of the self-relevance of the given stimuli, like admiring the image or feeling troubled. When doing such things, we become aware of the facts that (1) the stimulus (external or internal) is related to the self of the task taker, and (2) that the task is self-related.

However, in some cases, although we consciously processed the stimuli which were related to ourselves, and made responses to them, we were not aware of their nature of self-relatedness. Here, we call them "subconscious" self-processing, or "unrecognized" self-processing. In such cases, the awareness of self-relatedness is absent; the term "subconscious" or "unrecognized" is used to differentiate them from other categories, like "unintentional" and "subliminal" self-processing which we will discuss later.

4.1 "Subconscious" Self-processing

As just mentioned, the term "subconscious" here means the situations in which, although we consciously process the stimuli that are related to ourselves, and make responses to them, we are not aware of their nature of self-relatedness. We call them "subconscious" self-processing, or "unrecognized" self-processing, following Keenan et al. (2003).

One illustration of this category can be found back in 1925, when Werner Wolf presented subjects with their own voices, hands, handwriting samples, face profiles and other self-related stimuli (see Keenan et al., 2003). It turned out that many subjects failed to subjectively recognize the stimuli related to their own, but their response patterns to those unrecognized self-stimuli were different from those to self-unrelated stimuli. Generally, relatively extreme evaluations were given to the unrecognized self-related stimuli, in contrast to the self-unrelated ones, that is, the unrecognized self-stimuli tended to be assessed either "highly favorable" or "highly unfavorable" while self-irrelevant stimuli were rated more neutral. Such trends were replicated by C. W. Huntley (1940). In addition, Huntley found a reaction differentiation to recognized and unrecognized self-stimuli in men, who rated unrecognized self-stimuli extreme and recognized self-stimuli much more neutral, while this dissociation was absent among female subjects. An analogous study was conducted by Beloff and Beloff (1959), in which two faces were "fused" by the usage of stereoscope. Subjects who failed to realize that their own faces were fused into the presented faces were found to rate the fused and thus self-comprised faces more attractive than the control faces which were "pure" other faces. Also, when hearing one's own voice, subjects displayed greater physiological responses even though the voice was not recognized as belonging to his or her self. This branch of unrecognized or subconscious self-recognition studies illustrated the highly automatic nature of self-processing; that is, even though the self-relatedness of stimuli was not consciously registered, the self-related stimuli could still benefit from the specialty of self and evoke different responses compared with other stimuli.

4.2 "Unintentional" Self-processing

"Unintentional" self-processing happens in the situations when, though we know precisely that some of the stimuli are related to ourselves in a certain way, we do not completely realize that we had been performing self-related processing. In other words, we do it unintentionally.

For this category of self-processing, the most famous illustration is the self-esteem test based on the paradigm of the implicit association test (IAT, Greenwald et al. 1998). In this test, subjects were asked to do simultaneous classifications of words by valence and self-relevance: Firstly, they should respond to self-related information and good trait words with one key and respond to other-related information and bad trait words with another key as fast as possible, and then the key association was counterchanged, so that self-related and negative information shared the same response key and other-related and positive information shared another response key.

With this paradigm, it was found that subjects were more inclined to associate themselves with positive traits, therefore, the response time for the first response combination (self–good and other–bad) was faster than that for the second (self–bad and other–good) (Fig. 1). This phenomenon was termed as "self-positive bias." The size of bias was thought to reveal the subject's implicit self-esteem. In this test, although the subjects were aware of the self-related stimuli, they devoted themselves to doing a pair of discrimination tasks, neither of which literally related to self-attitude. However, the results revealed that the attitude to self had been somehow activated automatically.

Generally speaking, the typical characteristic of "unintentional" self-processing is that some self-processing which is not overtly required by the ongoing explicit task influences our behavior without being self aware. Here, just to be clear, we name them as "unintentional" self-processing. By this, we hope the readers keep in mind the common part of this kind of phenomena, that is, the absence of awareness of ongoing self-processing.

Various methods that were used to measure implicit self-esteem, including the just-mentioned paradigm, can be seen as examples of "unintentional" self-processing. Greenwald and Banaji defined implicit attitudes as "introspectively unidentified (or inaccurately identified) traces of past experience that mediate favourable or unfavourable feelings, thoughts, or actions towards social objects (p. 8)."

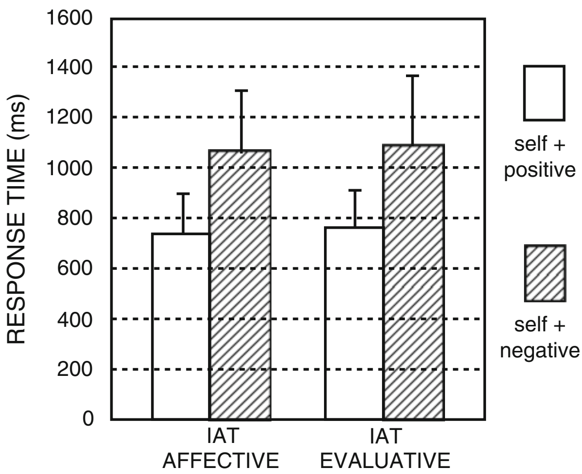

Fig. 1 IAT (from Greenwald and Farnham 2000). When self-related and positive information share the same response key (*white bars*), RTs are significantly shorter than the cases when they are associated to different response keys (*black bars*)

Especially, the implicit attitude to self was defined as "an automatic, overlearned, and nonconscious evaluation of the self that guides spontaneous reactions to self-relevant stimuli" (Bosson et al. 2000, p. 631). So, following the logic of these methods, the objects that are associated with self would be evaluated positively if the self is concomitantly viewed positively (Greenwald and Banaji 1995).

Therefore, if one has positive implicit self-esteem, self-relevant stimuli (e.g., one's possessions or name) should also be evaluated positively. An early version of measurement following this logic of spreading positivity is the name–letter effect devised by Nuttin (1985, 1987), who found that participants preferred the first letters of their given names and family names more than the rest of the letters in their names (study 1), and an conceptually analogous effect was also significant for the participants' birth dates and months. Furthermore, similar implicit self-esteem has been found in evaluative priming tasks (Hetts et al. 1999; Wentura et al. 2005).

Generally, the self-positive bias was found to exist both in implicit measures and explicit measures of self-esteem, suggesting that the implicit measures captured important aspects of self-evaluation. On the other hand, the size of bias in implicit measures of self-esteem were largely uncorrelated with that in explicit measures of self-esteem (e.g., the self-report measure). This is consistent with the opinion that self-attitude is generally represented and accessed at two distinct levels (Gawronski and Bodenhausen 2006; Wilson et al. 2000). So there is no reason to expect high concordance between explicit self-esteem and implicit self-esteem. In contrast, the unrelatedness found between implicit and explicit self-esteem measurements suggests that they did not assess identical aspects of individual differences in self-regard (e.g., Bosson et al. 2000; Conner and Barrett 2005; Greenwald and Farnham 2000; Karpinski 2004). Noticeably, several moderator variables have been identified, which indicate the at least occasional link between implicit and explicit self-esteem (Koole et al. 2001; Pelham et al. 2005; Nosek 2005; Wentura et al. 2005). Considering that self-esteem is believed to be a multifaceted construction that incorporates affective and cognitive components, it is possible that the implicit measures of self-esteem more reliably capture affective associates of self-esteem such as self-love and self-acceptance (Gawronski and Bodenhausen 2006; Hofmann et al. 2005a, b). In fact, it has been established that implicit self-esteem does predict some important psychological outcomes (e.g., Jordan et al. 2003; Shimizu and Pelham 2004; Steinberg et al. 2007; Zeigler-Hill 2006).

The results of implicit self-esteem measures illustrate that self-processing can be automatically conducted without awareness of self or without conscious online reference to self, not only at the physical level (e.g., body-part recognition), but also at the psychological level.

Also, in typical studies about the self-referential effect in memory, although the encoding task is self-related, the resulting memory advantage of self-related words is independent of explicit intention of the encoding task, that is, the memory advantage is produced without intention, or in other words incidentally. In this way, self-reference effect can also be considered as an illustration of unintentional self processing.

Finally, before moving to the third category, we would like to point out that the distinction between the aforementioned two categories is made out of the purpose to clarify and organize the meaning of demonstrations of unconscious self-processing in various paradigms, while the characteristics of each category are not necessarily mutually exclusive; in some situations, the self processing might possess the characteristics of both kinds. For instance, in Kircher and his colleagues' study on "incidental self-processing" (Kircher et al. 2002), although subjects were asked to classify some of the adjectives as self-descriptive (SD) and some as non-self-descriptive (non-SD) before fMRI scanning, during image acquisition self-specific activation was observed in both the "incidental" condition, when subjects conducted self-unrelated task with both SD and non-SD words, and intentional condition, when they conducted the typical self-descriptive judgment to these words (as in encoding phrases of the typical self-reference study). However, there is no explicit evidence as to whether subjects were explicitly aware of the self-descriptiveness or non-self-descriptiveness of each word during the self unrelated task. Consequently, the observed unique self-specific activation in incidental compared to intentional condition might be attributed to the lack of self-related intention as well as to the lack of awareness of self-relatedness in incidental condition.

4.3 "Subliminal" Self-processing

In those studies mentioned above, self-related stimuli were all presented above the threshold of consciousness. Here, we use the term "consciousness" to refer to internal and external stimuli entering awareness. Consequently, in these cases, if the self-processing was classified automatic or implicit, it was just because the participants did not decipher the involvement of self out of the processed information, or failed to realize the self-relatedness of ongoing tasks while they kept aware of the existence of meaningful and intelligible stimuli.

However, the question remaining here is whether psychological or physical self-processing can be evoked even when participants are not aware, in the first place, of the existence of the stimuli and the embedded information. In other words, the question is whether unconsciously presented self-related stimuli are capable of giving rise to self-processing. We call it here "subliminal" self-processing, to stress the overall unconscious state of stimuli in such cases.

It has been demonstrated that invisible self-stimuli can function as attitude-prime and sway affective judgment. In the subliminal attitude-prime task (Spalding and Hardin 1999), the subjects were firstly primed subliminally with some self- or other-related information, and then performed a lexical decision task, in which they had to judge, as quickly as possible, whether a trait word was positive or negative. It was assumed that, if the response was faster to positive words than to negative ones under the self-prime condition, it would mean that the self-positive association was stronger than the self-negative one, which in turn would reflect one's implicit self-esteem.

However, the existing studies suffered from a methodological problem. In the traditional paradigm, the unconscious perception of face was obtained by very brief presentation plus backward masking. However, this experimental paradigm allows a very short presentation to realize the subliminal perception of stimuli, which creates an obstacle in the exploration of unconscious self effect that may call for a longer presentation. In other words, the magnitude and extension of unconscious processing were underestimated by the traditional paradigm of brief presentation plus backward masking. Fortunately, a new paradigm called continuous flash suppression (CFS; Tsuchiya and Koch 2005) can be utilized to obtain stable and persistent unconscious presentation of stimuli. In CFS, the distinct images consisting of random color patches (Mondrian pattern, see Fig. 2) and flashing successively at ~10 Hz into one eye reliably suppresses a low-contrast unchanging image presented to the corresponding location of the other eye. The duration of such perceptual suppression can last tens of seconds or longer, at least ten times greater than that produced by binocular rivalry (Tsuchiya and Koch 2005). So this paradigm unites the advantages of binocular rivalry and flash suppression, and obtains stable and relatively long unconscious presentation of the appointed stimuli. Thus, CFS can avoid the instability, uncontrollability and unpredictability of suppression in binocular rivalry, and the contamination from conscious processing brought about by pre-adaptation in flash suppression. By this paradigm, we can not only investigate the temporal characteristic of unconscious self-image processing but can also explore further into the mechanism of unconscious self-processing.

With CFS, we subliminally primed subjects with their own or others' faces before they undertook certain tasks, so as to investigate what effects the unconscious physical self-processing might have on the subjects' behavior. The results of our study suggest the existence of the assumed "subliminal self-processing."

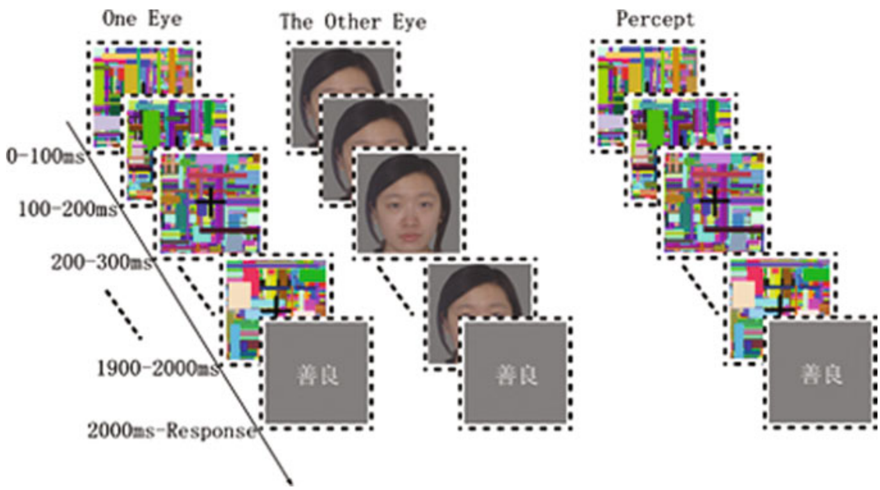

Fig. 2 Procedure of the lexical decision task primed by subliminal self-image (Geng and Li, unpublished)

For instance, in a lexical decision task, suppressed face images of self or a familiar other (Fig. 2) were used to prime the subjects' responses to the valence of trait words. It was found that subliminal exposure to one's own face indeed affected his/her response time to positive and negative trait words. At the same time, this unconscious self-processing was modulated by some personality factors, such as general self-esteem. That is, subjects low in self-esteem exhibited slower reaction to negative than to positive trait words both in the self-prime and other-prime conditions, while subjects high in general self-esteem exhibited merely self positive bias, that is, they reacted slower to negative than to positive trait words only in the self-prime condition, without analogous word valence effect occurring in the other-prime condition. This result can be interpreted as unconscious oversensitivity of the subjects low in self-esteem to evaluative information, which spread from the self-related to other-related condition. It occur in a manner of failure in inhibiting self-evaluation even in other-related condition because of their desperate desire to seek positive self-image. Another possibility is that people low in self-esteem are more sensitive to interpersonal information as a result of enhanced social monitoring in order to obtain a higher level of social inclusion (Gardner et al. 2005). In sharp contrast, when we primed subjects with visible face images of self or familiar other (conscious condition), a typical self-positive bias appeared (Geng and Li, The effect of prolonged subliminal self processing on affective lexical decision, unpublished). This dissociation of conscious and unconscious self-processing suggests that not only the self-concept was activated by unconsciously presented self-image but also self-evaluation and self-attitude could be activated by those subliminal self-primes and then produce significant behavioral effects.

In another study, we found that the time needed by self-face images to break the suppression of CFS noise is shorter than that of face-images of familiar other people. Actually, in other paradigms, it has already been established that self-related stimuli are much easier to become self aware or to come into consciousness. The cocktail effect (Wood and Cowan 1995) is a typical example, which describes a situation in which one can easily notice his or her own name in a noisy and attention-demanding environment. Though consciousness is not the typical perspective in which to discuss this phenomenon, it is generally accepted that this effect shows a special advantage of self-stimuli in attentional capture and something which can be called awareness entering. As a supplement to this, our break-suppression study suggests that self-stimuli are much easier to enter the focus of consciousness than other stimuli under the CFS condition, and that the specialty of self can be registered before being self aware. It seems that awareness or conscious activation of self is not a critical factor which negates self-processing.

5 Conclusion

In this chapter, we have given a brief and non-comprehensive review of research which suggests the existence of self-processing in situations when the self-related nature of stimuli or task is not registered consciously, that is, when implicit self-processing is conducted. The previous studies demonstrated that self-processing at both physical and psychological levels is able to be completed without the awareness of self.

Further, we suggest that the existent demonstration of unconscious self-processing can be divided into three categories: (1) “subconscious” or “unrecognized” self-processing, which means the situations in which, although we consciously processed the stimuli that were related to ourselves and made responses to them, we were not aware of their nature of self-relatedness, as illustrated by the extreme evaluation of unrecognized self-body-part; (2) “unintentional” self-processing, which refers to the situations in which though we knew precisely that some of the stimuli were related to ourselves in certain ways, we did not completely realize that we had been performing self-related processing, that is, we did it unintentionally, as in the IAT test; and (3) “subliminal” self-processing, the situations in which psychological or physical self-processing were evoked even when the participants were not aware of the existence of the stimuli and the embedded information, as revealed by studies using the CFS paradigm (Geng and Li, unpublished). The existing results suggest the wide existence of self-processing which is not dependent on subjective activation or awareness of self, hint at the automatic nature of self-related cognitive or social cognitive processing, and lay the groundwork for further investigation on unconscious self-processing.

Although the exact mechanism of unconscious self-processing is not yet clear, the existence of unconscious self-processing, either merely unintentional or evoked by a downright subliminal self-cue, might be a clue for further exploration of the nature of self and the relationship between self and consciousness. At least it suggests that it is probably not sufficiently cautious to equate self and consciousness simply and arbitrarily. Without awareness of self and/or of self-processing, our "self" is still in our mind and swaying our cognitive processing.

Still, we have to admit that our knowledge about the exact way in which self interacts with the states of consciousness is rather limited. Partially, this is due to the chaos in philosophical and psychological concepts and theories of both consciousness and self, as well as the lack of a precise and measurable index of unconscious self-processing, of consensus in the acceptable operational definition of unconsciousness, and of reliable methods to manipulate the states of consciousness, which all contribute to the relatively slow progress in this field. Some visual illusions involving the transition of the states of consciousness, such as binocular rivalry and CFS, might provide the solutions to render the perceived self-stimuli out of consciousness.

Further efforts must be made to reveal the cognitive mechanism, behavioral effect and neural correlates of the consciousness-independent self-processing, the results of which might contribute to the thorough understanding of nature of human self.

Inspiringly, there are recent theories about the mechanism of unconscious self processing promoted on the fundaments of neural cognitive results. For instance, in their insightful review, Panksepp and Northoff (2009) conceptualized core-self which holds the basic representation of self by defining the primal characterization of the organism in relation to the environment by self-related processing (SPR), which is primarily implicit and automatic, that is, as Panksepp and Northoff put it, "either cognitively preconscious or unconscious and thus implicit, but accompanied by experienced shifts in affective feeling states that are pre-propositional and hence hard to put into words" (p. 206); and this core-self, as Panksepp and Northoff suggested, is realized by distinct neural process and acts in reciprocal modulation with cognitive and conscious processing of higher order, and is carried out by the more cortical, especially more prefrontal, neural system. Also, Lieberman et al. (2004) presented an analogical distinction between an X-system, an intuition-based implicit and automatic self-knowledge system involving activation in the vmPFC, the N. accumbens, and the amygdala, and a C-system, an evidence-based self-knowledge system that involves cognitive, controlled and conscious, self-related processes accompanied by activation in the lateral prefrontal cortex, hippocampus and posterior parietal cortex.

Such theories from the perspective of neural cognition suggest the dissociation between self-related processing with and without participation of consciousness and provide enlightening ideas of the nature of self, consciousness and unconscious self-processing. However, they did not take into account the diversity in the quality of "unconsciousness" in unconscious self processing, as we have illustrated in our brief review. In fact, the lack of awareness of self-relatedness of stimuli and the lack of awareness of the stimuli as a whole might involve, or leave behind, different extents or components of a hierarchical structure of self or of consciousness. Consequently, it might be valuable to identify the actual character of a claimed unconscious self processing before using it as a tool to investigate the nature of self and consciousness.

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Brain, Behavior, and Culture: Insights from Cognition, Perception, and Emotion

Nicholas O. Rule, Jonathan B. Freeman, and Nalini Ambady

Abstract Recent developments in cultural neuroscience have provided insights showing that human brain function can vary along cultural lines. In the present article, we review the contributions of cultural psychology to the study and understanding of human cognitive neuroscience by focusing on three key areas of importance: cognition, perception, and emotion. We first review what is known about the influence of culture on the brain with regard to some basic cognitive processes: language, mathematics, memory, and perspective-taking/theory of mind. We then review cultural influences on the neuroscience of perception, focusing on the perception of objects, scenes, and social cues. Finally, we review the role of culture in the understanding of emotion recognition from a cognitive neuroscience perspective. Together, these three components of human behavior and brain function serve to illustrate how a unique understanding of cognitive neuroscience can be gained from the study of culture.

Psychology as an empirical discipline emerged as recently as the late nineteenth century, perhaps marked by Wilhelm Wundt's establishment of the first psychological laboratory in 1879. The consideration of culture's influence on the mind and behavior was present even in these early days, as Wundt himself is considered one of the first cultural psychologists (see Heine 2008). Despite a series of starts and fits, however, the study of psychology across cultures as it is known today did not take hold until the latter half of the twentieth century. This is largely because of the focus on behaviorism, and later cognition, that dominated mainstream psychological thinking during much of the period between. Yet the groundwork for what are presently the foundations of cross-cultural psychology were active throughout those times, even if only on the margins of psychology – spilling over from disciplines

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such as cultural anthropology (e.g., Benedict 1934) and sociolinguistics (e.g., Whorf 1956).

The goals of studying psychology across cultures can be largely simplified as understanding similarities and differences between groups with culture standing as the moderating variable in between. For example, a study by Zebrowitz et al. (1993) showed that European-Americans, African-Americans, and Koreans all showed relative agreement in their perceptions of various personality and physical traits from faces belonging to all three groups. Thus, we might say that impressions of facial attractiveness, for instance, are fairly constant across cultures – a face that is found attractive in one culture is generally found attractive in another, foreign culture (see also Cunningham et al. 1995). In a second study, though, Peng et al. (1993) found that, although Americans and Koreans agreed in their perceptions of the rate of speech of American and Korean speakers – they both agreed who was speaking slowly and who was speaking quickly – they disagreed about what meaning that held. Specifically, Americans attributed higher status to individuals who spoke quickly, whereas Koreans attributed higher status to individuals who spoke slowly. Thus, their perceptions were the same but their interpretations were strikingly different.

Some of the most seminal studies in cultural psychology have investigated cross-cultural similarities and differences in a similar fashion. For instance, Hofstede (1980) conducted a large international survey of employees of the company IBM living in numerous cultures. From the data he collected on the workers' self-reported values, he was able to parse a handful of critical dimensions that seemed to describe major differences between cultures, such as distinctions of individualism and collectivism. Another classic study of cultural differences is derived from Witkin and Asch's (1948) measure of field dependence known as the rod-and-frame test. Described simply, participants are presented with a rod within a frame both of which are capable of being moved. The test requires that the participant aligns the rod to a certain angle as the frame is moved. Field independence is described as the successful capacity to orient the rod to the proper angle regardless of the position of the surrounding frame. Field dependence, in contrast, is believed to be in effect when the position of the frame influences where the participant places the rod. That is, perception of the rod's position is relative to the field that is created by the frame. Witkin and Berry (1975) reviewed cross-cultural differences in performance on the rod-and-frame test and reported that individuals who work together collectively (such as farmers) tended to show greater field dependence than did individuals living in industrialized areas where they were more likely to live and work in a more independent or individualistic fashion.

Indeed, in a more recent but influential study, Ji et al. (2000) showed a dissociation between East Asians and Westerners (Americans) on the rod-and-frame test that was reflective of overall differences in holistic versus analytic processing. Americans were found to be field-independent, able to focus on the rod while ignoring the frame. East Asians were found to be field-dependent, highly influenced by the frame's position in judging the angle of the rod. Thus, perhaps because of differences as basic as individualism and collectivism between the two cultures (see also Witkin and Berry 1975), Americans expressed isolated perception and thinking of a single entity (the rod) whereas East Asians expressed integrative perception and thinking of the whole by incorporating literal frames of reference (the physical frame) into their perceptions.

Contemporary work in cross-cultural psychology has continued to broaden our conceptions of other fundamental aspects of behavior and thought in other ways. In one impactful theoretical paper, Markus and Kitayama (1991) provided distinctions of how the self is understood differently in many East Asian versus many Western (e.g., American) cultures. In brief summary, they described how Westerners may think of individuals as independent and constant entities, with the self and others existing quite distinctly, whereas East Asians may think of the self and close others as much more interdependent and existing in relation to particular contexts; i.e., the notion that one does not exist separately from others but in relation to others. Hence, Westerners may be more likely to see themselves as possessing fixed traits regardless of what situation they are in (e.g., "I am a respectful person"), whereas East Asians may be more likely to incorporate the context in assessing their behavior (e.g., "I am respectful with my family"). As a result, East Asians appear more likely to incorporate the situational context and their relationships with others into their self-concepts, basing their views of themselves upon integration of others.

As cultural psychology has continued to grow, it has gained ever more breadth. Rather than cultural psychology existing as the product of spilling over from the fringes of other fields, such as anthropology, cultural psychology has now begun to itself spill over into new disciplines, such as cognitive neuroscience. A currently emerging field is what is known as cultural neuroscience (Ambady and Bharucha 2009; Chiao and Ambady 2007; Han and Northoff 2008). Work in cultural neuroscience has begun to link the differences that have been observed in thought and behavior along cultural lines to what is known about the functions of the brain related to those behaviors. One central example is a recent study by Zhu et al. (2007), which extended Markus and Kitayama's (1991) descriptions of differences in the self between Western and East Asian cultures. Specifically, Zhu et al. (2007) found that the medial prefrontal cortex (mPFC), a brain region previously known to be involved in representations of the self (e.g., Kelley et al. 2002), showed differential activity when individuals thought about themselves versus others for both Western and Chinese participants. Critically, however, when Chinese participants – but not Western participants – thought about their mothers, this also activated the mPFC region. The Chinese participants' overlapping activation in mPFC during thoughts about themselves and their mothers provides evidence for Markus and Kitayama's (1991) descriptions of interdependence in the self-concept of East Asians, whereas Western participants' distinct activation in mPFC during thoughts about themselves and their mothers provides evidence for Markus and Kitayama's (1991) descriptions of independence in the self-concept of Westerners.

The still nascent field of cultural neuroscience is therefore well poised to provide supporting evidence as well as novel insights into the role of culture in thought and behavior. Two domains in which this potential has already begun to blossom are in the contributions of cultural neuroscience to cognition and perception, including the perception and recognition of emotion.

1 Contributions to Cognition

Culture exerts a strong influence on how we think. Indeed, many of the fundamental, core aspects of human cognition are known to vary according to an individual's cultural group membership. These influences span from largely intrapersonal thoughts, such as mathematic processing, to highly interpersonal thoughts, such as communication and considering another's perspective. The confluence of the study of culture with the brain bases of cognition has therefore provided a rich opportunity for a better understanding of how culture shapes thought.

1.1 Language

Perhaps the area of human behavior most marked by cross-cultural differences is language. Language is, indeed, one of the most tangible markers of culture and is perhaps one of the greatest dividers by which cultures remain distinct from one another. As cultures change and evolve, the way in which individuals within a culture communicate both mirrors and guides its changes. These changes and differences are believed to be adaptations to the needs of the people that make up a culture (e.g., Romaine 1994). As such, it has been purported that language provides unique insight into the ways that individuals within a culture think.

One of the most prominent intersections of the study of language and culture exists in the Sapir–Whorf hypothesis. Sapir and Whorf theorized and provided evidence for the influence of one's language upon one's thought (see Sapir 1929; Whorf 1956). An example of this can be found in Boroditsky's (2001) recent work on speakers of Mandarin and English. Mandarin conceptualizes time as running vertically (up and down) whereas English conceptualizes time as running horizontally (left and right). These differences shaped the speakers' habits in terms of thinking about time (e.g., Mandarin speakers were quicker to say that March preceded April when primed with a vertical array consistent with their representation of time), but they were also malleable; that is, English speakers showed evidence of thinking of time vertically after brief training to do so. Thus, although language may have an influence upon tendencies in thought, it does not necessarily constrain thought in a fixed manner.

In terms of brain function, there are data showing that culture can influence the representation of language for both spoken and read speech. For instance, Bolger et al. (2005) conducted a meta-analysis of neuroimaging studies for reading words across different languages and cultures. They found that, despite commonalities across languages in the activation of the visual word form area (VWFA) – an area in the left fusiform gyrus that is selective for reading words (e.g., McCandliss et al. 2003) ideographic writing systems like Chinese were marked by greater activation in the bilateral visual cortices than were alphabetic writing systems like English. Similarly, variations in the brain regions involved in dyslexia has been found across different languages, presumably because of the differences in orthographic (writing) systems (Paulesu et al. 2001). Indeed, the selective representation for written words in the VWFA is, itself, an example of neural adaptation to culture given that writing is one of the fundamental markers of cultural construction and has only existed for a small percentage of humans' existence as a species.

Similarly, Pallier et al. (2003) reported evidence for both cultural universality and cultural specificity in the brain response to spoken speech. Both Korean adoptees to France and native French speakers showed similar responses to sentences spoken in Korean, French, or other foreign languages. The native French speakers, however, showed greater activations when hearing French sentences than did the French-Korean adoptees. In addition, Kovelman et al. (2008) showed that bilinguals exhibited different patterns of brain activity compared to monolinguals, with both groups exhibiting responses in Broca's area but bilinguals showing unique activations in the dorsolateral and prefrontal cortices.

1.2 Mathematics

Cross-cultural differences in the brain response to mathematical calculations are believed to also be influenced by a speaker's language. For instance, Tang et al. (2006) compared native English and Chinese speakers' neural activity as they performed numerical and non-numerical tasks. Similar to the differences in reading found for speakers of alphabetic versus ideographic orthographies, the English speakers showed greater activation in Wernicke's and Broca's language areas and the Chinese speakers showed greater activation in areas involved in visuospatial processing. Thus, mathematical calculations may rely on phonological processing for speakers of alphabetic languages who may be retrieving the mathematical concepts somewhat verbally but may rely on visual processing for speakers of ideographic languages who are less accustomed to associating specific symbols with specific sounds. The language in which mathematics is learned may therefore influence how it is processed, though further work will be needed before a definitive understanding of these differences may be reached.

1.3 Memory

Human memory is one of the most distinguishing and fundamental capacities that we possess as a species. Our ability to remember is essential to learning, adapting to the environment, and overcoming challenges. Being such a core aspect of human growth and survival, behavioral studies have shown that our ability to remember is relatively constant across cultural lines, yet some differences do exist. Park and Gutchess (2006) found that East Asian and Western individuals encoded objects into memory differently depending on environmental context, much like the differences observed between holistic and analytic processing reported by Ji et al. (2000) using the rod-and-frame test.

In elaboration of this effect, Gutchess et al. (2006) conducted an fMRI study in which East-Asian Americans and non-Asian Americans performed a memory task that included objects and scenes. Although both groups performed equally well, they showed differences in the brain regions they used to complete the task. In particular, non-Asian Americans showed enhanced processing in areas related to object processing (such as bilateral middle temporal gyrus, left superior parietal/angular gyrus and right superior temporal/supramarginal gyrus), though no striking differences emerged between the two groups for the processing of scenes. These data may therefore reflect what is known behaviorally about Westerners' focus on independent objects (such as the rod in the frame), whereas East-Asian Americans may be processing both the scene (e.g., the frame without a rod) and the complex scene (e.g., the frame with a rod) somewhat similarly. Future research may seek to explore these phenomena further to better understand the precise nature of this difference in brain activation, particularly given that both types of processing resulted in equivalent performance on the task.

1.4 Perspective-Taking

The ability to understand others' thoughts is one of the most defining attributes of human behavior (e.g., Saxe and Baron-Cohen 2006). This "thinking about thinking" is often referred to as "theory of mind" as it requires the theorizing that others have minds like one's own and that one may therefore be able to use one's own mind to understand what is occurring in others' minds (see Gallagher and Frith 2003, for a review of theory of mind). Naturally, the ability to infer what is going on in others' minds can be mitigated by the assumptions inherent in one's own culture and the adjustments needed to be made when inferring the state of mind for persons belonging to a different culture.

In one test of this, Kobayashi et al. (2006) presented false-belief and cartoon tasks to American and Japanese children while measuring their brain responses using fMRI. An example of such a task would be that someone places an object into a cupboard in the presence of an observer. The observer then leaves and the object is moved from the cupboard into another location. The test, then, is to see whether the child will understand that the observer still thinks the object is in the cupboard (since this is where the observer saw it placed) or if the child will mistakenly apply his or her own knowledge about the object's true, current location to the observer. If the child expresses a theory of mind, she should be able to take the perspective of the observer and assume that he will look for the object in the cupboard. In this instance, Kobayashi et al. (2006) found that the American and Japanese children both showed common responses in the ventromedial prefrontal cortex (vmPFC) and precuneus. Thus, children from both cultures recruited the same brain regions when taking the perspective of others.

A second study of perspective-taking in adults showed similar commonalities. Employing a task known as the "reading the mind in the eyes" test (Baron-Cohen et al. 2001), Adams et al. (2010) found that both American and Japanese participants showed responses in the superior temporal sulcus (STS) – a region previously implicated in understanding others' intentions – when inferring the mental states of others. The particular task involved presenting American and Japanese participants with photos of American and Japanese faces, cropped so that only the eyes were visible. Participants were then asked to select from two choices the adjective that best described the target's mental state. This task is believed to require the perceiver to take the perspective of the target in order to infer his or her state of mind. Hence, individuals who lack mental inference abilities (such as patients with neurological damage) show severe impairment in choosing which adjectives best describe the targets' mental states (Adolphs et al. 2002).

Although both the American and Japanese participants showed activation in the STS during this mental inference task relative to simply judging the sex of the targets' eyes, each group showed stronger activation for members of their own culture relative to members of the other culture. Specifically, Japanese participants showed a stronger response in the STS when inferring the mental states of other Japanese targets than they did when inferring the mental states of American targets. Conversely, American participants showed a stronger response in the STS when inferring the mental states of other American targets than they did when inferring the mental states of Japanese targets. Thus, although the pattern of responses was similar and congruent across cultures, it was moderated by the relationship with the culture of the target being perceived.

2 Contributions to Perception

Perhaps one of the most apparent influences of culture is its effect on how we perceive and interpret the world. Culture can influence how we perceive and interpret higher-level constructs, such as ourselves and others (e.g., Markus and Kitayama 1991; Zhu et al. 2007) and it can also influence how we perceive and interpret more basic, lower-level information, affecting vision and attention (e.g., the rod-and-frame test; Ji et al. 2000). Given that the visual system is perhaps the most thoroughly studied topic in the cognitive neurosciences, the intersection of culture and the cognitive neuroscience of vision holds great explanatory power for understanding cultural differences in thought and behavior.

2.1 Object and Background Processing

Culture can have profound effects upon what things we see and how we see them. As already introduced above, behavioral studies have shown that East Asians are more likely to perceive objects and scenes as wholes, with their component parts interrelated to one another, whereas Westerners are disposed towards perceiving objects and scenes according to their distinct parts, considering them to be separate independent entities. Consequently, East Asians may attend more to the background in a scene whereas Westerners may attend more to the objects in a scene.

In evidence of this, Kitayama et al. (2003) created an adapted version of the rod-and-frame test. Rather than present participants with a moveable rod and frame and asking them to consider their relative angles, they instead printed lines within boxes and asked participants to attend to the lines' lengths. Participants were then instructed to reproduce a line of the same length either by drawing a line of the same absolute length of the original line or by drawing a line of the same proportional length with reference to the line's distance from the printed box/frame. Consistent with the previous work using the traditional rod-and-frame test (e.g., Ji et al. 2000), Americans were more accurate at reproducing lines of the correct length when asked to attend to absolute size and Japanese were more accurate at reproducing lines of the correct length when asked to attend to relative size. These differences suggest cultural variation in visual attention that may occur because of differences in how percepts are integrated and related to one another across cultures.

Hedden et al. (2008) provided further understanding for these effects by conducting a modified version of this task while scanning American and East Asian participants using fMRI. Participants were instructed either to make absolute or relative judgments of the lines as a means of judging whether they matched a previously presented line and box stimulus. When participants performed judgments that were inconsistent with their cultural orientation (i.e., East Asians making absolute judgments and Americans making relative judgments), they showed activation in a robust and widespread network of frontal and parietal brain regions involved in the exertion of attentional control. Thus, performing the task in a manner that is believed to be incongruent with the preferred independent (American) and interdependent (East Asian) method of perception required great effort and cognitive control. These data therefore demonstrate the strong influence of culture on the development of perceptual preferences.

Other studies have provided similar insights. For instance, Goh et al. (2007) found that elderly East Asian, Singaporean participants showed less of an adaptation response in the object-processing areas of the brain compared to older Western adults. That is, Westerners who were presented with images of an object placed in various scenes showed reduced neural activation to the object with subsequent presentations (they adapted to seeing the object). In contrast, East Asians who were presented with images of an object and scene continued to show an equally strong neural response during subsequent presentations of the same object, with all iterations showing a response as if they were seeing the object for the first time. Consistent with Gutchess et al.'s (2006) findings that East Asians and Westerners process objects and scenes differently when encoding them into memory, these findings suggest that Westerners are allocating greater attention to objects (i.e., they are noticing them and adapting to them) than are East Asians, whose attention may be directed elsewhere (such as to the background or to consideration of the object's relationships to other percepts). However, Goh et al. (2007) only observed these effects among older adults and not among young adults. Therefore, further work will need to examine these phenomena in more detail before firm conclusions can be reached.

2.2 Social Cues

A corpus of research has investigated the similarities and differences involved in perceiving social cues across cultures. As mentioned above, Zebrowitz et al. (1993) investigated the perceptions and attributions made to same-culture and other-culture faces for a host of traits and found fairly strong consistency in how both same-culture and other-culture faces were perceived by African-American, European-American, and Korean perceivers. Similarly, Albright et al. (1997) observed that American and Chinese perceivers agreed in their perceptions of extraversion and agreeableness for the faces of same-culture and other-culture faces, and Cunningham et al. (1995) observed consistency between American and Taiwanese perceivers in judgments of facial attractiveness. Finally, Rule et al. (2010) found that American and Japanese perceivers agreed in their judgments of personality traits (dominance likeability, and trustworthiness) and facial maturity from the faces of American and Japanese political candidates. In addition, their judgments were significantly related to the percentage of votes that the candidates received in their respective elections. The traits that predicted these outcomes, however, differed: traits related to power (dominance and facial maturity) significantly predicted the American candidates' success whereas traits related to warmth (likeability and trustworthiness) significantly predicted the Japanese candidates' success. In turn, when American and Japanese participants were asked to indicate how likely they believed it was that members of each culture would vote for a given candidate, their judgments only predicted the election outcomes for targets from their own culture. Therefore, although there is consistency across cultures in the perception of many traits, what is done with this information may be relative to the individual cultures.

One trait of particular importance to social behavior is dominance (Mazur 2005). Dominance can be readily observed from nonverbal cues (Schmid Mast and Hall 2004) and exerts particularly strong effects upon the way that individuals interact, as well as the establishment of status hierarchies (Schmid Mast 2001). Moreover, dominance is consistently recognized across cultures (Rule et al. 2010). Given the cultural differences in the treatment of status between collectivistic and individualistic cultures, it therefore seems possible that cues to dominance and submission might hold different meanings for members of collectivist (e.g., East Asian) and individualist (e.g., Western) cultures. Indeed, in the USA, there is more encouragement to be dominant, as dominant thinking and behavior is positively reinforced. Conversely, in Japan, there is more encouragement to be submissive, as paternalism and subordination are positively reinforced (e.g., Bhappu 2000; Jung et al. 1995). Americans are therefore encouraged to be independent and assertive, whereas Japanese individuals are encouraged to be sociable and cooperative (e.g., Moskowitz et al. 1994), reflecting dominance and subordination, respectively.

One study directly tested whether differences in expressions of dominance and submission may elicit differences in neural responses from members of a collectivistic culture (Japan) and an individualistic culture (the USA). Freeman et al. (2009) presented American and Japanese participants with outlines of bodies posing dominant and submissive postures and administered a survey assessing the participants' personal tendencies towards dominance or submissiveness after the scan. Americans reported a proclivity towards expressing dominant behavior, whereas Japanese reported a proclivity towards expressing submissive behavior. Moreover, the neuroimaging results revealed that the head of the caudate nucleus and the mPFC, two important components of the mesolimbic reward system, showed stronger responses to dominant stimuli in the American perceivers and stronger responses to submissive stimuli in the Japanese perceivers. Lastly, activity in the right caudate and mPFC correlated with the participants' self-reported behavioral tendencies towards dominance and submission, such that stronger responses in the caudate and mPFC to dominant stimuli were associated with more dominant individuals and stronger responses in the caudate and mPFC to submissive stimuli were associated with more submissive individuals.

Perceptions of dominance and submission from the nonverbal displays of others were, respectively, more rewarding for individuals who themselves were characterized by those behaviors. Moreover, regardless of individual differences in preferences for dominance and submissive dispositions, cultural group membership was also associated with stronger neural responses for the type of behavior that was more endorsed by the perceiver's culture (i.e., Americans found dominant stimuli more rewarding and Japanese found submissive stimuli more rewarding).

3 Contributions to Emotion Recognition

One area of perception that has been particularly well studied cross-culturally is that of emotion recognition. Perhaps the most fundamental contribution to our understanding of the expression and recognition of emotions across cultures is Ekman and colleagues' account of the universality of emotion displays and recognitions across diverse nations, both highly industrial and incredibly rural (e.g., Ekman 1980; Ekman et al. 1969). This work led to the development of the concept of the five basic emotions: anger, fear, happiness, disgust, and sadness.

Subsequent behavioral work has expanded what is known about the expression and recognition of emotions across distinct cultures. One influential account was a meta-analysis by Elfenbein and Ambady (2002) that uncovered a significant cultural ingroup advantage in emotion recognition. That is, although almost all emotion recognition judgments surveyed were found to be categorized significantly better than chance guessing (about 58% accurate, overall), there was a statistically significant increase (about 9% greater, on average) in the ability to recognize the emotional expressions of members of one's own group versus the emotional expressions of members of a different group. One explanation offered for this effect is that the ability to read the emotions of ingroup members would provide an adaptive advantage and would facilitate social interaction. In addition, the increased ability to recognize the emotions of one's ingroup could be the result of increased exposure and experience with ingroup members versus outgroup members – what is called the "familiarity breeds accuracy" effect (Elfenbein and Ambady 2003).

One neuroimaging study investigated the ingroup advantage in emotion recognition. Chiao et al. (2008) presented American and Japanese participants with American and Japanese faces posing angry, fearful, happy, or neutral expressions. Both American and Japanese participants showed significantly greater bilateral amygdala response to the perception of fear faces when posed by same-culture, ingroup faces as compared to fear expressions posed by other-culture, outgroup faces. Thus, American participants showed a stronger amygdala response to fearful American faces and Japanese participants showed a stronger amygdala response to fearful Japanese faces. Notably, no significant differences were observed for anger, happy, or neutral expressions. In accordance with an evolutionary perspective on emotion recognition, however, this finding is sensible. Fear expressions may be some of the most important for communicating with ingroup members. Expressions of fear may provide information about dangers in the environment; thus, they would be particularly valuable for ingroup members who, through similarity and shared experiences, might also be vulnerable to such potential threats. In addition, expressions of fear may be particularly valuable for evoking the help of others (see Marsh et al. 2005). Thus, it would again be adaptive to recognize fear signals from ingroup members, as they might motivate helping behavior that would contribute to the survival of the group.

4 Conclusion

Growing out of the very beginnings of the empirical study of psychology, cultural neuroscience is a field with great promise. As we have shown here, the many advances in cultural psychology that have benefitted our understanding of the role of culture in human thought and behavior are now themselves becoming the beneficiaries of critical insights from cognitive neuroscience. These insights have thus far allowed for a deeper understanding of the processes that underlie the cross-cultural similarities and differences previously observed in behavioral work. In addition, they hold great potential for an increased understanding of how culture influences behavior, the mind, and the brain. Together, then, cultural neuroscience not only presents critical and helpful information for understanding the mind and behavior but also presents information relevant and useful for understanding the neural basis of many psychological processes, as well as a more complete picture of the plasticity and adaptive capacity of the brain's response to its culture and environment. Thus, though still in its infancy, cultural neuroscience shows considerable potential for what it may offer in the decades to come.

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Psychological Time, Time Perspective, Culture and Conflict Resolution

Dan Zakay and Dida Fleisig

Abstract This chapter discusses the dimension of time in relation to various aspects of life. After presenting several types of time – physical, biological and psychological time – the relationship between time and personality and time and behavior are discussed. Two cultural categories are defined – the Western technological culture and the "non-Western" cultures, differing in their attitude toward time: Western technological culture, having a linear and quantitative perception of time, as opposed to "non-Western" cultures, having a cyclical and qualitative perception of time. The concept "time perspective" – the subjective organization and perception of the past, the present and the future – is introduced, and differences in time perspective between individuals and between cultures are discussed. It is argued that time is strongly related to the emergence of conflicts. Several time-related heuristics and aspects linking dimensions of time to the emergence of conflicts are presented. As conflict resolution processes take time, negotiators' relation to time influences those processes. Time is often tactically used as a source of power by the party lacking a sense of urgency, and is frequently used in setting deadlines. And time is essential in building trust between negotiating parties. As the temporal perspective is a major factor in conflict resolution, holding future time perspectives by both parties might be optimal.

Keywords Conflict · Culture · Personality · Time- Urgence · Time- Perspective

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1 Introduction

Time is an inseparable part of every event or occurrence and human experience (Flaherty and Meer 1994). The dimension of time is essential to the lives of all living creatures. It affects the ability to optimally adapt to the environment, and therefore it is a decisive factor in determining the ability to survive (Michon 1985). This statement is true of every living creature, and human beings are no exception to this rule. It would be impossible to describe the way of life in any human culture without referring to the dimension of time. The relationship to time is what enables social life, trade and economy, interpersonal communication and more (Zakay 1998). As it plays such a central role, the dimension of time is discussed in relation to many and varied aspects of life (see Brix 2009).

In this chapter, we set out to analyze the dimension of time, as an attribute of individual personality, and of culture, while emphasizing the concept of time perspective, and discussing its implications on negotiation processes and the ability to resolve conflicts and feuds.

2 Types of Time

Time is multifaceted. We may consider several types of time, the central ones being physical time, biological time and psychological time.

Physical time (*clock time*). It is objective and consistent, and when measured with any type of clock, reflects a defined and standard change occurring within a defined physical element. Physical time is characterized by its steady and consistent pace. It is conceptualized as a continual progression from the past to the future. This type of time is not dependent on the essence and nature of the events that occur within it.

Biological time. It represents the occurrences of biological processes that take place in living organisms. These processes are controlled and regulated by biological and physiological time keepers. Biological time is reflected in cycles such as circadian rhythm. Biological time is continuous; however, its pace is not necessarily steady and consistent in all situations. There is a direct and monotonous link between biological time and clock time.

Psychological time. This is the time as experienced by consciousness, and as such it is perhaps unique to mankind. Various species of animals are capable of time dependant behavior, but this does not necessitate the assumption that they have an awareness of the passage of time (Roberts 2002).

Psychological time is essentially different from clock time and biological time. It is not necessarily continuous, its pace is not steady, and its direction may be from the future to the past, as is sometimes the case in states of consciousness such as dreaming or hallucination. Psychological time is relative, and context dependant. Thus, for example, when we are engaged in an interesting activity, we do not feel the passage of time. On the other hand, when we are experiencing pain, or a state of boredom, time is perceived to "stretch out."

Psychological time itself is dependent on its method of measurement. A predominant distinction is made between "retrospective" time, which refers to the sense of time pertaining to an event that has already taken place, and "prospective" time, which refers to the sense of time pertaining to an event as it is occurring. The experience of time in each of these cases is intrinsically different (Zakay and Block 1997), as are the cognitive processes which are at the foundation of each of these time experiences (Zakay 2007).

3 The Essence of Time

The essence of time has always been illusive and unclear to man. Fourth century philosopher, St. Augustine, expressed this poignantly in his book "Confessions," in which he wrote: "What then is time? If no one asks me, I know what it is. If I wish to explain it to him who asks, I do not know."

The conclusion reached by St. Augustine was that, whatever time is, it is subjective by nature (Roeckelein 2008). Eighteenth century philosopher, Immanuel Kant, argued that time and space are both a priori dimensions, meaning that they are not the product of a perceptual process we undergo through life, but rather that they are built into our consciousness from the start. Modern perception also considers time to be a product of consciousness, rather than a product of a naturally existing chronometric order (Trautman 1995). Either way, the effects of time, and the relationship to it, are prominent attributes when it comes to characterizing an individual's personality and behavioral style.

4 Time, Personality and Behavior

The relationship to time is one of the elements which reflect the personality structure of an individual. This finds expression in several aspects and attributes. The attribute referred to as "time urgency" reflects the degree to which an individual experiences a sense of time pressure as part of everyday behavior. Time urgency was found to be linked to behavioral patterns, referred to as type A and type B, as well as to patterns of sickness and health (Gastorf 1981). Those characterized as having a high time urgency are always in a rush. They perform tasks quickly and always feel that there is not enough time, compared to those characterized as having a low time urgency.

Another example of the relationship to time as a qualifier of human personality and behavior, is the distinction that is made between having a "monochronic," i.e., "individualistic" relationship to time, versus having a "polychronic," i.e., "collectivistic" relationship to it (Hornik and Zakay 1996). Those with a monochronic or individualistic perception of time tend to deal with one subject in any given unit of time, and follow a precise timetable that progresses sequentially from one subject to the next. Unlike individuals with a monochronic or individualistic perception of time, those with a polychronic or collectivistic perception of time tend to deal with a range of topics within a given unit of time, and do not tend to follow a set timetable.

Additional personality attributes that are related to time are, for example, punctuality versus procrastination. Some people are pedantically accurate and always arrive promptly on time to every meeting. Others, on the other hand, consider the set time of a meeting to refer to an area in time, rather than to a specific point in time. Punctuality bears no significance for such individuals. Of course, this has an effect on the ability of such individuals to maintain regular social frameworks with others, and to adapt to various social demands that require sticking to schedules. Good time orientation is a criterion that attests to an ability for reality testing, which is characteristic of the normal personality. In pathological cases, in which the reality testing ability is impaired, the time orientation ability of the individual will also prove to be damaged.

The dimension of time is tightly linked to the construction of self identity, but we will return to this point subsequently. First, let us discuss the link between time and culture.

5 Time and Culture

Culture is delineated by the system of beliefs and concepts held by all of those who belong to it (McInerney 2004). The relationship to time and the manner in which it is conceptualized are a central factor in distinguishing between various cultures, as well as in distinguishing between various behavioral attributes of the members of a culture, such as pace of life, punctuality, and more. The structure of the language prevalent within a certain culture is also linked to the conceptualization of time within that same culture. For example, if a certain culture has no linguistic concepts pertaining to the past, present or future, in a distinct manner, it is highly likely that the members of this culture themselves do not make any distinctions between the past, present and future. Behaviorally, they operate within a “single time space.” This is evident in the lack of ability amongst very young children to conceptualize time and the differences between past, present and future. Although this is not a “culture” in the conventional sense of the word, it serves to demonstrate the link existing between the conceptualization of time, language, and behavior. Very young children reside in a continual present, for as long as their cognitive ability to conceptualize time remains undeveloped (Pouthas et al. 1993). It is possible to analyze the differences between cultures based on several attributes of time. These include the distinction that is made between past, present and future; the direction of time; relating to time as being “quantitative” or “qualitative”; time’s relationship to man; the value of time and the pace of life; and time perspective.

Roughly speaking, cultures may be divided into two categories in terms of their relationship to time. In doing so, we do an injustice to a variety of cultures, but lack of space necessitates such a division.

One category is that of the Western technological culture (hereinafter referred to as "techno-Western" culture), while the other is an aggregate of "non-Western" cultures, such as the Eastern cultures, and the indigenous cultures in South America and other places. These include, for example, the American Indian tribes during the times predating Western conquest, and the ones still existent today (some refer to the time associated with these cultures as "Indian time").

We shall review the differences between these two categories of culture, according to the dimensions previously specified.

5.1 The Degree of Distinction Between Past, Present and Future

In the techno-Western culture, the distinction is clear. Linguistic expressions describing the various times are well defined, and the grammar of the language clearly formalizes the manner in which verbs are to be conjugated, according to the time they are depicting. In non-Western cultures, in many cases the past is often unified with the present, or the present is unified with the future. This is demonstrated in the language of the American Indian Hopi tribe, in which there are no terms representing past, present or future, as well as no verb conjugations corresponding to the different times.

5.2 The Direction of Time

There is a central distinction that is made between having a linear perception of time, as progressing from the past through the present and into the future, as opposed to having a cyclical perception of time. A linear perception of time is characteristic of the techno-Western culture, and is grounded in the Newtonian concept of time. A cyclical perception of time is characteristic of non-Western cultures, and reflects a relationship to the cycles of nature, such as the seasons of the year, which are significant when it comes to agriculture, or the cycle of life which manifests as birth, death, reincarnation, and rebirth. Thus, time revolves progressively and eventually returns to its initial point of departure.

These conceptualizations have different implications when it comes to planning the future. According to the linear approach to time, the future is still to come. According to the cyclical approach on the other hand, the future is deterministic in nature, and therefore planning it is utterly insignificant, for "what has been will be again, and there is nothing new under the sun" (Ecclesiastes, Chap. 3, 1–9). It appears that in non-Western cultures the significance of planning is diminished, as opposed to the status it holds in the techno-Western culture.

5.3 Relating to Time as Being "Quantitative" or "Qualitative"

"Qualitative time," which is also referred to as "event time," is characteristic of the non-Western cultures. The units of qualitative time are not uniform, as they depend on the events occurring within them. Thus, for instance, in Bedouin culture, the length of time it takes to walk from one place to another may be defined as "the time it takes to smoke a cigarette." Linguistically, time is not divided into small and arbitrary units such as "second" and "minute." Rather, it is divided into larger units that reflect natural phenomena, such as "month," or "year."

This is demonstrated in expressions such as "the time it takes to milk the cows" in Uganda, or "the time it takes to catch the fish" in Eskimo culture. Both these expressions are used to describe qualitative lengths of time which cannot be quantitatively measured. The members of the "Koa-Choa" tribe living in South America have no linguistic expression referring to the difference in hours, yet they do have the qualitative measure of "the time it takes to boil potatoes."

Punctuality is of lesser value in qualitative cultures, compared to its importance in quantitative cultures. This is effectively reflected in the fact that little importance is placed on arriving promptly to meetings set at specific times, or to following tightly defined schedules. Thus, for instance, the American Indians have a saying according to which "an event will occur when the time is ripe for its occurrence."

"Techno-Western" culture is characterized by its quantitative perception of time, which is grounded in the physical Newtonian concept of time, according to which time is a dimension independent of all other dimensions. All units of time are identical regardless of the events taking place within them. Accordingly, the language includes terms for describing small units of time such as "second," "minute," and "hour." These are arbitrary units that do not directly reflect natural phenomena. In cultures adhering to quantitative time, life is conducted according to set schedules, and punctuality is a value with which the society indoctrinates its members.

5.4 Time's Relationship to Man

According to the techno-Western culture, time is a natural phenomenon, which is neutral by nature and therefore has no value-appropriated relationship to man. According to non-Western cultures, however, time is not neutral. Sometimes, time is man's enemy, for death indeed arrives with the passage of time. On the other hand, time can also be man's friend, as it represents renewal, new birth and the potential for healing.

5.5 The Value of Time and the Pace of Life

From all of the above it is clear that there is a difference in the value of time in the techno-Western culture, as opposed to its value in non-Western cultures. In the techno-Western culture, time is a financial resource (time equals money). It is a resource that can be spent and saved, and so, accordingly, there are linguistic expressions that express this notion. Techno-Western culture has seen the development of an approach to time referred to as “temponomics,” an expression which incorporates terms from the realms of time and economics (Hornik and Zakay 1996). This is an economic approach to, and concept of, time, which dictates that time must be utilized, therefore resulting in a fast pace of life.

The value of time in non-Western cultures is not economic, and, as has already been stated, its value depends on the nature of the events occurring within it. The pace of life in these cultures is also dependant on the events taking place, and tends to be slower, compared to life in the techno-Western culture.

6 Time Perspective

We have delayed the discussion of time perspective to this point, as it is an attribute of individuals, as well as of cultures. Time perspective refers to the subjective organization of the past, present and future, and to the relative importance given to each of these time zones (Macey 1994).

Time perspective is defined as “the process whereby individuals and *cultures* assign the flow of personal and social experiences into the temporal categories of past, present or future, that help to give order, coherence and meaning to those events” (Zimbardo et al. 1997). It is a cognitive frame “used in encoding, storing, and recalling experienced events as well as in framing expectations, goals, contingencies, and imaginative scenarios” (Zimbardo and Boyd 1999).

Time perspective is comprised of the individual constructs and differences in experiences, judgments, values, functional responsibilities, and many other personal factors which cause different individuals to have different views. It can be considered as a framework of reference which gives order, organization and meaning to life events (Boyd and Zimbardo 2005). People may be characterized as having a past, present or future perspective. Respectively, people base their behavior on the events of the past, present occurrences, or their image of the future (Karniol and Ross 1996). This is an attribute which greatly influences behavior, and it is shaped and affected by personal, social and cultural events (Zimbardo and Boyd 1999). Thus, for example, it was found that the time perspective of Holocaust survivors tends to be largely based on the past, compared to others of the same age group who did not experience the Holocaust (Shmotkin and Lomranz 1998). Survivors perceive the Holocaust itself to spread out over the entire past, even though in terms of “clock time” it lasted only 4 years. The trauma of the Holocaust is what appears to have caused them to focus their life on the past.

There is a link between the time perspective of an individual and their lifestyle. An individual living solely in the future may find him/herself living in a world of pure fantasy, which makes it difficult to be grounded in reality. On the other hand, a person who has absolutely no regard for the future may experience difficulty in planning and directing his or her life. And indeed, having a healthy personal identity necessitates having a correct perception of the past, present and future, while maintaining a continual and sequential connection between the three. When no such connection is maintained, linking the past to the future, a person is not capable of constructing an integrative personal identity, and this could lead to the pathological condition known as "depersonalization."

Like individuals, groups and cultures can also be qualified according to their dominant time perspective. As was previously discussed, the techno-Western culture is characterized as having a greater degree of future perspective, compared to other cultures, which place more emphasis on the past. Traditional cultures that are based on religion tend to have a greater degree of past perspective, compared to the technological-secular cultures. According to Brisling and Kim (2003), American Indians live in the present, but they are also future-oriented.

6.1 Summary: Techno-Western Time Versus Non-Western Time

It is possible to characterize two cultural categories in terms of their relationship to time and their conceptualization of it.

6.1.1 Techno-Western Culture

This culture views time as an economic resource, and as a continual linear dimension which progresses from the past toward the future at a fixed and steady pace.

The essence of time does not depend on the events occurring within it.

Time has a neutral relationship to man.

The time perspective is future-oriented.

Emphasis is placed on the importance of punctuality and planning.

6.1.2 Non-Western Culture

This culture views time as cyclical.

Time is not measured quantifiably and its essence depends on the events occurring within it.

Time does not necessarily have economic value and it is not neutral in its relationship toward man.

The time perspective is past-oriented.

Punctuality and planning are not necessarily central values in this culture.

6.1.3 Conceptualizing Time in the Twenty-First Century

The descriptions of the conceptualizations of time, as were previously brought forth, provide a good portrayal of the situation that was prevalent in previous centuries.

Nowadays, it is difficult to find purely non-Western cultures, as the techno-Western culture has an increasingly expanding range of influence.

At the same time, however, our claim is that there are still many aspects of life which are deeply and significantly influenced by the conceptualization of time, within the different cultures. One of these aspects is the treatment of conflicts within these cultures, and the methods by which they are resolved. This is due to the profound ideological and emotional charge that is associated with many conflicts, which causes deep layers of the personality to rise to the surface, so to speak, and affect behavior. We shall demonstrate this point later on.

6.2 Time and Religion

The conceptualization of time, being a vital element of any attempt to explain human existence, constitutes a central and essential component of any system of religious beliefs (Birx 2009).

Furthermore, there is a tight link between culture and religion. Therefore, nearly all religions have a relationship to time and to the manner in which it is conceptualized.

Ultimately, when analyzing the perception of time and its conceptualization, the combination of culture and religion must be taken into account.

This combination has a unique significance when it comes to attempting to understand conflicts that include cultural as well as religious components.

7 On the Link Between the Dimension of Time and the Emergence and Development of Conflicts

The dimension of time is tightly linked to the emergence and development of conflicts. This is due to the fact that time is a dimension, which in many ways constitutes a type of boundary and buffer between people and cultures. Thus, for example, people live in different time zones, and this creates a social buffer which makes “active” communication difficult. The symbolic meaning, with which various cultures and religions endow certain dates and times, is another source of conflicts. An example of this is the commemoration of various holidays and memorial days in different cultures. Jamal (2009), notes that the relationship to time is one of the central obstacles toward achieving intercultural harmony. Elias (1992) points out that the division of time constitutes a mechanism which reflects the balance of power between different groups, with the side determining the division of time effectively forcing a certain quality of life upon the other. An example of this can be found in the setting of calendars, work days and vacations.

Another aspect linking time to the emergence of conflicts, is the fact that time is a limited resource. This is true in all societies and cultures, but is especially salient in techno-Western ones, which has an economic approach to time (temponomics). An example demonstrating this approach is the behavior displayed while waiting in a queue. A queue is a social system in which those who are waiting compete over the division of the resource of time. There is a basic expectation, held by all of those who are waiting, that distributional justice will be exercised in the division of the resource of time. However, in many cases, this expectation goes unfulfilled (Fleisig et al. 2009). As a result, conflicts, sometimes even violent ones, erupt amongst those waiting in line. In a comprehensive survey which polled 10,000 adults, it was found that, in couples, a difference in the attitude toward time held by each of the partners is a prominent factor in the development of conflicts (Boyd and Zimbardo 2005).

A third aspect linking the dimension of time to the emergence of conflicts is the fact that every conflict is a social process which develops along the axis of time. As a result, factors and processes that influence the length of a conflict can influence its development and its chances of escalating or diminishing.

7.1 The Effect of Time-Related Heuristics on the Emergence of Conflicts

Heuristics are intuitive, unconscious thought processes, which defy rational explanation, and they have been described at length by Tversky and Kahneman (1974). Some heuristics are influenced by the relationship to time, such as, for example, the "sunk cost" heuristic (Gerland 1990). This heuristic thinking manifests behaviorally in a willingness to take relatively high risks, in order to preserve results that were gained from action taken in the past. The risky course of action is chosen, even when rational analysis indicates that it is not worthwhile to do so, as there is much more to be gained by forgoing the action than by preserving it. A quintessential example of sunk cost-based behavior is the continued investment in a failing share on the stock exchange. This behavior seems to reflect a lack of willingness to admit that a mistake was made, and an attempt to justify action that was taken in the past. Sunk cost-based behavior can also lead to the escalation of conflicts, as one or both sides are not prepared to own up to mistakes that were made in the past. This in turn leads to an unwillingness to make sacrifices, even when it would be preferable, from a rational point of view, to make the sacrifices rather than to prolong the existing situation (Bruckner 1992).

8 The Effect of the Relationship to Time on Conflict Resolution Negotiation Processes

The concept of time is one of the most important formations of strategic management (Thomas and Greenberger 1998).

Conflict resolution is a strategic process which is often done by conducting various types of negotiation processes. These negotiations are conducted either directly between the parties, or by means of mediation and arbitration conducted by a third party. These processes take time, and therefore the parties' relationship to time influences these processes and their chances of success (Druckman 1994). We shall review several possible ways in which the relationship to time affects negotiation processes.

8.1 Tactical Use of Time as a Source of Power

A party under the impression that time is working for them, and lacking a sense of urgency when it comes to completing the negotiations within a short, set time, is in a position to use time as a source of power over their opponent, who is anxious to complete the negotiations. Possible tactics for doing so include postponing and procrastination. Raiffa (1982) conducted a laboratory study in which he found that the party who had better control of the time, and felt less urgency to complete the negotiations, had better chances of obtaining more favorable outcomes, compared to the party with lesser patience and control of the time.

8.2 Setting Deadlines

Setting deadlines is another tactic commonly used in negotiations. It was found that setting deadlines creates a sense of time pressure, and increases the tendency to make concessions, in those who feel that time is working against them (De Dreu 2003).

However, Druckman (1994) claims that setting any type of timeframe contributes to the advancement of the negotiations. This is due to the fact that in the absence of any defined time limit, both parties are liable to find themselves at a standstill.

8.3 The Effect of the Temporal Distance on the Date of Resolution

Henderson et al. (2006) found that it is easier to reach an agreement that is to be implemented in the distant future than it is to reach an agreement that is to be implemented in the near future. This is explained by time construal theory (Trope and Liberman 2003), according to which people relate to an event in the distant future on a global, elevated and abstract level, without putting too much emphasis on the details. On the other hand, people relate to events in the near future in a concrete manner, and with a great regard for detail.

8.4 The Effect of Time on the Building of Trust Between Parties to a Conflict

Building trust between the parties is a central and vital element of conflict resolution (Lewicki and Wiethoff 2000). These researchers note that building trust is a process which develops over time, since parties to a conflict must be convinced of the purity of their opponent's intentions, and that the promises and commitments that are undertaken will indeed be kept. This could be the reason why successful conflict resolutions are usually reached gradually, via a series of intermediate stages. An example of this can be found in the Israeli–Egyptian peace process, which was constructed with the aid of US Secretary of State at the time, Henry Kissinger, as a series of intermediate agreements, which eventually led to the complete and final agreement (Stein 1985). Another example is the conflict resolution process in Northern Ireland.

This gradual process allows the parties to witness the integrity of the other party's intentions, thus building mutual trust.

8.5 Temporal Perspective and Conflict Resolution

It seems to us that an important factor in determining the chances for conflict resolution is that of the temporal perspective of the negotiating parties. According to the analysis previously brought forth, temporal perspective is an attribute of individuals as well as of societies and cultures. In our opinion, when the temporal perspectives of leaders, who represent groups on opposite sides of the barricade, are not in accord, the chances of successful conflict resolution are diminished. The optimal situation is when both parties have a future time perspective. The future time perspective is what allows the parties to take a mature approach and choose a problem-solving strategy, while getting over their residual grievances from the past. Fisher et al. (1991) also agree, noting that in order to reach a favorable outcome that is agreed by all in a negotiation, the parties must focus on the future. Accordingly, Das (1991) states that time has been called "the hidden dimension of strategic planning" and the subject of strategic planning is concerned intrinsically with the temporal dimension, especially the future time dimension.

However, in many cases, parties are attributed as having past time perspectives, which cause them to immerse themselves in discussions of the past, holding on to the mission of turning back time. Punishment and revenge are possible motivations in such cases. This past time perspective prevents mature problem solving, since it is related to sunk cost mentality and a reluctance to make concessions. The outcome in such cases is likely to be one of escalation.

An analysis of several examples of successful conflict resolution indicates that the constructive treatment of past events, while focusing on solving problems for the future and abstaining from punishment or revenge, is what allowed the parties to reach a solution agreed by all.

The Reparations Agreement between Israel and Germany can be mentioned in this context (Feldman 1999). On the one hand, the agreement constitutes an admission by the Germans that the Nazi regime was guilty of the atrocities committed in the Holocaust. However, these very reparation funds are what enabled the State of Israel to build itself. And, indeed, as a result of the Reparations Agreement, a diplomatic relationship has gradually evolved to the point of being fully recognized by both states.

Another example is that of the settlement reached in South Africa between Nelson Mandela and F. W. De Klerk (Gibson and Goans 1999). The success of the agreement lies in the fact that, under the leadership of Nelson Mandela, the black majority was not seeking revenge against the whites for what took place under apartheid. Instead, a new social order was established, which was based on democracy, and through democratic elections, the government was effectively put in the hands of the blacks. At the same time, the whites were not being marginalized, and could continue to contribute to the economy of the new South Africa. Nelson Mandela was elected President, and F. W. De Klerk was appointed as Executive Deputy President. An interesting aspect of the settlement was the establishment of the Truth and Reconciliation Commission, to document human rights abuses committed under apartheid, and to grant amnesty to those confessing their nefarious deeds.

9 Summary

This chapter presented a discussion on the link between psychological time, the personality of the individual, and cultural attributes, and the effects these elements have on the emergence of conflicts and their resolution. Temporal perspective is a key concept in each of these components. It is a central attribute of the individual's personality, and of the culture at large. The analysis has demonstrated that the relationship to time has implications on the emergence of conflicts, and on the chances of successfully reaching a resolution. It has been suggested that the temporal perspective attributes of parties to a conflict play a significant role in determining the chances of reaching resolution. In optimal conditions, both parties have a future time perspective, whereas a problematic situation arises when both sides have a past time perspective. This element has not yet been sufficiently researched. We believe that a better understanding of this subject would greatly contribute to the chances of successful conflict resolution in various aspects of life.

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Co-creation Systems: *Ma* and Communication

Yoshihiro Miyake

1 Introduction

People are cooperatively creating improvisational group expressions in various interpersonal communications. Because this is quite a common situation, we usually do not think carefully about how it works. Looking more closely, however, we notice a number of interesting questions that are hidden in this improvisational cooperation process. In this chapter, we will discuss the mechanisms of interpersonal communication by which such cooperative behavior becomes possible.

To begin with, let us imagine a scene at a sporting event as shown in Fig. 1. Although this is a common cooperative behavior, when considering how such smooth interpersonal cooperation is possible we will notice that the elements or processes involved are not necessarily trivial. One might think, perhaps, that a great deal of practice would make this interaction possible, but in fact an extraordinary process is going on behind the scenes. To further clarify this point, we will discuss the scene from two different viewpoints.

The first viewpoint is that of an observer who is watching the game. It is the viewpoint of someone sitting in the stands at a stadium to watch the cooperative plays, as shown in Fig. 2. Players' actions can be perceived objectively, and objective space and time can be measured using a clock or a ruler with a scale common to all players, allowing the movement of each player during cooperative plays to be described as a trajectory in objective space and time. Briefly, the cooperative mechanism can be explained as a causal process in objective space and time. All scientific studies investigating cooperative mechanisms are included in this category. As an example, social simulations developed as multi-agent systems have become popular in recent years.

The second viewpoint is that of a player who is actually participating in the game, as shown in Fig. 3. These players are actually involved in the cooperative plays taking place on the field. In this case, perceptions of space and time are

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Fig. 1 Improvisational human communication (Catherine Trigg)

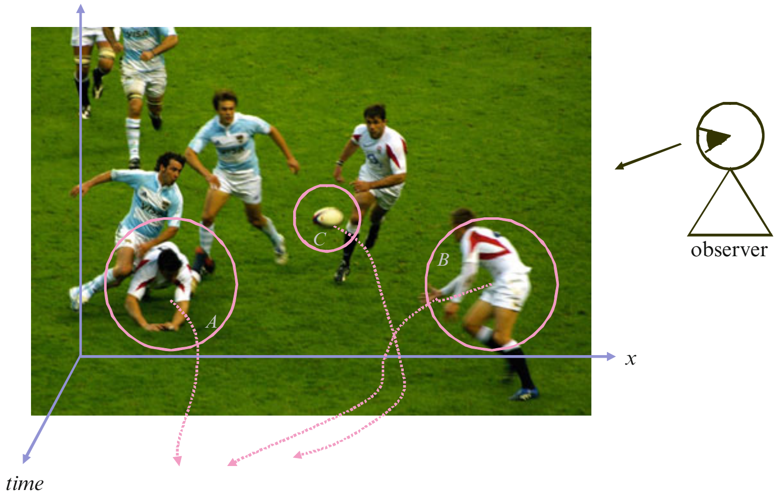

Fig. 2 Observer's viewpoint

subjectively generated in each player. In other words, no player is looking at his watch every moment to adjust the timing involved in passing a ball. Every player is cooperating with his teammates according to his own subjective space and time, which raises an essential issue.

Subjective space and time cannot be measured outside each individual, and thus are not always shared with other individuals in advance. Time passes quickly for one individual but slowly for another. From the subjective point of view, there is no

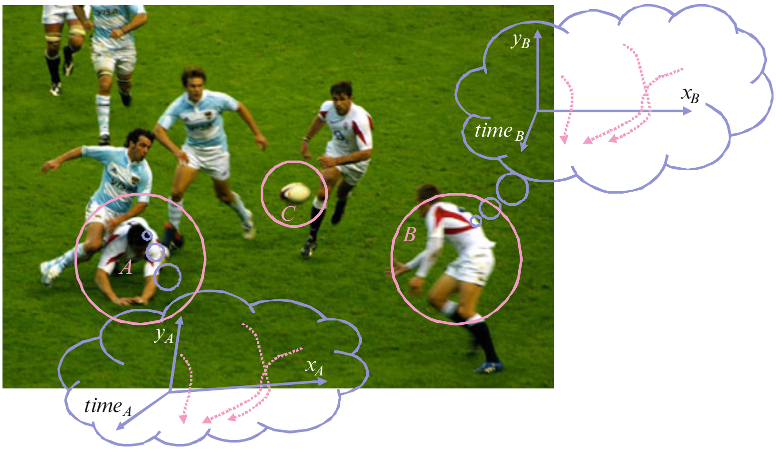

Fig. 3 Player's viewpoint

guarantee that a 5-s interval is the same for one individual as for another. This problem is not limited to time. For instance, there is not even any way to confirm that the color red that I recognize is the same as that perceived by you. How can individuals cooperate with others who live in such diversely different perceptions of subjective space and time? This may be rephrased as a question about the sharing of internal models. We should begin our questioning from this point.

Despite the apparently hopeless separation between individuals, in reality interpersonal communication seems to overcome this issue quite easily. It even seems that the issue is completely absent. What mechanism can mutually connect such subjective perceptions?

In our study, we call such subjective space and time *ma* and will inquire into the mechanism by which *ma* is interpersonally shared. In other words, we will investigate the synchronization of *ma*. Our anticipated answer is that the synchronization of *ma* does not connect separate subjective worlds but rather create and share subjective perceptions through mutual cooperative interactions. It is a co-creation of *ma*. Herein arises the need for co-creation in communication.

If individuals can cooperate with each other, *ma* that is co-created is indispensable. Is it not the co-creation of *ma* that allows players to execute improvised plays with mutual trust by sharing future scenarios? Such a mechanism would not be limited to dance or sports but would apply to a variety of situations to create a sense of safety and trust in social communication.

2 Standing on the Inside

Since the framework involved in the co-creation contains subjective realms, it is beyond the framework of so-called scientific fields that are limited to objective realms. Therefore, studies of cooperation as a co-creative communication based on a player's viewpoint should properly be said to be examining *cooperation from the inside*. In contrast, scientific studies based on an observer's viewpoint should be distinguished as being based on *cooperation from the outside*. Please refer to Figs. 4 and 5 to compare the differences between these two viewpoints. We will next see how these two viewpoints differ.

When you are observing a cooperating system objectively from outside the system, you as a subject are standing outside the system as an object. This is called a *subject–object separable system* that distinguishes a subject from an object. The system that you as a subject are observing appears as a self-completed realm that is spread out over objective space and time. Therefore, it becomes possible to control or optimize such an objectivized system. This way of perceiving the system is that of traditional scientific inquiry and is backed by a long history of system theory, which is outside the scope of this chapter.

On the other hand, when you are involved in a system with which you are cooperating, the situation is completely different. In this case, you are observing the system from the inside and you as a subject are in an inseparable relationship with a system as an object. This is called a *subject–object inseparable system*, which does not reflect a scientific point of view but rather a viewpoint in which human communication is emphasized. In this system, objective space and time appears as a self-incompleted realm for you as a subject (Fig. 5). Additionally, your own self-reference may be involved in the context of this self-incompleted realm.

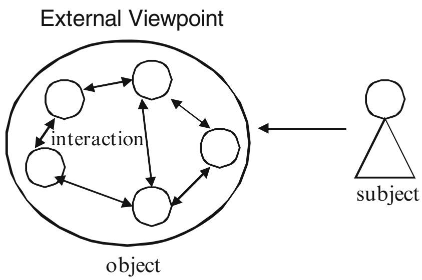

Fig. 4 Subject–object separable system

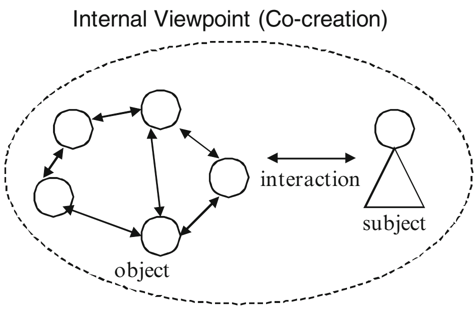

Fig. 5 Subject–object inseparable system

This is exactly the system that we want to discuss here and is actually the co-creation system. This is not a system to be observed as an object from the outside but rather one that contains an object itself as a subject that observes itself from the inside. In other words, it is not an objective system but an inclusive system. Therefore, we can probably say that human communication is perceived as a co-creation system.

A major goal of our study is to redefine communication as a co-creation system. This is motivated by a desire to enhance human communication as much as possible by reviving important viewpoints that have been left behind by present frameworks.

In particular, we investigate the sharing of *ma* by focusing attention on inter-personal cooperation, behind which *ma* resides as subjective time. Additionally, the working hypothesis of our investigation incorporates the concept of *duality*. Under this *duality* hypothesis, by focusing attention on not only explicit (conscious) interactions but also on implicit (subconscious) interactions, communication is discussed in the context of the complimentary relationship between these two types of interactions.

One way of rephrasing this concept is that the above hypothesis focuses on the multilayered property of communication. It has been said that about 30% of communication is verbal and the remaining 70% is nonverbal. Verbal communication is further divided into language and near-language communications. Near-language communication has acoustic characteristics and temporal patterns. Nonverbal communication includes many properties such as physical motions and proxemics. A sharing of subjective realms is thought, then, to become possible through all of these various communication channels.

The *duality* hypothesis becomes important when we discuss the social aspects of communication supports. Figure 6 shows the usage history of NTT DoCoMo, a major mobile phone service provider in Japan, between 1993 and 2004. The number of mobile phone calls started to increase beginning in 1995, and the use of mobile

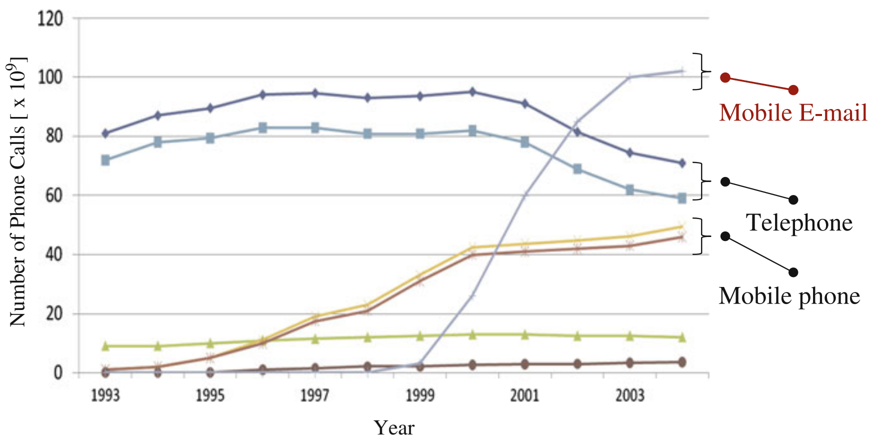

Fig. 6 Usage history of communication methods

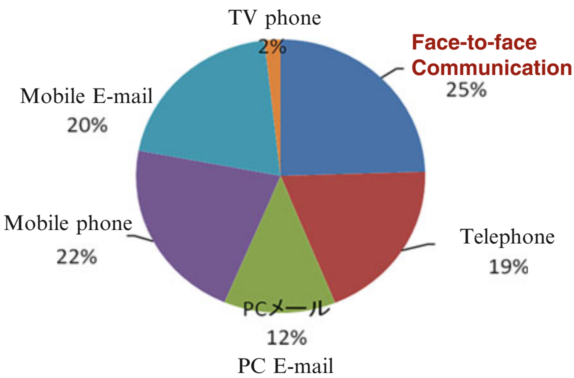

Fig. 7 Communication methods among family members

mail exploded, starting in around 2000. According to the same report on communication among family members, direct conversation was reported to account for only 25% of a family's entire communication (Fig. 7). These findings suggest that our communication channels are rapidly diminishing, which seems to inhibit co-creative communication in society.

3 Creation and Sharing of *Ma*

We have been studying co-creative communication based on the hypotheses described above, and specifically focusing attention on the temporal aspects of co-creative communication. In particular, we are investigating mechanisms by which subjective time is shared interpersonally, and cooperative behaviors become possible through the synchronization of timing between individuals. The final goal of these studies is to investigate the mechanisms of creation and sharing of *ma*. Additionally, we are aiming to reconstruct these mechanisms in the context of artificial systems, specifically human interface applications (Miyake 2005) supporting rehabilitation (Miyake 2009) and linguistic communication (Muto et al. 2009).

We will begin at this point to describe our psychological studies related to the creation and sharing of *ma* (Miyake et al. 2004; Takano and Miyake 2007). We have been focusing on a synchronized tapping task, which is a relatively simple experiment. This task involves tapping a button in synchrony with a rhythmic auditory stimulus (tone) as periodically produced by a metronome. Interestingly, the subjective time that each subject experienced did not coincide with the timing of their finger tapping.

In Fig. 8, subjective time, as measured by tap onset frequencies, is plotted as a function of objective time, which corresponds to physical time. Objective time was represented by tone onset time, which is depicted in Fig. 8 by a dotted line. Subjects subjectively experienced tone and tap onset times as coinciding with each other

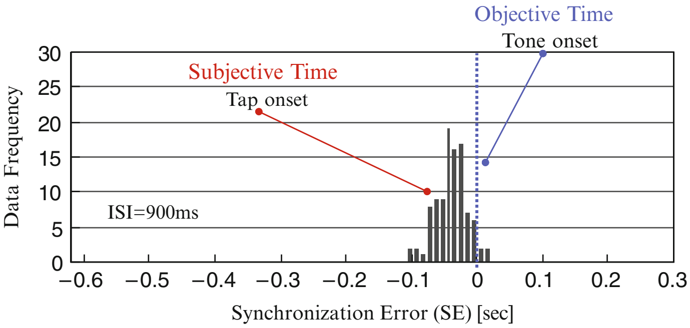

Fig. 8 Negative asynchrony phenomenon

however, the times that were objectively observed clearly differed, and tap onset time actually preceded tone onset time.

This phenomenon is called *negative asynchrony*, indicating that there is a gap between subjective and objective simultaneity. Furthermore, the subjective can *now* be considered to be objectively produced in the future. We understand this phenomenon to be a creation of *ma* as subjective time. According to this supposition, we are studying the mechanisms underlying the generation of subjective time and those related to the interpersonal sharing of subjective time.

We have been investigating the mechanisms underlying the creation of this subjective time based on the hypothesis of *duality* (a multilayered property of channels). Our investigation involves perceiving the co-creation as involving two complementary viewpoints: a conscious processing of information and a subconscious processing that precedes the conscious evaluation. In particular, this study became possible for the first time by applying a dual-task method. These two processes, relating to the generation of subjective time, are separated through a dual-task that each human subject is asked to perform concurrently, namely a synchronized tapping task and a word memory task that requires attention.

Figure 9 shows the results of this experiment. Incidence rates of *negative asynchrony* during a tapping task were plotted as a function of an interstimulus interval that corresponded to the period of a rhythmic auditory stimulus. The rates equaled those observed when tapping was performed prior to stimulus onset. At 100%, all the tapping actions were completed prior to stimulus onset. As you can see from this figure, longer auditory rhythm durations correlated with lower incidence rates of *negative asynchrony*.

As shown in Fig. 9, three different task conditions were applied: a simple synchronized tapping task without an additional task (N), a dual task in which a word memory task required recollection of four words, and a dual task involving memorization of five words. Subjects were asked to remember four or five words that were displayed on a monitor prior to tapping and then to repeat the words after tapping 100 times. In both tasks, subjects needed to maintain attention so as not to

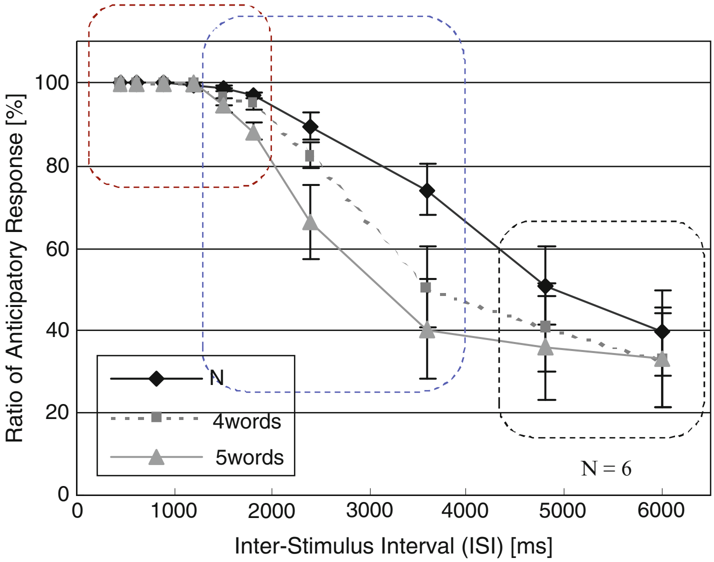

Fig. 9 Two time-generation mechanisms

forget the specified words while tapping. Through this investigation, we were able to evaluate the effects of conscious processes on the generation of subjective time.

These results clearly indicated that *negative asynchrony* was observed 100% of the time for all three task conditions when the interstimulus interval was less than 1 s, suggesting that word memory tasks had no effect on the generation of subjective time in this interval range. From 1 to 4 s, however, incidence rates of *negative asynchrony* differed significantly from each other depending on the task condition. In this interval range, word memory tasks actually affected the generation of subjective time. Beyond 4 s, the difference became smaller and *negative asynchrony* itself was less frequent.

These findings indicated that the mechanisms of generating subjective time observed during synchronized tapping could be divided into two categories. The first one which was not influenced from word memory task was observed with interstimulus intervals shorter than 1 s, indicating that this was an implicit mechanism in which conscious processes were not required. The second one was affected by word memory task, and was observed with intervals longer than 1 s. This was an explicit mechanism in which conscious processes were required. These findings clarified that the generation mechanism of subjective time is comprised of at least two types of information processing.

In the next step, to examine these mechanisms in detail, time-series data analyses were performed by measuring temporal changes in synchronization errors that were measured as the time differences between the onsets of auditory stimulus and of tapping (Komatsu and Miyake 2004). Figure 10 shows the results of the analyses, plotted in double logarithmic plots as a power spectrum.

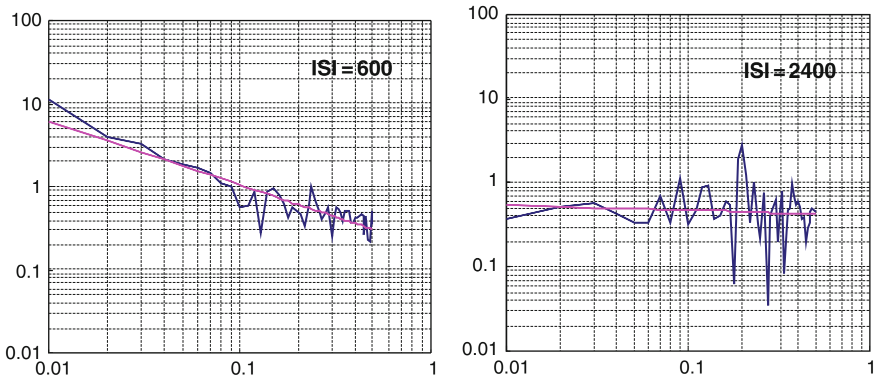

Fig. 10 Two types of dynamics

Under the condition in which subconscious processes were dominant, spectral data lay on a downward-sloping straight line (left figure). Thus, temporal changes in synchronization errors showed highly self-similar dynamics that followed a power law. Data patterns in both short and long time scales were similar, indicating fractal behavior. On the other hand, no such slope was found for the mechanism involving conscious processes (right figure). Instead, several peaks were observed, indicating that oscillation with high periodicity was occurred at a position corresponding to each peak.

In this way, it was shown that subconscious and conscious processes produced at least two types of dynamics regarding the control of synchronization errors. The degree of freedom in the former process was high, whereas that in the latter was low. This fact shows that these two processes consist of different dynamical systems, indicating that the dynamics are dualized. Additionally, fMRI neuroimaging of brain functions during each process demonstrated that the subconscious process originates mainly in the cerebellum while the conscious process results from activities in the prefrontal cortex as well as those in the cerebellum.

Based on these findings, we are also studying cooperative tapping involving two human subjects to clarify how *ma*, as subjective time, is shared interpersonally. By measuring temporal variations in synchronization errors and performing time-series analyses of these variations as similar to synchronization tapping, we are investigating the mechanism of subjective time-sharing from the perspective of dynamics. This is a kind of model estimation based on a statistics.

In this experimental task, the button taps of one subject were presented to a second subject as auditory stimuli. The second subject then pressed a button in synchrony with the stimulus and this tap was fed back again to the former subject as another auditory stimulus, thus comprising a cross-feedback system. Unlike the previous experiment in which each subject was asked to synchronize a tapping action with an auditory stimulus provided in a uniform rhythm, two subjects were providing auditory stimuli to each other and were asked to synchronize their tapping actions accordingly. Therefore, subjective time measured as the timing of a button tap by one subject was provided to another subject as an objective auditory stimulus. Time-series analyses of the corresponding synchronization errors were then performed as for the previous synchronized tapping task.

Two strong correlations were observed, as described below. Two interaction models were proposed corresponding to the dual dynamics found in the synchronized tapping task. One was an entrainment-based dynamic with strong real-time characteristics while the other was a dynamic with strong memory-related processes. The first dynamic could be correlated with subconscious processing of information and the latter with its conscious processing. These two dynamics are constructed as shown in Fig. 11. An interpersonal sharing of subjective time was found to be realized through such dual processes.

In this way, the generation process of subjective time, including an interpersonal sharing process, was elucidated by extending synchronized tapping to cooperative tapping. We therefore expect to be able to establish the basis of a system that cooperatively conducts itself along with co-creating *ma* as the future.

Further pursuance of such studies has become possible by clarifying and modeling the mechanisms of subjective time generation and interpersonal sharing. In this endeavor, we not only construct the model but also have individuals participating in it. Individuals are thus able to perform cooperative tapping with a non-human module, indicating that we can understand the model and also subjectively experience it.

When individuals engage in cooperative tapping with a non-human module, they experience the odd feeling that they are communicating with a real human even if they know that this is not the case. We succeeded in establishing such a human-like sharing model of subjective time. In the next section, we will introduce several applications we developed as interfaces.

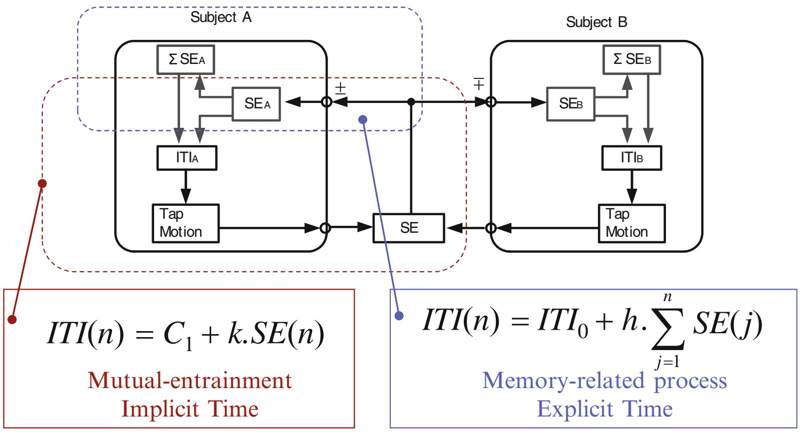

Fig. 11 Sharing model of "*ma*"

4 Supporting of Co-creative Communication

We are developing applications to interface between humans and artificial systems based on the dual co-creative communication model. As an example of this process, we show this model's role in rehabilitation support (Miyake 2009; Muto et al. 2007).

Most people naturally synchronize with other's footsteps while walking together, without giving attention to it. This type of interpersonal synchronization of *ma* is observed in various phases of daily life. We are focusing particularly on walk rehabilitation as it involves gait training in which the patient and therapist synchronize with each other. We aim to reproduce the patient–therapist relationship in the interaction between patient and machine by achieving coordinated walking via synchronization of *ma* between them.

As shown on the left side of Fig. 12, a synchronized walking system was constructed in which the patient and a virtual walking robot synchronize together by exchanging footsteps. This is a two-person walking system that was developed based on the experimental system of cooperative tapping explained in the previous section. One human module in the interpersonal cooperation model based on the cooperative tapping study is realized as a virtual robot on a computer. A real human functions as the other module.

This system is called *Walk-Mate*, in which subjective time *ma* is co-created in the process during which the human and the virtual robot are mutually synchronizing their walking motions. In other words, this is a walking robot that synchronizes *ma*. A virtual robot constructed based on a human module in the interpersonal cooperation model is implemented on a small wearable computer, as shown on the right side of Fig. 12. The human can cooperatively walk with a virtual robot that is simulated on the computer by exchanging footsteps.

We are specifically developing applications of the system that facilitate walking rehabilitation in the context of the patient–therapist relationship. We aim to achieve stable walking and co-creation of patients' motor function through cooperation with therapists. Through cooperative walking with synchronization of *ma*, several

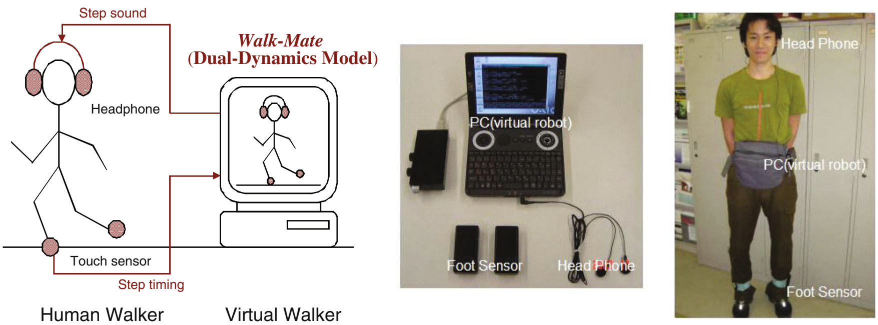

Fig. 12 Walk-mate

co-creative properties, including walking stability and subjects' sense of togetherness with the virtual robot, have already been realized.

Figure 13 shows the temporal variation of the walking cycle of the human and virtual robot during cooperative walking. Mutual exchange of footsteps starts at the dashed line on the left and ends at that on the right. As shown in this figure, an initial adaptation by human and robot to each other's walking rhythm allows synchronization between them and then they can walk with a common cycle. Additionally, fluctuations in the walking cycle after the mutual adaptation are significantly smaller than those prior to it, indicating that walking stability is achieved by the mutual adaptation. Even after the exchange ends, its effect remains and the stability of the walking rhythm is maintained. Furthermore, a questionnaire revealed that human could feel a sense of togetherness in this walking with synchronized *ma*.

We are currently developing applications of this cooperative walking system to gait training in rehabilitation. As shown in Fig. 14, fluctuations in the walking cycle in patients with hemiplegia were significantly reduced by cooperative walking, indicating that walking itself was stabilized. In Fig. 15, stabilization of festination in Parkinson's disease can be seen, which is defined as a monotonic decrease in walking cycle due to cooperative walking. In this manner, we are developing techniques that allow us to co-creatively share subjective time and stabilize motion in the course of mutually synchronizing *ma*. We are also creating some other applications, for example analyzing and reconstructing *ma* in linguistic communication (Muto et al. 2009) and developing various interfaces for supporting music ensembles (Kobayashi and Miyake 2003).

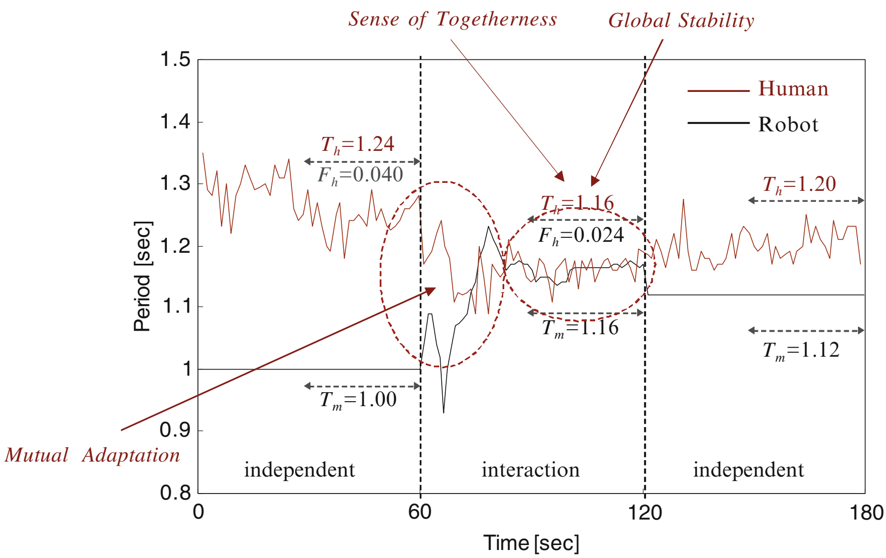

Fig. 13 Co-creative rehabilitation

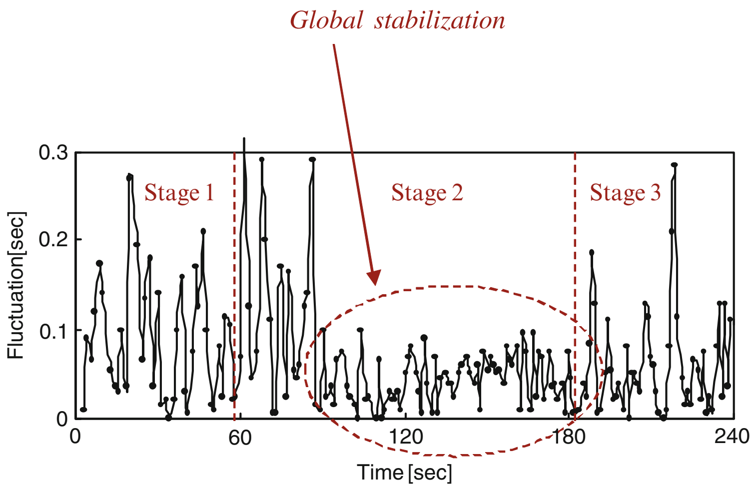

Fig. 14 Hemiplegia

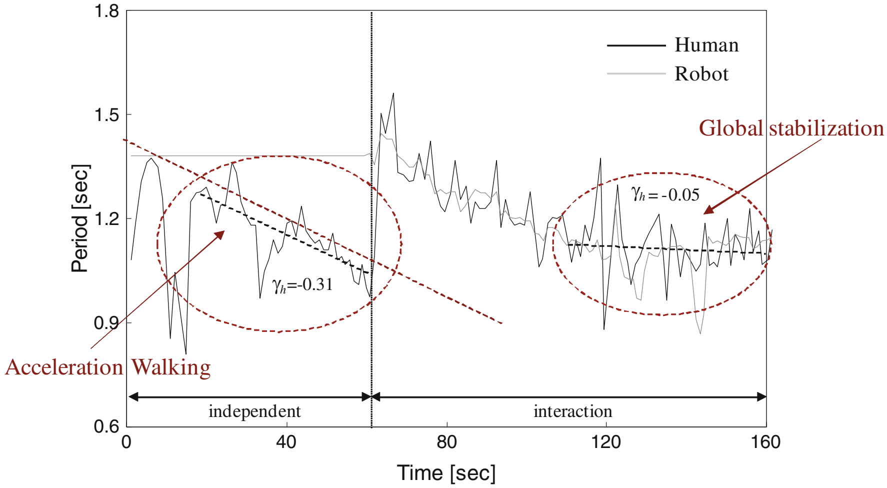

Fig. 15 Parkinson's disease

5 Summary

Our studies on co-creative communication clarified that subjective time *ma* is open to the future. And people live together by sharing *ma* as the future. This is where the importance of a reliable system as co-creation system comes in. It can be considered as a starting point of social intelligence that enables people to establish societies and to cooperate with each other. If this is possible, the sharing of *ma* will be indispensable and allow us to share future and to interact improvisationally in social relationships based on mutual reliance. It is expected that such a system can be applied to various co-creation process in social communication.

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Hearing Loss and Auditory Processing Disorders: Clinical and Experimental Perspectives

Elzbieta Szelag, Henryk Skarzynski, Andrzej Senderski, and Monika Lewandowska

Abstract This chapter focuses on hearing loss and auditory processing disorders (APD) with reference to culture and identity. Hearing impairments constitute a world-wide problem. They affect both language communication and social interactions, and hence, influence personal identity. APD are discussed from both audiological and neuropsychological perspectives. We present demographic data on hearing impairment and the most important methods applied to assessment and treatment of hearing disorders. We also discuss major cognitive deficits associated with hearing impairments across the life span and their psycho-social consequences. We also emphasize the importance of temporal aspects of auditory information processing which are crucial for broad aspects of cognitive function with special reference to language communication and learning ability. The reviewed literature data are illustrated with some results from our studies indicating psychophysical, electrophysiological and neuroimaging correlates of temporal processing after application of *Fast ForWord* training.

Keywords Auditory Processing Disorders · Cochlear implantation · Evoked Potentials · Fast ForWord · fMRI · Hearing loss · Temporal order · Temporal training

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1 Introduction: The Importance of Hearing in Our Everyday Life

Hearing is a complex process which involves both the auditory periphery's ability to detect environmental sounds and the brain's ability to interpret these sounds. The challenge for the auditory system is to process environmental sounds and to learn about their sources. The acoustic environment is crucial with respect to human everyday activity, language communication, and learning new information. Hearing disorders affect social behavior, make routine communication difficult, often interfere with vocational activity, and drastically reduce the quality of life. In addition to these individual effects, they affect substantially the social and economic development in communities and countries. In every society, the individuals with hearing deficits constitute a large group within society. Taking into account rehabilitation, special education and loss of employment, estimated costs to the economy in the USA are between US $170 and US $212 billion per year (Ruben 2000).

Hearing abilities are fundamental for human culture and personal identity. Over the last century or so, a "deaf community" has arisen whose purpose is to preserve a deaf culture.[1] The deaf community advocates deafness as a normal variant in the population and constitutes its own culture and heritage, rejecting cochlear implants and oral forms of communication with preference given to sign language (Ladd 2003). This is in contrast to the deaf community which includes individuals with profound to complete bilateral hearing loss and includes those that utilize various forms of amplification, including cochlear implants, and oral forms of communication. The past several decades, due to the development of advanced technologies such as otoacoustic emissions testing, universal newborn hearing screening, and enhanced hearing screening of school-age children, have heightened societal awareness and significance of early identification of hearing loss. Such early identification and technological advancements have seen significant improvements in socialization, academic achievements, and vocational–professional advancement in the deaf population, including the development of a high degree of oral skills and literacy in early cochlear implantation (Van Gent et al. 2007).

Currently, the appropriate intervention methods constitute an important goal of audiology and neuropsychology. In this chapter, we concentrate on both audiological and neuropsychological approaches applied to reduce hearing handicap. We will focus on language functions, as well as other cognitive functions. Finally, we present new directions in neuropsychological therapy, illustrating existing literature data with results of our studies on neural correlates utilizing specific auditory training.

[1] When capitalized, "Deaf Community" refers to a group of deaf individuals committed to preserving a deaf culture. When not capitalized, "deaf community" refers to the general population of individuals with profound or complete hearing loss. This is an important distinction.

2 Cross-linguistic Demographic Data on Hearing Impairment

Hearing loss is one of the most common types of disability. In adults, disabling hearing impairment is defined as a permanent unaided hearing threshold level (measured usually for frequencies 0.5, 1, 2, and 4 kHz) of 41 dB HL or more in the better ear. In children, disabling hearing impairment is defined as a permanent, unaided hearing threshold level for the better ear of 31 dB HL or more. However, pragmatically, it has been shown that in adults a hearing loss greater than 20 dB HL and in children a hearing loss greater than 15 dB HL is functional disabling. The higher levels serve political definitions rather than pragmatic definitions. According to World Health Organization (WHO), 255 million people worldwide in 2002 suffered from such a disability and could benefit from hearing aids; among them, 192 million people showed adult-onset loss (above the age 20), whereas 63 million people displayed childhood-onset loss. The most common cause of hearing loss in children living in Western countries is *serous otitis media*, affecting up to two-thirds of preschool children. On the other hand, in developing countries, *suppurative middle ear disease* is common and frequently accompanied by *intratemporal* or *intracranial complications*. Sensorineural hearing loss (see below) occurs in developing countries almost twice as often as in Western ones, with a greater proportion of infectious etiology, such as *measles* and *meningitis* (NICD 2008).

In Western countries, a substantial problem is noise-induced hearing loss. This is common not only in industry where the problem is recognized and regulated by law but also in adolescents due to listening to loud music using headphones. It is estimated that, in the USA, 12.5% of children and adolescents aged 6–19 years and 17% of adults aged 20–69 years have suffered permanent damage to their hearing from excessive exposure to noise (Niskar et al. 2001).

A strong association between an individual's age and hearing loss is commonly reported. The loss of auditory sensitivity resulting from normal chronological aging is termed *prescybusis*.[2] The prevalence of presbycusis is associated with aging ranging from 40% to 66% of the general population in individuals older than 75 years of age, and more than 80% in individuals older than 85 years of age (Yueh et al. 2003).

The major causes of hearing loss worldwide according to WHO (Disease Control Priorities Project 2006) are summarized in Fig. 1 and show that the three most frequent causes of hearing loss are genetic, otitis media, and presbycusis. Except for otitis media which is easily treated medically, genetic hearing loss and hearing loss caused by presybcusis require specific intervention including cochlear implants, hearing aids, and aural rehabilitation.

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[2]The term *prescybusis* is a general term used to designate hearing loss that cannot be directly accounted for by any known etiology and is therefore non-specific. Most people agree it is primarily due to unaccounted environmental factors (McPherson et al. 2008).

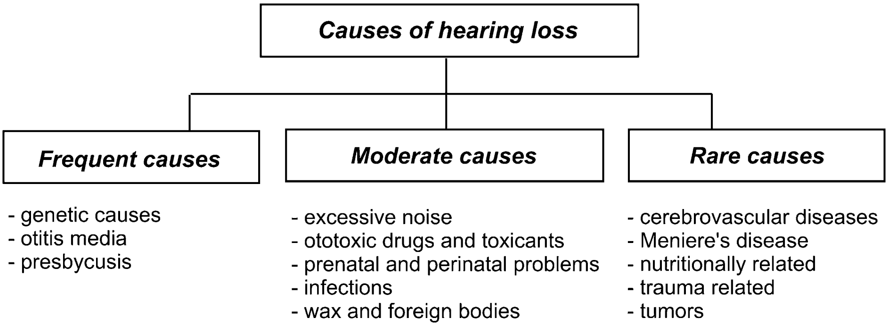

Fig. 1 Summary of major causes of hearing loss in accordance with WHO

3 Assessment and Management of Hearing Loss

Major determinants of the impact of hearing impairment include: type and degree of hearing loss, its pattern across different frequencies, laterality (unilateral/bilateral hearing loss), the locus (or loci) of abnormality within the auditory system (middle ear, inner ear, auditory neural pathway, subcortical or cortical brain structures), exposure to loud noises, and environmental or pharmacological toxicants to hearing. Each of these determinants, both separately and in combination, will have varying impacts on the auditory system and hence the functional ability of the individual. More specifically, the intervention techniques and procedures will vary considerably.

The scope of audiological diagnosis comprises the assessment of type and degree of hearing loss localization of damaged site and definition of possible causes of observed impairments. Such diagnosis is based on behavioral methods, i.e., pure tone audiometry which allows the assessment of hearing sensitivity across frequencies, speech audiometry, and a battery of auditory tests. An important part of audiological diagnosis, especially in young children, are electrophysiological objective methods, including impedance audiometry, otoacoustic emissions, auditory brainstem potentials, and middle and late latency auditory responses (Fig. 2).

In the audiology clinic, it is possible to distinguish three main types of hearing loss: *conductive*, *sensorineural*, and *mixed hearing loss*. Additionally, one can distinguish hearing disorders not related with loss of hearing acuity per se, but what is classified as *auditory processing disorders* (APD) which are located in the central portion of the auditory system. A *conductive* hearing loss is often due to ear infections and damage of the *eardrum* and *middle ear ossicles*. Appropriate medical care and reconstructive surgery of the middle ear may effectively treat these problems leading to recovery of normal or nearly normal hearing status in a substantial percentage of such problems. *Sensorineural hearing loss* caused by damage to the cochlea and auditory nerve is permanent and can only be alleviated using hearing aids or cochlear implants. APD constitute a deficit of neural processing of auditory information in the central nervous system that cannot be attributed

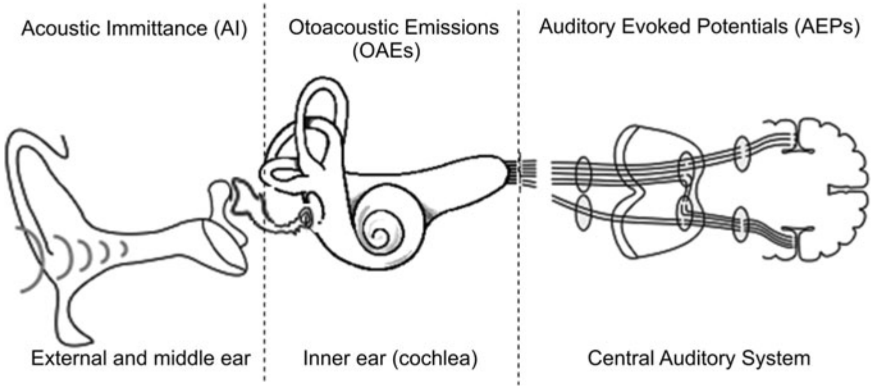

Fig. 2 Electrophysiological methods used for assessment of the auditory system

to other higher-order cognitive disorders, including those related to learning, attention, memory, or language-related skills caused by damage in the central nervous system.

The majority of the hearing impaired population can benefit from amplification. According to the WHO, there are currently 250 million people worldwide with hearing loss who could benefit from hearing aids. Two-thirds of these are in developing countries.

Cochlear implantation is a method of choice for treatment of children and adults with profound to severe bilateral deafness. In cochlear implantation, functional hearing is restored by direct electrical stimulation of the auditory nerve through an electrode placed in the cochlea (electric hearing). According to the Food and Drug Administration (FDA) as of April 2009, more than 188,000 people worldwide have been provided with cochlear implants (CI). Due to satisfied outcomes in both auditory receptive skills and the improvements of the quality of life following cochlear implantation, a clinical trend is observed in developing countries to expand the range of individuals who can benefit from this method of treatment. The new concept in treatment of hearing loss is combining acoustic and electric hearing. Individuals with normal hearing at low frequencies and profound hearing loss at middle and high frequencies (partial deafness) can benefit from using CIs, but have still preserved and useful hearing at low frequencies. The electric acoustic stimulation dramatically improves their communication abilities (Skarzynski et al. 2009). The particular method developed by Skarzynski and named "partial deafness treatment" is based on minimal invasive surgery and requires special surgical techniques and use of specially designed electrodes (Skarzynski et al. 2007).

For obtaining good outcomes, it is important not only to fit and appropriately program the hearing aid or cochlear implant but it is also paramount to instruct individuals on how to use the device. The crucial issue is that the individual's brain adapts to utilizing the new auditory information delivered from the periphery. The auditory rehabilitation greatly facilitates this adaptation. Although such adaptation is usually easier in young individuals because of higher brain plasticity, it is also observed in adults and may be fostered by new and unique rehabilitation programs. These programs constitute a major change in current thinking regarding auditory rehabilitation, and are discussed in details in following sections.

4 Deficits Associated with Hearing Loss Across the Human Life Span

If congenital hearing loss is not recognized and managed properly in early child development, it results in severe delay of speech, language and cognitive development. Therefore, universal newborn hearing screening is crucial in the early identification of hearing loss and early intervention such that rehabilitation begins prior to the critical periods for optimal language acquisition. Cohort studies have indicated that the proper diagnosis and intervention occurring prior to 6 months of age results in significantly better language and speech acquisition (Yoshinaga-Itano et al. 1998). The huge progress in audiological diagnosis and treatment in recent years (e.g., OAEs, automated ABR, bilateral or partial implants, early implantation) has resulted in integrative educational programs for deaf and hearing impaired children that significantly reduce the need for residential or special schools for the deaf, thus providing the individual with better education and integration into society. In school-age children, even a minimal hearing loss (20–30 dB HL) can have profound negative effects on speech and language comprehension, communication, classroom learning and academic achievement, and social development. Without proper intervention, there is a visible gap in school and academic achievements between children with mild-to-moderate hearing loss and their normally hearing peers (Bess et al. 1998). Moreover, communication difficulties often lead to social isolation and poorer self-concept (Brinton and Fujiki 2002, 2004).

In the elderly, high frequency sensorineural hearing loss is the most common type of hearing loss and is generally associated with *presbycusis*. It results in a loss of ability to hear consonants such as /s/, /f/, /t/, and /z/ (i.e., high frequency sounds) even though vowels may be heard relatively normally. Speech intelligibility is impaired in adverse acoustic conditions and in the presence of ambient noise. It decreases the ability to hear high-frequency auditory sounds like bird songs, rustling of leaves, and the voices of children and women. This may result in frustration, withdrawal from social activities, depression, and marital discord. Mulrow and others have shown in randomized trials that the use of hearing aids significantly improves communication, cognition and emotional function, including reducing the effects of depression (Mulrow 1990).

5 Auditory Processing Disorders from an Audiological Perspective

APD are distinct from peripheral hearing loss, language disorders and intellectual or cognitive problems and were recognized more than 50 years ago by Myklebust (1954). He identified children with normal peripheral hearing who demonstrated deficits in dealing with auditory information leading to communication, behavioral and social problems. Key behaviors seen in these individuals include: difficulties in listening in a background noise, oversensitivity to loud sounds, difficulties in location of the sound source, and deficiencies in phonological awareness leading to mishearing words or misinterpreting messages from verbal utterances, as well as delayed responses to auditory signals.

According to the American Speech-Language-Hearing Association, APD is defined as "perceptual processing of auditory information in the central nervous system and the neurobiological activity that underlies that processing and give rise to the electrophysiological auditory potentials" (American Speech-Language-Hearing Association 1996). The predisposing factors for APD include otitis media with effusion (sensory deprivation secondary to a peripheral disorder), neuro-maturational delay, and neurological insults to the central auditory system (DeBonis and Moncrieff 2008).

The diagnostic procedure for identification of APD is based on a series of psychoacoustic and speech perception tests. One can refer to five primary categories of behavioral tests that are sensitive for audiological diagnosis of APD, specifically, (1) dichotic listening, (2) monoaural low-redundancy speech tests, (3) auditory temporal processing and patterning, (4) binaural interaction and integration, and (5) auditory discrimination tasks. It is important to note that the classic tests of phonological awareness, phonemic synthesis and auditory comprehension are not diagnostic in the case of patients with APD (Cacace and McFarland 2009).

In audiological diagnosis, one of the commonly used dichotic listening tests is the dichotic digit test which has been shown to be sensitive to brainstem, cortical and corpus collosum dysfunctions. Moreover, monoaural low-redundancy speech tests (low-pass filtered speech, speech in noise, and time-compressed speech) assess the ability to "fill" the missing components of degraded speech signal and are sensitive to dysfunctions of the auditory cortex. Despite worldwide occurrence of APD, cross-linguistic comparisons on this deficit are still a neglected topic. Therefore, to form any general conclusions on cross-cultural aspects of APD, it would be necessary to develop corresponding versions of the above-mentioned tests for different languages. On the other hand, nonverbal stimuli are often used to evaluate a variety of auditory processes, including temporal resolution, temporal ordering, frequency or duration discrimination, and linguistic labeling, such as random gap detection test, duration pattern test, and frequency pattern test.

Despite existing several clinical diagnostic tests for assessment of APD, there are still controversies with respect to both the existence of this deficit and underlying neural mechanisms. Furthermore, there are also controversies with respect to the efficiency of methods applied in the rehabilitation of individuals suffering from APD.

Development of effective diagnostic tools and treatment methods of this disorder must be based on explicit theories of sensory information processing. One of the hypothetical concepts with a potential clinical value is temporal information processing theory. Taking such a hypothesis into account, in the following sections we present some existing evidence on importance of temporal processing as a possible basis for many deficits in audition, language, and cognition.

6 Central Auditory Processing from Neuropsychological Perspective

A broad overview on neuroanatomy and neurophysiology of hearing is beyond the scope of the present chapter because of the large number of observations, research articles, and books dealing with this issue. As we concentrate here on central auditory processing, we characterize only cortical structures involved in this processing.

Auditory information arrives to the *primary auditory cortex* (Heschl's gyrus, BA 21) by projections from the *medial geniculate body* via *internal capsule*, *insula* and *external capsule*. The *primary auditory cortex* is known to retain tonotopic organization of the *cochlea*. The *auditory association cortex* comprises Wernicke's area (BA 22), which is considered the region responsible for phonemic hearing and language, and thus for auditory comprehension. The additional auditory cortical structures comprise the inferior portion of the parietal and frontal lobes, the *supramarginal* (BA 40) and *angular* (BA 39) gyri, as well as the *fasciculus*; a larger fiber tract connecting Wernicke's and Broca's areas.

The posterior portion of Heschl's gyrus along the Sylvian fissure is the *planum temporal*, a part of the superior surface of the temporal lobe. Geschwind and Levitsky discovered that this structure is larger on the left than the right hemisphere in the majority of both right- and left-handed people. As such, asymmetry is also observed in prenatal brain maturation; the *planum temporal* is often thought as a neuroanatomical basis for left hemispheric specialization of language. A large number of clinical, psychophysical, and neuroimaging evidence has confirmed this specialization for broad aspects of language functions, including auditory comprehension, speech production, reading and writing (e.g., Hugdahl and Davidson 2003). Moving beyond the fact that functional hemispheric asymmetry exists, the question should be addressed on underlying neuropsychological mechanisms.

As all language functions require rapid changes within the auditory signal (e.g., formant transitions within single phonemes, proper sequencing of phonemes, syllables, words, etc.), they must engage specific timing mechanisms. Accurate temporal processing is crucial for language communication. Furthermore, left hemispheric specialization derives from timing (Tallal et al. 1996; Szelag et al.

2004). Combined data from various researches have indicated that the "clock," or timing, functions are relevant not only to language but also to the broader aspect of human cognition and behavior. It may be argued that temporal information processing constitutes a framework for human cognition, including auditory processing (Pöppel 1994).

On this basis, Steinbüchel and Pöppel (1993) proposed two classes of brain functions (see also Szelag et al. 2009). Functions of the first class, i.e., *what* functions, refer to their modular or local representation in the brain and are responsible for the mental context of our subjective experience. In case of auditory processing, *what* functions control the context of the incoming auditory signal and are represented in the cortical structures as described above.

In contrast, the functions of the second class, i.e., *how* functions, may be less localized in the brain and instead form a network of neural assemblies (see below for further discussion). These functions provide the formal basis for *what* functions creating the logistic basis for our mental activity. As temporal processing provides the crucial component of human cognition (including auditory processing), it should be concluded that, without a defined temporal structure, these activities would be chaotic. Hence, timing may be assumed as an example of *how* functions providing a framework for *what* functions and structure for auditory processing. Furthermore, imprecise timing may result in declined cognitive function reflected, e.g., in deteriorated language communication, movement control, memory, attention or decision making. These deficient mental functions may influence our personal identity leading to lower quality of life. It may be anticipated, therefore, that *how* functions provide the framework not only for our cognition but also for personal identity.

7 Temporal Patterning in Auditory Information Processing with Special Concern to Language

The accurate processing of temporal cues is crucial for perception of both verbal and nonverbal auditory information. It comprises not only our subjective experience of the time flow but also specific processing platforms or "time windows" within which incoming information is integrated into perceptual units within defined time limits (Pöppel 1994). In the existing literature, a few of these time processing platforms were distinguished, i.e., (1) gap detection corresponding to a few milliseconds, (2) event ordering related to some tens of milliseconds, (3) programming of motor acts in hundreds milliseconds, and (4) subjective present or feeling of "now" limited to a few seconds.

Taken together, at least two processing levels may be distinguished which are controlled by different neural mechanisms (Fraisse 1984; Pöppel 2004). One system concerns the low-frequency processing and reflects pre-semantic temporal binding of incoming events (both verbal and nonverbal) into larger units of a few seconds duration (Pöppel 2009; Szelag et al. 2004). In the case of language communication, such temporal integration can be reflected in segmentation observed in both oral and sign languages, where average duration of phrases (uttered or signed) is usually limited to a few seconds. Such a few seconds processing platform was indicated in human motor activity, perception of classic music, and many experimental paradigms (see Szelag et al. 2004, 2009 for an overview).

In contrast, the other domain is a high-frequency processing system, generating discrete time *quanta* of some tens of milliseconds duration. The existence of this time platform is also reflected in language communication, as spectrographic analyses of stop-consonants (e.g., /p/, /b/, /k/) in fluent speech in different languages is limited in time to around 40 ms (Fitch et al. 1993; Tallal et al. 1998). Additional support for these time windows in our brain computation comes from stimulus-triggered neurooscillations of typical 25–40 Hz, and from many psychophysical experiments, including choice reaction time, latency of eye movement, execution of simple ballistic movement, and perception of temporal-order (Szelag et al. 2004; Szymaszek et al. 2009).

Starting from Hirsh and Sherrick (1961), the temporal order paradigm was next employed in many experiments designed to study sequencing ability on the millisecond level which is strongly related to auditory comprehension and phonemic hearing. In the next sections, we focus on this aspect of auditory processing.

A large amount of psychophysical data have indicated that in normal young volunteers the temporal order of two stimuli presented in rapid succession can be properly identified if they are separated by a gap of at least some tens of milliseconds, independent of the stimulus modality and presentation mode. Results demonstrated that subjects characterized by the elevated gap often displayed parallel auditory comprehension deficits. Such coexistence has been confirmed in cases of language-learning-impaired children (Tallal et al. 1996), dyslexic individuals (Farmer and Klein 1995), aphasic patients (Fink et al. 2006), and some cochlear implant users (Szelag et al. 2004).

8 Auditory Perception of Temporal Order with Special Concern to Cognitive Aging

In series of experiments (Szymaszek et al. 2006, 2009), we indicated important age-related deterioration in auditory perception of temporal order using paired rectangular clicks presented monaurally (i.e., separately one click to each ear) and in rapid sequences. The subject's task was to identify the temporal order of two clicks presented within each pair, thus to judge whether it was "right–left," or "left–right." We assessed a threshold of such order identification, i.e., the minimum time gap between successive clicks within each pair at which the temporal order was correctly identified.

Age-related differences were studied in 86 healthy adults classified according to their age into five groups: 20–29, 30–39, 40–49, 50–59, and 60–69 years of age. We found that temporal-order-threshold remained relatively stable (approximately

65 ms) up to 60 years of life, but significantly declined (approximately 90 ms) beyond this age. The most interesting result was that chronological (biological) age was a poorer indicator of declined event ordering than cognitive competencies, i.e., attentional or intellectual resources. We interpret this as meaning that elderly individuals (beyond 60 years of age) with relatively preserved cognitive status may show less impaired sequencing abilities. The observed relationship between timing and cognition indicated that event ordering is probably not controlled only by "pure" timing mechanisms free of cognitive (nontemporal) influences. It seems important, because a large body of evidence has indicated age-related deficits in broad aspects of cognition; however, few attempts have related these deficits to deficient millisecond timing.

9 Neuroanatomical Loci of the Perception of Temporal Order

The empirical evidence of neuroanatomical loci of timing comes predominantly from clinical studies on brain-damaged patients and a growing body of neuroimaging data. The broader overview on brain representation of different time domains (milliseconds, seconds) was provided in our previous reports concerning clinical (Szelag et al. 2004) and fMRI data (Szelag et al. 2009). In this chapter, we focus only on neuroanatomy of event ordering, thus on the time domain of some tens of milliseconds which seems crucial to described auditory information processing.

Despite a growing body of neuroimaging data on temporal processing (e.g., duration judgment, duration discrimination), evidence on neuroanatomy of event ordering (millisecond timing) are rather limited and the results seem inconsistent. In general, there is evidence regarding the importance of the temporo-parietal junction as a neuroanatomical basis of temporal order detection (Davis et al. 2009). Moreover, the prefrontal cortex, basal ganglia, SMA and the cingulum have also been shown to be important in temporal order detection (Pastor et al. 2006). These results confirmed diffuse representation of event ordering and suggested the involvement of multimodal processes. Recent fMRI data do not support earlier theories postulating one common neural mechanism, such as an "internal clock" or "pacemaker," for timing operations.

Given the above discussion, in our fMRI block design study, we discovered a dynamic neural network engaged in event ordering, dependent on *task difficulty*. As task difficulty *increased*, activations were predominantly found in bilateral inferior parietal lobule (BA 40), and in the inferior frontal gyri (BA 45), with additional activations observed in the left medial and middle frontal gyri (BA 6, 8, 9); thus in classic regions related to attentional and working memory processes. Difficult event ordering engaged brain regions "working harder" and reflected the contribution of nontemporal cognitive processes to timing. Conversely, *decreased* task difficulty was accompanied by *increasing* involvement of other brain regions which in existing literature have usually been indicated as more specific to "pure" timing operations. These structures comprised bilateral medial frontal gyri (BA 10) and left cerebellum which were engaged in our study in *less difficult* timing tasks with lower cognitive load (no mental force).

These findings provide a strong support for dynamic neural networks engaged in difficult or easier event ordering, and may indicate the framework for understanding timing representation as the logistic basis (see above) of the brain. These data provide a strong support for earlier indications (Steinbüchel and Pöppel 1993) that the logistic basis for auditory processing (*how* functions) forms a network of neural assemblies, depending on the specific context of processed auditory information.

10 Timing Studies as a Starting Point to Modern Neurorehabilitation

The above evidence argued that many aspects of auditory processing derive, at least in part, from temporal processing. In a series of experiments, we therefore studied whether the application of specific auditory temporal training may ameliorate this processing.

In 36 normal volunteers (16 male, 20 female, aged 20–29 years), we compared the effectiveness of temporal training using the *Fast ForWord* program ($n = 15$) with that of a control nontemporal training ($n = 14$).

The *Fast ForWord* training (Scientific Learning Company 2009) comprised a set of computerized video games designed for auditory and language processing, using nonverbal or verbal stimuli and acoustically modified speech. Such programs may improve the speed of brain processes and is strongly rooted in improvement of timing. It provides intensive, highly individualized training across auditory attention, working memory, linguistic, and reading skills. Although *Fast ForWord* was originally designed to improve language competencies, in our studies we verified its effectiveness in improvement of nonlinguistic cognitive functions, like attention, short-term memory, and new learning ability in healthy young volunteers.

In our study, *Fast ForWord* training was composed of following three sets of adaptive exercises (1) language basics (*Drag Racer* and *Flying Saucer*), (2) literacy (*Spin Master*, *Space Racer*, *Lunar Tunes*, and *Galaxy Goal*), and (3) literacy advanced (*Sky Rider*, *Laser Match*, and *Meteor Ball*). All the exercises involve the ability to identify the temporal order of sounds, syllables, and words presented in rapid succession. The training was conducted during 8 weeks with four 1-h sessions per week. If the subject completed all these games earlier (e.g., after 6 weeks), the training was terminated.

The control nontemporal training consisted of seven adaptive games, specifically three different types of solitaires, *Marbles*, *Tetris*, *Mah-jong*, and *Checkers*. These games involved cognitive resources, i.e., attention or working memory, but were not related to auditory temporal processing. The control training was performed for the same period as the *Fast ForWord* training.

Before and after the training, we assessed both cognitive competences and auditory sequencing abilities using a few auditory temporal-order-threshold paradigms. All of them involved the perception of paired acoustic stimuli presented in rapid succession. The relationship "before–after" (temporal order) within each pair was identified by the participants. The assessment of cognitive function comprised two tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB; Cambridge Cognition 2005) designed for the assessment of *new learning ability* (paired-associates learning, PAL) or *short-term visual memory* (delayed matching to sample, DMS). Additionally, two aspects of attention, i.e., *alertness* and *divided attention* were assessed using test for attentional performance (TAP; Zimmermann and Fimm 1997).

10.1 Before Versus After Comparisons: Psychophysical Evidence

Following *Fast ForWord* training, we observed significant improvements in both cognitive function and temporal processing. The former improvements comprised all tested functions, i.e., (1) alertness (shorter reaction times), (2) divided attention (more valid reactions and less omissions), (3) new learning abilities (less errors and less trails to perform on PAL correctly), and (4) visual short-term recognition memory (more correct responses in DMS). These improvements were accompanied by better sequencing abilities (lower values of temporal-order-thresholds) observed in all applied paradigms. The threshold values on average decreased from approximately 70 ms before training to approximately 30 ms after training.

10.2 Before Versus After Comparisons: fMRI Evidence

The improvements evidenced in psychophysical measurements had neuroanatomical correlates. Using an fMRI block design protocol, we verified neuroanatomical loci of auditory temporal order perception in easy and difficult timing tasks. As described above in detail, before training we discovered different neural network involved in easy and difficult event ordering. Interestingly, after *Fast ForWord* training, activation in more difficult timing tasks shifted from classic regions related to attentional and working memory processes to medial frontal gyrus (BA 10) which before the training was engaged only in easy timing tasks (compare above).

10.3 Before Versus After Comparisons: Electrophysiological Evidence

Additional support for the neural background of neuroplastic changes following *Fast ForWord* application comes from our electrophysiological studies in which auditory *evoked potentials* were recorded from 64 electrodes ("10–20" system) using a Neuroscan system. Participants were asked to detect a rare or *deviant* stimulus (30%) by pressing a button in the sequence of a frequent or *standard* stimulus (70%). The stimuli were pairs of white noises (short–long and long–short) separated by 160, 60, or 10 ms, corresponding to three levels of TOJ task difficulty, i.e., "easy," "moderate," or "difficult." In half the participants, the deviant stimulus was a short–long (standard: long–short) and in the other half: long–short (standard: short–long). We analyzed the mean amplitudes and latencies of *late positive component* (*LPC*), appearing at approximately 300 ms after stimulus presentation in response to deviant stimuli. According to existing literature, this component reflects the involvement of cognitive function, e.g., that of attention in a given task (see Linden 2005 for a review).

We showed increased amplitude of *LPC* in difficult timing tasks following *Fast ForWord* training which was accompanied by more correct deviant detections. Such elevated *LPC* amplitudes were observed at Pz the electrode. These results indicate that the *LPC* amplitude may constitute an electrophysiological correlate of neuroplastic underlying improved temporal order perception after *Fast ForWord* training.

11 Conclusions

In the light of presented evidence, a key factor in development of modern neuropsychological therapy addressing improvements in auditory processing are neural mechanisms underlying accurate timing of incoming auditory information. This "top–bottom" approach allows for the design of new rehabilitation programs taking into account temporal information processing as a logistic basis of human cognition.

The assessment of an individual's effectiveness in timing should be, thus, incorporated as a part of both audiological diagnosis and proposed therapy, tapped by not only language deficits but also improvements of broad aspects of cognitive functions in normal healthy volunteers. Such an approach, however, is frequently forgotten or neglected because of a lack of awareness among clinicians of the possible neurophysiological basis of observed deficits. We would argue, therefore, that an interdisciplinary auditory processing team should be established and take into account recent advances from the area of neuropsychology.

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Broca's Area: Linking Perception and Production in Language and Actions

Eleonora Rossi, Marleen Schippers, and Christian Keysers

Abstract A distinction between action perception and production has always been emphasized by traditional accounts of brain function. The goal of this review is to show that this simple distinction seems no longer valid. Broca's area in particular seems to be important for both perception and production of language and action. Functional imaging studies suggest that Broca's area is active both when people produce and perceive syntactically complex sentences and while they produce and perceive complex actions. Lesions in this area disrupt the capacity to produce syntactically correct sentences and to perceive sentences in which syntax is essential. From an action-perspective, lesions to Broca's area disrupt the capacity to produce goal-directed actions and to perceive the actions of others. Furthermore, the property and location of mirror neurons in the monkey might provide the reason why Broca's area in humans has a dual function in production and perception.

Keywords Broca's Area · Action · Language · Mirror Neurons

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1 Introduction

Traditional accounts of brain function have often emphasized a distinction between action perception and production. For instance, the occipital and temporal lobe were considered to deal with visual and auditory *perception* while the frontal lobe was considered to deal with the *production* of goal-directed actions. In the domain of language as well, the classic distinction between Wernicke and Broca's aphasia suggested that one part of the brain deals with *perceiving* what other people say while the other deals with *producing* speech.

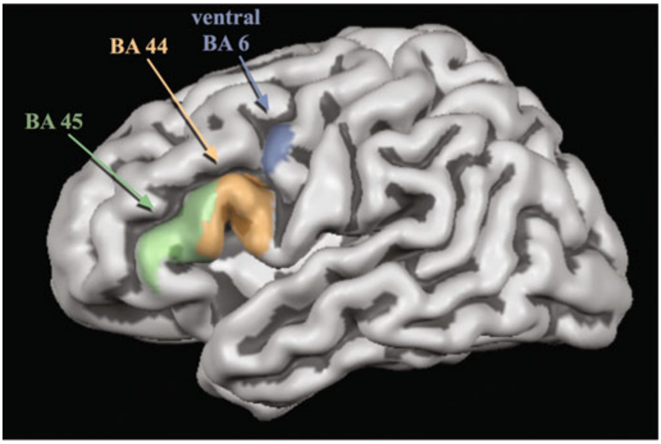
The goal of this review is to show that this simple distinction seems no longer valid. In particular, we will show how both in the domain of language and action, a brain area, called Broca's area, seems to be important for both perception and production. Finally, we will show how mirror neurons help us understand why and how a certain brain area can be important in both perception and production.

We will start by explaining where Broca's area is located in the brain. We will then show how lesions in this area disrupt the capacity to produce syntactically correct sentences and to perceive sentences in which syntax is essential. We will then show that lesions to Broca's area disrupt the capacity to produce goal-directed actions and to perceive the actions of others. We will then review data from functional imaging studies that suggest that Broca's area is active both when people produce and perceive syntactically complex sentences and while they produce and perceive complex actions. Finally, we will review the property and location of mirror neurons in the monkey and suggest that they may be the reason why Broca's area in humans has a dual function in production and perception.

2 Broca's Anatomy

The name "Broca's area" comes from the French neurologist Pierre Paul Broca, who brought the inferior frontal gyrus into the spotlight as a possible location for the seat of language in the human brain. When he investigated the brains of his deceased patients who suffered from a "loss of speech," he found lesions located in the frontal lobe. He decided, however, not to dissect the brains and only described the lesions from the outside. He sent the brains to a museum in Paris giving neuroscientists nowadays the opportunity to use modern imaging techniques to investigate his original findings (Cabanis et al. 1994; Castaigne et al. 1980; Dronkers et al. 2007). From these images, we know now that the lesions are not confined to parts of the inferior frontal gyrus only, but they extend medially into the arcuate/superior longitudinal fasciculus, which connects anterior and posterior language regions (Geschwind 1972).

The original finding of Broca, however, has led to a substantial amount of research on Broca's area, and these studies have made it further clear that Broca's area does not consist of one cytoarchitectonically well-defined area, but comprises several areas, including Brodmann areas (BA) 44 and 45 and the ventral part of BA 6. In the remainder of this chapter, we will use the term Broca's area to indicate BA 44 and 45 and the ventral part of BA 6.



3 Lesion Studies in Broca's Area: A Focus on Language Production and Comprehension

3.1 Language Production

As introduced, the term "Broca's aphasia" has been minted after Paul Broca's description of patient "Tan" to address production language impairment due to a damage in the posterior half of the left inferior frontal gyrus. The label "Broca's aphasia," though, seemed very soon too broad and unspecific to describe the complex pattern of linguistic deficits related to a brain damage in the "language production areas." After the fundamental studies of Arnold Pick (1898, 1913) the term "agrammatism" has been used to denote a type of Broca's aphasia, which involves a specific impairment at the grammatical level. Since then, the production deficits seen in Broca's aphasia and agrammatism have been described in a great number of lesion studies across languages (see Bates et al. 1991, for a review), studies which all converge in showing that lesions in Broca's area result in a production deficit with a particular involvement of grammar. The production deficits observed in Broca's aphasia are generally characterized by a decrease in speech rate, omission and/or substitution of function words (articles, prepositions, pronouns), a frequent use of uninflected verbs (particularly detectable in morphologically rich languages in which the non-finite form of verbs is morphologically marked, like Italian "mangiare" – to eat), and a reduced use of coordinated and subordinated sentences together with a loss of comprehension of complex syntactic structures. Miceli et al. (1984) showed that Italian aphasic speakers with a lesion in Broca's area omit free morphemes (articles and prepositions) and substitute bound morphemes (verb inflections for tense and person agreement). The same deficits were observed for German by De Bleser et al. (1995) and Luzzatti and De Bleser

(1996) who showed that agrammatic aphasic speakers were impaired in "syntax-dependent morphology," i.e., morphological processes which are more directly linked to syntactic operations (like verbal inflection).

As far as language production goes, the data provided by lesion studies seem to converge in showing that lesions in Broca's area produce an agrammatic speech output, which suggests that these brain areas are the locus in which syntax is stored. But if Broca's area indeed represents the anatomical locus for syntax, once a damage is located in that area, a language impairment at the syntactic level should not only be detectable in production but also in comprehension.

3.2 Language Comprehension

Thanks to a series of pioneer lesion studies on agrammatism (Caramazza and Zurif 1976; Grodzinsky 2000; Luzzatti et al. 2001; Shapiro and Levine 1990), it became clear that people with lesions in Broca's area (which had been addressed for a long time as the specific locus for language production) not only show deficits in production but they also show similar impairments in the comprehension of complex grammatical structures. Caramazza and Zurif (1976) were among the first to describe that patients with a lesion in Broca's area show deficits in comprehension of complex syntactic structures. The authors showed that agrammatic patients performed at chance when interpreting semantically reversible sentences, i.e., sentences that require a syntactic analysis to be correctly understood, like: "The girl was kicked by the boy." In contrast, they performed above chance with sentences that could be interpreted using semantic rules as a disentangling strategy, such as: "The ball was kicked by the girl." Further studies on comprehension deficits in Broca's aphasia (e.g., Grodzinsky 1995; Luzzatti et al. 2001) report that other complex syntactic structures, like passive and subordinate sentences as well as sentences with pronominal clitic pronouns, are difficult to interpret for aphasic speakers.

Lesion studies have provided (and still provide) fundamental information on the role played by Broca's area in language processing, providing converging evidence that Broca's area is involved both in language production and in language comprehension, disconfirming the initial thought that Broca's area was exclusively involved in language production. Second, the evidence is strong in favor of Broca's area being involved in syntactic processing, supporting the view that is this area is the locus of grammatical encoding.

4 Lesion Studies of Actions

Lesions in and around Broca's area are relatively well known for their association with Broca's aphasia, which we have discussed in the previous paragraphs. In this section, we will focus on how lesions in this part of the brain can cause disruptions in executing action and observing the actions of others.

4.1 Action Execution

Deficits in producing actions are known as *apraxia*. Patients who suffer from apraxia have difficulties in executing learned movements even though they are physically able to perform these movements. The disorders aphasia and apraxia very often occur together (De Renzi et al. 1980).

Lesions in Broca's area play an important role in apraxia (Leiguarda and Marsden 2000). They can lead to weakness of muscles that control oro-facial, laryngeal and tongue movements (Förster 1936). Furthermore, lesions in Broca's area can lead to difficulties in sequencing of actions (Harrington et al. 1998), to a loss of regularity of exploratory finger movements during manipulation of objects (Binkofski et al. 2001), to deficits in visuomotor associative learning (Binkofski and Buccino 2004), and to deficits in grasping (Dettmers et al. 2003).

Natural lesions that are restricted to one cytoarchitectonically well-defined brain area are rare. Fortunately, with the technique of repetitive transcranial magnetic stimulation (rTMS), it is possible to create temporary "lesions" in a particular brain area to investigate the necessity of this brain area during a certain task. To investigate the role of Broca's area during imitation of finger movements, Heiser et al. (2003) delivered rTMS over right and left Broca's area while participants had to perform this task. They found that these stimulations caused a disruption in the imitation task, while the control rTMS over the occipital cortex did not show such a disruption. This indicates that Broca's area could be the place in which a matching between observed and to-be-executed actions takes place. Since rTMS did not cause a disruption in a motor control task, the deficits in imitation could not have been caused by a disruption in planning or selection.

The design of this experiment was, however, criticized by Makuuchi (2005), who argued that the movement that had to be imitated was too simple. This has as a consequence that only in the first few trials has the observed movement really to be transformed into one's own motor representation, but in later trials, the observed movement merely functions as a visual cue to perform a learned movement. Makuuchi (2005) performed a new experiment from which he concludes that it is not imitation that Broca's area is essential for, but it is the delayed execution of actions.

Damage to Broca's area thus does not only have an influence on the production and perception of language, but also disrupts action production.

4.2 Action Perception

Besides disrupting action production, damage in Broca's area also has a profound influence on the perception of actions performed by other people. Damage to Broca's area leads to an impairment in conceptual knowledge about actions (Tranel et al. 2003).

Aphasic patients with lesions in the inferior frontal gyrus and the ventral premotor cortex have trouble with action understanding (Saygin et al. 2004). This is independent of whether the action is presented linguistically (i.e., a written description) or non-linguistically (i.e., visual presentation). Furthermore, the linguistic and non-linguistic deficits are correlated with each other in the mild and relatively fluent aphasics, which implies a common underlying cause of the deficits. Artificially lesioning this area with TMS disrupts action understanding of other people's actions (Pobric and Hamilton 2006). These results are in accordance with results of Aziz-Zadeh et al. (2006), who (in non-brain-damaged subjects) found overlapping activations for action observation and reading sentences about actions in Broca's area.

Pazzaglia et al. (2008a, b) provide evidence that indicate that the deficits in action production are related to deficits in action perception. First, they showed that brain-damaged patients who suffer from limb apraxia also show a greater impairment in recognition of gestures than brain-damaged patients who do not suffer from this disorder. Second, premotor and parietal lesions that impair *hand* action execution (as compared to mouth action execution) also selectively impair the recognition of hand gestures and their sounds (Pazzaglia et al. 2008a, b).

All these studies show that deficits in action comprehension and action production are very much interrelated and associated with Broca's area.

5 Functional Studies on Language

If lesion studies inform us on the specific linguistic deficits that Broca's patients show in production and comprehension, the growing use in linguistic research of neuroimaging techniques such as fMRI (functional magnetic resonance imaging), ERP (event-related potentials), MEG (magnetoencephalography), and PET (positron emission tomography) has made possible the investigation of language processing in healthy people. fMRI and PET, with their high spatial resolution, permit the localization of particular brain areas which are involved during specific language tasks. PET is used more often for production studies, given that it is less sensitive to movement and muscular artifacts, whereas fMRI has been extensively used in comprehension paradigms.

5.1 Language Production

In a PET study, Indefrey et al. (2001) elicited the production of sentences, which were increasingly grammatically complex. Participants were asked to describe short animated movies, which involved non-animated participants (a circle, an ellipse, and a square). Results showed that the production of syntactically more complex sentences resulted in an activation of the left anterior operculum, caudally adjacent to BA 44. Haller et al. (2005) performed an fMRI study involving open speech production. Participants were required to generate sentences given bare syntactic constituents (for example, using the constituents: "child," "throw," and "ball," should produce sentences like: "The child throws the ball"). The activation resulting from the sentence generation task was compared with a sentence reading and a word repetition tasks. Both contrasts revealed that BA 44/45 and BA 6 were activated. Word level production studies involving syntactic processing have also been performed. Jaeger et al. (1996) and Indefrey et al. (1997) investigated which are the neurocorrelates of regular and irregular past verb formation. According to linguistic accounts, regular past verbs are formed using morpho/syntactic rules, for example in English, affixing the –ed morpheme to the verbal root. Irregular past verbs, however, cannot be "blindly" formed applying a morpho/syntactic rule but their specific forms need to be stored in the lexicon. The two studies report that producing the past tense of regular verbs activates inferior frontal regions (regions that have been found to be active in morpho/syntactic processes), whereas producing the past tense of irregular verbs activates middle temporal regions (more involved with lexical processes).

5.2 Language Comprehension

Ben-Shachar et al. (2003) performed an fMRI study to check which were the areas involved in a specific syntactic operation, i.e., syntactic movement. Participants had to listen to sentences and after this make a grammatical judgment about them. Results show that Broca's area was activated when sentences contained a moved element. Broca's area (together with Wernicke's regions in both hemispheres) was activated in another fMRI study by Ben-Shachar et al. (2004). In this study, the task consisted of a comprehension test with two other types of grammatical structures involving syntactic movement, i.e., topicalization and embedded questions. These authors consider the activation of the left Broca's area crucial for syntactic processes. Meyer et al. (2000) found an activation of the left Broca's area during auditory presentation of grammatically correct and incorrect sentences. Fiebach et al. (2001) conducted a study aimed at detecting the areas involved in syntactic transformation or in the detection of syntactic anomalies. The results revealed that BA 44/45 were active in sentences with syntactic transformations, and BA 44/6 were active while detecting syntactic anomalies. Area BA 44 was activated in a study by Dapretto and Bookheimer (1999), when participants had to focus their attention towards more syntactic aspects of sentences compared to more semantic ones.

Summarizing the results from these studies, it is possible to speak about a network of regions within Broca's area, which support syntactic processing both for production and language comprehension. More specifically, the left inferior frontal gyrus with areas BA 44/45 are actively involved in more complex syntactic processing, while the frontal operculum seems to support the detection of whether a structure is grammatical or not.

6 Functional Studies on Actions

6.1 *Action Execution*

Activation in Broca's area is found during the programming of object-directed action execution, particularly when the action is a complex motor act which requires a high degree of sensorimotor control (Binkofski and Buccino 2004). In our laboratory, activation in Broca's area is always found when comparing object-directed action execution against rest (Gazzola et al. 2006, 2007a, b; Gazzola and Keysers 2009).

Further evidence for the fact that Broca's area is involved in the motor programming of actions comes from a study by Haslinger et al. (2002) in which participants have to perform increasingly complex finger movements. Results show that the more complex the sequence of movements, the more Broca's area is involved. Other studies by Schubotz and von Cramon (2001, 2002a, b, c, 2003) have shown similar results in that the ventral premotor cortex part of Broca's area is engaged when a sequential-based prediction of the action has to be made (for example, to predict the end state of a sequence of movements).

Examples of other kinds of motor acts that involve Broca's area are grasping actions (Decety et al. 1994; Ehrsson et al. 2000; Grafton et al. 1996), manipulation of objects (Binkofski et al. 1999), finger movements (Krams et al. 1998; Seitz and Roland 1992), and gesturing (Fridman et al. 2006).

Summarizing, parts of Broca's area seems to be involved in action execution, particularly when the action is complex (both in terms of movement and sequencing) and is object-directed.

6.2 *Action Perception*

Studies using movies of simple hand actions show that Broca's area is consistently activated when observing these simple hand or mouth actions (Buccino et al. 2001; Gazzola and Keysers 2009; Gazzola et al. 2007a, b; Grafton et al. 1996; Rizzolatti et al. 1996b). Broca's area is particularly involved when the action is goal-directed and includes an object, for example grasping a little cup, biting and chewing an apple (Buccino et al. 2001). Not only the visual perception of an action involves Broca's area, but the mere sound of actions also elicits a response in this area (Gazzola et al. 2006).

It is argued that, for Broca's area to respond to observed action, the action needs to be part of the motor repertoire of the observer. For example, Broca's area responds to the observation of mouth actions of humans (speech pronunciation) and monkeys (lip smacking), but not to mouth actions of a dog (barking) (Buccino et al. 2004). Gazzola et al. (2007a) extend this finding by showing that Broca's area is also involved in actions the kinematics of which we cannot match onto our own motor repertoire, but of which we do understand the goal (e.g., "human" actions performed by an industrial robot).

The fact that Broca's area was historically linked to language processing raised the question whether activation in this region is truly due to the processing of the action or to a form of inner verbalization of the action (Decety et al. 1997; Grèzes and Decety 2001). There is now, however, relatively wide agreement about the fact that the idea of "silent speech" cannot account for the activation in Broca's area. If activation in Broca's area would be due to inner speech, then one would expect that imitation with the left or right hand would activate this area similarly; however, Koski et al. (2003) found a difference in activation due to imitation with one hand or the other. Second, inner speech would predict that hearing and performing hand and mouth actions should cause similar patterns of activity in premotor regions. Gazzola et al. (2006) and Etzel et al. (2008), however, showed that hand and mouth actions determine different patterns of activity, which are, however, similar during execution and perception. In another study, rTMS was applied over left and right BA 44, causing a disruption in the imitation process (Heiser et al. 2003). Could it be a disturbance in the silent verbalization of the action that disrupted the imitation? The authors note that this is a highly unlikely explanation, since pre-verbal little children cannot verbalize actions but can imitate them.

Summarizing these functional studies, we can say that Broca's area is highly important for the perception of other people's actions and for programming the execution of complex actions of hands and mouth, given that these are not too repetitive.

7 Mirror Neurons and the Putative Mirror Neuron System

In the previous section, we have seen that Broca's area is involved in both perception and production of complex actions. Is it truly the same neural substrate that is responsible for these different tasks? In the monkey's brain there is evidence for the idea that production and perception depend on the same neurons, so called mirror neurons.

Mirror neurons were first discovered in Italy (Gallese et al. 1996; Pellegrino et al. 1992; Rizzolatti et al. 1996a). Activity from single neurons in the macaque monkey's brain had been recorded when the monkey was performing an action (i.e., grasping a peanut, shelling a peanut). The researchers discovered that some neurons in this area not only showed activity during action execution but also when the monkey *observed* the researcher grasping a peanut or shelling it. Later, the same laboratory would show that some mirror neurons also respond to the sound of a similar action (Keysers et al. 2003; Kohler et al. 2002). These neurons thus have the special property of firing not only when the monkey performs an action but also when a similar action is perceived. Mirror neurons therefore show a direct connection between perception and action. The areas in which mirror neurons have been recorded from in the monkey are the rostral part of inferior area 6 (area F 5) (Pellegrino et al. 1992; Gallese et al. 1996; Keysers et al. 2003; Kohler et al. 2002) and the rostral part of the inferior parietal lobule (area 7b) (Fogassi et al. 2005).

Since the moment of discovery of mirror neurons, the question arose whether such neurons would be present in the human brain. Indeed, evidence for a mirror neuron system in humans has been derived from neuroimaging and TMS studies, with the former showing that a network of areas is active both while people perform actions and while they view or hear other people's actions (Gazzola et al. 2006; Keysers and Gazzola 2006; Rizzolatti and Craighero 2004). In humans, this system seems to include the dorsal premotor, somatosensory, cerebellar and posterior temporal cortex in addition to BA 44 and 6 and the inferior parietal lobule (Gazzola and Keysers 2009).

But is it also true for humans that it is the same population of neurons that respond both to the observation and execution of actions? We cannot say anything about individual neurons, but on the level of individual *voxels,*[1] we can affirm that this is the case. Gazzola and Keysers (2009) have shown that, within individual subjects, they are truly the same voxels that respond both to the perception and production of complex actions. In addition, in a recent study, Etzel et al. (2008), using an analysis technique known as multivariate classification, could show that the perception and execution of actions not only both recruit Broca's area, but that they indeed determine similar patterns of activity in Broca's area, a finding most compatible with the presence of mirror neurons in the human Broca's area.

Mirror neurons show activation both in response to the execution of an action and to the observation of an action. In the human brain, we have seen that Broca's area is part of the putative mirror neuron system and has similar properties: it is active during perception and production of complex actions. Could it be that these two areas have a common evolutionary ancestor? Probably yes: there is a wide agreement that area F5 finds its homologue either in BA 44, 45, or 6. There is, however, less agreement about where exactly in these three areas it is (Amunts et al. 1999; Bonin and Bailey 1961, 1947; Campbell 1905; Grèzes et al. 2003; Grèzes and Decety 2001; Morin and Grèzes 2008; Passingham 1981, 1993; Petrides 2006; Petrides and Pandya 1994; Rizzolatti and Arbib 1998).

The discovery of mirror neurons has led to the idea that we understand, at least in part, the goal-directed actions of others such as grasping and manipulating objects by activating our own motor and somatosensory representations of similar actions (Buccino et al. 2001, 2004; Gallese and Goldman 1998; Gazzola et al. 2006, 2007a; Hamzei et al. 2003; Heiser et al. 2003; Iacoboni et al. 2005; Keysers and Gazzola 2006; Keysers et al. 2003; Kilner et al. 2007; Nishitani and Hari 2000).

8 Broca's Area: Between Language and Action

In the previous paragraphs, we reported a series of studies (both lesion and functional) that show that BA 44/45 and BA 6 are critical brain areas underlying language production and comprehension as well as action execution and perception.

[1]A voxel is a volume element that constitutes the building blocks of a 3D MR image of the brain. A voxel is analogous to a pixel in a 2D image.

Several studies addressed the question whether action and language share a common functional architecture in the brain. Damasio and Tranel (1993) performed a careful anatomical study in an agrammatic patient who showed a selective impairment in action naming.

Within the linguistic domain, one well-known phenomenon observed in Broca's aphasia is the noun–verb dissociation. Broca's aphasic speakers are reported to comprehend (and produce) nouns better than verbs (Miceli et al. 1984; Zingeser and Berndt 1990; Rossi and Bastiaanse 2008). This observation gave rise to a large number of studies investigating the causes of this dissociation. The first careful anatomical study in an agrammatic patient who showed a selective impairment in action naming was conducted by Damasio and Tranel (2003), who described that the patient presented a lesion in the left pre-motor frontal cortex. Saygin et al. (2004) reported an action comprehension study with 29 aphasic patients. Patients were tested with a comprehension task involving the process of actions presented visually (with a relevant drawing – pantomime) and linguistically (with a sentence). Results showed that patients were impaired in the comprehension of both modes of presentation. Arévalo et al. (2007) tested 21 aphasic speakers and a control group. Participants had to name, read or repeat single words, which were nouns or verbs. Behavioral results showed that both aphasics and non-brain-damaged speakers were less accurate in naming verbs, but a cross-item analysis revealed that the crucial factor that influenced the performance was "manipulability," and this was true across category (both for verbs and for nouns).

These studies importantly confirm that people with damage in language areas (BA 44/45) show difficulties in the comprehension of both language and pantomime actions which indicates that similar brain areas are recruited for both tasks, bringing evidence for a convergence between the areas that are important for language and pantomime processing.

Hamzei et al. (2003) explicitly addressed the question of whether action recognition and language production share a common functional architecture. They performed an experiment in which they instructed participants to either recognize an action shown in a picture or to silently verbalize an action verb written on the screen. They found an overlap between activation of the language and the action task in the Broca's area on a group level. On a single subject level, however, no overlap was found and no consistent spatial pattern could be detected between the two activation peaks. This indicates that there seems to be no functional subdivision for language and action in Broca's area.

The observation that language and action share common neural substrates opens the question of whether this occurs as a coincidence or whether this is the base for advocating a closer relation between the two systems.

There exist a number of speculative ideas about this. The first one is represented by the "motor theory of speech perception" (Liberman and Mattingly 1985) which states that we understand speech by perceiving the phonetic information as intended gestures of the sender, represented in the brain as motor commands. Galantucci et al. (2006) reviewed this theory and gathered evidence for the claims that perceiving speech is perceiving gestures and that the motor system is recruited for this. Another idea for why both action and language perception and production have overlapping brain substrates is the hypothesis of "embodied semantics," which claims that language comprehension stems from the internal referring to the actions that are conveyed by the language. This theory is supported by studies showing that listening to action-related sentences activates the motor-related areas in the brain (Aziz-Zadeh et al. 2006; Hauk and Pulvermüller 2004; Tettamanti et al. 2005). The third idea argues that language evolution originated from hand gestures, which is the reason they are represented in the same region in the brain (Rizzolatti and Arbib 1998).

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Language Attrition and Identity

Monika S. Schmid

Abstract This chapter will discuss the loss or attrition of a first language (L1) in an immigration setting. Based on two large-scale investigations of migrant populations with German as a first language (Schmid 2002; Schmid 2007), it will be investigated to what degree regular use of the first language in daily life and attitudes toward the culture of origin can influence L1 attrition or maintenance.

Investigations of language attrition typically find substantial differences within migrant populations. Some individuals are indistinguishable from native speakers, even after having lived in an emigration setting for many decades, while others are no longer recognizable as original members of the speech community. Over the past decades, many attempts have been made to identify the predicting factors for L1 attrition or maintenance. It has been shown that the impact of factors such as frequent use of and exposure to the language is much less pronounced than might have been expected. On the other hand, there seems to be a rather large role of the attitude toward the community of origin on the part of the speaker. This suggests that culture and identity may be the most important factors for the constitution of multilingual proficiency.

Keywords Bilingualism attitude · Identity · Language attrition

The traditional approach to research on bilingualism was, for many decades, characterized by the perspective of the monolingual native speaker as the norm. Achievement in second languages was measured against this yardstick, and mature first language competence was assumed to be the stable and unchanging baseline. Even though Weinreich pointed out as early as 1953 that "interference" between two language systems, "those instances of deviation from the norms of either language which occur in the speech of bilinguals" (Weinreich 1953: 1), is a phenomenon which can affect both second language (L2) and first language (L1),

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the recognition that a bilingual is not two monolinguals represented within the same mind/brain (Grosjean 1982) did not become widely accepted until much later. It was not until psycholinguistic investigations were able to demonstrate that all of a bilingual's language systems are, to some degree, active and in competition with each other at all times (e.g., Grosjean 2001) that the "multicompetence" view (Cook 2003) of a wholistic and interconnected system of knowledge and proficiency in and use of more than one language was formulated.

In this context, success in second language acquisition should therefore not be measured in terms of the failure to perform in an exactly "native-like way," but be seen in terms of the activation and inhibition of the competing linguistic systems. This view also entails that the development of the second language has ramifications throughout the overall system of multicompetence, and that one should also expect the knowledge and use of the first language to be involved in this development. A bilingualism effect in the L1 – behavior which differs to some degree from that of monolingual native speakers – is therefore to be expected for all speakers of more than one language. In this vein, it has been demonstrated that there is cross-linguistic interaction in the area of the mental lexicon (a facilitating effect for cognates and delayed access for non-cognates; e.g., Dijkstra and van Heuven 2002), in sentence processing (Hernandez et al. 1994), and in the structuring of phonetic space (Cutler et al. 1989; Flege 1987).

Such effects are usually very subtle and not readily apparent in "normal" linguistic interaction. In order to detect them, sophisticated techniques and measurements, such as reaction-time paradigms for the mental lexicon or highly sensitive auditory analyses in the case of phonetics, have to be applied. However, among speakers who have experienced language dominance reversal, i.e., who speak their second language with overwhelming frequency in their daily lives and only rarely have occasion to use their L1, the L2 impact on the native system can become more pronounced. Lexical retrieval difficulties can eventually impair communication and cause massive disfluencies (Schmid and Beers Fägersten 2010), the interaction between grammatical systems can lead to an increase in non-target-like structures (Tsimpli et al. 2004), and a foreign accent can develop which is perceptible in communication with other native speakers (de Leeuw et al. 2010). When the L1 has changed to such an extent, for example in the case of migrants, this development is commonly referred to as first language attrition.

Attrition research has often wrestled with the problem of whether it is possible to establish a distinction between the "normal" influence of the L2 on the L1, which all bilinguals probably experience to some degree (as is suggested by, among others, Cook 2003), and the (consequently to some degree "abnormal") process of L1 attrition, which is confined to migrants. It has recently been suggested that this distinction is not only impossible to draw but also unhelpful, as "bilinguals may not have one 'normal' language (in which they are indistinguishable from monolinguals [. . .]) and one 'deviant' one (in which knowledge is less extensive than that of monolinguals, and also tainted by interference from L1 in SLA [second language acquisition] and from L2 in attrition)" (Schmid and Köpke 2007: 3). Rather, while L1 attrition may be the most clearly pronounced end of the spectrum of multicompetence, and therefore a more satisfying object of investigation than the L1 system of a low-proficiency L2 learner (which may not show substantial and noticeable signs of change), attrition is undoubtedly part of this continuum, and not a discrete and unique state of development.

Given the multicompetence perspective on the development of both L1 and L2 in the mind of the bilingual speaker, it is interesting to see that the degree of L2 impact apparent in migrant's use of their native language can vary greatly, as is illustrated by examples (1) and (2) below. These stretches of text originate from oral history interviews with two German Jews who fled from Germany during the Nazi régime (for a detailed discussion of the corpus to which these interviews belong, see Schmid 2002). Both speakers grew up with German as their first (and only) language until the time of migration when both were 13 years old. For both speakers, the event of migration dates back some 60 years, and both report very infrequent use of their L1 since then.

(1) G.U.: wir hatten einen ähm # äh äh <u>refrigerator</u> äh
I: Kühlschrank
G.U.: Kühlschrank, elektrischen, und das war ziemlich neu in äh # dann äh <u>at</u> der Zeit und gra- grade wie die Nazis ah ma- in die Küche gehen um das zu zerstören der äh Kühlschrank # ähm machte einen wie wie wie die machten in mit gehen an
I: der Motor
G.U.: und de- de- da hatten sie Angst und da sind wollten sie nicht in die Küche gehen, und da s- sind so so die Küche war nicht zerstreut
Translation:
G.U.: *we had an ahm # ah ah <u>refrigerator</u> ah*
I: Kühlschrank
G.U.: Kühlschrank*, electric, and that was something quite new in ah then ah at that time, and ju- just when the Nazis ah ma- go into the kitchen to destroy that, the refrigerator # ah made an what what what they did in with they start up*
I: *the engine*
G.U.: *and the- the- then they were afraid and they were didn't want to go into the kitchen, and then s- were so so the kitchen wasn't destroyed*

(2) A.L.: ich war dann auf einer sogenannten <u>preparatory school</u>, einer Vorbereitungsschule in Bournemouth, wo ich todunglücklich war # ich konnte kein- ich konnte kein äh Englisch, es waren einige andere deutsche <u>boys</u> da, die sind alle durch dieselbe Verbindung nach England gekommen
Translation:
Then I was at a so-called <u>preparatory school</u>, a Vorbereitungsschule *in Bournemouth, where I was dreadfully unhappy # I didn't know any I didn't know any ah English, there were a few other German <u>boys</u> there, they all came to England through the same connection*

(Items which are *underlined* are instances of code-switches into English, the *symbol* # represents a pause)

The difference between the two speakers is striking: G.U. talks hesitatingly and slowly, her speech is marked by many pauses, filled pauses ("ahem," "ah") and repetitions of words, and she frequently asks the interviewer to help her with particular German words which she has difficulty remembering. Most of the words she uses are fairly unspecific high-frequency items, and she avoids complex constructions such as subordinate or embedded clauses.[1] In addition, her narrative contains a high number of what native speakers of German would probably consider lexical or grammatical "mistakes", as well as code-switches into English, and she has a marked English accent. A.L., on the other hand, also code-switches occasionally, and makes some mistakes; and his speech, too, contains some pauses, filled pauses and repetitions. The overall impression, however, is that he uses German fluently and confidently, and the only accent he has is a perfectly preserved instance of his native Rhenanian dialect.

In view of such differences in the overall lexical richness, syntactic complexity, fluency, accuracy, and degree of foreign accent in data from speakers for whom the overall circumstances of migration (age at migration, duration of migration, overall reported L1 use) and the linguistic habits were otherwise rather similar, an obvious question is what factors might condition the degree of change an L1 system of a multicompetent language user will undergo.

To some degree, these factors may be similar to what has been documented to determine success in L2 acquisition. In this respect, Paradis (2007), based on a neurolinguistic theory of bilingualism, predicts that attrition will be conditioned by language disuse on the one hand and by motivation on the other:

> [T]he cerebral substrate of any mental representation requires a certain amount of neural impulses in order to reach activation (its activation threshold). Each time a language item (a word or morphosyntactic construction) is used, its activation threshold is lowered, making it easier to activate again, but it slowly rises when inactive (as evidenced in frequency, recency and priming effects). [...] With extensive use of L2, the L1 threshold for certain items is raised [...] In a nutshell, attrition is the result of long-term lack of stimulation. (Paradis 2007: 124f.)
>
> Motivation has been shown to have a considerable impact on L2 acquisition/learning [...]. Motivation/affect may play an important role by influencing the activation threshold. Thus attrition may be accelerated by a negative emotional attitude toward L1, which will raise the L1 activation threshold. It may be retarded by a positive emotional attitude toward L1, which will lower its activation threshold. (Paradis 2007: 128)

In order to assess these factors in some more detail, an investigation of German migrants in Canada ($n = 53$) and the Netherlands ($n = 53$) was carried out. The data collected from these speakers were compared against a control group ($n = 53$) of speakers who had lived in Germany all their lives, and who had relatively minimal competence in and exposure to other languages. The data were collected in 2004

[1]Subordinate clauses in German are complex since they involve a word order which is quite different from that which applies in main clauses; more details can be found in Schmid (2002).

Table 1 Overview of participant characteristics

	Bilingual speakers (attriters)				Reference group (controls)	
	GECA: Germans in Canada ($n = 53$)		GENL: Germans in NL ($n = 53$)		GECG: control group ($n = 53$)	
	Mean	SD	Mean	SD	Mean	SD
Age at experiment	63.23	10.92	63.36	9.55	60.89	11.60
Age at migration (minimum 17 years)	26.13	7.15	29.08	7.53	–	–
Length of residence (minimum 15 years)	37.09	12.37	34.28	11.13	–	–

and 2005 in the country of residence of the speakers; for a concise overview of participant characteristics see Table 1.

The factors which were predicted by Paradis to impact on the attritional process were elicited by means of a sociolinguistic questionnaire (SQ), containing a total of 78 items on L1 use in a variety of situations, attitudes toward the L1, to the native and the host culture, and toward language maintenance and transmission to the next generation. Schmid and Dusseldorp (2010) conducted a principal component analysis on these predictors, and showed them to broadly fall into four categories:

1. Factors pertaining to the informal and familiar L1 use with other bilinguals, as is the case for the use of the L1 with partner, children and friends (*BilMod*)
2. Factors pertaining to L1 use with other bilinguals in situations where code-switching is inappropriate, either because the context is more formal (e.g., L1 use for professional purposes) or because the other speakers disapprove of code-switching (*IntMod*)
3. Factors pertaining to receptive exposure to the L1, e.g., through reading, TV or Internet (*Exposure*)
4. Factors pertaining to affiliation and identity (*Affil*)

The degree of proficiency which each individual attriter retained in her/his L1 was tested through a combination of formal skills, self-assessments, and an analysis of lexical and syntactic richness and complexity, overall accuracy, and perceived foreign accent in free speech (elicited through a film retelling task). Specifically, all participants completed the following tasks:

1. A *C-test* (CT, see Grotjahn 1987). The *C-test* is a fill-in test where the subject is presented with a text from which parts of words have been removed following a pre-determined schema and asked to complete the missing parts. The test consisted of five texts between 80 and 100 words in length, each of which contained 20 gaps. The *C-test* score was computed as the number of times a gap was filled in correctly; a high score on the *C-test* reflects high proficiency, with a possible range of 0–100
2. Two semantic verbal fluency (VF) tasks, where participants are asked to name as many items in a specific lexical category as they can within the space of 60 s (Roberts and Le Dorze 1997). The two stimuli used were “animals” on the one hand and “fruit and vegetables” on the other. The final VF measure was an

Table 2 Group differences on experimental tasks (one-way ANOVA with Tukey post-hoc procedure)

			GECA	GENL	GECG	$F(2,156)$	p	η^2
CT		Mean	75.26*	77.21	82.21	5.025	0.008	0.06
		SD	11.61	13.86	8.90			
VF		Mean	20.24*	20.91*	25.09	16.943	0.000	0.18
		SD	4.62	4.68	4.67			
Film retelling	D	Mean	70.45	63.93*	75.35	5.873	0.003	0.07
		SD	17.12	15.67	17.90			
	EP	Mean	16.17	16.23	6.32	9.003	<0.001	0.11
		SD	15.79	15.12	9.64			
	RP	Mean	4.88	3.58	2.23	4.430	0.013	0.06
		SD	5.71	3.50	2.94			
	RT	Mean	16.96	16.98	12.38	5.157	0.007	0.06
		SD	9.45	9.71	8.10			
	ERR	Mean	9.11*	9.30*	1.80	18.070	<0.001	0.19
		SD	5.91	1.99	2.56			

*Difference from control group <0.05 (Tukey)

averaged measure of the score on the two individual tasks. A high score on the VF task reflects high proficiency

3. *Free speech*: a set of controlled, largely monological, speech samples was produced by means of the Charlie Chaplin film retelling task described by Perdue (1993), which involves watching and then narrating a 10-min excerpt from the silent movie *Modern Times*. The following variables were established on the basis of these samples:
   Lexical richness (*D*): *D* is a measure of type-token ratios[2] based on random sampling of stretches of 50 words, i.e., it is not sensitive to variation in text length (see McKee et al. 2000). A high score reflects low type-token ratios, i.e., more lexical diversity
   Fluency: the incidence of silent pauses (EP), repetitions (RP), and self-corrections or retractions (RT), standardized per 1,000 words
   Non-target-like language use: total errors, standardized per 1,000 words (ERR)

Group differences on these measures were established by means of one-way ANOVAs, which revealed consistently poorer performance of the attriters (see Table 2). Effect sizes (η^2) were rather small, suggesting that the group differences were hardly dramatic. On the other hand, the very large standard deviations for virtually all measures among the attriters indicate that there was a great deal more variance in the performances for these groups than for the controls.

Schmid and Dusseldorp (2010) then conducted regression analyses in order to establish to what degree external predictors might account for the variance among the attriting groups – in other words, what factors would make a speaker attrite

[2]The type-token ratio of a text is the total number of words divided by the total number of different lexical items. Since language contains a large number of very high-frequency function words, longer texts will automatically have a lower type-token ratio.

more or less. The findings from these analyses were rather surprising: firstly, the amount of use which the speakers made of their first language had very low impact on any of the variables, and some factors, such as the use of the L1 with friends, did not impact on performance on any of the tasks. In particular, all fluency measures appeared entirely unaffected by any of the predictors. This finding was very surprising, as "amount of L1 exposure" is typically and intuitively taken to be the strongest predicting factor for L1 attrition. However, a number of ongoing investigations of the attrition of other languages, using the same experimental design, have come to corroborate these findings (Cherciov 2010; Dostert 2009; Keijzer 2007; van der Kooi in preparation; Yilmaz in preparation). It was hypothesized that the accessibility of the first language may be affected more by the fact that all attriters have a highly active L2 system to contend with, so that their problems lie less in the activation of the L1 system (which might be differentially affected by frequency and recency of use) and more in the inhibition of the L2 system (which all bilingual speakers are affected by, irrespective of how often they use the L1).

Nor did the measures of attitude and identity applied in Schmid and Dusseldorp's (2010) study have any impact on the outcome variables. Again, given the predictions relating to the impact of emotional and motivational factors made by Paradis, this finding is surprising (and again, it appears to be replicated by other studies). Here, however, the problem might be of a different order: by definition, studies of language attrition are conducted a long time after migration has taken place (speakers investigated in such studies typically have a period of residence in the L2 environment of several decades). The operative factor for the degree of attrition, however, is probably the attitude toward both L1 and L2 at the beginning of this period, when massive and intensive L2 learning is taking place, affecting the overall system of multicompetence. However, attitudes are not stable and constant across a person's life, and what is measured at the moment that the degree of individual attrition is assessed may bear very little relationship to the original feelings of the speaker.

It is difficult to see how this methodological problem can be overcome, as it is impossible for the attrition researcher to go back in time, and impractical to measure attitudes at one point in time and attrition effects at a second point, decades later. In this respect, the data mentioned at the beginning of this chapter allow unique insights: the German-Jewish migrants introduced here belong to a group of refugees who had to flee from their home country under extremely drastic circumstances, which are historically very well documented. It is conceivable that an important factor for the way a migrant establishes his or her new identity in a foreign country may be the reason or circumstances that led to the emigration. In cases where a persecuted minority had no choice but to leave their country of origin, it has often been speculated that a rejection of elements of identity associated with that country might ensue (cf. Clyne 1981: 64; Romaine 1989: 43). Especially in cases where the minority, prior to emigration, was part of the same linguistic community as the majority, such a conflict could very well influence first language attrition.

The attitudes toward Germany and the German language among the victims of Nazi persecution span the entire spectrum of identification. The fact that there were some who were not entirely uprooted and alienated from their German identity was most famously expressed in Thomas Mann's legendary "Wo ich bin, ist Deutschland" ("Wherever I am is Germany"). The other extreme is represented by an equally decisive rejection from the speaker who was referred to as G.U. at the beginning of this chapter, who states categorically: "America is my country, and English is my language" (quoted in Schmid 2002: 27).

Both these cases are examples of a dramatically changed external situation that made it necessary for the individual to reconstruct elements of their identity. From its very beginnings, the Nazi regime had made it clear to German Jews that they were not welcome, and had essentially denied them the right to identify themselves as Germans. When such a severance is effected on the part of a dominant majority, it seems that there are two possible ways of coping left to the minority: the "Thomas Mann" strategy, which refuses to let itself be robbed of its national and linguistic identity and conversely and logically denies it to the barbarians that now populate one's home country, and the strategy that says, "If that's what being German is, I want no part of it." Which of these two strategies an individual chooses, and to what extent, may be influenced by personal experiences, by the degree of persecution that he or she was subjected to.

The persecution of Jews under the Nazi regime was not a process that started immediately and in full force after the Nazi seizure of power (*Machtübernahme*). The erosion of legal and civil rights that eventually culminated in the genocide was a gradual one, and it was clearly characterized by several phases.

During the first phase from January 1933 to August 1935, persecution was focused on and aimed toward Jews in public life. Within months of the *Machtübernahme*, boycotts against Jewish shops and businesses were organized, and Jewish doctors, lawyers and judges lost their licenses under the "law for the re-establishment of the professional civil service" (*Gesetz zur Wiederherstellung des Berufsbeamtentums*), which stated that all civil servants of "non-Aryan descent" were to be retired, unless they had held their positions since before August 1914 or were the fathers or sons of soldiers who had died in World War I (Walk 1981). Further laws and regulations to exclude German Jews from certain professions and restrict their educational opportunities were to follow.

It was thus at a very early stage of the Nazi regime that anti-Semitism came to pervade almost every aspect of daily and public life for the Jewish population, not only because of the laws and regulations that were passed but also through the changes in behavior, the open aggression, of large parts of the non-Jewish population. At this stage, however, many people still felt that it would all soon blow over, that it could not possibly get any worse than it already was. Those who did emigrate during this early period usually did so because they belonged to one of the (comparatively small) professional groups for whom the continuation of either their occupation or of their education had become impossible (Hilberg 1996: 138).

It was in September 1935 that the persecution entered a new and more radical stage, as the Nuremberg racial laws (*Nürnberger Rassengesetze*) were passed: the "citizenship law" (*Reichsbürgergesetz*), the "law for the protection of German blood and German honor" (*Gesetz zum Schutze des deutschen Blutes und der *deutschen Ehre*), augmented in October 1935 by the "law for the protection of the genetic health of the German people" (*Gesetz zum Schutze der Erbgesundheit des deutschen Volkes*). These laws were fundamental to the subsequent measures of persecution in that they made a clear and basic distinction between the rights of "people of German or related blood" and "people of foreign blood," namely Jews, Gypsies, Blacks, etc. The citizenship law essentially established two classes of citizenship according to this "racial" distinction, assigning those who were not considered "Aryans" an inferior status, resembling that of foreigners. This status was defined predominantly in the citizenship law and laid the foundation for all subsequent laws that were specifically discriminatory against these groups.

This distinction between "races" was applied in the other two laws mentioned above, in that "Aryans" were no longer allowed to marry or have sexual relations with "non-Aryans," and infractions of these laws were defined as "racial disgrace" (*Rassenschande*), a criminal offense. The subsequent years were characterized by a continually increasing persecution and exclusion from public life, and

> [i]n the course of the next few years the machinery of destruction was turned on Jewish 'wealth'. In increasing numbers, one Jewish family after another discovered that it was impoverished. [...] The Jews were deprived of their professions, their enterprises, their financial reserves, their wages [. . .] We shall refer to this process as 'expropriation.' (Hilberg 1961: 54)

It was in 1938 that the climate again changed substantially. This was a process that began with the *Anschluss* on March 12, the date when Austria became a part of Germany, and the attending surge of nationalist and anti-Semitic feelings (Rieker and Zimmermann 1998: 235). But then, in late 1938, two events took place which marked the beginning of a hitherto unimaginable phase. The first of these was the deportation of all Jews of Polish citizenship to Poland, subsequent to a declaration by the Polish government that all citizens who had not been to Poland for more than 5 years would lose their citizenship on October 31. Among those who were deported were the parents of Herschel Grynzpan, a German Jew living in Paris. On November 7, 1938 he shot a member of the German embassy, Ernst vom Rath, whose death gave a convenient excuse for the pogrom of November 9, come to be known as *Reichskristallnacht*. In what were implied to be "spontaneous uprisings," organized groups of mainly SA-men (storm troopers) but also civilians destroyed more than 1,000 synagogues and 7,500 houses and businesses during that night. While 91 people were killed according to official records, the actual numbers are almost certainly much higher than that. More than 30,000 were arrested and taken to the concentration camps of Buchenwald, Sachsenhausen, and Dachau (Rieker and Zimmermann 1998: 245).

This was a turning point. It was no longer a matter of laws and regulations; virtually everyone who experienced that night came to feel what it was like to be in immediate danger of their lives.

After November 9, 1938, the segregation of Jews took on a new force and pace, laws and decrees being passed which made the process of expropriation complete. After Germany had invaded Poland on September 1, 1939, thus starting World

War II, the Jewish population was quickly stripped of what remaining rights they had. They lost all professional opportunities. Jewish children were no longer allowed to attend non-Jewish schools. Jewish men were compelled to do forced labor. Jews were made to give up their houses and apartments and live in special “Jewish houses” (*Judenhäuser*). They no longer had the right to read the daily newspapers, own a radio or a telephone or even use public telephones. They were only allowed to do their shopping at special times. And from September 19, 1941 onwards, they had to wear the “yellow star” that marked them as Jewish in public. In October 1941, deportations to Poland started (Rieker and Zimmermann 1998: 250).

On January 20, 1942, in a committee meeting that has come to be known as *Wannseekonferenz*, 15 high officials decided on how to organize and administer the deportation and genocide of European Jews.

The process by which the status of German Jews was changed, from one of legal equality and social assimilation to one of outcasts who had lost any right including the right to live, can therefore be seen to have progressed in three clearly defined and distinct phases:

1. January 1933 to August 1935: when the persecution was aimed at the exclusion of Jews from public life
2. August 1935 to September 1938: when activities were targeted at clearly defining Jews as a group, i.e., as outsiders and “non-Germans” as well as at their dispossession
3. November 1938 to May 1945: the genocide

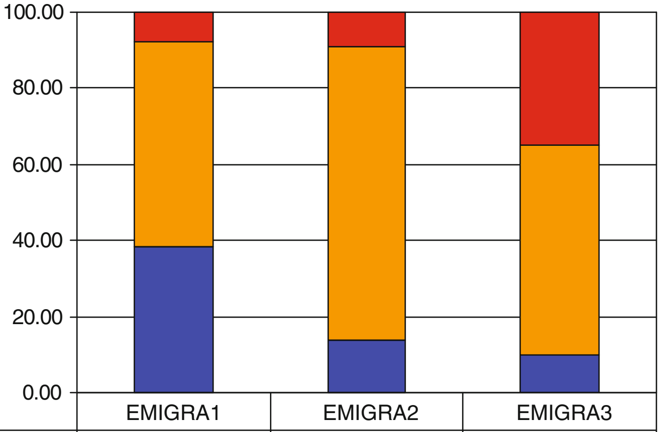
In order to assess to what degree the experience of these different historical phases influenced individual L1 maintenance or attrition, Schmid (2002) conducted an investigation of attrition effects in a corpus of 35 oral history interviews with former citizens of the city of Düsseldorf (among them the speakers introduced above as G.U. and A.L.). She compared the speakers who had left Germany during each of these periods, and found clear differences in the levels of attrition/maintenance for all groups: the speakers who had left earliest not only had the lowest numbers of errors across a range of grammatical phenomena, their speech was also the most lexically diverse and syntactically complex, and they were perceived to be the least foreign-sounding by native listeners. By contrast, those speakers whose migration took place after the pogrom showed the strongest signs of attrition across all of these measures, and the intermediate group consistently fell between these two extreme points.

In order to gain some further insight into issues of attitudes and identification processes among this population, a questionnaire was sent to all interviewees, in which they were invited to comment on their attitudes toward Germany and the German language. The statements which were elicited in this manner fell across the full range of the attitudinal spectrum mentioned above. For example, the speaker quoted as A.L. at the beginning of this chapter stated that, even though he had been only 13 years old when he came to England, German had remained his mother tongue to this day. On the other hand, many speakers echoed G.U.'s categorical break with their German identities, and said that the German language "repulsed" them.

All positive, neutral and negative statements occurring in these questionnaires were counted, and the proportion of each was established across the three groups (see Fig. 1). From these responses, a clear picture emerges of how the original positive attitude felt by many German Jews toward their culture and language was eradicated over the years of the Nazi régime.

The emotional distancing which is implied in these statements can furthermore be traced back to the use of some linguistic structures in the interview themselves. A further analysis was carried out to establish this, concerning the use of the pronoun *we* by all speakers. *We*, of course, includes the speaker and one or more other person(s); and for all those instances where this pronoun was used in narratives which were situated in the German, pre-migration context, it was established whom the speaker had included with him- or herself. Figure 2 shows that, while for all groups the referents of the inclusive pronoun are predominantly family members, this trend appears to have become more pronounced with progressive radicalization of the climate. This may be due to the fact that, in an increasingly threatening sphere, contacts outside the own family became progressively reduced, as people were made to feel that no-one was to be trusted.

Interestingly, across all groups, the use of the inclusive pronoun for unambiguously non-Jewish referents is negligible. However, the strongest difference between the groups of speakers can be perceived in those cases where the speaker refers to someone else without making it clear whether that person was



	EMIGRA1	EMIGRA2	EMIGRA3
% negative statements	7.69	9.09	35.00
% neutral statements	53.85	77.27	55.00
% positive statements	38.46	13.64	10.00

Fig. 1 Distribution of statements embodying positive, neutral, and negative attitudes toward Germany and the German language by emigration group (EMIGRA1: 1933–1935; EMIGRA2: 1935–1938; EMIGRA3: 1938–1939)

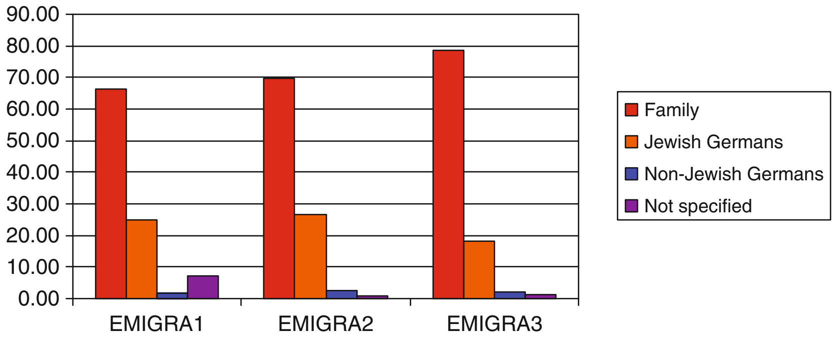


Fig. 2 Referents of the inclusive pronoun *we* across groups

Jewish or not: while the earliest group of migrants has a substantial proportion of such cases, they all but disappear for those speakers who experienced the passing of the Nuremberg laws. The categorization into "Aryans" and "non-Aryans" imposed by these laws may therefore have been so pervasive that it carried through in these narratives many decades later.

Both analyses confirm the assumption that strategies of identity and identification varied markedly between those migrants who left Germany during the three historical phases outlined above. These identification mechanisms tally with the degrees to which a deterioration of the first language system was found in the interviews. These findings therefore suggest that forgetting a language might be a process that is in part governed by attitude and identification.[3] While those speakers who emigrated after the Nuremberg laws had been passed apparently felt a reluctance to use German any longer, which resulted in the language system "atrophying" to some degree, it is only those who experienced the pogrom for whom this distaste became so great that they acquired features which seems to mark them as "non-native speakers": The language of the childhood home and family may have been tainted by the Nazi atrocities to the degree that they no longer wanted no part of it.

The reasons for this pattern of L1 attrition probably lie in a situation where the persecuted minority had the same L1 as the dominant majority, and the L1 thus became associated with elements of identity of that dominant group. In such situations, a symbolic link between the language and the persecuting regime can lead to a rejection of that language. Discovering such a link and its impact on the language attrition process is extremely complicated for most groups of migrants, since measurements are usually applied a long time after migration took place. However, the findings presented here suggest that it is the attitude at the moment of

[3]Professor Eva Ruhnau of the Ludwig-Maximilians-Universität, Munic, Germany (p.c.) suggested that there may also be an element of personality involved: taking an early decision to migrate may be associated with different character traits than remaining in the country as long as possible. While this is an intriguing suggestion, it unfortunately cannot be established or verified on the basis of the data available for the present investigation.

migration, not what is assessed several decades later, that impacts most strongly on the attritional process.

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The Logic of Constellations: A Complementary Mode of Thinking that is Crucial for Understanding How Reality Actually Takes Place

Albrecht von Müller

Abstract It is argued that in human thinking there exist two basic modes of connecting mental content. One is the rather well-understood and well-formalizable "ratio-morphic concatenation" (RMC). This mode corresponds to the factual aspect of reality and it lends itself for precise analysis. Most of the history of "logic" focused on this mode of thinking. There also exists, however, a second, phylogenetically much older, less precisely definable mode of connecting mental content. For this mode, the notion "logic of constellations" (LOC) is introduced. LOC has hitherto often been addressed with black-box concepts such as "intuition" or "gut feeling". Taking LOC seriously as a second mode of thinking in its own right implies starting to ask about its internal structures and processes. Analyzing LOC in this way shows that it is composed of three distinguishable sub-dynamics. Firstly, there is a process in which the different components of a constellation interpret each other mutually, and thus unfold their specific meaning in their actual constellation. Secondly, there emerges, out of all these "bilateral" processes of semantic unfolding, a global, overarching "picture" or "meaning". This emergent "big picture" is meaningful, but never well-defined. Thirdly, the overarching picture starts to impact – in a kind of top-down re-interpretation – on its own constituents and sharpens their meaning once again. These three sub-dynamics together constitute the LOC. LOC is complementary to RMC, and it is essentially an asymptotic, i.e., never completely finished, and thus never well-defined process of "semantogenesis". LOC is important because it allows us to address the *actual taking place of reality in the time–space of the present*. This actual taking place of reality is an aspect of reality in its own right, complementary to the factual aspect of reality for which RMC is the appropriate mode of thinking. Insight into the existence as well as into the internal structures and dynamics of LOC has implications for a very broad range of issues, i.e., for all issues that are characterized by strong self-referentiality and autogenesis. These issues range from foundational topics in science, like the famous "measurement problem" in quantum physics or

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the emergence of life and subsequently consciousness, to the perception of sense and meaning. But it is argued that LOC is equally important for understanding how art and creativity work, and for insightful, responsible decision making despite "objective uncertainty", i.e., in coping with an open, undetermined future.

Keywords Autogenesis · Categorial Apparatus · LOC – The logic of constellations · Self-referentiality · Thinking

1 Introduction

The task of this chapter is to briefly outline the notion of a "logic of constellations" (LOC) and its practical implications. Usually, we associate with the notion "logic" rules for connecting different cognitive operations in a formally correct way. In the Western-occidental tradition, Aristotle was the first to raise this issue systematically, and it is astonishing to what degree his pioneering observations are still valid today. The modern version of this classical logic was developed in the first half of the nineteenth century by the great English (autodidact) Mathematician and Philosopher George Boole.

I resorted to the notion of a "LOC" (von Müller, 2010) when finding that, due to a necessary rethinking of our physics ontology, there must exist a second mode of connecting mental content, complementary to classical logic. LOC is not a variant of a formal logic, like, e.g., multi-valued, modal or so-called "quantum" or "temporal" logics. LOC is radically different in at least three ways:

- In LOC, the authentic presence of the content that is to be connected is required (i.e., no "place holding" is possible).
- LOC describes the rules of semantic unfolding, this means that the meaning of the involved components is not static, but they unfold their meaning mutually – in and due to their very constellation.
- In LOC, there exist no formal conclusions and no formal truth criteria; authentic experience is the only way to judge whether a statement "*makes sense*" or not.

One could question whether, given all these constraints, it is still useful to talk about a "logic" in the first place. I would staunchly defend this, because I think that (1) it is a fundamental, i.e., irreducible mode of connecting mental content, that (2) it is much closer to how we actually think than any formal logic – the latter can even be seen as a very special case of LOC, and that (3) the original, ancient Greek meaning of "logos" – as articulated so forcefully by Heraclites – is much closer to LOC than to any formal logic. There is a certain relationship to Hegel's very rich and fascinating notion of logic. This, too, allows for, and is even based on, semantic unfolding. Hegel, however, conceptualizes this unfolding as part of a (rather) closed philosophical system (Filk and von Müller, 2010) i.e., it is characterized exactly not by the genuine and constitutive openness of the approach developed here.

In order to elaborate the notion of a "LOC" in its context, I will proceed in four steps. First, I will briefly recapitulate the needed rethinking of our physics ontology.

As this has been elaborated elsewhere (Filk and von Müller, 2009) in detail, I will only summarize some key points in order to allow the reader to get the general thrust. In the second part of the argument, I will derive what follows for advanced cognition, assuming that human thinking is the hitherto most advanced cognitive adaptation to the actual taking place of reality.

The third part will then be a more detailed discussion of the principles and sub-dynamics of the LOC. The chapter will end with a fourth and last part in which some conjectures about possible implications of LOC for cultural cognitive neuroscience and the future development of artificial cognition are derived.

2 Discovering the Existence of Categorial Apparatus (pl.)

We have known from long ago, at the latest since Immanuel Kant's great re-thinking of thought, that "below" all our thinking there are categories. These constitute, so to speak, the interface between thinking and reality. What we were not sufficiently aware of is that these categories do not come in isolation but as an entire "categorial apparatus", i.e., with strong internal interrelations.

There is a "classical" categorial apparatus that constitutes the "factual aspect" of reality. (In the following, it is called "F apparatus".) It consists of four fully interdependent components (Fig. 1).

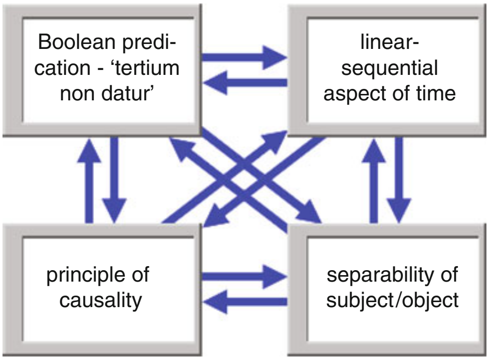

Fig. 1 "F apparatus" "Classical" categorical scheme that constitutes the "factual aspect" of reality

But this way of addressing reality is not comprehensive, as we know from at least two independent sources: the advent of quantum physics since 1900, and Gödel's proof of 1931. The incompleteness of the factual aspect of reality automatically poses the question what else is there and how can it be addressed. Complementary to the factual aspect of reality, there should exist one in which the "actual taking place of reality", and the "self-constitution of reality" (as we see it in the state reduction in quantum physics, or in the phenomenon of strong self-referentiality), can be addressed. Given the close relationship between the factual aspect of reality and the F apparatus, it is likely that we need a second categorial apparatus to address this aspect of reality.

Formulating it, however, requires to first understand the general structure of a categorial apparatus. Asking for the "functional niches" that are addressed by the F apparatus, we can identify the following four. Firstly, a structure of a predication space is defined (Boolean logic). Secondly, a constitutedness of time is introduced (linear-sequential time). Thirdly, a way to concatenate events is fixed (causality). And fourthly, a basic epistemological setting is established (subject/object dichotomy). These four "slots" thus define the general structure of a categorial apparatus (Fig. 2).

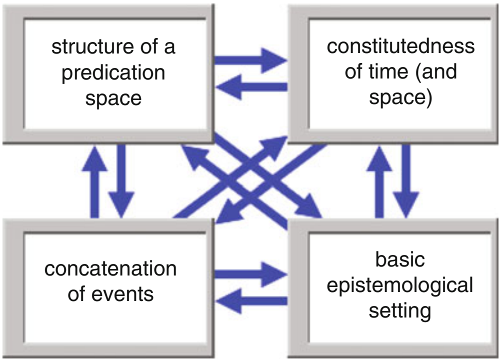

Fig. 2 "Functional niches" addressed by the F apparatus

Equipped with the insight into this general structure, we can now start to ask if a second categorial apparatus can be developed and how it could look like, i.e., by which four alternative components the four slots could be filled in a self-consistent way. The answer to this question is the E framework with the following four mutually interrelated components (Fig. 3).

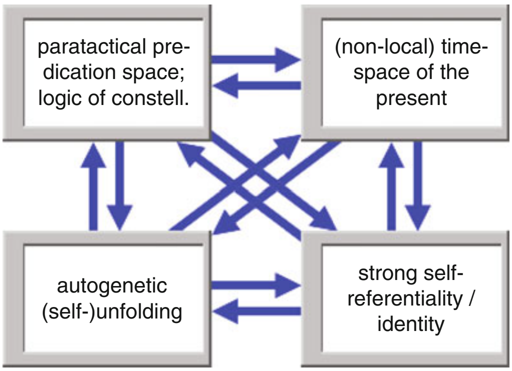

Fig. 3 "E apparatus": second categorical apparatus

(For a brief characterization of each of the four components see Sects. 3, 4 and 5).

The E framework corresponds to the "statu nascendi aspect of reality", i.e., the coming into being of reality. Each of its four components leads immediately to massive inconsistencies, if we project them (erroneously) into the F apparatus. But together, i.e., taken appropriately as a categorial apparatus in its own right, they are consistent and mutually stabilize each other, just like the four components of the F apparatus do.

We now possess a significantly richer categorial framework that consists of the “F” and the “E” apparatus, and the two are complementary in a strict sense: no phenomenon can be addressed comprehensively by drawing on only one of the two.

The next question is how the two need to be combined. Although they are complementary and neither can be reduced to the other, the relative weight can shift dramatically. The appropriate mix varies in a continuum from “almost all F” to “almost all E”. Which relative weights are appropriate depends on the relevance of self-referentiality for the phenomenon to be addressed. For addressing a classical physics experiment, “almost all F” applies, while for talking, e.g., about meditational experiences, “almost all E” may be appropriate.

3 A Novel Account of Time and Reality

Instead of the traditional “facts only” account of reality, the combined E and F frameworks allows the realizing and addressing of three interrelated layers of reality (marked below as yellow, green and blue) (Fig. 4).

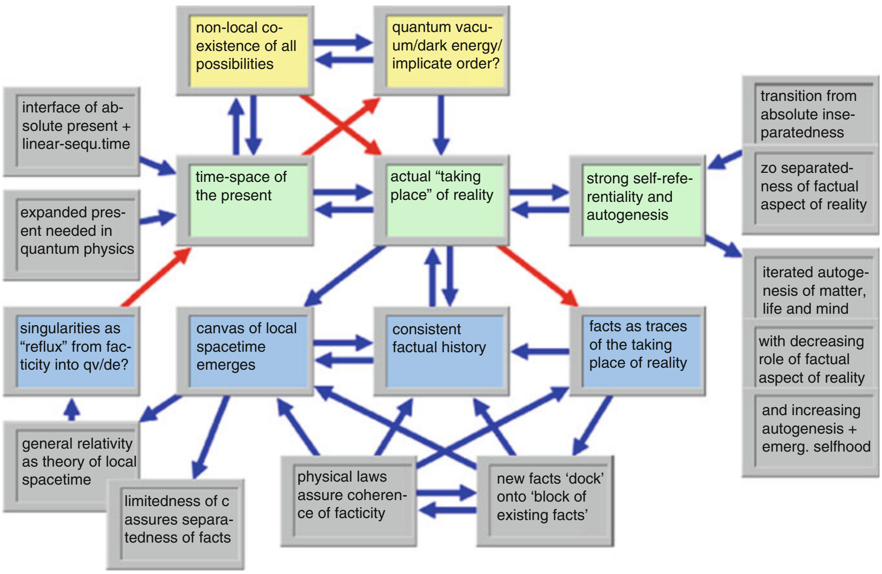

Fig. 4 New model of the taking place of reality drawing on the “F” and the “E apparatus” and thus able to address three layers of reality (marked as yellow, green and blue)

In this new model of the taking place of reality, the blue layer represents the factual aspect of reality. On the right hand side, novel facts are constantly added to the already existing ones. In this way, it is made sure that new facts do not contradict existing ones, i.e., the consistency of history is assured, by the conservation principles. Unlike in most other models, it is assumed that the "canvas" of local space–time emerges only together with factization, i.e., to already apply it for the pre-factual state of reality (the green, and even more so the yellow layer) leads to irresolvable enigmas and contradictions. *The canvas of local space–time applies to the factual aspect of reality – and only to it – because it emerges only together with factization.*

In this account of reality, the singularities of GRT gain a very important, constitutive role. As it is proposed that the factual aspect of reality can never give a comprehensive picture, the theory *requires* such a "point of irreducible insufficiency" in any F-type theory. The melt-down of the local space–time canvas in singularities provides exactly this predicted loop-hole. And, as also predicted, this "structural insufficiency" of the factual account of reality is directly related to the phenomenon of strong self-referentiality. Singularities occur when gravity starts to impact so much on itself that a "run-away increase ad-infinitum" (within the respective quantum limits) occurs.

A nice side aspect of this novel account of reality is that the finiteness of the speed of light (c) can also be derived directly: infinite c would make the separability of local space–time collapse, and with it also causality, the applicability of Boolean logic to physics and the subject/object dichotomy would be gone. Only because "it takes some time" to get from one point in local space–time to another, spatio-temporal extendedness – and with it separability as the underlying, cross-cutting feature of the factual account of reality – is possible.

The green layer represents the actual taking place of reality in the time–space of the present, i.e., this is where all of reality actually *occurs*. The category of causality cannot be applied to this actual occurring. In the time–space of the present, reality takes place in and out of itself, i.e., in autogenesis. Hypostasizing hidden causal variables "behind" this actual taking place of reality amounts to a major category mistake – and the violation of Bell's inequalities provides elegant empirical evidence for this.

The green layer can, thus, be interpreted as the ongoing transition into facticity. But, transition from where? The yellow layer represents a radically non-local aspect of reality which can be characterized as the absolute superposition of all possibilities. Possibly, this aspect of reality is closely related to the phenomenon of the quantum vacuum and David Bohm's interesting notion of an "implicate order". Even more speculatively, one might relate this aspect of reality to the mysterious phenomenon of dark energy. But these speculations are by no means crucial for the argument presented here. Mentioning them has the only purpose of offering a latching point to the framework presented here for those who struggle with these phenomena.

In sum: what the three-layer model of the taking place of reality should achieve is to provide us with a conceptual framework that (1) overcomes the cognitive *facticity imprisonment* of modern science, that (2) makes addressable what is there beyond facticity, that (3) explains how facticity comes into being, and that (4), by doing so, offers a new way of looking at some of the most persistent problems in modern science, like the relationship between quantum physics and general relativity.

4 A Present-Based Concept of Time

A crucial feature of the new account of time and reality is its novel, present-based interpretation of time. The classical, three-pronged schematization of time as "past", "present" (in the sense of a point-like now), and "future" turns out to be a special case that belongs *altogether* to the (blue) factual perspective on reality. This applies even to the future, because within this F framework, the "future" is about nothing else but (probabilistic) future *facts*.

Even the notion of an explicitly open, i.e., not yet determined, future (which plays a key role in some interpretations of quantum physics) does not solve the problem as it, too, misses the crucial ingredient of the new present-based notion of time: temporal non-locality, i.e., the "orthogonal" expandedness of the time–space of the present vis-à-vis the usual, linear-sequential aspect of time.

The novel concept of time contains three aspects of time that correspond directly to the three layers of the novel account of reality shown in the above model:

(a) the radically non-local co-presence of all possibilities in the sense of an "absolute present" (yellow stratum)
(b) the time–space of the present (TSP; green stratum); the TSP is the "platform" on which all of reality actually takes place as the transition from (a) to (c); the TSP is still non-local in that it is not yet sequentially structured, but it is no longer directly all-encompassing, as was (a)
(c) the linear-sequential aspects of time – corresponding to the factual aspect of reality – in which a "prior" is clearly separated from a "later", and thus the three-pronged aspect of time, with past, point-like now, and an (open or deterministic) future, has fully unfolded (blue stratum)

The TSP, i.e., the transition from layer (a) to layer (c), is where all reality actually "*takes place*", i.e., becomes part of local space–time, and wherein we live. The TSP still has the aspect of temporal non-locality, i.e., the "real" present is still characterized by an inherent unseparatedness of "prior" from "later". On the other hand, the TSP no longer enjoys the immediate co-presence of all. Being the transition from (a) to (c), the TSP *reaches* into both the stratum of "omnidentity" respectively "omnipresence" (yellow layer) and separable facticity (blue layer), Our experience of a present is no longer seen as a "subject-side confabulation" – like in classical and relativistic physics – but as the hitherto most advanced *cognitive adaptation to the way reality actually takes place* – namely in the TSP.

This new view also makes sense in an evolutionary perspective: the experience of the present – irreducibly intertwined with the phenomenon of consciousness – is a neuro-biologically, rather late and very costly feature; as such a "expensive capability" could never have survived evolutionary selection pressures if it did not serve a real purpose, i.e., if it did not give us or improve our access to an important aspect of reality.

In sum: in the novel concept of time, the present moves to the center and it is (re-) introduced into physics, but as the TSP, and not as a point-like "now".

While the introduction of an "objective present", in the sense of a common, mandatory point-like now, would be in contradiction with relativity, the introduction of a non-local TSP is not. On the contrary, it is even a logical prerequisite for *stating* the existence of a block universe (in the F perspective of reality) and for understanding the phenomenon of singularities (with their characteristic collapse of the local space-time fabric).

5 Autogenesis and Strong Self-Referentiality

The notion of "autogenesis" is used as a technical term; it denotes (1) that something comes into being, and (2) that this happens in, out of and towards itself. "In itself" means that it unfolds more and more internal richness. "Out of itself" means that this happens in the absence of an external causation. "Towards itself" means that there is something like an "emergent self-hood".

We assume quite easily that our universe could be of autogenetic origin. But, we oversaw that this αρχή (in the dual sense of "origin" and "dominating principle") might imply that autogenesis is a cross-cutting feature of all of reality.

It is not by chance that we struggle so much with perceiving and understanding the phenomenon of autogenesis. In the history of our "post-socratic" thinking, we focused increasingly – and with great success – on the factual aspect of reality. But, what if it turns out facts are only the traces of the "taking place of reality"? In this case, it might be that the "coming into being" itself cannot be addressed and captured adequately in the conceptual framework that applies for facts. In this vein, it will be shown how we can re-think time and reality, and that-by doing so-we can overcome our cognitive "facticity imprisonment".

Weak self-referentiality means something refers to parts or aspects of itself; strong self-referentiality means that something refers to itself in its entirety. Gödel's proof of 1931 demonstrated that strong self-referentiality is an inevitable feature of all formal systems, strong enough to derive natural numbers.

Autogenesis and strong self-referentiality are twin phenomena. Strong self-referentiality is the structural portrait of autogenesis; autogenesis is the procedural implication of strong self-referentiality.

Strong self-referentiality transcends any single Boolean framework, and it causes problems with the entire categorial apparatus into which Boolean logic is embedded (e.g., it also violates any strictly linear-sequential notion of time). At the same time, strong self-referentiality is not just a formal gimmick but an inherent feature of the taking place of reality.

Due to its problematic consequences in any well-defined, Boolean framework, strong self-referentiality, and its twin, autogenesis, were increasingly marginalized during the advance of modern, analytical science. Only now, we are starting to understand that this suppressed problem may lurk behind a broad spectrum of open issues, from state reduction in quantum physics to the origin of mass, and from the self-constitution of life to that of consciousness.

6 The Taking Place of Reality and the Logic of Constellations

We know how to address the factual aspect of reality, namely by predications according to the F apparatus. The (yellow) layer of a radically non-linear co-presence of all possibilities is hardly predicable at all. But what about the green layer, the actual taking place of reality in the time–space of the present?

It is argued that, in a paratactic predication, space propositions are related according to the "logic of constellations" (LOC), and that this is the only appropriate way of addressing the phenomena of autogenesis and strong self-referentiality (Fig. 5).

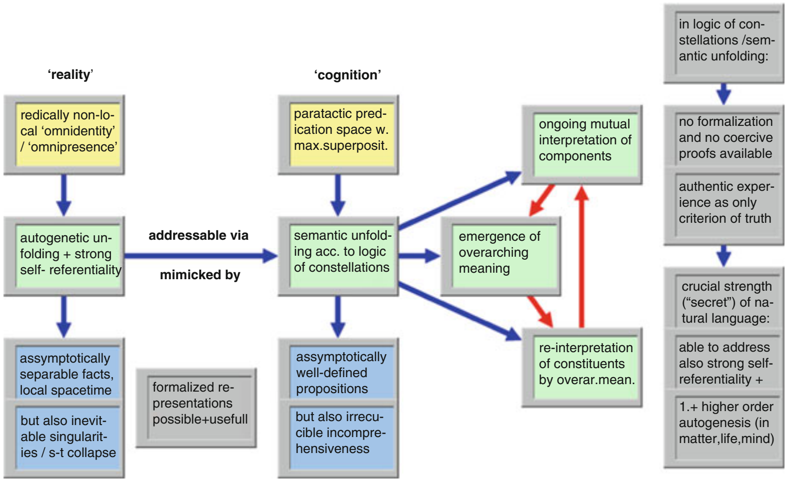

Fig. 5 The Taking Place of Reality and the Possibility of Addressing it via the Logic of Constellations

The LOC is not only the cognitive equivalent to the autogenetic unfolding of reality in the time-space of the present. It is also most closely related to our experience of a present. The latter is not a subject-side confabulation of an objectively factual reality; it is, instead, the hitherto most advanced cognitive adaptation to the way in which reality actually takes place.

For the E aspect of reality, binary (i.e., Boolean) "tertium non datur" logic fails and a paratactic predication space with LOC applies. Constellations are settings in which the components interpret each other. LOC consists of three different sub-dynamics:

- a mutual interpretation of the individual components,
- the emergence of an overarching meaning,
- the re-interpretation of its constituents by the overarching meaning.

A constellation is a "semantic powerhouse" unfolding new levels of meaning, and, thus, fitting mimetically with the autogenetic aspect of reality. As the "facticity imprisonment" developed, science was separated from art, and art became the enclave of the constellatory aspect of reality. But, by gaining insight into the existence of LOC, we can re-gain this aspect of reality, without opening the doors for all kinds of “voodoo thinking” (Fig. 6).

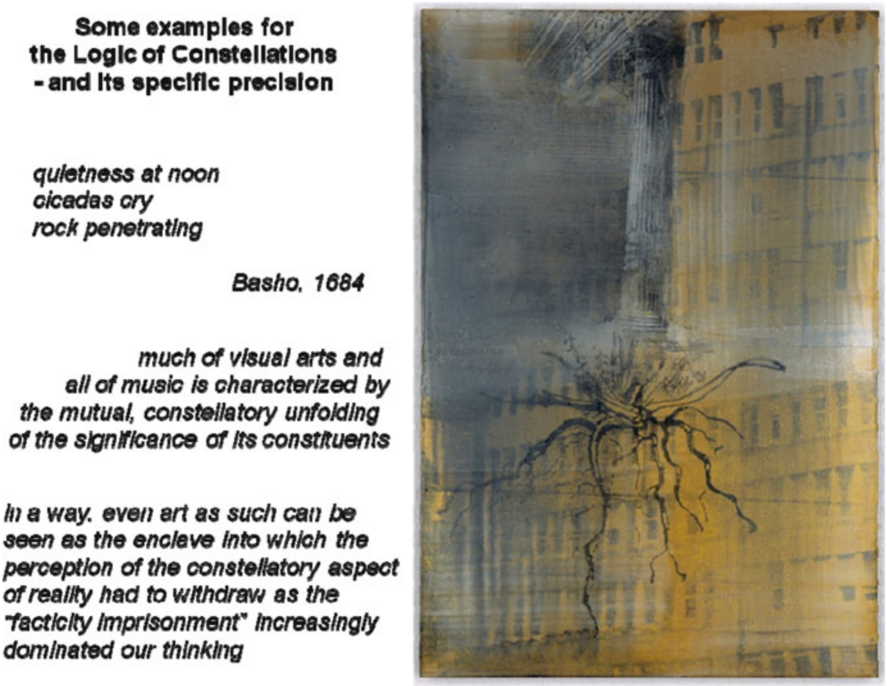

Fig. 6 From Igor Sacharow-Ross: Yellow-Orange

How does LOC actually materialize in Basho’s wonderful Haiku? Cicadas cry is characterized by abrupt interruptions, an instant, concerted transition into silence. This abrupt ending of the noise is what makes the quietness all the more “hearable” and impressive. Vice versa, when the silentium is broken again, the cry of the cicadas is even more intensive, to the degree that it even penetrates the rocks. But is it only the cry of the cicadas that penetrates the rocks – or, possibly even more so, the quietness? And so forth and so forth…

These inadequate and insufficient verbalizations just try to indicate the kind of semantic unfolding that occurs between the three constituents of the poem. All three start and continue to unfold their meaning in and due to the presence of the others, thus giving a wonderful example for the first sub-dynamics of LOC.

Out of these “bilateral” interactions emerges a scene in its never completed entirety and integrity (second sub-dynamics). And this emergent, overarching meaning, – the hot, breath-taking noon between (unmentioned, but almost inevitably confabulated) grass and the hard, impenetrable but yet penetrated rocks – makes us finally even more aware of the staggering interplay of silence and noise (third sub-dynamics).

In a comparable manner, the elements in Igor Sacharow-Ross painting unfold their meaning mutually in, due to, and into their *co-presence*. And, as already indicated, I would argue that, in all art, the involved components mutually unfold and gain their very meaning in their very constellation.

But, even if this would be roughly correct, what could all this have to do with science? Very much, I would argue, at least, if we do not restrict science to the factual aspect of reality.

If the above mentioned model of reality holds water, restricting science to the F aspect of reality would mean depriving it of the most relevant and most fascinating aspects of the "taking place of reality". And we would, deliberately, give up understanding all strongly self-referential, and thus also autogenetic, phenomena like quantum physical state reduction, life or consciousness. That cannot be the way to go. But if we give up the facticity constraint of science, we need to allow constellatory predication. The latter will never be as precise or coercively provable as F-type observations. But, alas, if reality is like that, we have to cope with it as good as we can. We cannot continue to ignore a major aspect of the taking place of reality just for the sake of our cherished, F-type "scientific rigidity and precision".

It is important to understand the novel, complementary type of predication as well as possible – in order to not open doors for all kinds of nonsense – just "qualified" by violating rational argumentation. Exactly this "qualified opening", i.e., the ability to still separate between what is more likely to make sense and what is not, is the purpose of trying to understand the internal structures and dynamics of LOC.

In closing this part of the argument, I would just like to stress two phenomena once again. Firstly, E-type predication can never be proven in a factual manner, and thus nobody can ever be forced to accept any LOC propositions. Authentic experience is the only criterion of truth in this domain – and deliberate acceptance the only way that somebody can be convinced. Any E-type observation that pretends to be mandatory ("you *must* accept that...") is a non-starter in the first place. Secondly, most people would accept that art is a fascinating and legitimate approach to reality. But, as reality is only one, art tells us something about "how reality actually works". By (re-)gaining insight into the complementarity between F-type and E-type predication the historically grown rift between art and science may start to close again.

7 Outlook: Further Practical Implications of LOC

If LOC is the appropriate way of addressing the taking place of reality, it is obviously of relevance for quite a broad spectrum of issues. In this last step of the argument, I will briefly touch on a few of those topics.

7.1 Towards a Coherent Account of Evolution

If the taking place of physical reality is already – in the quantum physical reduction of state – characterized by strong self-referentiality and autogenesis, a novel way of interpreting the phylo and ontogenetic self-constitution of life becomes possible.

There exists no longer a categorial hiatus between non-living and living entities. Instead, life can be interpreted as "second order autogenesis" in the sense that first order autogenetic processes (constituting matter energy) configure at a higher aggregate level into a "second order" self-referential setting. Looped chains of chemical reactions, like, e.g., the hypercyles analyzed by M. Eigen and P. Schuster, seem to be close to perfect instantiations of this conceptual pattern.

Likewise, the emergence of first consciousness and subsequently self-consciousness can be seen as forms of yet higher order self-referentiality and autogenesis. In this way, i.e., through the E framework and with LOC as an integral part of it, a coherent account of all evolution – from the self-constitution of matter to that of mind – seems to become feasible.

7.2 Coping with Objective Uncertainty

As long as we have only the F framework at our disposal, we are almost bound to see uncertainty as epistemic. This means, however, that there is no objective uncertainty, just a lack of knowledge. The attitude that derives from this ontological assumption is to try to get more and more detailed information in order to reduce this inherently epistemic uncertainty.

If we assume, instead, objective uncertainty and this even on macroscopic scales – due to the structure of strong self-referentiality – we develop a completely different attitude. We try to gain as much insight as possible, but after that, the best we can do is to look at the *constellation of possibilities*. That is, instead of searching to become a kind of Laplacean demon, we now consciously confront objective uncertainty, and use the power of LOC to make as much sense as possible out of the constellation of possibilities.

For strategic decision makers, this modified attitude amounts to a paradigm shift in which cognitive "zooming-in" is no longer the only way to go. Now, instead, the opposite cognitive move, i.e., "zooming-out" and resorting to LOC for the overall assessment of the situation at hand, also becomes a legitimate and, on some occasions, clearly advantageous procedure.

In sum: Instead of endless (and eventually useless) zooming-in, we start to search for the "optimal cognitive distance" (OCD).

7.3 Responsible Decision Making Despite High Levels of Complexity

This phenomenon is closely related to the prior one. Under conditions of high complexity, decisions are hardly ever made in a purely rational-analytical manner. Intuition comes inevitably into play, whether we like it or not. Intuition is essentially the interpretation of *a constellation of weak signals that mutually unfold their meaning*. This is the first reason why LOC plays an important and irreducible role in responsible decision making. The second reason is that, for intuition to work, *a synoptic* mental representation of the entire issue at hand is required. Exactly this, however, gets lost by cognitive fragmentation and the pundit patchworks that invade so many high level decision-making processes today. Gaining insight into both the limited exactness but also the inherent strength of LOC may be a good antidote and an efficient way to regain the ability to make responsible decisions despite complexity levels that defeat any purely analytical approach.

7.4 The Phenomenon of Freedom and the Perception of Meaning

If freedom exists, a free decision cannot be driven by external causes. But it also cannot be just indeterministic in the sense of a pure random process. Free will requires reasons when opting for something. This means that free will can only be a quintessential autogenetic process, i.e., one that has its reasons, but within itself. This quintessential self-referentiality and autogenesis of free will explains why we had and still have insurmountable difficulties in dealing with the phenomenon of freedom in a conceptual framework that is tuned only to the factual aspect of reality. We cannot even grasp what freedom is, as long as we restrict ourselves to the cognitive constraints of an “F only” world.

And the same holds true for the phenomenon of experiencing sense and meaning. As long as they are caused by something else, they eventually dissolve. Sense and meaning, like freedom, never exist in the format of a sheer fact. If they exist, they *are* as an on-going taking place that continuously occurs anew, in the time–space of the present. Only by learning to think in the thought patterns of autogenesis and strong self-referentiality, and thus by applying LOC, we start to understand the essence of these phenomena.

7.5 The Secret of Natural Language and the Future of AI

When having the E framework and LOC as an integral part of it at our disposal, natural language starts to unveil a hidden secret. It is, like human cognition in general, a very smart and advanced evolutionary adaptation allowing us to address and deal with the taking place of reality in all its aspects.

It combines a high degree of semantic constancy and continuity, needed for coping with facticity, with the openness and the possibility of semantic unfolding, needed for coping with the emergence of the genuinely novel.

It would probably have been extremely easy for cognitive evolution to develop a formal logic (not to speak of a “Sheffer stroke”, respectively a “nand” or “nor” operator). These, however, do not suffice for coping with reality in an “autogenetic universe”. For this, an extremely delicate equilibrium had to be developed between semantic constancy and constellatory unfolding of meaning. This delicate equilibrium is the hidden hallmark of human cognition, and it is congenially supported by natural language.

For AI to really flourish, I would argue and predict, it will take a fundamentally novel approach, one that, at least partially, incorporates LOC and its ability to tolerate constellatory semantic unfolding. I do not take sides regarding the question whether this will be possible at all. But if it should turn out to be possible, we will necessarily get into the realm of "authentic cognition". This means that the respective processes will no longer be fully deterministic – they will be inherently open, instead – and that we will have to ponder whether the respective cognitive agents, through their authenticity, gain some kind of irreducible dignity.

8 Conclusion

All our thinking rests on categorial foundations. They are, so to speak, the interface between cognition and reality. There is a classical categorial apparatus, the F apparatus, which corresponds to the factual aspect of reality. It is very precise and powerful, but it does not cover all of reality. Only by complementing it with a second categorial framework, the E apparatus, also the actual taking place of reality, can be addressed adequately. Via LOC, it is possible to also address the twin phenomena of strong self-referentiality and autogenesis, which are maximally incompatible with the F apparatus, and whose accession would unravel it.

Being a feature of the taking place of reality as such, strong self-referentiality and autogenesis, however, are cross-cutting features of all ongoing phenomena (as long as they have not receded into sheer facticity). This in turn means that LOC is a fundamental, complementary mode of thinking which is of cross-cutting relevance whenever we are not addressing pure facts.

A crucial aspect of LOC is that it bridges the rift between natural sciences and humanities, thus allowing for a coherent account of reality. The more one moves from matter, through the appearances life to the phenomenon of mind, the higher the degree of self-referentiality and autogenesis, and thus the relevance of LOC within the overall description of the respective phenomena. But, by already applying to the quantum physical state reduction, i.e., the ongoing self-constitution of matter/ energy, it allows for a non-dichotomist and non-deterministic account of evolution, from big bang to our present thoughts right in this moment.

Appendix

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Three Modes of Knowledge as Basis for Intercultural Cognition and Communication: A Theoretical Perspective

Ernst Pöppel and Yan Bao

Abstract Human knowledge expresses itself in three different modes, i.e., as explicit, semantic or verbal knowledge, as implicit, tacit or intuitive knowledge, and as visual, pictorial or episodic knowledge. To refer to knowledge only as "explicit knowledge" would neglect the other modes of knowledge that are of equal importance for higher cognition. Unifying frames of the different modes of knowledge are the aesthetic principle on a formal level and the mimetic principle on the level of reference.

1 Three Modes of Knowledge

How is intercultural communication possible? We speak different languages, we are embedded in different cultural traditions with different rituals, but still believe we are able to communicate with each other and to understand each other. It is believed that intercultural communication is based on a common denominator in cognition, and we claim that, without such a common denominator being reflected in anthropological universals, communication would be impossible. It is our evolutionary heritage that provides a unifying frame (Darwin 1998; Lorenz 1943; Piaget 1970; Poeppel and Hickok 2004; Skinner 1981; Tinbergen 1956). From a logical point of view, cultural specifics can only be discovered if they relate to a common

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frame within which such differences are expressed. We believe that the common denominator is represented in different modes of knowledge that are shared by everybody and, perhaps not surprisingly, these modes of knowledge have been recognized since antiquity. The different cultural and religious traditions apparently independent of each other have all referred to explicit, implicit and pictorial knowledge as we like to refer to these knowledge systems today.

The Christian bible in the King James version begins with the words: “In the beginning God created the heavens and earth. The earth was without form and void, and darkness was upon the face of the deep; and the Spirit of God was moving over the face of the waters. And God said, ‘Let there be light’; and there was light. And God saw that the light was good; and God separated the light from the darkness. God called the light Day, and the darkness he called Night.” This text from Genesis refers to three different modes of knowledge, i.e., explicit or verbal knowledge (saying, calling), implicit or action-oriented knowledge (creating, doing), and visual or pictorial knowledge (seeing, recognizing). Similarly, Sura 96 of the Koran which is considered to be the first revelation of Mohammed refers to the act of creation, to pictorial knowledge (reading), and to the teaching of explicit knowledge. And in the Chinese tradition, we find a similar reference to different knowledge systems in Lun-yu II-18, when Confucius tells his student Zizhang how to get a higher position in the government: “Listen more, put aside those doubtful words and say the rest cautiously (explicit knowledge), then you will make fewer mistakes (action-oriented knowledge). Watch more (visual knowledge), put aside those perilous actions and do the rest carefully, then you will have less regret. With fewer mistakes in your words and less regret in your behavior, you are doing exactly what will bring you to what you want.”

The different bases of knowing are a consequence of how we process sensory information, how we feel or remember, how we make decisions, or how we think. Although this many-fold basis of knowing is inherent in us, we have to remind ourselves of this fact; what is self-evident is easily overlooked. Only after the self-evident is lost or damaged will its importance be recognized retrospectively. Effortless perception and action providing an adaptive advantage are primary goals of evolutionary selection (Mayr 2001), and as a result of such selective processes, self-evident activities like seeing a tree or saying a word occur without time-consuming reflection. However, as these activities are self-evident, they remain in the background of attention (Bao and Pöppel 2007). Self-evidence provides a frame of unquestioned confidence. Only if after circumscribed injuries of the brain pictorial knowledge is shattered, voluntary movements have become impossible, or verbal communication is limited (Farah 2000; Goldstein 1944; Luria 1973; Pöppel 1989; Pöppel et al. 1973; Weiskrantz 1986; Zihl et al. 1983), then do we realize that such basic activities like categorizing and comparing, wanting and acting, seeing and talking, thinking and deciding, are gifts of nature. When functional competence is disrupted, attention is drawn to the self-evident (if the neuronal machinery controlling attention is not itself affected), indicating that the unquestioned confidence in the operations of the mind is made available by a complex neuronal machinery (Nauta and Feirtag 1986; von Steinbüchel and Pöppel

1993). The loss of effortless processing is an indirect proof of the operative power of this machinery under normal circumstances.

How can the three modes of knowledge be characterized? We can rather describe than define them, and although they are discussed separately, it should be kept in mind that in the normal brain's activity they are interlinked; because of the architecture of the brain with its widespread projections, no independence of any functional system can be assumed (Nauta and Feirtag 1986; Pöppel et al. 1991). The different modes of knowledge have to be understood within a frame of functional interdependence obeying the principle of complementarity (Pöppel 2006), i.e., each system relies on the others.

2 Aspects of Explicit Knowledge

Explicit knowledge (EK) is information with meaning which can usually be expressed verbally (Baars 1988; Cassirer 1994; Pinker 1994; Wittgenstein 1921). EK is consciously available and it can be communicated using symbol systems like language (Graubard 1988). When EK is forgotten, it can be recovered from documents, i.e., EK is represented in an encyclopedia, in textbooks, or nowadays on the internet. EK is accumulated by learning, and this learning results in a corpus of semantic knowledge that one owns and that one can refer to in a distinct way. EK is the kind of knowledge that has dominated Western culture during the last centuries, and many believe that whenever one refers to knowledge one only has EK in mind. An important historical example for EK is given by René Descartes with his "Discours de la Méthode" (1637/1990). In this discourse, Descartes formulates four rules that should be applied if one is confronted with a complex situation: a problem has to be formulated clearly and distinctly (and one should approach the problem without prejudice and haste); a problem has to be reduced to a set of several limited problems, if it cannot be solved as a whole; one should move from the simple to the more complex in proper order; and fourth, all aspects of the problem should be taken into account (the requirement of completeness). These rules appear to be self-evident, and they are a necessary ingredient of human reasoning in science and beyond. What is hidden behind these apparently simple rules is, however, the unquestioned claim that they can in fact be successfully applied. The rationalistic program implies that it is possible to pose a question clearly and distinctly, to abstain from prejudices when solving a problem, to reduce a complex question to a full set of simpler ones, and to obey the law of completeness. These Cartesian rules exemplify the belief in the power of the human mind as represented in explicit knowledge.

Retrospectively, this approach has been extremely successful (Kuhn 1979). Scientific discoveries are an expression of EK. The development of modern science would hardly have been possible if there had not been a strong belief in rational conjecture; the fruits of thinking are scientific laws and on their basis technological developments (Bacon 1990; Feynman 1965; von Helmholtz 1896; Kant 1781/1787). However, to believe that human knowledge is limited to EK may create some difficulties, even in science (Nietzsche 1980). One example of some shortcomings if one trusts only in EK is the (short) history of artificial intelligence (Graubard 1988). In the beginning, proponents of artificial intelligence (AI) believed that human knowledge in its entirety can be expressed in physical symbols, i.e., in an explicit form. As an explicit representation can be expressed symbolically, it was thought that on such a basis algorithms could be developed that unambiguously mimic mental acts. As it turned out, however, it appeared to be impossible to transform human knowledge in its entirety into physical symbols; new developments take, for instance, embodied or tacit knowledge into account (Pfeifer and Bongard 2007).

Although it is in a way a caricature, EK can also be referred to with a neuronal metaphor as being mediated mainly by processing modules of the left cerebral hemisphere. This picture is based on the observation that patients with injuries of the left hemisphere may lose their capacity to communicate EK; in particular, lesions of the temporal lobe may result in the loss of semantic competence (Pinker 1994), suggesting that the patients no longer command explicit knowledge. Alternatively, one could argue that the brain of such patients can no longer link EK to a meaningful representation in language; some such patients report that their thoughts no longer find a way to words. Independent of these special problems, one can, however, state that EK is selectively vulnerable.

What are the mental operations necessary to create explicit knowledge? Presumably, EK is generated in a hierarchically organized system of neuronal operations beginning with categorization (Pöppel 2006). Any categorization takes place within a particular cognitive frame or reference system giving a semantic context; only if categories have been formed can they be related to each other, thus allowing for instance comparison between them. A comparison can be made either with respect to quantitative or qualitative differences. The notions of equality and inequality, identity and change, are necessary conditions for further operations like choice, selection or decision. These different operations of the neurocognitive machinery can be subsumed under the general process of abstraction which enables us to refer mentally to something in an explicit way.

What could be the purpose of explicit knowledge? It is suggested that this knowledge system is primarily used for the reduction of complexity of information allowing the construction of a corpus of valid semantic knowledge to be communicated to others in an effortless way. Reduction of complexity becomes an issue, if one looks at the neuronal level of information processing; the different neuronal modules are confronted with the problem that afferent information is distributed both spatially and temporally in an unpredictable way. Because of the transduction processes on the receptor level which introduce temporal indeterminacy of information within sensory channels, and because of the neuronal architecture of the afferent systems being characterized by a certain degree of projective divergence, neuronal information is rather ill-defined in central processing stages. By using a process of complexity reduction, for instance, temporal integration windows (Chen 2004; Mates et al. 1994; Pöppel 1971, 2009; Pöppel et al. 1990), and presumably by a complementary use of local and global features or bottom-up information and top-down schemata (Pöppel 2006), some obstacles may be overcome to create explicit knowledge; this mode of knowing, which is created in the past to be used in the future, can be made available to oneself or others using language or other forms of symbolic representation, like words or other signs. Using explicit markers, communication is enhanced in speed, precision and efficiency.

3 Aspects of Implicit Knowledge

The second mode of knowing refers to implicit knowledge (IK), i.e., to what we can do without being able or even wanting to explicitly indicate how or why we do something. The difference between EK and IK might be characterized by two short statements, one going back to the Greek philosopher Socrates who explained while defending himself in court: "I know that I don't know anything." With this statement, he meant to say (according to our interpretation) that the corpus of his EK is extremely limited. Restating this sentence to characterize IK, one could say: "I do not know that I know."

The fundamental difference between EK and IK can also be exemplified by a classical quotation from the writings of Augustinus who, in the 11th book of his "Confessiones," writes: "Quid ergo est tempus? Si nemo ex me quaerat, scio; si quaerenti explicare velim, nescio." ("What then is time? If nobody asks me, I know it; if I want to explain it to somebody who asks me, I do not know it.") Here, Augustinus uses the concept of knowledge within two different frames, at first as IK and then as EK. Thus, this rather famous statement from Western antiquity is poisoned with a categorical error, i.e., mixing two different frames of reference. (Actually, one can easily replace the word "time" by other terms, like "space," "consciousness," "beauty," "thinking" or "knowledge," and one can always give the same answer of knowing, but not knowing.) The categorical error is also true for the statement "I do not know that I know"; in this case, EK and IK are also related to each other within different frames of reference, at first as EK and then as IK. The point we want to make here is not that it is rather easy to fall into the linguistic trap of a categorical error but that the possibility to do so indicates that we easily connect different modes of knowledge, i.e., EK and IK, without being aware of the fact that they belong to different frames of reference.

Implicit knowledge comprises not only intuitions that remain silent, i.e., that lack a verbal representation, but it also refers to bodily knowledge like movement patterns or sequential acts that are beyond explicit monitoring, like playing a musical instrument, hitting a golf ball or driving a car. Expertise in such cases means that conscious control is no longer required at every instant. Procedures can become automatized, and during action it is impossible to indicate in detail how something is done, and which components have to be integrated for a complex movement to be smooth or an act to be efficient. Retrospectively, it may be possible to appreciate the instantiation of such kinds of IK as having been successful; if a movement pattern was imperfect, or an action was interrupted, IK can more easily be subjected to an explicit analysis.

An expression of IK is also ritualized knowledge that characterizes daily activities. From morning to evening, and throughout weeks, months and years, we are embedded in repeating frames of activities and duties which are never questioned, and which only become apparent when there is a change. Ritualized IK defines our meals, the sequential duties of our work, the time frame of holidays, or symbolic behavior in religious services (Eibl-Eibesfeldt 1995). We would like to submit that ritualized IK leads to the feeling of security as repeating sequences of events result in habit formation (Helson 1964). The adaptation to the sequential structure of socially or self-defined events creates a reliable time structure that reduces mental work load and, thus, allows effortless behavior. The functional goal of habituation is to remove regular events from the focus of attention, as carrying redundant information (Baars 1988).

A special form of ritualized IK are prejudices which can be looked at not only as mindless behavior but primarily as an expression of complexity reduction within the social domain allowing fast judgment about others in an economical way (Darwin 1998). Representatives of another group are tagged with a specific mental category which simulates quick information. As any percept or thought operation happens within a frame or reference system which usually remains mute to the observer or thinker, everybody is vulnerable to prejudices (Pöppel 2006). Again, only retrospectively do we sometimes realize having fallen into a trap of bad judgment.

Although prejudices are a negative example, we would like to claim that most human activities are in a positive sense an expression of implicit knowledge. We are much less rational than we are inclined to believe about ourselves. The philosopher Friedrich Nietzsche once remarked (in:"Jenseits von Gut und Böse" – Beyond Good and Evil), that it is impossible to accept the statement of René Descartes: "Cogito ergo sum" – "I think therefore I am." The most one could say would be: "It thinks," and even this may be too much. Thinking is rather an implicit process, and occasionally a result of this process may surface, and this may be experienced for what the Greek mathematician Archimedes is known for after having discovered the principle of the specific gravity (relative density) sitting in his bath-tub: "Heureka" – "I have found it," the expression of a sudden insight.

What one refers to as intuition is also an expression of implicit knowledge. Critical tasks of the mental machinery like decisions are often (or usually) made without an explicit representation of all necessary variables that should be taken into account. Decisions are usually embedded within an emotional frame, although this frame might not necessarily be explicitly represented when a decision is made. Intuitive or IK is, however, not irrational (with the exception perhaps of certain prejudices), because retrospectively it is possible to analyze within a rational frame whether a decision made sense, and as it happens, intuitive decisions are not known to be worse than others.

In fact, it is impossible to make a decision on a merely explicit basis as too many intervening variables in a decision process play a role that remain in the attentional background. The richness of IK is unfortunately (or fortunately) beyond computability; there are too many factors one would have to consider to compute potential states of implicit knowledge. If we assume only 100 different modules in the brain, either being active or inactive, such a brain would have already 10 to the power of

30 potential brain states, if one accepts the premise that any functional state is implemented by a spatio-temporal pattern of modular activities (Fodor 1983). Most likely there are more modules which characterize mental activities, and taking only two different modular states is a rather conservative guess; this means that, from a computational point of view, any individual brain at any instance is characterized by a unique neuronal pattern. Thus, because of the large number of brain states which are beyond computability, the output of the brain as reflected in experience or behavior in detail is unpredictable. Using an image, IK can be seen as an ocean with invisible activities under the surface; sometimes the surface is penetrated from below and an island is formed apparently giving (or simulating) a stable landmark. In this image, islands represent explicit knowledge which can be made communicable, and it is the functional complementarity of IK and EK that characterizes the neurocognitive machinery.

Implicit knowledge as a special functional domain can also be conceptually derived from observations obtained with brain-injured patients (Luria 1973; Pinker 1994; Teuber 1960; Tulving 2002). After a special lesion, a patient may report being blind for some areas in the visual field. Asking the patient whether he recognizes something, he will report that he cannot see anything. But still, there is some residual vision (Pöppel et al. 1973). He can process visual information, for instance, with respect to where something is, without being able to explicitly report "seeing" an object. Some patients can discriminate simple patterns without having consciously (or verbally) access to their successful performance. A special form of this paradoxical ability has been called "blindsight" (Weiskrantz 1986), which indicates that EK and IK can be dissociated. Apparently, the human brain, even on a very high level of information processing, can do things that remain mute, and that traditionally have been associated with conscious representations.

Describing the different aspects of IK, it becomes clear that IK itself is not a homogeneous knowledge system, but that we have to deal with several, at least two, sub-systems. On the one hand, IK refers to implicit cognitive processes whose results sometimes come to a surface being subjectively represented as an insight or a decision; on the other hand, IK refers to bodily knowledge as reflected in movements or behavioral sequences. A movement can be either expressed in simple or complex trajectories which are usually acquired by sensorimotor learning, or it can be expressed in behavioral sequences that are often ritualized. With respect to the purpose of IK, we would like to suggest that, in all its manifestations, it serves the goal of allowing fast action, of implementing quick decisions, of reducing mental workload, and of providing a feeling of security and trust in one's behavior.

4 Aspects of Pictorial Knowledge

The third mode of knowing is pictorial or visual knowledge (PK or VK), and PK itself can be subdivided into different domains, like sensory knowledge (Kohler 1951; Zeki 1999) within the subjective present ("present PK"), mnemonic PK as it is represented in episodic memory (Tulving 2002), and topological PK (Chen 2004) as it is seen in geometric figures, visual models, diagrams or histograms, and that allows the construction of maps being used, for instance, in navigation.

4.1 Present Pictorial Knowledge

It may come as a surprise to refer to visual perception proper as "knowledge," but we follow here both a tradition going back to Greek antiquity, namely that "aisthesis" not only means perception but also knowledge or understanding, and an argument by Zeki (1999); he writes (p. 8): "The pre-eminent function of the visual brain is the acquisition of knowledge about the world around us." The reason why we tend to forget that seeing is knowing depends perhaps on the fact that present VK is so self-evident that its importance is only realized when it is lost or when certain attributes of visual experience are altered; the loss of color or movement perception, the inability to move around in one's own environment, or the reduction of foveal sensitivity after macular degeneration make one realize that the effortless access to knowledge in the world around us has been disrupted.

When we open our eyes or when we are experimentally exposed to a complex new stimulus, visual knowledge is accumulated in much less than a second (Boring 1933). Although on a pre-semantic level, i.e., if we look at the projected image on the retina, we are merely exposed to visual surfaces and edges, it is hard to convince ourselves that this should already be "seeing." Our visual brain creates instantaneously perceptual objects; apparently, we are forced to always see "something," and when the "something" does not make sense because it is geometrically impossible (as in some pictures of the Dutch artist Escher), we attribute meaning. It is impossible to see the impossible. Presumably, using complementary mechanisms (Pöppel 2006), visual percepts are constructed binding topological invariants (Chen 2004) with local features from the afferent channel. The construction of the visual word is an effortless process, and what is perceived is taken to be true; this latter statement can be more easily expressed in German, as perception ("Wahrnehmung") is related to truth ("Wahrheit"); what we perceive ("wahrnehmen"), we take as being true ("für wahr nehmen"). Thus, seeing is knowing.

That present PK is a separate mode of knowing can be shown if one looks at patients with visual agnosia, who may still have a rather intact peripheral visual system, but who cannot make sense out of what they are seeing (Farah 2000; Goldstein 1944; Teuber 1960). A special case of agnosia is the difficulty to recognize different human faces. Apparently, the human brain is endowed with a neuronal module that enables us to effortlessly identify persons. In prosopagnosia, this self-evident capacity is lost; such patients can still see a face as a face, but they are unable to identify a special person using distinct facial features. If such patients want to recognize somebody, they have to use other means like the voice or certain attributes (like the color of the hair). The observation that there may be a dissociation between the recognition of "faceness" in general and individual faces may be of philosophical interest. We would like to conclude from this surprising dissociation that a special neuronal module represents a general scheme of faces. Under normal circumstances, this scheme is complemented by local visual information to allow the perceptual construction and, thus, the identification of an individual face. In prosopagnosia, the local information is no longer available or (more likely) it can no longer be attached to the spared scheme, thus leaving the representation of the general scheme empty. Philosophically speaking, such a scheme may correspond to the Platonic ideal, and the special lesion allows us to look not only into the neuronal machinery of visual perception but also empirically into the components of an epistemological theory. This applies also to a statement by Immanuel Kant from the "Critique of Pure Reason": "Gedanken ohne Inhalt sind leer, Anschauungen ohne Begriffe sind blind" ("Thoughts without content are empty, percepts without notions are blind"). Rephrasing the Kantian sentence, one could say that schemata without content (i.e., sensory information) are empty, and sensations without schemata are blind.

4.2 Mnemonic Pictorial Knowledge

Whereas present PK obviously refers to any given moment, mnemonic PK is anchored in the past. Certain episodes that have some personal relevance can be stored in memory, and it is an important feature of episodic memory that only one exposure to an event leads to long-term storage (Tulving 2002); this feature of "one-trial-learning" separates episodic memory from semantic memory which is built up with much more time-consuming effort. The images in episodic memory are preferentially (but not always) stationary pictures, they are always related to a specific place, and the episode that led to imprinting had a high emotional impact. If one analyses these pictures from the past (unpublished observations from several hundred observers), one is surprised how small is the number of images that can be actively brought into working memory, i.e., into the subjective present. Independent of age or sex, it is on average only 10–30 images that can actively be remembered from the past days. If one asks how many images can be evoked from the previous week leaving out the previous day, it is approximately the same number. This observation implies that images in episodic memory have a rather short half-life, and that presumably only those with high personal importance are stored for a life-time. On average, we can refer to only a few hundred images in our episodic memory. It should be noted that these images are actively remembered, the number of images that can be recognized is much higher. This poses the question why the "inner museum" of humans should be so limited. One reason might be that personal images from the past are essential elements for the definition of personal identity. Only such images are maintained (like in a real museum) that are significant, and which allow a personal anchoring in one's own past. As Tulving (2002) has pointed out, we can do some time traveling going back into our personal history. This time traveling goes only to relevant events to the past and may support our self-identity, as a visit to the museum assures cultural identity.

There is another aspect about images in episodic memory that should be noted, i.e., that such images undergo surprising changes. Some observers report that, when visualizing the same image on successive days, thus having a longer temporal interval between the imprinting of the image and the reactivated image, contours of persons or objects become less precise; they seem to fade away. This observation would imply that images are represented in a topologically organized way as pictures, and it would suggest furthermore that basic neuronal processes like lateral inhibition which characterizes normal vision (Ratliff 1965) also operate on a stored image; the gradual fading of precise contours indicates the operation of a neuronal process being equivalent or perhaps even identical to lateral inhibition in normal vision. Images from the past are usually colored although with less hue, and they are always visualized in front of oneself, i.e., centered around the visual axis; the periphery of the visual field is hardly represented in episodic memory. This observation implies that mnemonic VK is person-centered, i.e., images are not stored with respect to an external coordinate system, which in principle might also have been possible.

4.3 Topological Pictorial Knowledge

Topological PK is qualitatively different from present or mnemonic PK; whereas the latter refer to natural images past or present, topological PK is based on abstractions as they are expressed in geometrical figures, or as they visualize observations in diagrams or models. Prior to the two-dimensional or three-dimensional concepts as developed in Euclidian geometry, a fundamental abstraction was necessary, i.e., the "discovery" of the line and the point. As real objects in visual perception are created only by edges and surfaces, the abstract idea of a line or a point had to be conceived which, together with the concepts of a surface and a body, are fundamental for geometrical reasoning. Topological PK as expressed in geometry made itself independent of real objects.

Visual representations of geometric PK are all aesthetically pleasing like the conic sections allowing the construction of a circle, an ellipse, a parabola or a hyperbola. Similarly, squares, rectangles, in particular those that use the golden section as a constructive principle, symmetric triangles, or helical spirals carry an intrinsic aesthetic pleasure perhaps because of their simplicity and apparent order. With the advent of analytical geometry, it became possible to visualize complex processes as expressed in mathematical formula in a simple way like growth functions. The sigmoid curve in all its simplicity characterizes phase transitions in all domains of scientific discourse as in psychology, if one looks at learning curves, or in chemistry, if one studies the time course of chemical reactions; any transition between qualitatively different states shows a sigmoid characteristics, and the visualization of these transitions indicates that, in spite of a rather different material basis of these processes, the operational logic is similar or even identical. Topological VK allows a fast insight into an otherwise complex data-generating mechanism.

Statistical distributions are typical expressions of data-generating mechanisms. When measurements are collected, the specific form of a histogram showing how the single data points are distributed gives a first and important cue; a Gaussian distribution allows a judgment about the structure of the data and suggests the selection of statistical tools to be used for further analysis. A bimodal or multimodal distribution indicates that the data-generating process is not homogeneous; outlying observations that destroy the symmetry of a distribution sometimes carry unexpected information that can be creatively harvested (Pöppel 1970). Visualizations of correlations or the representation of functional dependencies in a diagrammatic form again use the effortless availability of a visual percept for judgment.

A further domain of topological PK refers to models and maps like the visual model of the planetary system, models in physics (like Bohr's model of the atom), chemistry (like visual models in chemical bonding), or biology (like the visualization of evolution as a tree). In each case, reality is radically simplified using specific abstractions suggested by theory for the construction of a pictorial representation. The driving force behind the desire to express knowledge in a visual way is a special feature of the visual system, i.e., to allow access to information in an effortless way. Thus, pictorial representations to create topological PK are automatically created in such a way as to comply optimally with the processing of the visual system. If this line of argument is accepted, it follows that the adaptation of such models to the features of the "visual frame" leads to a limited view of the original fact or even to misrepresentations. Any visual model is necessarily a caricature.

5 The Aesthetic and the Mimetic Principles: Unifying Concepts of Knowledge

5.1 The Aesthetic Principle

First, we would like to have a look at the perceptual or aesthetic principle (Baumgarten 1750–1758) which is considered to be essential in the arts, like unity or completeness of what is represented, order or the relation of the parts to the entire gestalt, harmony or rhythm for temporal patterns, and simplicity and effortless access to a picture, a melody or a verse (at least within some theoretical frames). It was the Roman poet Horatius who more than 2,000 years ago called for the "simplex et unum" in the arts (in "De Arte Poetica"), i.e., that there must be unity and congruence between what is perceived in a piece of art and what has been previously experienced by the person. A mismatch between present perception and a frame of knowledge built up in the past would be an indicator of bad quality or a challenge to define a new frame as has been demonstrated many times in art history.

What are the aesthetic principles that characterize knowledge, and that similarly apply to the arts? We would like to refer to explicit knowledge following again the analysis of Descartes in his "Discours de la Méthode" (see above). Descartes stresses that clarity and precision of a percept or a thought are essential; order has to be recognized or created if necessary; a problem has to be appreciated in its entirety, i.e., as a unity. Furthermore, explicit knowledge is characterized by simplicity, and scientific laws gain easier acceptance if they provoke some aesthetic pleasure, the latter even being sometimes used as a criterion for truth. Although it may be a metaphysical statement, we trust in "Occam's razor," i.e., that the simplest explanation is believed to be the best explanation. Simplicity and clarity of explicit knowledge are also necessary elements for effortless communication; to reach other people in an efficient way, knowledge has to be transferred reliably, and as communication should be fast if we take an evolutionary point of view, the content of what is communicated has to be precise. Taken together, the attributes that characterize explicit knowledge like clarity, order, unity or simplicity are the same attributes that are considered to be unifying principles of aesthetics. As communication in the explicit mode depends on these principles, it follows that social cohesion also depends on the aesthetic principle.

Thus, the concept for instance of unity is both fundamental for knowledge and the arts. However, unity is a self-evident phenomenon that becomes enigmatic only if it is lost. Goldstein (1944), for instance, considered the fundamental disorder caused by damage to the frontal lobe to be the inability to grasp the entirety of a complex situation. Patients with such lesions show a difficulty in keeping two things in mind; they can focus only on separate aspects of a story, and have difficulties in understanding a story as a whole. Equivalent observations have been made by Luria (1973) with a rather simple test. His tapping test requires to remember two rules: the patient has to tap once when the experimenter taps twice, and he has to tap twice when the experimenter taps once; during the test, the patient has to inhibit the tendency to mimic what the experimenter is doing. Both young children and frontal lobe patients have severe difficulties in performing the task successfully. These observations indicate that the creation of unity is an active mechanism of the human brain which may be disrupted selectively. Similarly, other brain lesions may result in a difficulty in recognizing or creating order, or in allowing abstraction of processed information. As the basic attributes of knowledge are vulnerable, they must reflect intrinsic mechanisms of how the brain processes information; thus, aesthetic principles cannot be constructed in a normative way, but they follow rules defined by neuronal mechanisms.

Similar aesthetic principles as identified for explicit knowledge are also characteristic of the other modes of knowledge. Present pictorial knowledge has been said to function effortlessly; schemata are necessary to recognize, for instance, a face, and such schemata are simple. The perceptual process creates "something" (a visual image), which is just "one" image, i.e., the percept within this "inner theatre" is characterized by unity. The percept can be conceived as appearing within a frame; as the percept is always just one, the surround beyond the focus of attention simulates a physical frame. But there is also an abstract frame: in this latter sense, every percept is generated within a frame of expectation, and every percept is the verification or falsification of a hypothesis in a given moment (Pöppel 2006). Without a top-down component complemented by bottom-up sensory information, pictorial knowledge would be empty.

The relevance of frames or personal reference systems and the aesthetic principle of unity are also true for mnemonic pictorial knowledge; only images that have some personal meaning are stored within our "inner museum." These singular images from the past which had some emotional impact when they were imprinted (and which always refer to a specific place) represent our personal history and define our identity; if these images are lost, we lose ourselves. As most images in our episodic memory represent other people, mnemonic pictorial knowledge is also instrumental in creating a social bridge from the past to the present, and from the present to the future. Mnemonic pictorial knowledge is fundamental for the development of the notion of time; we can intentionally travel backwards in time to visit our "inner museum," and we can construct on this basis the notion of a future and define a present. This conception of a linear time is again characterized by aesthetic principles, i.e., simplicity and unity, and time is conceived as being unidimensional and time is homogeneous "that flows equably without relation to anything external" (as Newton states in his Principia Mathematica Philosophiae Universalis; for an alternative view, see Ruhnau and Pöppel 1991).

The aesthetic principles of simplicity and unity also apply to topological pictorial knowledge. A visual representation of a relationship as expressed, for instance, in a sigmoid curve or a Gaussian distribution allows effortless access to a corpus of data that may represent a complex functional system. Symmetries and deviations from symmetries give insight into data-generating mechanisms. The sensitivity of the visual system to detect mirror-symmetries makes the system in particular useful to detect deviations from symmetries which often provoke new scientific insights. Thus, this aesthetic principle can even be used as a research tool. Topological pictorial knowledge expresses abstracted knowledge which implies that a process of abstraction must precede the visual representation itself. From this necessary sequence of mental operations, one can conclude that the process of abstraction intrinsically follows aesthetic principles. What is abstracted complies already with our sense of beauty.

For the aesthetic principle that is characteristic for implicit knowledge, we would like to refer to the reafference principle (von Holst and Mittelstaedt 1950), as this principle may provide an additional cue for a unifying principle. In its original form, the reafference principle expresses the following idea: any movement is regulated both by an efferent command to the effectors, as well as by a copy of this command (the "efference copy"); when the movement is finished, reafferent information from peripheral sense organs is compared with the efference copy. If the reafference matches the efference copy, the movement has been successfully completed. Thus, the comparison of efferent commands and reafferent signals allows a monitoring of bodily states which results in perceptual stability, and as Teuber (1960) has pointed out, in perceptual identification.

A generalized reafference principle (GRP) can be used as a theoretical frame not only for simple movements or percepts but for actions in general, i.e., for instantiations of implicit knowledge. Any act and any action following an explicit or implicit command or plan are neuronally controlled by efferent signals to the effector organs and efferent copies stored centrally. Efferent copies of intended acts and actions allow a continuous monitoring; a mismatch between the copy of the intention and the reafferent information tells the system that act or action is not yet completed. However, if the reafference corresponds to the efference copy, an act or an action has been brought to an end. The basic idea of the GRP is that it operates independently of a particular time window. The GRP can explain short-term control of movements like eye movements, it applies to ritualized movement or actions of a longer duration, and it refers to long-term plans that may take days, weeks or months (or even longer) to be completed. Thus, the GRP represents an endogenous monitoring system indicating the completion of acts and actions. The subjective impression of fulfillment or satisfaction after having made a movement or after having reached a goal is the result of the final comparison of reafference and efference copy.

We would like to suggest that the feeling of unity of a movement after its completion can be understood using the operative mechanisms of the generalized reafference principle. A host of human activities are characterized by the wish to be satisfied by the gestalt of a movement or a performance like hitting a golf ball, sailing a boat, playing a musical instrument, or giving a talk. Satisfaction about the intended gestalt is a retrospective experience of unity. Thus, the striving for unity in acts and actions, and the (occasional) accomplishment of such unity, indicate that, in the domain of implicit knowledge as it is instantiated in the control of movements or in the organization of complex behavioral sequences, it also obeys the aesthetic principle.

Taken together, the following aesthetic (or perceptual) principles have been identified as attributes both for the arts and the different modes of knowledge, and as has become apparent, these principles were already formulated during antiquity and have been reiterated since. To exemplify the aesthetic principles in a concrete way, one can imagine being in different situations (as an internal point of view is both more satisfying and convincing): watching a bird in the sky, successfully hitting a golf ball, remembering a verse from Shakespeare ("Shall I compare thee to a summer's day"), activating an episode of love from memory, being surprised by a sudden understanding of experimental data, looking at a portrait from Rembrandt, giving a lecture to students, having a meal with friends, or hearing the Tristan motif by Wagner. For all these activities that refer to the arts, to perceiving, acting or knowing, there is (in the ideal case) unity of experience and the impression of completeness, there is simplicity as a successful reduction of complexity, there is clarity of thought suggesting reliability and precision, there is order with a proper relation of the parts to the whole, there are rhythm and harmony triggering satisfaction, and there are conceptual and emotional frames defining the meaning of what is experienced and creating an atmosphere of affiliation and empathy. If these attributes of knowledge or the arts are missing, sometimes because of a lack of one's own concentration and sometimes because of bad quality, a feeling of frustration, of anger, or of incompetence, the consequence may be important signals indicating that the aesthetic principle has been violated.

5.2 The Mimetic Principle

We believe that the driving force to establish knowledge is "mimesis," i.e., the internalization of regularities by imitation. Thus, knowledge is basically a copy, a view which in the tradition of psychology was first expressed in psychophysics by Fechner (1860), i.e., that mental representations represent physically definable and defined situations (Boring 1933; Helson 1964; Stevens 1986). A similar view is, for instance, taken by Piaget (1970) or by Eibl-Eibesfeldt (1995) on the basis of observations made with children or by looking at the developmental function of playing. At early phases of human development, knowledge is acquired in a playful way by imitation and repetition. Thus, mimesis in a general sense results in the ownership of knowledge, i.e., knowing is owning.

What can we own? In visual knowledge, the world around us is represented retinotopically in our visual brain; representation "copies" the world around us, i.e., mimesis creates some match between the physical world and a "copy" of this world in our brain. But this "copy" is not a passive and mirror-like representation, but the physical world around us ("Realität" in German) is actively incorporated into our cognitive machinery resulting in a subjectively meaningful representation of reality ("Wirklichkeit" in German). Thus, one has to distinguish between two meanings of "reality," one referring to the physically described world around us, and one referring to the subjective representation of this world, the latter being correlated with the physical world but not being an image like a photograph. A corresponding doubling of the world applies to mnemonic visual knowledge, as we carry with us the images of the past. In the case of mnemonic visual knowledge, mimesis is more selective, keeping only such scenes in our memory that prove to be of long-term significance and are essential for the maintenance of our identity; we are a copy of our past. In topological visual knowledge, mimesis is embedded in a process of abstraction leading to a lawful representation of a partial set of reality. Laws mimic regularities that we observe in the physical world. Furthermore, the mimetic principle also applies to implicit knowledge; any act or any action is the instantiation of an intention or a plan, and the mimetic drive creates a copy from a central matrix in our brain and transfers this copy into action. Finally, explicit knowledge represents facts about the world. Representation even on the abstract level is necessarily a copy, and the process of copying is the consequence of the underlying drive to create knowledge by mimesis.

Coming back to intercultural communication and cognition, we would like to submit that, because of our evolutionary heritage, we all share the same modes of knowledge and their unifying principles. They provide a common frame, but within this common frame, cultural and individual specifics are expressed which make us different. If we ask ourselves “what it means to be human,” we would like to conclude that we enter the world with genetic programs of possibilities which are common to everybody, but that cultural and individual environments result in a selection of specific neuronal programs by processes of imprinting as has been shown by ethological analyses of human behavior (Eibl-Eibesfeldt 1995). Thus, culture determines structural selections of neuronal processes, i.e., culture becomes a structure of the brain. However, these selections by imprinting can happen only within limits; basic principles of neuronal processing of the cognitive machinery are conservative and remain robust against changes that would move human behavior too far away from “how we are meant to be.”

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Two Modes of Thinking: Evidence from Cross-Cultural Psychology

Britt Glatzeder

Abstract The long history of the study of human thought is shaped by a dichotomy of two different views of the nature of thinking: the logical, analytical, rule-following thinking on the one hand, and the intuitive, and holistic, experiential thinking on the other. Recently, a lot of empirical evidence has been accumulated for the dual mode view of thinking. In this chapter, I shall highlight some of this evidence and interpret findings in cross-cultural research on thinking in order to better understand and train holistic thinking, which has been neglected in our logocentric Western culture. The underlying claim is that thinking draws on both modes and that, instead of prioritizing one of the two, we are challenged to develop both concerted expert analytical thinking and expert intuitive–holistic thinking and to master their interplay.

Keywords Cross-cultural research · Dual processes · Gestalt · Thinking

1 Introduction

Thinking has been a perennial theme of philosophical enquiry since the time of the ancient Greek philosopher Parmenides. However, only a century ago, it shifted from the philosopher's armchair to the science laboratory. Despite the immense advances gained since the twentieth century by the cognitive revolution and the rise of the neurosciences, we still do not have generally accepted answers to the questions: What is thinking? What are its decisive features? How does it actually proceed? What is the nature of the process as a whole, as well as in its parts, and basic

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operations? What is the real difference between good and bad thinking? And what are the neural correlates of thinking processes?

There is "something tragic" – to quote one of the major founding figures of the scientific study of thinking, Max Wertheimer – in the long history of all these efforts to understand human thinking (Wertheimer 1959, 2):

> Again and again when great thinkers compared the ready answers with actual, fine thinking, they were troubled and deeply dissatisfied – they felt that what had been done had merits, but that in fact it had perhaps not touched the core of the problem at all.

According to Wertheimer's diagnosis, research on human thought has been widely determined by two classical views about the nature of thinking: the view of traditional logic and the view of association theory. Associated with these traditional views is a concept of thinking as a process of step-by-step operations in which the basic components of mental content – be it the empiricists' atomic sense impressions, Kant's representations, or rather symbols as in contemporary computational theories of mind – are combined and manipulated according to formal (e.g., logical) rules respectively similarity and contiguity.

These approaches, Wertheimer contends, have impeded progress because they ignored essential features of thought processes, in particular "the view of the whole" (Wertheimer 1959, 42 f.).

In my view this statement of utmost importance and relevance to the progress in understanding thinking. The point I want to stress in this chapter is that almost a hundred years ago Wertheimer – and with him all the German Gestaltists (e.g., Duncker 1945; Köhler 1925) – proposed that the essential operations in human thinking are characterized by the very processes and operations that are ignored by the traditional theories of thinking (Wertheimer 1959, 234):

> In these processes we found factors and operations at work – essential to thinking – which had not been realized by the traditional approaches, or had been neglected by them. The very nature of these operations, e.g. of grouping, of centering, of reorganization, etc., adequate to the structure of the situation is alien to the gist of traditional approaches and to the operations which they consider.

Wertheimer called this form of thinking "productive thinking," in contrast to "reproductive" or "blind" thinking, which refers to thinking as conceived by the traditional theories. Reproductive thinking solves problems by referring to previous experience and what is already known; productive thinking solves problems through insight, i.e., sudden, discontinuous thought processes, which defy explanation in terms of gradual step-by-step operations, or habit learning. The distinct characteristics of productive thinking processes are (Wertheimer 1959):

> They are not piecemeal, they are related to whole-characteristics, determined by structural requirements for a sensible situation.

Productive thinking is defined as the ability to conceive of the general principles of a problem that allow for a transfer to other problem-solving situations in different fields. The fundamental mechanism within productive thinking was identified as re-structuring, i.e., to perceptually or conceptually re-group given information, problem constituents, or preconceptions in order to allow for new constellations to emerge that eventually solve the given problem (Knoblich and Öllinger 2006).

In his "formula" of Gestalt theory Wertheimer clarifies what he means by "whole-characteristics" (Wertheimer 1924):

> The fundamental "formula" of Gestalt theory might be expressed in this way. There are wholes, the behavior of which is not determined by that of their individual elements, but where the part-processes are themselves determined by the intrinsic nature of the whole. It is the hope of Gestalt theory to determine the nature of such wholes.

The role that reproductive thinking is given in this process is viewed as functioning as a part of and in relation to the whole (Wertheimer 1959, 235):

> While it is true that operations considered in the traditional interpretations are involved in the process, they likewise function in relation to whole-characteristics. This is essential for the way they come into the picture.

In this last quote's definition of the role of logical–analytical and associative thinking, Wertheimer not only differentiates between two modes of thought. In addition, a crucial re-evaluation is being carried out in Wertheimer's theory of thinking: whereas for the majority of Western philosophers and scientists of all times, logical–analytical thinking is of higher value, Wertheimer proposes the opposing prioritization and uprates the holistic mode over logical and analytical thinking.

In this chapter, I would like to tie in with Wertheimer's distinction of two modes of thinking and to point to potential implications the progress in understanding thinking and particularly for enhancing our thinking skills. The underlying claim is that thinking must draw on both modes and that, instead of prioritizing one of the two, the challenge is to develop both concerted expert analytic thinking and expert intuitive–holistic thinking and to master their interplay. I shall first highlight some of the empirical evidence that has I shall only recently been accumulated for the dual mode view of thinking Subsequently I shall interpret findings in cross-cultural Since holistic-intuitive thinking research on thinking in view of the possibility of training holistic thinking, such a training should has been neglected in the logocentric Western culture enhance thinking skills in Western people.

2 A Glance at the History of the Dual Mode Idea

In the long history of theorizing about human thought, Wertheimer and the other Gestalt psychologists of the early twentieth century were the first who studied thinking with scientific experimental methods. However, the distinction of two modes of thinking had been around long before Wertheimer and the Gestalt theory of thinking. It actually reflects a decisive aspect of the entire multifarious history of studying thinking: it is shaped by a dichotomy of two different views about the nature of thinking.

The roots of this dichotomy may be found in ancient Greek philosophy that made a strong differentiation between a mode of thinking that generates true knowledge and a mode that gives us experiential pseudo-knowledge about the world around us. Which concerned ancient Greek philosophy and was elaborated by the Pre-Socratics' successors, Plato and particularly Aristotle. With the two kinds of knowledge goes the distinction of two different cognitive processes, i.e., pure logical, conceptual thinking on the one hand and perceiving, intuiting, experiencing on the other. This dichotomy between what can be known and reasoned logically versus what can be experienced and apprehended, and the prioritization of the first, has shaped Western thought and culture to this day. In line with the classical definition of man as the "animal rationale," philosophers of all times as well as most modern cognitive scientists assume that it is logical, analytical, formal thinking that counts as real thinking. Famous champions of this kind of prioritization are Thomas Hobbes (1651), Gottfried Leibniz (1981), or Immanuel Kant (1998), and in more recent times, Jean Piaget (1953), Alan Newell and Herbert Simon (1972), John Anderson (1996), Jerry Fodor (1975), or Hilary Putnam (1960).

At the same time, there have always been, albeit fewer, spokesmen for the reverse view contending that what in truth guides the thinking animal are unconscious instincts, intuition, and gut feelings. This camp is characterized by names like Arthur Schopenhauer (1998), Friedrich Nietzsche (1967), Sigmund Freud (1975), Henri Bergson (2007), William James (1981), Hermann von Helmholtz (1977) and in our days by Hubert Dreyfus (1979), Gerd Gigerenzer (2007), or George Lakoff and Mark Turner (1989).

As clearly as the distinction of two modes of thinking may emerge as an underlying theme of Western philosophy and psychology, it is problematic for several reasons. To begin with, the multiple kinds of attributes offered by different thinkers and researchers to describe the two modes are widely not consistent with each other. Characterizing the two modes in a precise and empirically verifiable way has proven elusive. In particular, the non-logical, non-formal mode of thinking is extremely hard to grasp with the scientific tools of the day. The failure to operationalize these processes has thus led to neglecting research on holistic and intuitive thinking and to focusing on the study of straightforward logical reasoning.

Despite these difficulties, robust and reliable evidence has lately been accumulated supporting the plausibility of the distinction and the complementarity of two different forms of thinking that can generically be characterized as logical–analytical versus intuitive–holistic. Support is coming mainly from three fields of research:

1. From the increasingly popular "dual process theories" of thinking, reasoning and decision making in cognitive and social psychology (Evans 2003, 2008a; Evans and Frankish 2009)
2. From recent cross-cultural research (e.g., Nisbett et al. 2001; Nisbett and Norenzayan 2002; Nisbett 2003; Nisbett and Miyamoto 2005)
3. From the fairly novel approach of transcultural neuroimaging research (Han and Northoff 2008)

3 Recent Dual Mode Accounts of Thinking

The most recent revival of the perennial theme of two modes of thinking has been going on during the past four decades in mostly disconnected fields of psychology, where a growing number of researchers have developed dual processing or dual system (see below) accounts of cognition in a range of areas, including learning (e.g., Reber 1993), attention (Schneider and Shiffrin 1977), reasoning (Evans 2003, 2008a, b), decision making (Kahneman and Frederick 2002) and social cognition (Chaiken and Trope 1999). The main point for developing dual process theories of reasoning was the observation of the fact that logical processes seemed to compete with non-logical biases in determining behavior on various deductive reasoning tasks (Evans 1977; Goel 1995).

The rekindled interest in the dual mode view might also partly be owed to the cognitive revolution and the idea that the concept of two different modes can be clarified by conceiving of them in analogy to sequentially versus "multiply" processing computer programs (Neisser 1963). Moreover, the evidence provided by cognitive neuropsychology for the powerful role of unconscious or preconscious, automatic, subpersonal, and inaccessible cognitive processes has certainly contributed to reviving the dual process approach (Reber 1993; Evans and Over 1996). To give a taste, I shall quote a small choice of pertinent authors whose contributions helped to shape the contemporary dual process debate in cognitive psychology.

The term "cognitive psychology" was coined by Ulric Neisser in 1967, in a book of the same name. Interestingly enough a couple of years earlier, Neisser (1963) wrote an article with the title "The multiplicity of thought," in which he not only explicitly refers to the Gestalt psychologists but also points out that their distinction of two forms of thinking has appeared as alternative possibilities in the design of "artificially intelligent" systems, i.e., in programming computers. In this field, the two possibilities are often called "sequential" and "parallel."

> Many writers have distinguished 2 types of mental processes. One kind of thinking is conscious, straightforward, predictable, and rather pedestrian; the other is confused, rich, productive of novelty, emotionally charged, and generally outside of consciousness. It is suggested that the latter arises from a multiplicity of processes going on together, while the former represents a single sequence among the crowd. These concepts are clarified by showing that sequence and multiplicity arise as alternative modes of organizing computer programs for pattern recognition. Even in the computer, multiple processing exhibits a superior ability to deal with novel or irregular input, while sequential processing appears less wasteful, and better adapted to fully predictable situations. The properties that have been said to distinguish primary and secondary process, autistic and realistic thinking, creativity and constraint, insightful and rote activity, and the like, are shown to follow from the multiplicity of thought.

Jerome Bruner, another leading figure in the study of thinking, discusses two modes of thought as "analytic" and "intuitive." Again, the Gestalt idea of the "whole" is to be heard quite clearly in Bruner's characterization of intuitive thinking as based on an "implicit perception of the total problem" (Bruner 1960, 57, 58):

> Analytic thinking characteristically proceeds a step at a time. Steps are explicit and usually can be accurately reported... Such thinking proceeds with relatively full awareness of the information and operations involved. It may involve careful and deductive reasoning, often using mathematics or logic and an explicit plan of attack. Or it may involve a step-by-step process of induction and experiment...
>
> Intuitive thinking characteristically does not advance in careful, well-planned steps. Indeed, it tends to involve maneuvers based seemingly on an implicit perception of the total problem. The thinker arrives at an answer, which may be right or wrong, with little if any awareness of the process by which he reached it.

In the twenty-first century, the idea of two modes of thinking has come to the fore in the decision-making field with the paper by Kahneman and Frederick (2002). The authors use the terms "System 1" and "System 2" (first introduced by Keith Stanovich 1999), which became the standard terminology among dual process theorists of thinking and reasoning. Daniel Kahneman concisely sums up the contemporary dual process approach in the Western cognitive psychology literature when he states (Kahneman 2003a):

> Many of us who study the subject think that there are two thinking systems, which actually have two very different characteristics. You can call them intuition and reasoning, although some of us label them System 1 and System 2. There are some thoughts that come to mind on their own; most thinking is really like that, most of the time. That's System 1. It's not like we're on automatic pilot, but we respond to the world in ways that we're not conscious of, that we don't control. The operations of System 1 are fast, effortless, associative, and often emotionally charged; they're also governed by habit, so they're difficult either to modify or to control. There is another system, System 2, which is the reasoning system. It's conscious, it's deliberate; it's slower, serial, effortful, and deliberately controlled, but it can follow rules. The difference in effort provides the most useful indicator of whether a given mental process should be assigned to System 1 or System 2.

Kahneman calls his theory an "evolutionary speculation," and he claims that the intuitive system is an adaptation of the human perceptual system. Perceptual rules determine how we see the world, and Kahneman contends that very close analogs to these rules apply to thinking. This claim is again highly reminiscent of the Gestalt psychologists' theory of more than a century before.

4 Dual Process/System Theory in a Nutshell

Jonathan Evans (2003, 2004, 2008a, b; Evans and Frankish 2009) has recently provided state of the art reviews of a wide range of modern dual processing accounts of higher cognition in different fields. These accounts come under many labels, but they all make a distinction between two different cognitive processes, respectively systems such as sequential and multiple (Ulric Neisser 1963), intuitive and analytical (Jerome Bruner 1960), formal and heuristic processes (Newell and Simon 1972), type

1 and type 2 (Peter Wason and Jonathan Evans 1975), implicit and explicit (Arthur Reber 1993), intuitive and reflective (Dan Sperber 1994), associative and rule-based (Steven Sloman 1996), rational and experiential (Seymour Epstein et al. 1996), System 1 and System 2 (Keith Stanovich 1999), intuition and reasoning or holistic and analytical.

Meanwhile, a lot of evidence has been accumulated in favor of the dual approach to cognition and thinking (Evans 2003; Evans and Frankish 2009; Lieberman 2003). Nevertheless, the distinction remains problematic. It is far from clear how and if at all these proposals relate and can be made consistent. Are Wertheimer's productive/reproductive distinction and Neisser's multiple and sequential thinking or Nisbett's holistic and analytical thinking the same? (See Buchtel and Norenzayan 2009). And what exactly distinguishes intuition from closely related constructs such as instincts or insight? Evans and Frankish (2009) and Evans (2003) concedes that closer inspection suggests that, while System 2 may be a coherent concept, System 1 is not. Moreover, the crucial problem of the interplay between these non-conscious forms of cognition and explicit reasoning processes is as yet far from being fully understood.

However, what may be said at a very crude level is: dual process theories in general contrast cognitive processes that are fast, unconscious or automatic with those that are slow, effortful, and conscious (Samuels 2006; Goel 2003). They term the first "System 1" the latter "System 2" processes. System 2 is predominantly seen as the controlled, effortful, generally explicit thinking that can, but does not always, override the results of System 1 thinking, checking if the latter produces "sensible" output (Evans 2003, 2008a, b; Evans and Frankish 2009).

Recently, moreover, several authors have proposed the strong claim that there may be two neurologically and evolutionarily distinct cognitive systems underlying the two different processes (e.g., Evans and Over 1996; Stanovich 1999; Epstein and Pacini 1999; Reber 1993; Goel 2003; Evans and Frankish 2009). Hence, theories of dual *processes* are to be distinguished from dual-*system* theories. According to Evans' (2004, 205, 206) diagnosis, the attempts to map dual processes onto underlying cognitive systems are highly problematic, because despite similar characteristics, it is far from evident at present that a coherent theory based on two *systems* is possible. Evans (2008a, b) thus opts for a terminology that does not commit to a two-system view. He suggests talking about type 1 and type 2 processes since all theories seem to contrast fast, automatic or unconscious processes with those that are slow, effortful and conscious (Samuels 2006).

The following table (Evans 2008a, b, 257) provides an overview on the various properties attributed to the two processes of thinking by assembling clusters of terms for the two systems used by various theorists:

System 1	System 2
Cluster 1 (consciousness)	
Unconscious (preconscious)	Conscious
Implicit	Explicit
Automatic	Controlled

(*continued*)

System 1	System 2
Low effort	High effort
Rapid	Slow
High capacity	Low capacity
Default process	Inhibitory
Holistic, perceptual	Analytic, reflective
Cluster 2 (evolution)	
Evolutionarily old	Evolutionarily recent
Evolutionary rationality	Individual rationality
Shared with animals	Uniquely human
Nonverbal	Linked to language
Modular cognition	Fluid intelligence
Cluster 3 (functional characteristics)	
Associative	Rule based
Domain specific	Domain general
Contextualized	Abstract
Pragmatic	Logical
Parallel	Sequential
Stereotypical	Egalitarian
Cluster 4 (individual differences)	
Universal	Heritable
Independent of general intelligence	Linked to general intelligence
Independent of working memory	Limited by working memory capacity

5 Evidence

During the past decade, the claim that there are two different types of human thinking and reasoning received substantial support from a number of fields of psychology (Evans and Frankish 2009), particularly from imaging studies pointing to dual neural pathways during deductive reasoning (e.g., Goel et al. 2000; Goel and Dolan 2003). Dual process theory was originally motivated by the striking finding of cognitive reasoning research that human judgment frequently violates traditional normative standards. In a wide range of reasoning tasks, people often do not give the answer that is correct according to logic or probability theory (e.g., Evans 2002; Kahneman et al. 1982). Influential dual process theories of thinking have explained this “rational thinking failure” by positing two different human reasoning systems (e.g., Epstein 1994; Evans 2003; Goel 1995; Kahneman 2003a; Sloman 1996; Stanovich and West 2000).

The main pieces of evidence for dual processes in thinking and reasoning are studies of belief–logic conflict problems (Evans 2003). In particular studies, which specifically support the idea that System 2 processes can interfere with or inhibit System 1 processes, which will otherwise lead to pragmatic or belief-based responding on a task where deductive reasoning is required (Evans 2003, 455). Vinod Goel has conducted a number of studies of reasoning using fMRI techniques (Goel 2005; Goel and Dolan 2003). He repeatedly observed that reasoning with congruent items activated a left temporal system whereas a bilateral parietal system was activated when people tried to solve the incongruent problems. The parietal system was also specifically engaged when people reasoned with belief-neutral problems where beliefs neither biased nor helped reasoning (e.g., "All X are Y. Z is an X. Therefore, Z is a Y"), and people could only rely on logical, analytic thinking to solve the problem. This led to the suggestion that the left temporal pathway corresponds to the heuristic system while the bilateral parietal pathway corresponds to the analytic system (e.g., Goel 2005).

6 Evidence from Cross-Cultural Research

Of further support and relevance for the assumption of two modes of thinking are recent findings by cross-cultural psychologists who draw on the distinction between "analytic" and "holistic" thinking, and argue that these two modes are unevenly distributed across cultures – the former is more prevalent in Western cultures, whereas the latter is more prevalent in East Asian cultures. Lately, cross-cultural findings have, moreover, been supported by studies in transcultural neuroimaging research (Han and Northoff 2008).

In the 1990s, Richard Nisbett and his collaborators began to examine the idea that one's cultural background could influence not only the content of one's thoughts but also the very processing strategies used to think about and know the world (Nisbett 2003; Nisbett et al. 2001; Norenzayan et al. 2002). In a series of studies comparing people from Western (European and American) and East Asian (Chinese, Japanese, Korean, etc.) cultures, the "culture-and-cognition" approach (Nisbett and Norenzayan 2002) found that people who grow up in different cultures do not just think about different things, they actually think differently. Under identical task conditions, thinking among Westerners tends to be more analytic, i.e., reasoning is decontextualized, attention is focused on objects and the categories to which it belongs, and they use on the other hand rules (e.g., formal logic) to interpret their behavior. East Asians on the other hand think in a more holistic way, that is, attention is distributed across the field, paying greater attention to context and relationship, relying more on experience-based knowledge than abstract logic, and showing more tolerance for contradiction (Nisbett et al. 2001; Masuda and Nisbett (2001); Buchtel and Norenzayan 2008).

In one study by Masuda and Nisbett (2001), for example, students from Japan and the USA were shown an animated underwater scene, in which one larger "focal" fish swam among smaller fishes and other aquatic life. Asked to describe what they saw, the Japanese subjects were much more likely to begin by setting the scene, saying, for example, "There was a pond" or "The bottom was rocky," or "The water was green." Americans, in contrast, tended to zoom in on the biggest fish, the brightest object, the fish moving the fastest. Overall, Japanese subjects in the study made 70% more statements about aspects of the background environment than Americans, and twice as many statements about the relationships between animate and inanimate objects. Shown the same larger fish swimming against a different, novel background, Japanese participants had more difficulty recognizing it than Americans, indicating that their perception was intimately bound with their perception of the background scene.

In another study, Richard Nisbett and Ara Norenzayan (2002) found indications that, when logic and experiential knowledge are in conflict, Americans are more likely than Asians to stick to the formal rules. For example, presented with a syllogism like "All animals with fur hibernate. Rabbits have fur. Therefore, rabbits hibernate," the Americans were more likely to accept the validity of the argument, separating its formal structure from its content, which might or might not be plausible. Asians, in contrast, more frequently judged such syllogisms as invalid based on their experience that not all animals with fur do in fact hibernate. A further example for this differing bias is an experiment showing that, given a choice between two different types of philosophical argument, one based on analytical logic, devoted to resolving contradiction, the other on a dialectical approach, accepting of contradiction, Chinese subjects preferred the dialectical approach, while Americans favored the logical arguments.

Cultural differences are also evident in social cognition. In a game that involved two individuals interacting, Chinese participants were more in tune with their partner's perspective than Americans (Wu and Keysar 2007). Furthermore, Chinese people were more likely to describe memories of social and historical events and focused more on social interactions, whereas European Americans more frequently focused on memories of personal experiences and emphasized their personal roles in events (Wang and Conway 2008; Han and Northoff 2008).

The findings of cross-cultural researchers about cognitive differences are mainly based on comparing the behavioral performances of Westerners and East Asians. Only very recently were these findings assessed by transcultural neuroimaging studies (Han and Northoff 2008). Using functional MRI and event-related brain potentials, the fairly novel approach of transcultural neuroimaging research measures neural activity in individuals from different cultural groups who are performing the same cognitive tasks, or in individuals from one cultural group after they had been primed with different cultural knowledge. These studies have accumulated evidence that culture influences the neural mechanisms that underlie both low-level perceptual and attentional processes as well as high-level social cognition.

7 Implications: From Dual Process Theory to Dual Process Practice

Without going too far into the issue of how and to what extent the analytic-holistic distinction maps on dual process models of thinking and reasoning (Sloman 1996; see Buchtel and Norenzayan 2009, for an extensive analysis on this issue), I would like to point out a few aspects in the cross-cultural literature that I find highly relevant for the understanding of thinking, in particular for the understanding of the non-logical, non-sequential mode.

As Buchtel and Norenzayan (2008, 2009) suggest, holistic and analytic thinking as discussed in cross-cultural research are in many ways very similar to the dual process theories that have been described by Western cognitive psychologists. The cross-cultural evidence in fact supports the plausibility of the dual process approach. However, the cross-cultural studies also point to several aspects that do not quite fit into the dual process categories.

A glance at Evans' list of characteristics attributed to the two modes of thinking (Table above) reminds us that holistic thinking is classified as "System 1" in line with unconscious (preconscious), implicit, automatic, low effort, default process, etc. Contrary to this view, cultural psychologists have traditionally conceived of holistic thinking as a culturally elaborated form of thinking in its own right. Holistic thinking can be taught, learned, trained and enhanced, and can thus be done consciously, deliberately, effortful and controlled (Buchtel and Norenzayan 2009, 222; Koo and Choi 2005).

A second issue that I would like to stress is the idea that the emphasis on holistic thinking in East Asian societies may also have led to the development of a more sophisticated kind of non-analytic thinking than in the West (Buchtel and Norenzayan 2009, 229 f.). A possible implication of this would in my view be that, by exploring the forms of thinking that have been shown to be particularly East Asian, we might find new ways to home in on a better understanding of the holistic mode of thinking, which – as discussed above – has proven so elusive in the Western research tradition.

A crucial finding of cross-cultural researchers in view of training and enhancing thinking skills is the role of the self-concept in evoking holistic thinking. Western subjects exhibit increases in holistic cognitive processing after being primed with an interdependent self-construal, while East Asian subjects move towards analytic thinking when primed with independent self-construal (e.g., Cha et al. 2005; Kühnen and Oyserman 2002). The link between intuitive processing and successful social inference has also been supported by their mutual dependence on brain structures required for implicit learning (Lieberman 2000).

In addition, studies have shown that holistic and analytic thinking can also be transmitted through formal education. Exposure to Western-style formal education in non-Western cultures increases the tendency to decontextualize deductive arguments (Cole and Scribner 1974). These studies suggest that (1) the cultural differences are best conceptualized as differences in habits of thought, rather than differences in the actual availability of information processing strategies in the cognitive repertoire, and that (2) holistic and analytic ways of thinking can be differentially encouraged in their development and use by different cultural and situational constraints (Buchtel and Norenzayan 2009, 219).

These findings from cultural psychology are of particular relevance when seen in the light of recent studies that have suggested that, in complex situations, intuitive, holistic thinking has a distinct advantage over conscious, analytic reasoning (Dijksterhuis 2004; Dijksterhuis et al. 2006; Dijksterhuis and Nordgren 2006; Dijksterhuis and van Olden 2006). If it is indeed the case that Western thinkers have culturally elaborated logical and analytical reasoning, and are more prone to engage in this mode of thinking, then in order to enhance their ability to cope with complexity, the more neglected holistic–intuitive mode of thinking. Moreover, when seen in the light of recent studies that have suggested that in complex situations, intuitive, holistic thinking has a distinct advantage over conscious, analytic reasoning (Dijksterhuis 2004; Dijksterhuis et al. 2006; Dijksterhuis and Nordgren 2006; Dijksterhuis and van Olden 2006) the findings from cultural psychology point to the importance of learning to shift between the two modes and to modulate their interplay according to the specific conditions and contexts. If it is indeed the case that Western thinkers have culturally elaborated logical and analytical reasoning, and are more prone to engage in this mode of thinking, then in order to enhance their ability to cope with complexity, they should train and possibly support the more neglected holistic-intuitive mode of thinking. An important goal of future research is to develop training methods that integrate and apply the findings in cross-cultural studies and thus allow for developing the full potential of human thinking.

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Outcome Evaluation in Decision Making: ERP Studies

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Abstract Decision making can be regarded as an outcome of mental processes (cognitive process) leading to the selection of a course of action among several alternatives. Every decision-making process produces a final choice. In this chapter, we would use the event-related brain potential (ERP) technique to study neural correlates of outcome evaluation in decision making.

Firstly, we used the motivation to be deceptive as a way to manipulate the motivational state of participants. Results showed that in both groups, losing money evoked a negative component (FRN). The amplitude of FRN was higher, and the latency shorter, in the deception group than in the simple response group. In addition, monetary losses also elicited a P3 peaking at around 400 ms, which was larger in the deception group than in the simple response group. Source modeling suggested a dorsal anterior cingulate cortex (ACC) source for the FRN and a rostral ACC source for the P300. These results suggest that motivation can influence the evaluation of performance outcomes. The FRN may reflect a process signaling that the outcome is worse than what participants expect, and P300 may be related to the emotional processing of disappointment and regret.

Secondly, in a simulated deception situation with graded monetary incentives, participants made a decision to lie or be truthful in each trial and held their response until a delayed imperative signal was presented. Spatiotemporal principal component analysis (PCA) and source analysis revealed that brain activities dominant in the left lateral frontal area approximately 800-1000 ms post-stimulus and over the central-frontal-parietal and right frontal areas after 1300 ms were significantly more negative in the deceptive condition than in the truthful condition. These results suggest that two serial cognitive processes, decision-making and response preparation, are related to deliberate deception.

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Thirdly, an ERP experiment was conducted to investigate the component processes underlying error related feedback and regret following incorrect decisions. Results showed that the amplitude of the FRN following an incorrect choice, the personal responsibility people accepted for an incorrect choice, the regret they expressed about it, and the counterfactual thinking they reported were higher when they alone made the choice than when they were not alone in their incorrect choice. No differences were found on the FRN or behavioral measures when participants were joined by one versus two others in their incorrect choice. The P300 amplitude, in contrast, was inversely related to the responsibility levels, consistent with the notion that personal accountability of a choice influences the allocation of attentional and cognitive resources to the task. Together, these results are consistent with neural modeling indicating that regret promotes error related processing and learning.

Lastly, Compared with non-anxious people, anxious people are suggested to judge the negative events as more likely to happen, and more likely to interpret the ambiguous outcomes as negative ones. We predicted that the FRN should be different between high trait-anxiety (HTA) and low trait-anxiety (LTA) groups. We discovered that the amplitude of the FRN indicating negative versus positive outcomes was significantly larger for LTA participants than HTA participants. However, the intergroup difference of the FRN indicating ambiguous versus positive outcomes didn't reach significance. The result indicated that there was a relationship between the FRN and the participants' individual differences in anxiety, which possibly reflected the impact of anxiety on outcome expectation. This finding provided insight about the underlying features of anxiety.

Keywords Decision making · Outcome expectancy · Outcome evaluation · feedback-related negativity (FRN) · event-related brain potential (ERP) · Trait anxiety

1 Decision Making and Outcome Evaluation

Decision making can be regarded as an outcome of mental processes (cognitive process) leading to the selection of a course of action among several alternatives. Every decision-making process produces a final choice (Reason 1990). The output can be an action or an opinion of choice.

Human performance in decision-making terms has been the subject of active research from several perspectives. From a psychological perspective, it is necessary to examine individual decisions in the context of a set of needs, the preferences an individual has and values they seek. From a cognitive perspective, the decision-making process must be regarded as a continuous process integrated in the interaction with the environment. From a normative perspective, the analysis of individual decisions is concerned with the logic of decision making and rationality and the invariant choice to which it leads (Kahneman and Tversky 2000).

Outcome evaluation is generally conducted to provide feedback to the outcome value which is categorized as good or bad, effective or ineffective. A principal function of the human brain is to rapidly evaluate the outcomes of behavior and to use this evaluation to guide future behavior. Outcome evaluation is a fundamental factor in future decisions which can help people to adjust their subsequent behaviors.

In this chapter, we would use the event-related brain potential (ERP) technique to study neural correlates of outcome evaluation in decision making.

2 ERP Components of Outcome Evaluation

In recent years, there has been a great deal of interest in the neural correlates of feedback evaluation processing. ERP studies have found two ERP components, the feedback-related negativity (FRN) and the P300, associated with the evaluation of performance outcomes in simple learning tasks and monetary gambling games (e.g., Balconi and Crivelli 2010; Gehring and Willoughby 2002; Gu et al. 2010; Miltner et al. 1997; Nieuwenhuis et al. 2004b; Yeung and Sanfey 2004).

The FRN, also known as feedback negativity (FN), medial-frontal negativity (MFN), and feedback error-related negativity (fERN), is a negative-going component of the ERP spanning the interval between 200 and 300 ms after the onset of feedback stimuli.

Using a time-estimation task in which participants received feedback stimuli indicating whether they had correctly estimated the duration of 1 s, Miltner et al. (1997) reported that feedback indicating incorrect performance evoked a negative deflection peaking between 230 and 330 ms. Gehring and Willoughby (2002) observed the similar negative ERP component that was greater in amplitude following feedback stimuli indicating monetary losses than that indicating monetary gains in a simple gambling task. Since then, the FRN, also called the MFN due to its medial frontal scalp distribution, elicited by feedback stimuli in simple learning tasks and monetary gambling games, has been confirmed in many studies (Cohen and Ranganath 2007; Hajcak et al. 2006; Holroyd et al. 2004a; Luu et al. 2003; Nieuwenhuis et al. 2004b; Ruchsow et al. 2002; Yeung et al. 2005). The FRN has the characteristic of fronto-central distribution, peaking 250–300 ms after feedback presentation, with a larger amplitude after feedback stimuli associated with negative outcomes, such as incorrect responses or the loss of money, than after positive outcomes. Source localization modeling and functional magnetic resonance imaging (fMRI) studies have suggested that the FRN might be generated in the prefrontal cortex, especially in the ACC (Cohen and Ranganath 2007; Elliott et al. 2000; Gehring and Willoughby 2002; Holroyd et al. 2004b; Luu et al. 2003; Miltner et al. 1997; Ruchsow et al. 2002; Ullsperger and von Cramon 2003).

Previous ERP studies on feedback evaluation have mainly focused on the FRN, but the functional significance of the FRN remains elusive. The FRN was originally observed following feedback indicating incorrect performance (Miltner et al. 1997), leading to the idea that this component reflects a neural process involved in error detection. Moreover, because the topography and generator of FRN is similar to another ERP component termed error-related negativity (ERN) or error negativity (Ne) that is a response-locked component observed after making an error response in the tasks requiring rapid responses (Falkenstein et al. 1991; Gehring et al. 1993), the FRN is considered to be related to the ERN component and thus also called feedback ERN by some researchers (Nieuwenhuis et al. 2004b). Another theory, called the reinforcement learning theory, postulates that the FRN is generated when an outcome is worse than expected, and that it reflects a negative reinforcement learning signal used to change the way responses are controlled by the motor system (Holroyd and Coles 2002; Nieuwenhuis et al. 2004b). Similarly, Gehring and Willoughby (2002) suggested that the process reflected by the FRN is involved in quickly determining the motivational impact of ongoing events, i.e., whether the outcome is good or bad.

The P300, also called P3, is an ERP component elicited by infrequent, task-relevant stimuli. The P300 was first reported by Sutton et al. in 1965. It is considered to be an endogenous potential as its occurrence links not to the physical attributes of a stimuli but to a person's reaction to them. It is usually elicited using the oddball paradigm in which low-probability targets are mixed with high-probability ones. When recorded by electroencephalography (EEG), it appears as a positive deflection in voltage with a latency of roughly 300–600 ms. The signal is typically measured most strongly by the electrodes covering the parietal lobe though it is generated by various parts of the brain including the hippocampus. The presence, magnitude, topography and time of this signal are often used as metrics of cognitive function in decision-making processes. While the neural substrates of this ERP still remain hazy, the reproducibility of this signal makes it a common choice for psychological tests in both the clinic and laboratory.

The P300 is a positive potential following the FRN in feedback evaluation, with a maximum over medial parietal sites, and is believed to be functionally dissociable from the FRN in feedback processing (Yeung and Sanfey 2004). Early studies reported that negative feedback indicating incorrect performance elicited a larger P300 than positive feedback indicating correct performance (Picton et al. 1976; Squires et al. 1973). In these studies, however, the negative feedback was less probable than the positive feedback. Because P300 amplitude can be affected by the probability of the eliciting stimulus (Donchin and Coles 1988), negative and positive feedback elicited equally large P300 when they occurred equi-probably (Campbell et al. 1979; Johnson and Donchin 1978). Recent studies revealed that the P300 following the feedback stimulus indicating the outcomes of monetary gambles increased in amplitude only with the amount of money won or lost, no matter the valence of feedback was negative or positive (Sato et al. 2005; Yeung and Sanfey 2004). Some other studies, however, found that P300 amplitude is larger for positive outcomes than for negative outcomes (Hajcak et al. 2005; Holroyd et al.

2004a; Johnson and Donchin 1985). Therefore, unlike the FRN, it remains unclear whether the P300 is related to the valence of performance outcomes. In addition, compared with the theoretic implications of the FRN, those of the P300 elicited by feedback stimuli have received less attention. Yeung and Sanfey (2004) reported that, although P300 amplitude was insensitive to the valence of chosen outcomes, it increased when alternative outcomes were better than the chosen outcome (i.e., after feedback stimuli indicating that participants had made an incorrect choice), and they thus proposed that the P300 might reflect an affective evaluation, such as regret or disappointment.

3 Role of Expectancy in Outcome Evaluation (1)

One important factor in feedback evaluation is people's motivation to do the task. People's motivation can be modified either passively through changing the reward value of performance or actively through adjusting the task instructions. Although Yeung and Sanfey (2004) reported that FRN was insensitive to the magnitude of the reward, several other publications revealed that the modulation of reward indeed influences the FRN (Holroyd et al. 2004a; Nieuwenhuis et al. 2004b; Yeung et al. 2005). For example, Holroyd et al. (2004a) reported that the FRN amplitude is determined by the relative value of the presented feedback among all possible feedback, rather than by the objective value of the presented feedback alone. They thus proposed that the FRN is context-dependent and modulated by the relative value of feedback. In two experiments using the identical gambling task except that the utilitarian aspect of the feedback was salient in one experiment and the performance aspect of the feedback in another experiment, Nieuwenhuis et al. (2004b) demonstrated that FRN amplitude is dependent on the information that is emphasized in the feedback. In addition, Yeung et al. (2005) reported that FRN amplitude was greater in a monetary gambling task in which participants had to make a choice than in a similar task in which participants made no active choices and no overt actions, suggesting that the FRN is associated with participants' involvement in the tasks. More recently, Hewig et al. (2007) also proposed that FRN amplitude would be proportional to the reward expectation associated with the active intention of the participant.

Motivation has also been found to play an important role in the P3. Studies showed that P3 amplitude is sensitive to the absolute magnitude of the feedback, suggesting that the motivational significance of the eliciting stimulus may affect the P3 (Sato et al. 2005; Yeung and Sanfey 2004). In addition, Yeung et al. (2005) reported that the amplitude of the P3, like that of the FRN, varied with participants' involvement in the tasks (being greater in the Choice task than in the No-choice/No-response task). Sato et al. (2005) in their study also found positive correlations between P3 amplitude and trait positive affect scores that reflect appetitive or incentive motivation (Mineka et al. 1998). Taken together, these previous studies have found the modulation of passive (e.g., changing the reward value) and simple active (e.g., task involvement) motivation on the FRN and P3. However, it is still not clear whether or not other more complex and natural active motivational factors can modulate these two components in feedback evaluation.

The purpose of the present experiment was to investigate the influence of those complex motivations such as deception on the feedback evaluation, and thus further understand the functional significance of the FRN and P300. In addition, the design allowed us to investigate the cognitive processes and brain mechanisms underlying the outcome of deception. Some researchers have proposed that deception consists of intention and action stages, and many previous studies about deception focused on these two stages (e.g., Furedy et al. 1988; Johnson and Rosenfeld 1992; Johnson et al. 2003, 2005; Rosenfeld et al. 1998).

However, how people respond to the outcomes of their deceptive behaviors is also an important part of deception. To our knowledge, no electrophysiological studies have investigated this until now. In our study, we designed a monetary task which divided the deception process into three stages: the deceptive intention, action and feedback. We manipulated the motivational state of participants through asking them to be deceptive in this monetary task. We hypothesized that the motivation to deceive would modulate the feedback evaluation, particularly the FRN and P3 components.

Experimental Design: As shown in Fig. 1, a red fixation cross was presented in the center of the screen for a randomized duration between 300 and 400 ms. After a 300- to 400-ms randomized delay, a cue was presented in the center of the screen. The cue stimulus consisted of a square, triangle, or circle with a probability of 25%, 25%, and 50%, respectively.

Participants were asked to prepare to make corresponding responses according to the cue. The cue remained on the screen for 500 ms, following a 1,500-ms delay. Then the target was presented in the center of the screen. The target stimulus consisted of a white arrow randomly pointing up, down, left, or right, which corresponded to the arrow key on the keyboard. The target remained on the screen for 500 ms, following a 300-ms delay. Participants were instructed to respond by pressing the arrow key according to the meaning of the cue as soon as possible when the target appeared. Finally, a positive or negative number lasting 500 ms was provided as feedback. The feedback stimulus consisted of "+1," "−2" and "+3" presented in yellow, as well as "−1" in yellow or in red, which were related to the

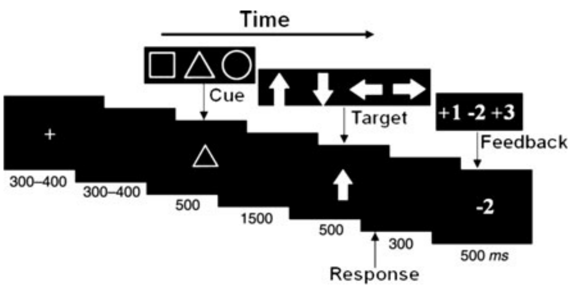

Fig. 1 Procedure of the task

reward or penalty that participants would receive (see below). The inter-trial interval (ITI) was 1,500 ms. When the participant made an incorrect response or responded so slowly that the reaction time was more than 800 ms, the ITI was 2,000 ms.

After we placed the electrode cap on the participant's head and finished all electrode preparation, the participants were asked to position the index finger, middle finger and ring finger of their right hand on the "←," "↓" and "→" keys, respectively. Then, participants in group 1 and group 2 were provided with the following different instructions for the three cues.

Group 1 – Simple Response Group: When participants saw a SQUARE, they needed to prepare to press the same key on the keyboard as the following target. For example, if the presented arrow pointed up, participants needed to press the "↑" key. A yellow "+1" would be presented if participants responded correctly, and the reward would increase 0.1 RMB (1US dollar = 7 RMB) correspondingly. When participants saw a TRIANGLE, they needed to prepare to press a key that differed from the following target. For example, if the presented arrow pointed up, participants needed to press any one of the "←," "↓," "→" keys, and not the "↑" key. The feedback would be either "−2" or "+3" without certain rules, indicating that the reward would decrease 0.2 RMB or increase 0.3 RMB, respectively. When participants saw a CIRCLE, they had to decide on their own how to respond: they could choose either to press the key that was the same as the target or one of the keys that differed from the target. In this condition, participants were required to press the same key or a different key randomly with a probability ratio of around 1:1. If they responded with the same key, a yellow "+1" would be presented, and if they responded differently, a "−2" or "+3" would appear without certain rules. The feedback also indicated the corresponding penalty or reward.

Group 2 – Deception Group: The participants were first told that this was a study about lie detection, and that we had recently designed lie-detection software and wanted to know its validity.

When participants saw a SQUARE, they were told to prepare for responding honestly, and when a target appeared to press the arrow key on the keyboard having the same direction as the presented arrow. A yellow "+1" would be presented if the participants responded correctly, and the reward would correspondingly increase 0.1 RMB. When participants saw a TRIANGLE, they needed to prepare for responding deceptively, that is, to prepare to cheat the computer, and when a target arrow appeared, they were required to press the arrow key on the keyboard which differed in direction from the presented arrow. They were told that the computer would monitor their brain activity to detect their deceptive responses. If they cheated the computer successfully, i.e., the computer believed they were honest, a yellow "+3" would appear in the screen, and their reward would increase 0.3 RMB correspondingly. But if they cheated the computer failure, i.e., the computer detected they were lying, the feedback would be a yellow "−2" and their reward would decrease 0.2 RMB. When participants saw a CIRCLE, they needed to decide by themselves whether to be honest or deceptive. In addition, they were required to decide to be honest or deceptive randomly with a probability ratio of around 1:1. If they responded honestly, a yellow "+1" would be presented, indicating that the reward would correspondingly increase 0.1 RMB. If they responded deceptively, a yellow "+3" or "−2" would appear to indicate the success or failure of their deceptive attempts with corresponding increase or decrease of their reward.

To be unknown to the participants in both groups, the feedback "−2" and "+3" appeared randomly with probability ratio of around 1:1. We used feedback magnitudes of −2 and +3 in order to keep the average bonus (+1) the same on same versus different trials in group 1 and honest versus deceptive trials in group 2.

To encourage rapid, accurate responses, feedback could also be a yellow "−1" if they responded incorrectly in square and triangle cue conditions or a red "−1" if they responded too slowly (more than 800 ms) in all three conditions; in both cases, their reward decreased 0.1 RMB. The experiment consisted of 480 trials. Participants were given a rest after every 48 trials. The correspondence between shape and cue meaning was balanced across subjects. To familiarize the participants with the procedure and pace of the task, participants were trained with a block of 32 trials with EEG recording before the formal ERP experiment. At the end of the experiment, participants were informed of their total bonus. They received 10 RMB plus their final bonus as payment. Note that the reward values were chosen so that participants always experienced a net gain in bonus money.

ERP Results: Grand-average ERP waveforms for the two outcomes (loss "−2" and gain "+3") are shown in the left part of Fig. 2 for the simple response group and deception group, respectively. Inspection of the waveforms suggests that, consistent with previous studies of feedback evaluation processing, the feedback of loss, compared with the feedback of gain, elicited a negative deflection (FRN) that peaked approximately 300 ms following feedback in both groups. This negativity (FRN) overlapped with a large positive deflection (P300) which peaked around 400 ms after loss feedback presented. Instead of measuring the FRN and P300 in the

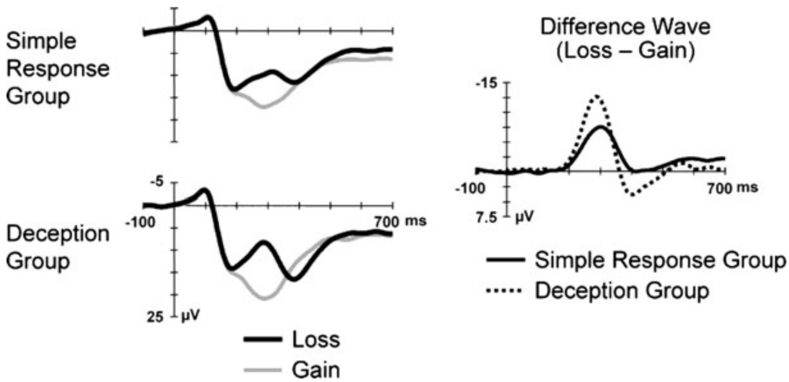

Fig. 2 The *left part* shows the grand average ERP in group 1 (simple response group, *top figure*) and group 2 (deception group, *bottom figure*) to gain and loss feedback. The *right part* shows the difference wave of subtracting gain from loss in the simple response group and deception group. Time = 0 ms corresponding to the onset of the feedback presentation. The presented electrode site is FCz

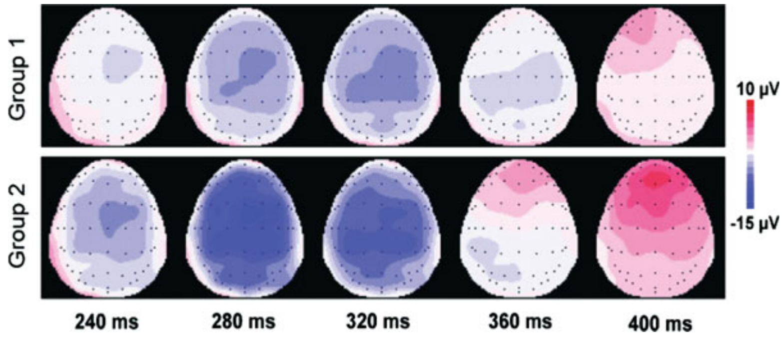

Fig. 3 Scalp topography of the voltage differences between loss and gain feedback in the simple response group (*top row*) and deception group (*bottom row*). Timings are given relative to the onset of the feedback stimulus

raw waveforms due to the difficulty of detangling the overlap of them, we measured the two components in the loss-minus-gain difference waveforms. In addition, according to the purpose of the study, it makes less sense to measure them in the raw waveforms. Therefore, to examine the FRN and P3 differences between two groups, we subtracted the feedback-locked ERPs evoked by gains from that evoked by losses and quantified the two components in the loss–gain difference waveforms.

Figure 2 also presents the loss minus gain different waves in the two groups. As shown in the right part of Fig. 2, the FRN amplitude was larger, and the latency was shorter, in the deception group than in the simple response group.

As for the scalp distribution of the FRN, as shown in Fig. 3, the FRN was greatest at midline fronto-central locations in both groups.

P3 amplitude was also greater in the deception group than in the simple response group. As shown in Fig. 3, the P3 was largest at midline frontal locations in the deception group (Fz: 2.70 μV) and left frontal locations in the simple response group (F3: −0.10 μV).

Dipole Localization: Using the BESA, we estimated the dipole source of the FRN and P3 elicited by losses in the deception group. The dipole was fitted within the time interval of 250–330 ms for FRN without constraining its orientation and location. A single dipole model located in the vicinity of the ACC was able to account for 89% of the variance in the observed data for the FRN. Then, a second dipole was added to fit within the time window of 330–410 ms for P3 without constraining its orientation and location. The second dipole also located in the ACC accounted for 94% of the variance in the scalp distribution of the P3 components. Superimposing the dipole locations on standard MRI showed that the dipole locations were close to the ACC (Fig. 4). It is important to note here that, although both FRN and P3 may originate in the ACC, they might locate in the different subregions of ACC. Inspection of Fig. 4 shows that the estimated neural source of FRN is near the caudal dorsal ACC, but that of P3 was closer to the rostral ACC. The simple response group showed a similar but less prominent FRN and P3, leading to

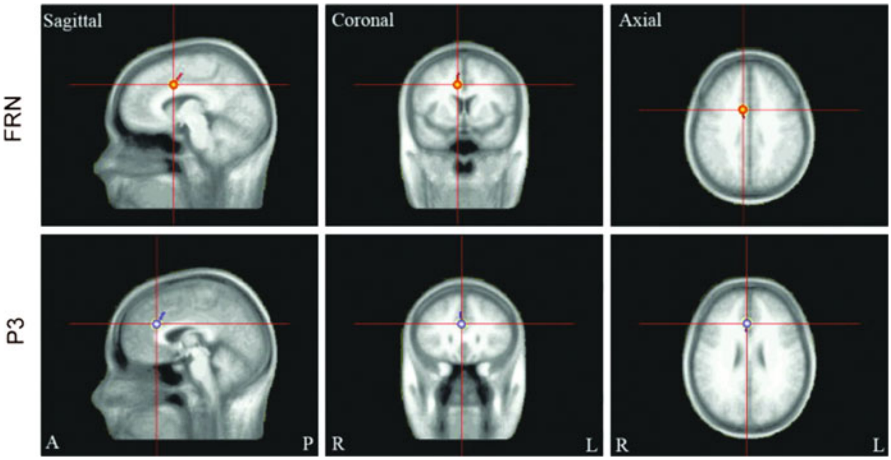

Fig. 4 FRN (*top row*) and P3 (*bottom row*) estimated neural sources from the loss feedback in the deception group

a less reliable source localization. As a result, we did not estimate the dipole source of the two components for the simple response group.

The purpose of the present study was to examine how a complex motivational manipulation would affect the evaluation of performance outcomes. The procedure of the two groups is identical, except that the instruction to participants is different between groups. We manipulated the motivational state of the subjects by giving one group of instructions to deceive the computer. We found that the amplitude of FRN was greater and the latency was shorter in the deception group than in the simple response group. We also found that the P3 amplitude was greater in the deception group than in the simple response group. These findings suggest that the modulation of two ERP components, the FRN and the P3, reflects the modulation of feedback processing by a complex motivational manipulation.

According to the reinforcement leaning theory (Holroyd and Coles 2002), the FRN reflects a negative reward prediction error, a signal elicited when the actual outcome is worse than the expected one. The amplitude of the FRN depends on the relationship between actual and expected outcomes. In the simple response group, participants always expected a gain after they pressed the key, and thus when the outcome was a loss, the FRN was evoked because the actual outcome was incongruent with what they expected. The value of the outcome, that is, its motivational significance, may have been larger in the deception group. In the deception group, when participants made a deceptive response, they expected not only to get money but also to succeed in their deception. According to this view, when the outcome was deceptive failure, the difference between actual and expected outcome was greater than when it was simply a monetary loss, resulting in a higher amplitude and shorter latency of the FRN. Our results provide the evidence to the hypothesis proposed by Hewig et al. (2007) that FRN amplitude would increase along with the reward expectation associated with participants' intention. In addition, the behavioral data showed that, compared with the simple response group, the deception group responded more quickly, and made more errors in the incongruent/ deception condition than the congruent/honest condition, which suggests that participants in the deception group had a stronger motivation and thus a greater expectation when they made deceptive responses than did those in simple response group when they made incongruent responses.

Other studies found that the FRN is insensitive to the magnitude of feedback, but is only related to the valence of the feedback, suggesting that the FRN might reflect the early appraisal of feedback based on a binary classification of good versus bad outcomes (Hajcak et al. 2006; Yeung and Sanfey 2004). In our study, although the FRN amplitude was greater for loss outcomes than gain outcomes in both groups, it was also greater in the deception group than in the simple-response group, suggesting that the FRN might reflect more than just the simple binary categorization of good versus bad outcomes, but might also be affected by motivational factors.

Some researchers have proposed that the FRN is the same component as the response-related ERN, both reflecting the same neural processes of error detection (Miltner et al. 1997; Nieuwenhuis et al. 2004b). However, if an error is defined as incorrect performance, error detection theory might not explain why the deception group and simple response group showed remarkable FRN differences regardless of the fact that participants in both groups got the similar negative feedback for incorrect performance. Yeung et al. (2005) also reported the FRN following unfavorable outcomes even in task contexts without overt response choices or executed actions. In addition, some studies have found that the scalp topographies of the FRN and ERN are different: the FRN is more frontal distribution than the ERN, which suggests that the neural generators underlying the two components might not be the same (Donkers et al. 2005; Gehring and Willoughby 2004). Moreover, although the neural origins of both FRN and ERN seem to be located in the ACC, the ACC is not a unitary structure but includes several subregions. We do not yet have solid evidence that ERN and FRN originate in the same subregion of ACC. Therefore, the FRN and ERN might not reflect the same process.

The P3 was also observed during feedback evaluation, and the amplitude of this component was greater in the deception group than in the simple response group. Previous studies suggested that the P3 amplitude can be affected by the simple manipulation of participants' motivation such as the magnitude of reward and participants' involvement in the task (Sato et al. 2005; Yeung et al. 2005; Yeung and Sanfey 2004). Our results provide further evidence that the P3 can also be modulated by complex motivational activities, such as deception. Although whether the P3 is sensitive to the valence of feedback remains in debate, some studies have found that P3 amplitude is greater for affectively negative images or words than for positive images or words (Bernat et al. 2001; Ito et al. 1998), indicating that the P3 is related to the emotional valence of stimuli. Yeung and Sanfey (2004) also proposed that the P3 might reflect affective processing, such as disappointment or regret. In addition, some fMRI studies, using a gambling task, have reported several brain areas related to disappointment and regret in feedback processing, such as middle temporal gyrus, dorsal ACC, medial orbital frontal cortex (OFC) and anterior hippocampus (Camille et al. 2004; Coricelli et al. 2005). We thus proposed that the P3 elicited by monetary loss feedback might reflect this kind of negative emotion processing, such as disappointment, or regret. Moreover, the P3 amplitude was greater in the deception group than in the simple response group, suggesting that the P3 may be related to the degree of emotional activity. In the deception group, the participants experienced not only disappointment or regret induced by loss of money but also by the failure to deceive the computer. That is, participants in the deception group may have had a stronger negative emotional activity when the outcome was a loss than those in the simple response group. Our proposal that P3 amplitude might reflect the degree of emotional activity is supported by the findings of previous studies that P3 amplitude increased along with the reward magnitude (Sato et al. 2005; Yeung and Sanfey 2004) and participants' involvement in the tasks (Yeung et al. 2005). The more money participants gain or lose or the more participants are involved in the task, the stronger is their emotional activity, and thus the greater is the P3 elicited.

Dipole source localization analysis suggests that the FRN may originate in the dorsal ACC, which is consistent with previous studies (Gehring and Willoughby 2002; Luu et al. 2003; Miltner et al. 1997). Furthermore, our analysis showed that the P300 might also originate in the ACC. Compared with the FRN, however, the generator of the P3 was closer to the rostral region of the ACC. These results are consistent with the proposal of the separation of cognition and emotion in the ACC (Bush et al. 2000). They suggest that the two major subdivisions of the ACC, the dorsal division and the rostral-ventral affective division, subserve cognitive and emotional processing, respectively. Viewed from the perspective of the reinforcement learning theory (Holroyd and Coles 2002), the FRN was first elicited when the actual outcome (loss) was different from what participants expected, i.e., gain, at about 300 ms after the stimulus. The P3, occurring slightly later (400 ms) may represent a negative emotional response based on the evaluation represented by the FRN (Yeung 2004).

In addition, there is an interesting phenomenon that fMRI studies on the processing of reward feedback tend to interpret results just from the view of emotion processing (Camille et al. 2004; Coricelli et al. 2005). However, we believe that the two processes of cognition and emotion cannot be separated by the fMRI technique due to its limitation of low temporal resolution. Hence, not all these brain areas which are active in feedback processing, such as the dorsal ACC, middle temporal gyrus, OFC and hippocampus, are related to the emotion processes of disappointment or regret alone. Some of them, such as dorsal ACC, might be associated with the cognitive processing in feedback evaluation. Further investigations are thus necessary to testify the dissociation of cognition and emotion in feedback processing by combining the fMRI and ERP techniques.

It is important to note that we used source localization modeling to locate the generators of the FRN and P3. Because there is no unique solution in the source analysis of ERPs (the inverse problem), this modeling must be viewed with caution.

In addition, the current modeling is done on the grand mean data because they have higher signal–noise ratio than individual data do, which might lead to an imprecise source localization. It is possible that the FRN and P3 embody complex brain processes accomplished by multiple areas and their interactions, and thus it is somewhat risky to propose there was only one generator to account for such a high-level evaluation process. Such a possibility is supported by fMRI studies of reward feedback processing (Camille et al. 2004; Coricelli et al. 2005; Elliott et al. 2000; O'Doherty et al. 2001), which find many cerebral areas activated, such as the dorsal ACC, middle temporal gyrus, dorsal brainstem, OFC and hippocampus. Future studies designed to establish more firmly the generators of the FRN and P3 should consider the potential contributions of these areas, especially in light of the connections between these regions and the ACC.

4 Role of Expectancy in Outcome Evaluation (2)

The primary purpose of the experiment 2 (Sun et al, in press) is to investigate the neural correlates of processes leading to deception, particularly that related to deception preparation preceding actual responses, by ERP technique. In the study, we applied a modified "S1–S2" paradigm with feedback, which required the participants to decide whether or not to lie after seeing the primary stimuli (S1, act as the monetary incentives to induce deception behavior) but not to execute until seeing an imperative signal (S2). Therefore, the setting that participants decide for themselves whether or not to lie includes the intention component of deception. Meanwhile, the delayed responses made it possible to observe the S1-related activities at the preparing stage that before the deceptive responses (Dawson 1980; Furedy and Ben-Shakhar 1991; Furedy et al. 1988). In the typical S1–S2 paradigm, a slow negative wave termed as contingent negative variation (CNV) emerges before the S2. It is widely accepted that CNV consisted of two separate components (for reviews, see Fabiani et al. 2007; van Boxtel and Becker 2004): an early initial CNV, reflecting the processing and evaluation of the warning signal (e.g., Weerts and Lang 1973) and a late terminal CNV (tCNV), being associated with motor preparatory processes and the anticipation for the imperative stimulus (Brunia and van Boxtel 2001; Damen and Brunia 1994; Leynes et al. 1998). Previous studies have shown that enhanced CNV is related to the constraint deceptive stimuli (Fang et al. 2003) and a negative deflection (N450) can be elicited by a truth that is told with deceptive intention (Carrión et al. 2009). We hypothesized that the same results would obtain in the self-decided deception, that is, greater CNV before deceptive than before truthful responses.

The secondary purpose is to explore the effect of cognitive load on deception. Under the cognitive framework, deception is cognitively more demanding than truth-telling (DePaulo et al. 1996; Vrij et al. 2006; Zuckerman et al. 1981). This declaration primarily comes from behavioral evidences such as the participants' subjective assessment, longer response latency, more speech hesitations, greater pupil dilation, and fewer body movements, as well as neural evidence that deception always associates with the activity of the high-level cortices (e.g., the prefrontal cortex). Therefore, Vrij et al. (2006) suggest the use of a concurrent secondary task which increases the cognitive demanding of the examinees so as to improve the efficiency of lie detection. In the present study, the cognitive load was manipulated. We expected the high cognitive load parallel task would make the deception even more cognitive-demanding. Thus, the enhanced differential ERP activity between deception and truth-telling would improve the detectability of CNV as an indicator for lie detection.

Pictures of the 1 Renminbi bill were used in this experiment. In addition, there was a faked 1 RMB picture marked by the number code "00000000."

We created a simulated "bill-identification" experimental situation in which participants were required to pick out the genuine RMB pictures from a set of mixed faked ones. They should press the left key to report genuine RMB pictures and the right key for faked ones, with the left and right index finger, respectively. However, all participants were told that for each genuine RMB picture, they could decide for themselves whether to "declare" (tell the truth) or "smuggle" (lie), and we were testing the validity of our lie-detecting software, which would judge whether they were lying about the genuine RMB picture. Telling the truth would award them a small but certain monetary reward (+0.10 RMB), whereas lying may have lead to a larger potential gain (+1 RMB) if they escaped from being caught, but carried the risk of a double penalty (−2 RMB) if they were detected by the software. They also learned that their final reward was added to the sum of their outcomes to a basic compensation of 30 RMB, but not exceeded 60 RMB. In addition, the participants were informed that the software judged whether they are lying by comparing their brain activities between genuine and faked RMB pictures, thus they should always respond truthfully to the faked ones and had better make approximately equal deceptive and truthful responses to genuine RMB in order to earn more. The participants did not realize that the feedbacks for their deceptive responses were random until they finished the experiment, when we explained to them the real intention of our design. Hand–response relationship was balanced between subjects (Fig. 5).

In each trial, after 500 ms presentation of fixation, an RMB picture (S1), genuine or faked, was presented. The participants were instructed to decide their choice after the onset of each RMB picture but not to response until seeing the "*" signal (S2). Between the S1 and S2, there was a fixed stimulus onset asynchrony (SOA) of 1,800 ms. The "*" terminated at the response press or 1,000 ms after its onset if response latency was longer than 1,000 ms. The trials with response latency beyond 1,000 ms were excluded from further data analysis. Feedback (+0.10, +1.00 or −2.00, as aforementioned) was presented 300 ms after response. There was a rest interval of 1,500–3,000 ms between trials.

A secondary task was embedded in the deception task to manipulate the cognitive load. The participants had to undergo two experimental sessions, the low-load and high-load conditions, in random order. Each session contained five blocks. Each block contained 45 trials. At the end of each block, a question was presented,

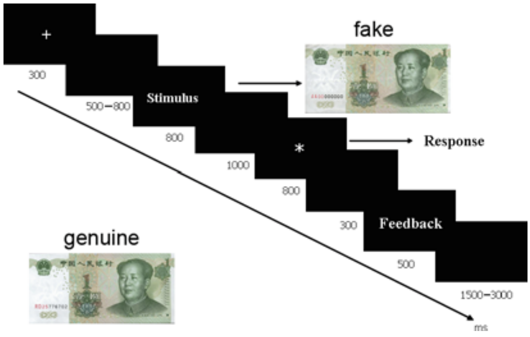

Fig. 5 Procedure

requiring the participants to answer with the proper number key. For the cognitively low-load condition, they were asked to recall whether the first RMB in that block was genuine or faked and to press "1" for the genuine and "0" for the faked. For the high-load condition, they were asked to recall how many faked RMB pictures were consisted in that block (no more than nine faked RMB pictures in each block). The total experimental duration was about 1 h, including a 10-min practice for participants to familiarize themselves with the procedure.

On visual inspection of the global grand average waveforms, it could be seen that the ERPs at mid-line sites were most sensitive to the experimental manipulation.

0–700 ms: The MANOVAs did not reveal any significant effects in either of these seven time bins.

700–1,100 ms: The omnibus MANOVAs did not indicate any significant effects. However, the main effect of cognitive load was significant in the first two 100-ms bins at Cz and CPz and significant in the last two bins only at Cz. As shown in Fig. 6, the potentials were more negative in the low cognitive load conditions than in the high load conditions.

1,000–2,000 ms: These effects indicated that deceptive preparations were associated with greater negative deflection. At specific individual electrode sites, the ERPs of deception started to depart from that of truth-telling a little later. The mean amplitudes in deceptive conditions were significantly or marginally significantly more negative than in truthful conditions from 1,400 ms to the end at FCz and Cz (Fig. 1).

For the results above, there seem to be two temporally dissociable stages respectively related to the processing of cognitive load and deception preparation, corresponding to the ERP activities in 700–1,100 ms followed by that after 1,400 ms. The primary aim of the present study was to identify the neural correlates of cognitive processes leading to deception. We hypothesized that the deception preparation is associated with greater (more negative) CNV. This hypothesis was supported. The amplitudes were significantly more negatively in deceptive conditions after 1,400 ms (400 ms before the imperative stimuli), while this interval is highly representative for the late CNV. This result supports the feasibility of using late CNV as an indicator for lie detection. We further expected the parallel high

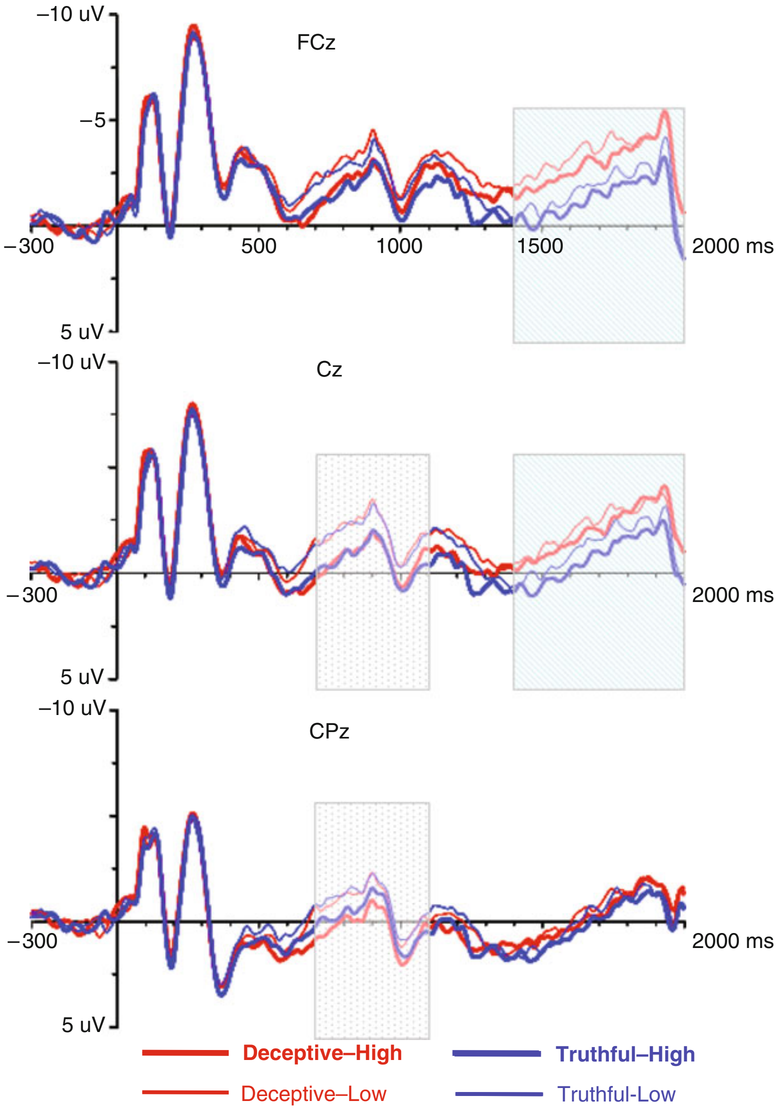

Fig. 6 Grand average waveforms at FCz, Cz and CPz. *Shading with dots* indicates significant main effect of cognitive load. *Shading with diagonals* indicates significant main effect of response type

cognitive load task would improve the detect ability of CNV. However, the current results did not support this. Compared with the high cognitive load, the low cognitive load elicited more negative deflection in an early interval (700–1,100 ms post the RMB picture, presumably related to the early CNV). However, the cognitive load did not interact with the deception. Neither did the hit rate of late CNV as the lie detector was influenced by the cognitive load.

The deception task in the present study included the intention component of deception by leaving the participants to decide for themselves whether or not to lie in each trial with the monetary incentives. Consistent with previous studies (Carrión et al. 2009; Fang et al. 2003), enhanced CNV (late CNV in this study) was observed before the deceptive response in contrast to the truth-telling. Two main factors related to the processes leading to deception may contribute to the enhanced CNV. One is the emotional experience, such as anxious, or fear of being detected when deceivinge (DePaulo et al. 2003; Vrij and Mann 2001). The other factor is the cognitive or motor preparation including preparation for the appropriate mental state (Carrión et al. 2009), inhibiting the pro-potent truthful response and monitoring the conflict (Johnson et al. 2003, 2004, 2008).

The early CNV was greater in the low cognitive load context. Parallel to the deception task, the participants were required to retain an item whether the first RMB picture was genuine or fake in the low load context, and to retain and update how many fake RMB they had encountered in the high load context. There are studies showing that early CNV reflects the orientation response, stimulus analysis and evaluation, and attention to more task demands (e.g., Becker et al. 2004; Leynes et al. 1998; Weerts and Lang 1973). Based on this background, we initially think that the amplitude of the early CNV should increase when the participants are preparing a lie, since deception needs more cognitive resources. However, the result rejects this hypothesis. The early CNV did not distinguish between deception and truth-telling. Given the fact that the task is more difficult in high cognitive load, the current result of greater early CNV in low load also excludes the possibility that the amplitude of the early CNV increases linearly with task difficulty. It seems that the early CNV is associated with the available rather than the needed cognitive resources. More exactly, it reflects a primary allocation of the available cognitive capacity in the dual task. Under the low cognitive load context, more cognitive resources are drawn to the deception task. While at this early stage, the decision to deceive is not yet made. That is why no effect of deceptive preparation was found in early CNV. Other evidence for the notion that the early CNV reflects primary processes comes from a study which showed the early CNV only differs between motor and non-motor tasks (Chiu et al. 2004).

It sounds remarkable that the ERP response of deception differs from that of truth-telling before an actual lie is "spoken out," since one might consider utilizing this characteristic to detect the lie at its preparation stage. Compared with P300 as a lie detector, the CNV approach has an important advantage. It detects whether the coming response is deceptive or truthful rather than whether one has some knowledge of the content of a lie such as crime-related information (Fang et al. 2003). The individual diagnoses provide evidence for utilizing CNV as a lie detector. Further, opposite to our expectation, the detection of deception by CNV was not compromised by the high cognitive load in the current manipulation. It might suggest the CNV as a lie detector is immune to interference or even some possible countermeasures. However, similar results are found in physiological measures including skin conductance, respiration, heart rate and finger pulse, which show that the parallel interfering task does not influence the detectability in a concealed information test (Ambach et al. 2008). It should still be prudent to consider the possibility that the high cognitive load manipulation does not differ enough from the low load to compete with the deception task for cognitive resources. Further researches with other interference tasks in the future may provide incremental information to confirm the effect of cognitive load on deception and on lie detection.

5 The Components of Regret in Decision Making

A favorite mythical species of economists, Homo Economicus, is assumed to be purely rational in decision making (Leavitt and List 2008). In everyday life, however, human decision making is also influenced by emotions and heuristics (e.g., Thaler and Sunstein 2008). Rather than evolutionary errors, these non-rational influences appear to be broadly adaptive mechanisms for a species with limited information-processing resources to deal with imperfect information about an uncertain world. Regret is a case in point. Feelings of regret are greater following decisions that lead to the lesser rather than the greater of two outcomes (Bell 1982; Loomes and Sugden 1982), and are higher when personal responsibility is high than low (Mellers et al. 1999), and promote learning and decision making (Marchiori and Warglien 2008).

Feelings of regret represent the conscious endpoint of a poorly understood series of information-processing operations. Research on the diffusion of responsibility suggests that the intensity of regret should vary with personal responsibility (Latane and Darley 1968), which provides a means of experimentally manipulating the intensity of regret while holding constant the information about the choices per se. Research using ERPs has identified two component processes that may be especially relevant to understanding the constituent mental operations underlying regret. The feedback error-related negativity (fERN) is a negative component stemming from the supplementary motor area or anterior cingulate cortex that occurs when a respondent realizes that they made an error, and the P300 is a positive component that reflects the summation of activity from multiple, broadly distributed neural generators and occurs when additional attentional resources are allocated to a stimulus (Fabiani et al. 2007). Respondents receive negative feedback when they choose an option that provides the lesser of the two choice options. Although error-related processing could be triggered when individuals learn they made an incorrect choice, we hypothesized that the human facility to dodge accountability for adverse outcomes (Goethals and Cooper 1975; Latane and

Darley 1968) suppresses error-related negativity when participants share responsibility with others for an incorrect choice.

On the study conducted by Zhang and Luo (2008), the participants were told to gamble cooperatively with two other players (confederates), and to try to earn as much as possible during the game and to pay attention to the confederates' as well as to their own outcomes. This task was divided into four phases: decision, highlighting their choice, feedback about the choices made by the participant and the confederates, and feedback about the amount they had won or lost on that trial (see Fig. 1).

In each trial, the participants' task was to press a button with his/her left or right index to select which of the two cards marked the location of the reward. Participants thought the other players (confederates) were doing the same things in other rooms, separately. Only if all chose the right card would they each receive the designated reward. Participants were encouraged to learn from their experience as the game progressed to predict where the reward was located. Following their decision, they saw their chosen card highlighted by a thickening of the white outlines of the card. Participants were further told that the result of each gamble would be displayed by an equilateral triangle (each side 5 cm, 3.82 wide, 2.83 high): each side stood for a player (the base side for the participant; the other two sides for the confederates), and the color of each side stood for the outcome of the corresponding player's choice (red for right/wrong and green for wrong/right were counterbalanced between the participants). After receiving the outcome, the number "+5" (in the conditions that all of them had made a correct choice) or "−5" (in the conditions that any of them had made a mistake) was displayed to inform the participant of the net effect of the trial outcome on their stakes. Participants next performed 20 practice trials before beginning.

The independent variable, Responsibility, was manipulated on a trial-by-trial basis as the number of people responsible for choice (the participant alone, the participant and one other player, the participant and both players). When the participant saw the base side was red, and red indicated that he/she had made an incorrect choice, the level of responsibility was manipulated to be 1 (just the participant himself/herself had made an incorrect choice, e.g., as indicated by a red base and two green hypotenuses); 1/2 (the participant and one of the confederates had made incorrect choices, e.g., as indicated by one a red base and hypotenuse and a green hypotenuse); 1/3 (the participant and both confederates had made incorrect choices, as indicated by all three sides being red). These three experimental conditions were embedded in trials in which all eight possible outcomes were presented as feedbacks (see Fig. 7). The experiment consisted of 640 total trials, divided into 16 blocks. Unknown to the participants, the two confederates were virtual players, and all the feedback was arranged in a pseudorandom order such that no more than three trials with the same outcome could appear in succession, and every type of outcomes had an equal frequency of appearance by the conclusion of the trials.

In each trial, the time for decision was limited to 2,500 ms, and the highlighted card was presented between 500 and 1,000 ms (length determined randomly). The appearance of the outcome and reward lasted for 1,500 and 1,000 ms, respectively.

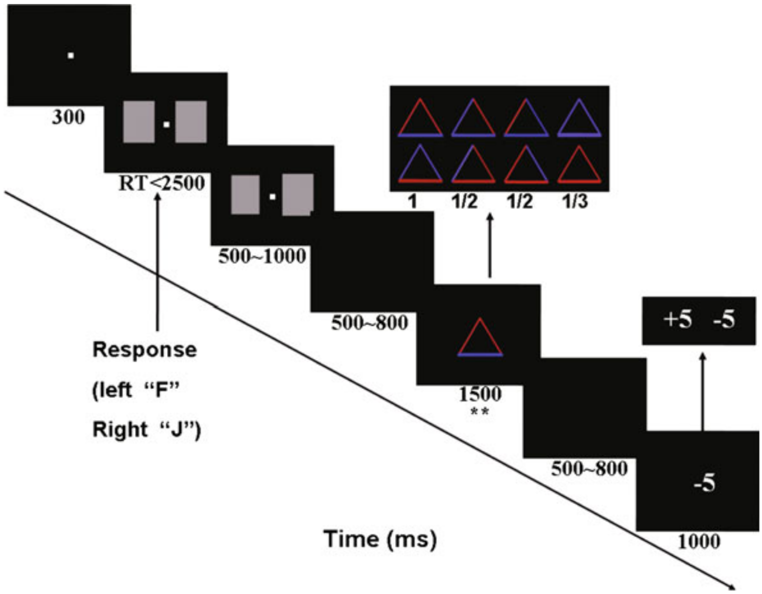

Fig. 7 The sequence of events during a single trial of the cooperated gambling game. The ERP waveform was analyzed at the presentations of the *triangle mark*. The *top line* of the feedback box indicates the incorrect choice by participant, while the *bottom line* indicates the correct choice by participant

The ISIs were determined randomly and ranged from 500 to 800 ms, and the inter-trial interval (ITI, offset to onset) was determined randomly and ranged from 2,000 to 2,500 ms.

During the rest between blocks of trials, participants received information about the frequency of incorrect choices on the prior block and the amount of money earned in that block of trials. Participants were told that a small penalty would be levied if the number of incorrect choices (error rate) exceeded 62.5% within any block of trials, and that the higher the error rate, the larger the penalty. Finally, at the conclusion of EEG recording, the participants were asked to evaluate the performances of themselves and their confederates, their level of regret, the degree of sense of responsibility, and counterfactual thinking using a 9-point scale presented on the screen after which time they were debriefed, paid, and dismissed.

As hypothesized, participants felt "houhui" ("regret" in Chinese) when they made an error (78.57%, 71.43%, and 57.14%, respectively, for making an error alone, participant and one confederate incorrect, and participant and both participants incorrect), and regret differed as a function of Responsibility (7.07, 4.64, and 4.36 respectively, for making an error alone, participant and one confederate incorrect, and participant and both participants incorrect; see Fig. 2). Self-rated responsibility also varied as a function of Responsibility (7.21, 4.21, and 3.93, respectively; see Fig. 2). Thus, the manipulation of Responsibility was successful.

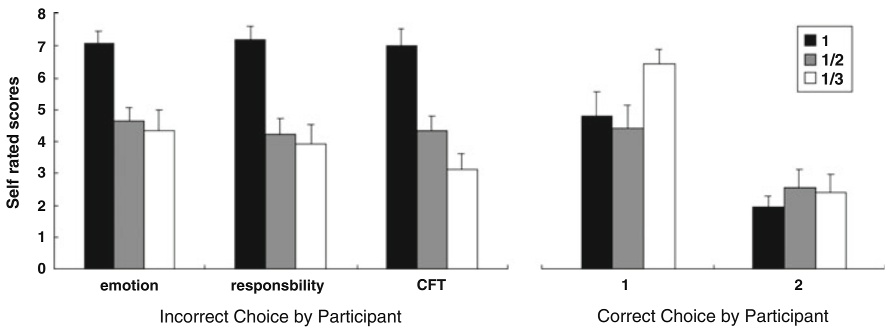

Fig. 8 The self-rated evaluation across the three levels in three facets: the significant responsibility effect on regret; the significant responsibility effect on sense of responsibility; the significant responsibility effect on counterfactual thinking (CFT)

Finally, we compared the likelihood that participants would change targets following an incorrect versus correct choices. As expected, participants changed their choice more frequently after making an incorrect (0.59) than correct choice (0.31) (Fig. 8).

5.1 ERP Results

FRN: The grand-average waveform for the FRN is depicted in Fig. 9. The mean peak latency of the FRN over the six midline electrodes was 274.6 ms and did not differ significantly across conditions or electrode locations. More importantly, on trials on which participants made an incorrect decision, a 3 (responsibility) $\times$ 6 (electrode location) repeated measures ANOVA of the FRN amplitude revealed a significant main effect of Responsibility. Post hoc comparisons showed that the FRN amplitude was larger when the participant was solely responsible for the incorrect choice (-4.49 μV) than when they and one (-2.67 μV) or both other players chose the incorrect response (-2.65 μV), and these latter conditions did not differ. Finally, the Responsibility $\times$ Electrode Location was significant. Post hoc tests showed that the amplitude in the condition of 1/3 is slightly larger than that of 1/2 at the frontal electrodes (Fz, FCz, Cz), while this pattern is reversed at the posterior electrodes (CPz, Pz, POz), but the simple main effect tests were not significant (see Fig. 9).

We next compared FRN amplitude in the condition in which the participant made a correct choice: a 3 (responsibility) $\times$ 6 (electrode location) repeated measures ANOVA of the FRN amplitude revealed a significant main effect of Responsibility. Post hoc comparisons showed that the FRN amplitude was larger when the participant was the only one making the correct choice than when one or both other participants also made the correct choice, and mean amplitude to the latter two conditions did not differ.

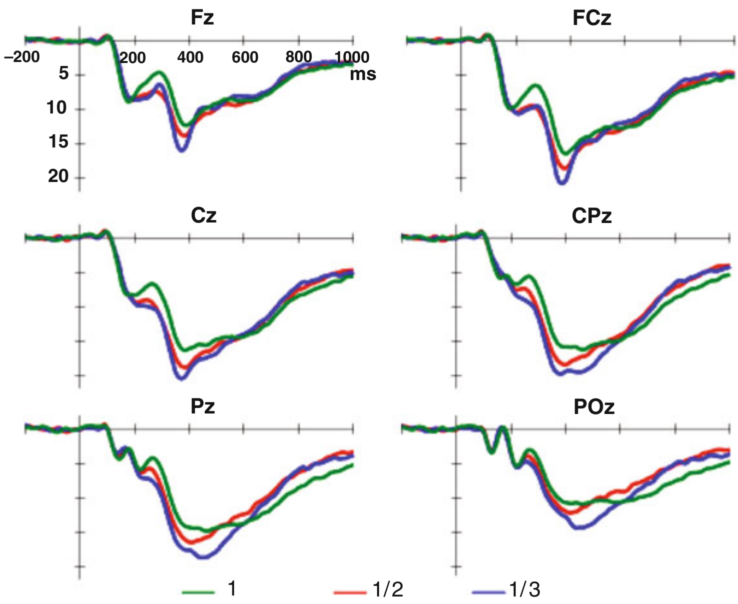

Fig. 9 Event-related potentials elicited by different level of responsibility when participant made decision error: 1, 1/2 and 1/3 at the midline electrode

The relationship between the FRN and behavioral change was further investigated. Specifically, trials in which participants made an incorrect choice were divided into two groups according to the decision that was made in the following trial (change or maintained). The amplitude of FRN on a trial in which they made an incorrect choice was larger at frontal electrodes (Fz, FCz) when the participant chose the opposite target on the following trial (−3.9 μV) than when they selected the same target (−2.73 μV; see Fig. 10).

P300: The grand-average waveform for the P300 is depicted in Fig. 3. The mean peak latency of the P300 over the six midline electrodes was 394.62 ms and did not differ significantly across conditions or electrode locations. The same comparison was employed as that used in the analysis of FRN. When participant made an incorrect decision, the 3 (responsibility) × 6 (electrode location) repeated measures ANOVA of P300 amplitude revealed a significant main effect of Responsibility, and post hoc comparisons revealed differences in P300 amplitude between all pairwise comparisons (13.6, 14.9, and 16.0 μV, respectively, for sole responsibility, one of two, and one of three).

Source Analysis: Finally, we reconstructed the sources over the time window of 250–310 ms (FRN) and 400–460 ms (P300) in a four-shell head model. Source analysis of the FRN was performed for the difference waveform between the conditions of making an incorrect versus correct choice when responsibility is largest, as these conditions maximized differences in error-related feedback. Source analysis of P300 was performed for the difference waveform between the

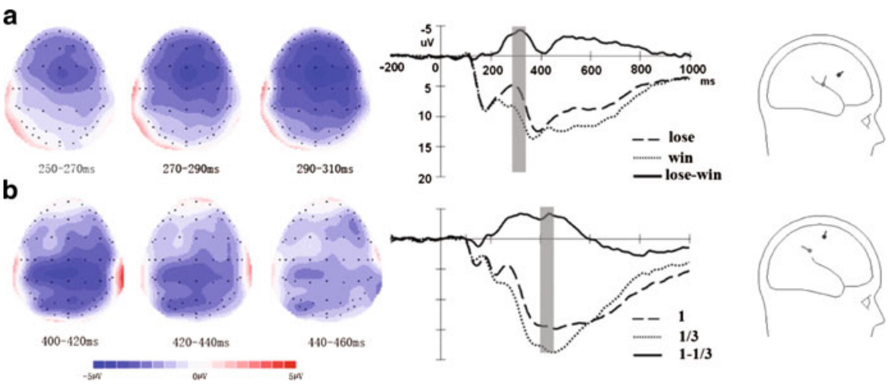

Fig. 10 The source dipole of the FRN and P300. (**a**) The source of the difference wave (wrong–correct) in the condition of 1 at the time window of 250–310 ms; (**b**) The source of the difference wave (1−1/3) at the time range of 400–460 ms

conditions in which the participant was solely responsible for the incorrect choice and all three players made the incorrect choice, as these conditions maximized differences in felt responsibility.

The source analysis of the FRN revealed two dipoles in the right ACC (Brodmann area 24), consistent with the previous results (Gehring and Willoughby 2002), and right thalamus (see Fig. 10a).

The source analysis of P300 between 350 and 400 ms revealed a dipole in the right medial frontal gyrus (Brodmann area 6), and right cingulate gyrus (Brodmann area 31; see Fig. 10b).

We introduced a modified gambles paradigm in the present study in which levels of responsibility felt for an incorrect decision were varied experimentally. The results indicated that experimentally varied levels of personal responsibility elicited the predicted differences in emotional response. Participants reported more counterfactual thinking and feeling more personal responsibility and regret following incorrect choices for which they were solely responsible than those for which they shared responsibility for the incorrect choice, whereas none of these responses differed when participants were one of two versus one of three to make an incorrect choice. And analyses of the ERP components revealed that personal responsibility for an incorrect decision increased FRN amplitude and decreased P300 amplitude, but these components were affected somewhat differently by personal responsibility. Finally, we found the FRN to be larger in response to an incorrect choice when participants changed their choices on the next trial than when they did not change their choices, suggesting that the FRN reflected learning as a result of making an error. Together, these results extend the understanding of regret following incorrect choices by demonstrating the time course of and the role of responsibility in regret.

Regret is an intense feeling related to the difference between the obtained outcome and the best outcome which could have been attained if the individual had chosen another option. Regret is associated with individuals' desire to change their decision or choose more conservatively to avoid experiencing the emotion (Bell 1982; Cohen 2008; Connolly and Zeelenberg 2002; Loomes and Sugden 1982; Marchiori and Warglien 2008; Mellers et al. 1997, 1999; Mellers and McGraw 2001; Reb 2008; Yager 2004; Zeelenberg et al. 1996; Zeelenberg 1999; Zeelenberg and Beattie 1997). Our result is in line with former research showing that the commission of an error yields different emotional states (Coricelli et al. 2007; Mellers et al. 1999; Zeelenberg et al. 1998, 2000): most of the subjects feel regret in the face of their own mistakes, whereas they feel "disappointed" upon seeing others' mistakes. This means that the personal responsibility they feel plays a key role in emotional states. Consistent with this reasoning, we found differences in reports of emotional intensity, responsibility, and counterfactual thinking between conditions in which participants made an incorrect choice versus those in which others made an incorrect choice. We further explored these differences as a function of responsibility and found that regret was influenced by the different levels of responsibility.

In addition to the behavioral analysis, evidence from ERP data and dipole source are employed to investigate the neural basis of regret. The FRN is generally considered to be related to error or negative outcome processing. Some theories treat the FRN as a manifestation of an early binary evaluation ("good/bad") of an outcome (Goldstein et al. 2006; Hajcak et al. 2005, 2006; Holroyd et al. 2006; Itagaki and Katayama 2008), whereas others treat the FRN as involved in the behavioral adjustments required to avoid future errors (e.g., Nieuwenhuis et al. 2004a; Cohen and Ranganath 2007). In the present study, participants received error feedback equally often when they were alone, when they were one of two, or they were one of three who made an incorrect choice. Consistent with both theoretical perspectives, the FRN was larger following feedback indicating they had made an incorrect than correct choice. However, the additional finding that the amplitude of the FRN was larger when they were solely responsible for the incorrect outcome than when they shared responsibility, and the diverse pattern when the negative feedback (the amplitude of the FRN was largest when participants were alone in their incorrect choice, and there were no differences in FRN when participants were joined by one versus two others in their incorrect choice, which just mirrored the results of the rating data) indicated that the other players rather than they had made the incorrect choice, favors the latter theoretical perspective. If the FRN simply reflected an early binary classification of a response as correct or an error, then it should not matter whether or not participants were alone in having made an incorrect choice or whether or not they had any responsibility for a negative outcome.

In addition to the aforementioned perspectives, enhanced ERN components (response ERN, peak at nearly 100 ms after response and feedback ERN, peak at approximate 300 ms after the onset of feedback) are also proposed to be associated with greater allocation of attentional resources (Moser and Simons 2009). Counterfactual thinking has also been found to affect attention and behavior regulation

(Epstude and Roese 2007; Galinsky and Moskowitz 2000). Therefore, our results favor the notion that FRN, a signal that reflects future behavioral adjustments, is associated with the allocation of attentional and cognitive resources to solve a task.

Prior research indicates the P300 amplitude is influenced by task relevance or involvement and reflects an allocation of attentional or cognitive resources to the task or to context updating (Duncan-Johnson and Donchin 1977; Fabiani et al. 2007; Polich 2007). In the present study, the amplitude of P300, on the other hand, showed a more graded effect, with the P300 amplitude smallest when participants alone made the incorrect choice, intermediate when they and one other player made the incorrect choice, and largest when they and both other players made the incorrect choice. That is, the brain's response to personal responsibility for regret appears to increase in nuance as time unfolds. This result is inconsistent with an account based on the allocation of cognitive resources and probabilistic features of the feedback if one assumes participants first attended to whether or not they chose the correct response. If so, the probability that participants received feedback indicating they had made an incorrect choice was 50%. Given they made an incorrect choice, they shared responsibility with one other player on 33% of the trials through twice the number of ways of achieving this outcome as when they shared responsibility with both players. This speculative explanation warrants further research.

Finally, neuroimaging studies indicate that the ACC is not only involved in error detection but plays a role in changing behavior in accord with rewards and punishments (Blair et al. 2006; Hampton et al. 2006; Rushworth and Behrens 2008; Wrase et al. 2007). For instance, the activation of the ACC is enhanced on switch compared with stay trials following incorrect responses (Hampton et al. 2006; Holroyd and Coles 2008). Though limitation of currently used dipole source modeling is only suggestive (Armoundas et al. 2001; Wang and Yang 1995), our results are consistent with Coricelli and colleagues' neural model of regret (Coricelli et al. 2005, 2007) as well as the notion that the conditions triggering regret also activate brain regions involved in behavioral adjustments, presumably to minimize a repeat of the conditions that triggered regret.

6 Anxiety on Decision

As mentioned before, many aspects of the FRN are still in debate, including whether or not the FRN reflects a prediction error; whether it depends on a behavioral response; whether it is generated by the ACC; and whether the reinforcement process implemented by ACC depends on midbrain dopamine, and so on (see Holroyd et al. 2006). Researchers have found that they could hardly come to a consensus when they studied the underlying cognitive and neural processes of the FRN. In our opinion, it is partly due to the lack of consistency among the results from different studies.

For example, most researchers believed that the amplitude of the FRN should be larger following unfavorable outcomes, but the results of many experiments somehow contrast with this viewpoint (Nieuwenhuis et al. 2004a; Donkers et al. 2005; Hajcak et al. 2005). Aside from the difference in the experiment paradigm and technique, we would like to point out the possibility that the personality of the participants might also play a role. The reason why we hold this opinion is the underlying relationship between the FRN, outcome expectancy, and trait anxiety.

A number of studies have indicated that the FRN is influenced not only by the valence of the outcome but also by its expectedness, showing that the amplitude of the FRN varied with the magnitude of the subjects' prediction errors. In particular, the FRN appears to be greater for unexpected negative outcomes than expected ones (Holroyd et al. 2003). This view has been supported by numerous studies (Cohen et al. 2007; Holroyd et al. 2003, 2004a, b; Yasuda et al. 2004). For instance, in a recent study, Bellebaum and Daum asked their participants to complete a guessing task that allowed them to predict reward probabilities by learning an explicit rule. After the participants had learned the rule, the amplitude of the FRN became significantly larger for less likely negative outcomes (Bellebaum and Daum 2008).

Similarly, an abundance of evidence indicates that higher levels of trait anxiety are associated with lower outcome expectancy in risk-taking tasks. For example, when involved in a risky situation, individuals with high trait anxiety (HTA) judged the negative event as more likely to happen than did those with low trait anxiety (LTA) (Eisenberg et al. 1998; Lauriola and Levin 2001; Mitte 2007). This phenomenon has been cited by some researchers to explain the observation that HTA participants are more risk-avoidant than other subjects in many decision-making experiments (Maner et al. 2007). Although the explanation for this phenomenon is still under debate, it had been widely accepted that the relationship between trait anxiety and subjective probability of negative outcome appears to be a consistent one.

The aim of this study was to examine the relationship between trait anxiety and the FRN. In view of the findings discussed above, we predicted that, when participants received a negative outcome during a decision-making task, the amplitude of the FRN would be significantly lower for HTA compared to LTA participants, since the outcome expectation of the former would be expected to be more pessimistic.

To test our hypothesis, we used a variant of Gehring and Willoughby's (2002) monetary gambling task, as well as ERP recording, which has been slightly modified by other researchers (Nieuwenhuis et al. 2004a). In this simple task, which has been shown to consistently elicit FRN, participants were asked to gamble for rewards, and their choices were followed by feedback events.

A total of 79 college students participated in a mass screening with the Chinese version of Spielberger's trait anxiety inventory (STAI). This scale has demonstrated good internal consistency, as well as convergent and discriminant validity (Shek 1993; Spielberger et al. 1983). Participants who scored high in trait anxiety (in the upper 25% of the distribution) were assigned to the high-trait anxiety (HTA) group, while the participants who scored low (in the lower 25% of the distribution) were assigned to the low-trait anxiety (LTA) group. As a result, 33 participants

(19 females; mean age 23.61 years) were studied, 16 in the HTA group (8 females) and 17 in the LTA group (11 females).

For the paradigm, each trial began with the presentation of a central fixation point, adjoined on either side by two rectangles. After 500 ms, the numbers "5" or "25" (indicating the score) were individually presented in either of the two rectangles. The participant then selected one of the two alternatives by pressing the "F" or "J" keys on the keyboard with their left or right index finger ("F" for the alternative on the left, and "J" for the one on the right). The alternatives remained on the screen until the participant made a choice, which was then highlighted by a thickening of the red outline of the chosen rectangle for 500 ms. All stimuli but the fixation point then disappeared for a short interval, of random duration between 1,000 and 1,500 ms, then the point was replaced by the result of the participant's choice with the "+" or "−" symbols, indicating the valence of the outcome (see Fig. 11). There were five possible outcomes: "+5," "−5," "+25," "−25," and "?". The "?" symbol indicated an ambiguous outcome, the valence of which the participant had to guess (in fact, the computer counted the "?" as zero score). The feedback display remained visible for 1,500 ms, then a black screen was presented for a short interval that varied randomly between 800 and 1,200 ms.

Before the experiment, the participants were instructed about the meaning of the feedback display. They were told to respond in a way that would maximize the total score amount. The higher the score they earned, the more bonus money they would receive at the end of the experiment. Furthermore, they were encouraged to choose any strategy to achieve their goal. Unbeknownst to the participants, the outcomes

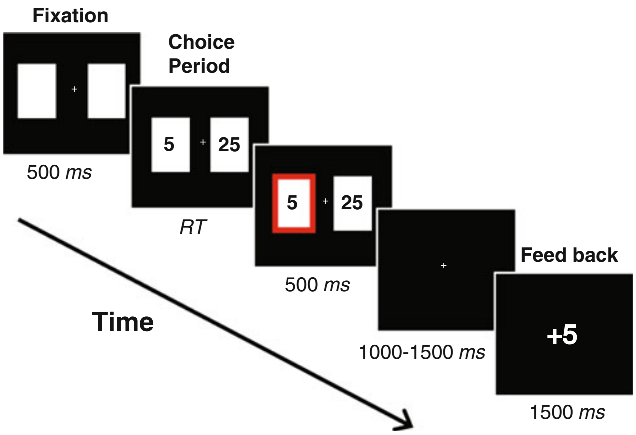

Fig. 11 The sequence of events within a single trial of the monetary decision-making task. On each trial, the participants were presented with a choice of two alternatives, one of which they were asked to select using their left or right index finger. Their choice was highlighted for 500 ms. After a subsequent interval of 1,000–1,500 ms, the participants received feedback, lasting 1,500 ms, that indicated the score they had gained or lost. After an additional 800–1,200 ms, they were presented with the next trial. *RT* response time

were provided according to a prespecified pseudorandom sequence. In other words, the outcomes were determined randomly, and it was thus not possible for the subject to devise any meaningful strategy to learn. If participants had been aware of this fact, there was a strong likelihood that they would lose the motivation to seek any strategy during the experiment. To prevent this, we added the ambiguous outcome (described above) to our task, so as to make it less likely for the participants to realize out that there was, in reality, an equal probability of win or loss.

Figure 12 illustrates the ERP waveforms obtained when participants made risky choices and risk-avoidant choices. In agreement with previous studies (Gehring and Willoughby 2002), we observed the feedback negativity when ERPs were evoked by the presentation of outcome stimuli. The highest peak of the FRN appeared around 330 ms at the Fz electrode site.

The feedback negativity was greater after losses than after gains, and greater after numerically larger outcomes than after smaller outcomes.

We concentrated on electrode Fz to perform simple effect analyses in order to decompose the valence $\times$ group interaction effect, since the FRN reached maximum amplitude at this site (reported above). The amplitude of the FRN was significantly larger for LTA participants than HTA participants on negative feedback trials, which corresponded with our hypothesis (see Fig. 13). In addition, the difference between two groups on positive feedback trials was also significant.

However, when we calculated correlations between the amplitude of the FRN and the participants' trait-anxious score, the results indicated that only the amplitude of the FRN on negative feedback trials, but not on positive feedback trials, was significantly correlated with the trait-anxious score.

Consistent with previous research, the classic feedback negativity was observed after the feedback presentation in our decision-making task. The FRN was not only greater after losses than after gains, but also greater when the outcome magnitude was larger (25). Extending these findings, we found, notably, that the amplitude of the FRN was significantly larger for LTA than for HTA participants when the outcomes were negative, which was consistent with our hypothesis.

This novel finding demonstrated that the individual personality of participants can influence the FRN significantly. In view of these results, the trait anxiety level of participants should be considered an important control variable in any study of the FRN, as it may act as an interference factor. We suggest that the observed intergroup difference in FRN amplitude reflected the fact that HTA people are more likely to predict negative outcomes.

Surprisingly, analysis of our questionnaire results revealed no correlation between trait anxiety level and subjective probability of outcome. It may have been that the questionnaire, taken after the experiment, was not a suitable way to measure the participants' actual expectations. Recently, Hajcak et al. (2007) suggested that participants' outcome expectations might be inconsistent on a trial-by-trial basis. In our study, the self-report of reward expectations given after the task was retrospective, and thus may have been only loosely tied to the participants' real expectations during the task. In contrast, Hajcak et al. asked participants to indicate during each trial whether or not they expected to receive reward, and found a

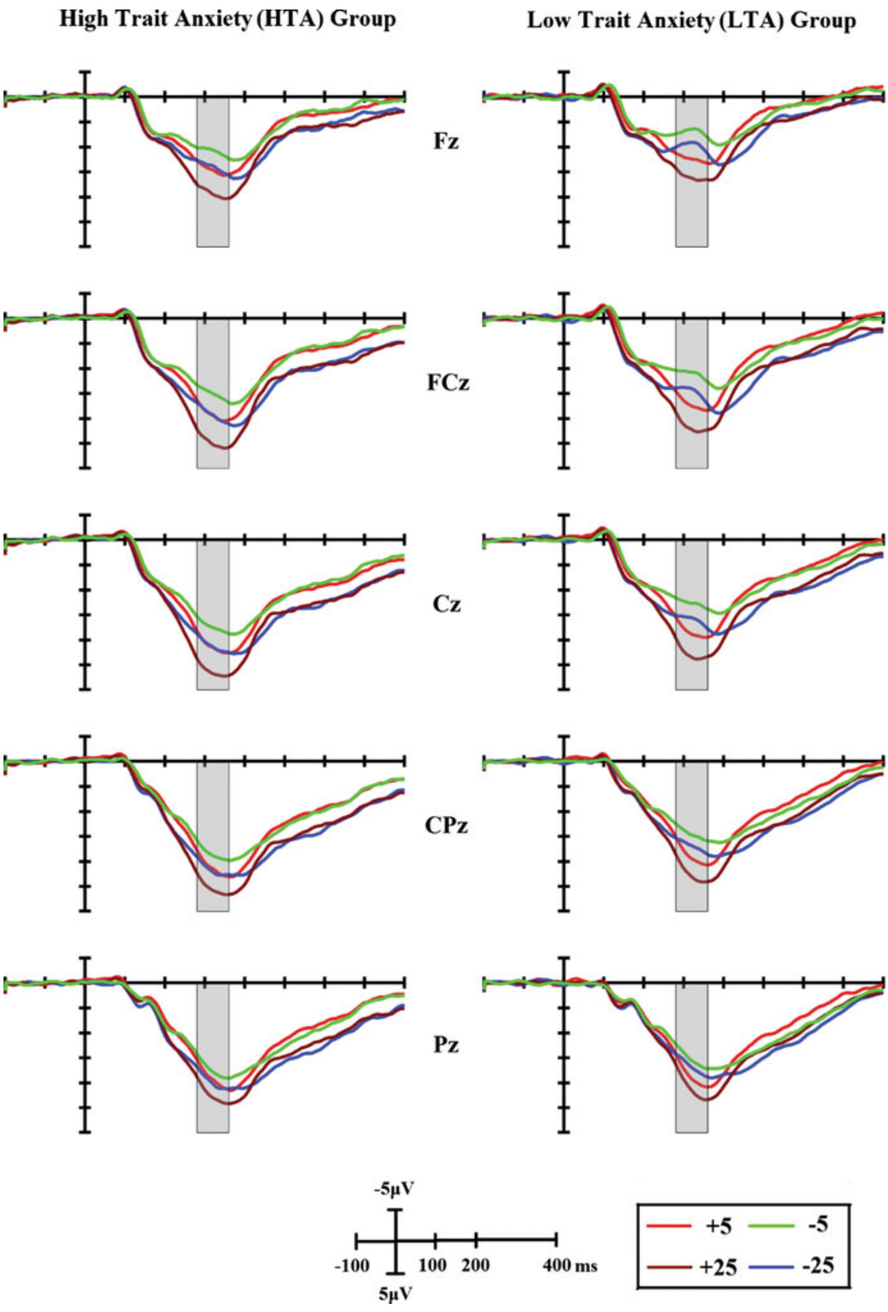

Fig. 12 Grand-average ERPs evoked by the presentation of feedback. The feedback negativity was apparent only at frontal sites. The areas shaded in *gray* indicate the 280–360 ms analysis window in which the FRN was quantified. +5, −5, +25, −25: different kinds of feedback

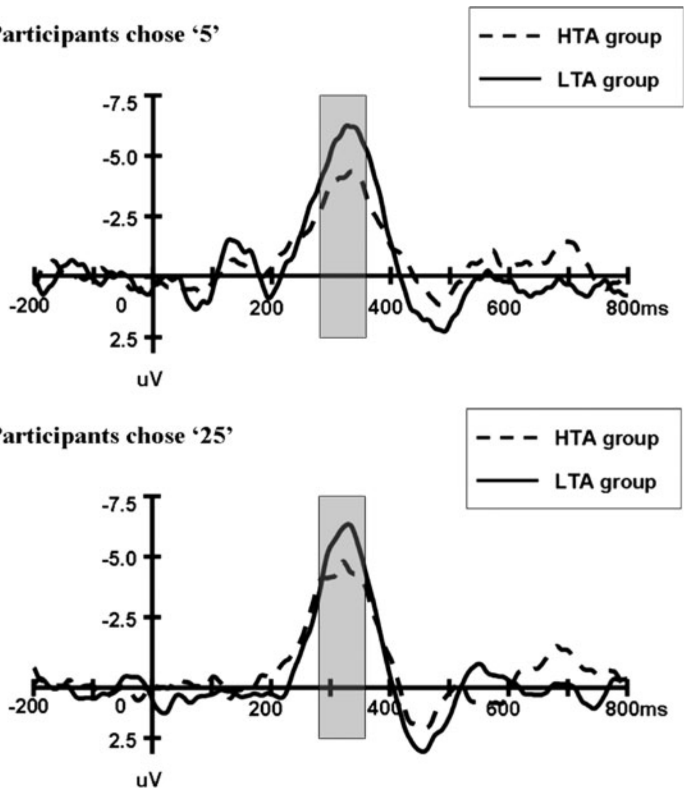

Fig. 13 Negative minus positive difference waves of HTA and LTA groups at the Fz site. Since the outcome magnitude showed a main effect on the amplitude of the FRN, we separately showed the ERP waveform in the upper panel (the difference waves when participants chose "5") and the lower panel (participants chose "25"), so as to clearly show the group interaction. The gray shaded areas indicate the 280–360 ms analysis window in which the FRN was quantified

relationship between outcome expectation and the amplitude of the FRN (Hajcak et al. 2007). We did not ask the participants to report their outcome expectation during the task. This might be one of the reasons why the correlation between outcome expectation and trait anxiety did not turn out significant.

The format of the questionnaire items might also have influenced the result, since we asked participants to rate their subjective probability on a numerical scale. Mitte (2007) reported that HTA subjects estimated the probability of a negative event higher than did those with LTA only when using verbal response formats, and not when using numerical ratings. Mitte argued that the numerical format was less subjective than verbal format, while requiring more cognitive processing. As a result, the impact of anxiety on outcome expectation from self-report might have been attenuated.

Furthermore, we would like to discuss the relationship between ERN and the FRN. The ERN was a fronto-centrally maximal response-locked ERP component observed approximately 50–150 ms after participants made an error, which was similar in morphology and scalp topography to the FRN (Gehring et al. 1993; Nieuwenhuis et al. 2004b). Remarkably, it has been reported that the HTA participants have enhanced ERN relative to non-anxious control subjects (Hajcak et al. 2003). Since, in our study, the HTA participants had lower FRN than LTA participants, it may be more appropriate to consider the ERN and FRN to be distinct phenomena. However, this viewpoint is in conflict with the "reinforcement learning theory of the error-related negativity" (RL-ERN theory), which considers the FRN and the ERN to be the same kind of signal, both indicating negative reward prediction error. According to RL-ERN theory, these two ERP components both reflect a process of rapid evaluation of ongoing events along an abstract good–bad dimension (Holroyd and Coles 2002; Nieuwenhuis et al. 2004a). However, it remains difficult for RL-ERN theory to explain why the anxiety factor influenced the ERN and the FRN in two different ways, if we consider these two components to be the manifestations of an identical error-monitor mechanism. Aside from this evidence, it was reported recently that the ERN amplitude is not related to error detectability but rather to error significance (Maier et al. 2008), while the FRN amplitude has been proven by many researchers to be insensitive to the significance of prediction error (Hajcak et al. 2006; Toyomaki and Murohashi 2005; Yeung and Sanfey 2004). Taken together, it is more likely that the ERN and the FRN were separate, as some researchers have suggested (Gehring and Willoughby 2002). Resolution of this problem must await further research, since the functions underpinning the ERN and the FRN are still unclear.

7 Conclusions

Our results point to an influence of motivation on rapid medial frontal processes for monitoring performance outcomes. Our findings are consistent with a model in which an initial evaluation of the feedback stimulus in the dorsal ACC signals that a negative outcome is worse than expected, and a later process in the rostral ACC reflects an affective response to that evaluation. Although other models might also be consistent with these data, it is clear that rapid processes involved in evaluating performance feedback are sensitive to the motivational properties of the feedback, in addition to the actual monetary reward value of such feedback. The motivational manipulation we used here was based on an instruction to the participants to be deceptive in their responses. To arrive at a more detailed theory, one aim of future studies will be to explore what other kinds of motivational influences can affect these rapid evaluative processes.

The results of the experiment 2 suggest that, before the actual response of the deliberated deception, there seems to be a primary allocation of the available cognitive resources followed by the cognitive preparation or emotional experiences. Cognitive load might regulate the primary resource allocation, while not influencing the deception preparation.

Social cognition and emotion play important but still poorly articulated roles in efficacious human decision making over the long term. The allocation of attentional and cognitive resources to a task may be necessary but may not be sufficient for behavioral adjustments to occur following performance feedback. Error-related processing may also be required. In the present study, we found that error-related processing could be modulated by more than the available information regarding alternative outcomes. It was also influenced by the level of responsibility (Coricelli et al. 2005, 2007), which in turn modulated feelings of post-decision regret. We further found that regret coincides with the FRN and is in a position to improve decision making, consistent with the findings of Marchiori and Warglien (2008).

ERP results in our study revealed that there existed a significant difference in FRN amplitude between the HTA and LTA groups. However, the precise relationship between the FRN amplitude and different outcome expectation was not clear in other areas of our study, possibly because of the way we tested the participants' outcome expectation, and will require further attention.

Our results prompt the question of what other kinds of personalities might similarly influence the FRN. For instance, depression symptoms have been shown to be negatively related to the participants' probability ratings for positive events, particularly for children and adolescents (Canterbury et al. 2004; Muris and van der Heiden 2006). The relationship between depression and the FRN might thus be a fruitful area of future study.

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Mindfulness in Leadership: Does Being Mindful Enhance Leaders' Business Success?

Sebastian Sauer and Niko Kohls

Abstract Is mindfulness – being open, present, and receptive to what is happening from one moment to the next without cognitively evaluating a given state or situation – an omnipresent capacity that can significantly contribute to enhancing leadership performance – or is it a context dependent potential? In this treatise, leadership *as a general ability* is understood as an anthropological constant as opposed to the prevalence of *specific differences* in leadership styles found in different cultures or contexts. This chapter advocates that mindfulness can be particularly helpful for leaders and executives as it may enhance leadership as a general ability. We outline a rationale for how and why mindfulness may increase the capacity to lead as well as act as a role model, discuss intercultural aspects related to mindfulness and leadership, and address potential restrictions. The proposition that mindfulness, if properly understood and brought into application, may be a useful tool for enhancing the personal and business success of leaders is developed in four subsections: (1) An epitome of what leadership is and what leaders are supposed to do in their professional role as an implicit criterion for assessing the potential benefits of mindfulness. (2) A definition of what is frequently understood by mindfulness and the changes in psychophysiological parameters that go along with regular mindfulness training, as reported by some empirical findings. This includes an analysis of what can be regarded as fact rather than fiction in the context of mindfulness. (3) A discussion of the potential benefits of mindfulness for leaders based on a general model of what leadership constitutes, as worked-out in the first section. (4) A caveat that takes into account some conceptual and practical pitfalls, to which one may easily fall prey, so as to prevent

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misunderstandings and misbehavior related to mindfulness. The final section summarizes the above mentioned sections with the conclusion that mindfulness can indeed be helpful but that both research and practical work remain to be done.

Keywords Intercultural · Leadership · Management · Mindfulness

1 Introduction

What have fish and organizations in common? A plethora of commonalities may certainly be envisaged and listed, depending on one's originality and creativity. A frequently cited proverb states that "A fish rots from the head down"; and interestingly enough, this is a popular figure of speech found in more than 30 languages, ranging from Chinese to Russian (Garratt 2003). Apart from its linguistic and cultural–historic implications, this statement may also be directly placed in the context of leadership. That is to say, the development and decline of organizations are mainly based on (wrong) strategic decisions made by holders of leadership positions. For sure, there may a lot of mistakes apart from leadership errors an organization may commit and still manage to survive, but, with poor leadership, not many of its endeavors will be likely to be fruitful and sustainable. A popular assumption is that leaders have the tough job of running, maintaining, and developing an organization in rapidly changing environments. Leadership is, without doubt, comparable to steering a ship through stormy weather, having to avoid sharp cliffs and shallow waters – the crew cannot prevent the ship from running aground in the absence of clear-headed navigation and well-founded orders from the captain's bridge.

Leaders have, without doubt, been under pressure across time and cultures since time immemorial, as they have had to live up to expectations and responsibilities that come along with acting as decision makers and role models. Leaders and executives[1] throughout all cultures face a tough time today as they are subjected to severe criticism. Leaders in the business context, in particular, have been castigated as pinstriped malefactors whose greed exceeds their disrespectfully high salary. For example, in a 1984 essay, Peter Drucker persuasively argued that CEO pay had rocketed out of control and implored boards of trustees to keep CEO compensation to no more than 20 times what the rank and file made (Drucker 1984). As it seems, his plea has remained largely unheard: Although top executives suffered from a collective pay cut in 2007 and 2008, according to Forbes Magazine, some business leaders at the top of the compensation ranking still get incredibly high salaries. These days, even leaders who are not so extraordinarily well paid are subjected to criticism if the company's quarterly figures underperform the market;

[1] As most executives are also leaders (the opposite not always being true), in this treatise we use the term "executive" synonymously for "leader".

in the event of above-par market performance, leadership lacks interpersonal or ethical and aesthetic qualities (King 2007; Blair et al. 2008).

From a pragmatic point of view, management is "the process of getting things done through the effort of other people" (Mondy et al. 1986). Leadership can be regarded as the process of getting the *right* things done. However, high expectancies, rapidly changing context conditions, and the resulting pressure make the leader's job a hard one today. A plethora of tools have been developed in order to help leaders in doing their job better so that they can satisfy the expectancies that are part of their job descriptions. Interestingly, although the mindset of successful leaders and their respective world views, values, and belief systems have been a focus of research interest, less attention has been paid to the states of mind related to leadership success. In the last few years, a substantial research body has been established that suggests that a particular way of being or state of mind frequently referred to as "mindfulness" may improve health and performance (Giluk 2009). Yet, extant studies have focused on indicators such as health parameters, and the studies that have looked at performance parameters have predominantly investigated the classical performance variables frequently used within school or university contexts. Although still subject to debate, evidence is mounting that mindfulness is an effective buffer against distress and improves numerous quality of life parameters. It is therefore interesting to raise the question of whether the state of being mindful may also be beneficial for a leader in a profit or nonprofit context. And, if that is the case, is there a certain uniqueness to mindfulness that cannot be found in the enormous amount of leadership methods the world has seen and forgotten? This chapter discusses the relationship between leadership and mindfulness, why and how mindfulness may be beneficial for leaders, and what caveats are to be taken into account. Finally, some implications are drawn that may be suitable for leaders working in all sorts of contexts, such as business, science or nonprofit.

2 An Outline of Leadership Responsibilities in the Light of Today's Challenges

According to popular leadership author Covey, management is concerned with getting up a ladder in the most efficient manner. To the contrary, leadership warrants that the ladder is leaned against the right wall (Covey 2004). Hence, leadership can be used as an overarching term in the sense that climbing up a ladder is useless unless the ladder is leaned against the right wall. In this treatise, we therefore employ the more general concept of leadership as an umbrella term, although the difference between leadership and management is still a subject of debate (Mullins 2007; Daft and Marcic 2008).

Leadership as such can indeed be regarded as a major anthropological constant because the phenomenon of leadership has been found in virtually all organizations in all cultures since time immemorial. Correspondingly, leadership can be regarded as an excellent subject for studying intercultural differences in leadership styles that reflect the general ability to lead. Why does leadership prevail in all organizations, across cultures and time? Human beings organize their lives in groups in order to distribute work, which in turn forms the make-up of the interpersonal relationships and the hierarchical composition of organizations and societies. Hierarchical organization seems to be another cultural anthropological constant that is presumed to be a prerequisite for leadership. Interpersonal relationships are naturally asymmetrical due to various reasons, such as differences in competence, age, or social position, to name just a few. This is especially the case in formal organizations with explicit and implicit roles and specializations, such as tribal groups, guilds, business enterprises, or governments. As a result of dividing labor in a hierarchical manner, one individual may be asked to supervise several others and eventually become a leader. To give an example, in the traditional culture of Samoa, a communal way of life is cherished and practiced, and correspondingly, all activities within this culture are done together. For instance, the traditional living quarters contain no walls to separate rooms. Nevertheless, there are clear signs of social asymmetry as well as leadership (Duranti 1992), with strong local cultural particularities. According to this culture, in a public meeting, the orators of high rank are to be placed in the front of the house where the meeting is being held. The front of the house is apparently associated with a position of dignity, and individuals who sit in the front are correspondingly those who deserve more respect; they are recognized – at least implicitly – as leaders. However, even in modern days, there exist tangible differences between cultures with regard to leadership style. The renowned researcher on cultural management, Hofstede, has identified several dimensions on which different nations can be pinpointed (Hofstede 2003) culture wise. For example, in an international study, he found that social status differences are much more valued and authority is more respected in Chinese organizations compared to German organizations. Indicators for such high "power distance" as Hofstede labels it, are the demonstration of rank or status and more autocratic decision-making styles (Thomas 2008).

One of the approaches aiming to explain what leadership is all about that has received considerable attention, is that of Gulick (1937). Gulick proposed the POSDCORB model. In short, this model describes the following seven major tasks and duties of any leader

- Planning: Working out an outline of the things that have to be done (i.e., objectives) and envisaging the respective methods and tools
- Organizing: Establishing the formal structure of the organization with a focus on the formal and informal reporting lines (who reports to whom?)
- Staffing: Personnel and talent management operations, which comprise the whole process of attracting, selecting, hiring, training, employing, maintaining, promoting, fostering, and motivating talent
- Directing: Making decisions and breaking them down into understandable instructions for the staff; acting as a role-model, and being recognized as a leader in the organization
- Coordinating: Synchronizing and interrelating the various business processes so that they fit into each other and allow a smooth workflow

- Reporting: Communicating visions and strategies, decisions, and outlines to the staff through meetings, reports, research, and inspection
- Budgeting: Allocating financial resources, including accounting and controlling

The POSDCORB structure has been widely acknowledged as a valuable framework for the analysis of leadership and management functions in a structured way. However, this model has also been criticized for its inward orientation, highlighting the fact that it does not take environmental factors into account (Moore 1995). According to Moore, the single most important function of a leader is to understand and shape the environment of the organization, primarily, by means of the products and services it delivers to the customers (Moore 1995). While it is true that leaders, especially at the top level of organizations, cannot sustain the amount of specific knowledge that a subject expert has, leaders still need to understand substantial aspects of the problem.

Mintzberg, one of the most influential researchers on leadership and management, has suggested classifying leadership roles into three categories: interpersonal roles, informational roles, and decisional roles (Mintzberg 1990). The interpersonal roles comprise social interactions of a broad variety, such as greeting touring dignitaries, motivating subordinates, and liaising with peers. By virtue of their informational roles, leaders emerge as the nerve center of the organization. The importance of information transmission for leaders has been impressively shown by a study conducted by Mintzberg. He found that CEOs under investigation in his study spent 40% of their contact time on activities devoted exclusively to the transmission of information and up to 70% of their incoming mail was purely informational (as opposed to mail calling for a decision). As can be derived from this study, the work of leaders is largely focused on information exchange and communication – scanning, receiving, and evaluating information as well as condensing and disseminating it. The dissemination of information, in particular, includes both internal and external contacts; internal contacts can be subordinates, peers, and superiors, while external groups comprise shareholders, legal representatives, and consumer groups, amongst others. Despite the substantial amount of time devoted to it, communication processing is, in itself, only a partial aim; for the most part, it is the basis for making sound decisions. This is mainly for two reasons; on the one hand, the leader is the formal authority who is given the power to lead an organization. On the other hand, as the leader is part of the communicational hub of an organization, he or she is much more interconnected to all parts of the organization than anyone else and hence has more access to information relevant to the organization. As Mintzberg points out, leaders appear to be comparable to jugglers: both juggle a number of balls in the air, the number of parallel projects, in some cases, even adding up to 50. Occasionally, one ball touches the ground, and at times, additional balls are added as new projects emerge. They may have to deal with windy conditions while trying to keep the system of balls in balance, or another mean player may try to snatch some of the balls, or even worse, someone might try to make the leader stumble. As these examples show, leaders are not only proactive formers of the course of action but also "disturbance handlers", who frequently have to react to imminent or existing crises. It needs to be underlined that deciding on the allocation of resources – predominantly money, but also including privileges, powerful positions, and allowance – is a key facet of leading and decision-making alike (Mintzberg 1971, 1990).

In practice, however, these three types of roles are naturally intermingled. Networking with peers and leading subordinates may pay out well not only in establishing, maintaining and developing relationships and networks, but also in acquiring the latest information (at times in the form of gossip and hearsay). In the same vein, informational and decisional roles cannot always be disentangled. Leaders pay attention and listen to colleagues and partners in order to be able to make a decision, and then disseminate information so that their subordinates can make decisions within their areas of authority.

It is a myth, as Mintzberg put it, to believe that leaders devote their time to investigating the information they have received in a reflective, systematic way, as scientists are supposed to conduct their research. In contrast, leaders prefer much more verbal, face to face communication over documents such as written reports. Also, as has been revealed by social research, networks and resilient relationships provide the sort of social loyalty and stability that is centrally important to the power preservation of a leader (Aharoni 1994; Gomes-Casseres 1994; Ibarra and Hunter 2007; Byham 2009; Hennessy and West 1999). Additionally, the work of foremen and leaders is heavily fragmented, interrupted, and characterized by brevity, interruption, and discontinuity. Correspondingly, leaders have to be able to adapt quickly to a given situation by conducting mental shifts from one task to the next or even to operate multiple tasks in parallel (which, from a neuroscientific point of view, is impossible).

Drucker's famous statement that leadership or, at least, management "effectiveness can be learned" (Drucker 2007) has in parts been eroded by recent empirical research. It appears that personality traits – which are widely deemed to be stable across time and situations – exert substantial influence upon the ability to lead people and steer organizations. One of the five fundamental personality dimensions, extraversion, was identified as the most consistent correlate with leadership qualities such as leader emergence and leadership effectiveness. Overall, the results provide strong support for the leader trait perspective (Judge et al. 2002). Does this mean that a successful leader is simply a lucky combination of suitable trait characteristics predetermined by genes? Of course not; traits may only partly account for leadership effectiveness as learning processes are more important. Additionally, even personality traits are not set in stone, but may change over time.

Today, the classical image of a leader has been contested and questioned. In short, these days success on a short term scale is no longer sufficient; a leader is expected to do more than merely ensure the sustainability of his or her business. Moreover, as the ethical and moral pressure on leadership has also risen substantially, leaders are expected to adhere to moral codes to restore the trust that has waned tremendously in the course of the last few years.

To summarize, leadership activities have, in essence, been defined as the interplay of key work elements to ensure that things are being conducted appropriately.

This is undeniably a demanding job, especially during times of market turmoil as in recent days. Hence the question arises as to what a leader can do to be as successful as possible. In the next section, we discuss what mindfulness is. This will serve as a basis for a discussion on the potential benefits of mindfulness for leadership performance.

3 Mindfulness: What Is It – and What Not?

Have you ever left your groceries at the local store or zoned out during your drive home from work? That is what Harvard psychologist Langer calls "mindlessness" (Langer 1989). Mindlessness is behavior characterized by overlearned and, thus, automatic reaction tendencies: You have conducted a particular activity, such as driving your car, so many times that you simply don't think about it any more and that's exactly when you "abandon your agenda" and start thinking of something else. The opposite behavior can be termed "mindfulness", and it has become the focus of attention of a considerable community of researchers and practitioners alike, most notably in the context of health sciences. Put simply, mindfulness can be defined as keeping one's attention on what is happening at the moment without cognitively evaluating it. Technically speaking, merely observing from moment to moment, without interpretation, is exactly what characterizes mindfulness. As a matter of fact, everyone has the capacity to be mindful (Brown and Ryan 2003). However, there are differences in the degree to, and the period of time for, which individuals are able to focus their attention on the present moment. It is the nature of the human mind to be distracted from mere observation, e.g., starting with internally commenting on mental content, evaluating it, or drifting to other thoughts. That is the reason why mindfulness requires some training before one is able to keep the attention stable and focused; normally, humans tend to operate in "automatic pilot" mode to a considerable degree. Often, unwanted thoughts, sensations, memories, emotions, or sentiments enter the mind. This is usually accompanied by an immediate evaluation of the current stream of thoughts, frequently by literally thinking "no, I don't want that!". Mindfulness, in contrast, proposes being aware of the pure experience of what is occurring in the present moment, and staying in the present moment without evaluating the respective experience. Hence, most researchers agree that mindfulness is best described by two components, namely "attention to the present moment" and "acceptance" (Velting et al. 2004; Kohls et al. 2009). Mindfulness can be carried out either formally or informally. Formal practice is based on systematic and regular mental exercises such as concentration on the breath, slow and conscious walking, or fostering what we perceive through our senses, deliberate sorting out of mental evaluations, comments, and prejudices. Informally practiced, mindfulness training may be incorporated in virtually each everyday activity. For instance, while brushing the teeth, or waiting for the bus, our awareness can be directed to the respective sensations and perceptions. While sitting, for example, one can repeatedly renew the awareness of the sitting posture, be conscious of the bodily sensations and the thoughts that are passing through our minds, etc.

A growing research body corroborates the health relevant effects of mindfulness training despite methodological shortcomings (Grossman et al. 2004; Baer 2003; Chiesa and Serretti 2009; Ledesma and Kumano 2009). Particularly, the paucity of randomized control trials precludes final conclusions as to the effectivity of mindfulness. However, less vigorous studies have found mindfulness to be beneficial for a variety of psychological symptoms such as distress, anxiety, and depression as well as psychophysiological variables such as pain, sleep quality, immune parameters, and allocation of attention resources, just to mention a few (Ledesma and Kumano 2009; Sheridan et al. 2003; Kabat-Zinn 1982; Kabat-Zinn et al. 1998, 1992; Deyo et al. 2009; Sun et al. 2002; Shapiro et al. 2008; Sephton et al. 2007). It has also been hypothesized that mindfulness alters the concept of the self, which may in turn produce the health relevant effects of mindfulness (Shapiro et al. 2006). Moreover, recent neurobiological evidence suggests that mindfulness training may change not only brain functions but also structures (Lazar et al. 2005). For example, Hölzel et al. investigated MRI brain images of 20 mindfulness practitioners, using voxel-based morphometry, and compared the regional gray matter concentration to that of nonpractitioners (2010, 2008). Results confirmed greater gray matter concentration for mindfulness practitioners in the right anterior insula, which is involved in interoceptive awareness. This group difference presumably reflects the training of bodily awareness during mindfulness meditation. Furthermore, mindfulness practitioners had greater gray matter concentration in the left inferior temporal gyrus and right hippocampus. These are regions that have previously been found to be involved in mindfulness (Benson et al. 2005).

In the context of cognitive performance, regular practice of meditation may have neuroprotective effects, strengthen the capacity of the working memory (Jha et al. 2010), and reduce the cognitive decline associated with normal aging (Pagnoni and Cekic 2007). Brefczynski-Lewis et al. purported that activation of neural attention networks in a concentration test showed an inverted u-shaped curve in which mindfulness practitioners with moderate levels of practice had more activation than novices, but mindfulness expert had even less activation. Their results confirm their hypothesis and suggest that mindfulness training may reduce the working memory capacity (Brefczynski-Lewis et al. 2007).

To date, there exist few examinations of the intercultural differences in the psychological and neurobiological processes of mindfulness. Anecdotal accounts and cultural analysis, however, suggest that mindfulness seems to be more formally integrated in some cultures (e.g., East Asia) than in others (e.g., Western culture). More interestingly, recent neuroimaging studies provided evidence that the activity of the cortical midline structures that are thought to be related to self-referential processing is influenced by participants' cultural backgrounds (Han and Northoff 2008). Given the strong self-referential aspect of mindfulness, it seems likely that the state of being mindful may not only be understood differently in different cultures, but may also exhibit different neural pathways, depending on the cultural context. For instance, a study by Han et al. found enhanced evaluative processes of self-referential stimuli in the cortical midline structures such as the dorsal medial prefrontal cortex (Han et al. 2009). This finding is supported by Farb et al., who found a reduction in midline structures (medial prefrontal cortex) in participants with mindfulness experience (Farb et al. 2007).

Despite the growing knowledge and interest in mindfulness, there exist many uncertainties, even myths, about the very concept. It is one aim of this essay to distinguish fiction from facts, thereby hopefully contributing to clarifying the concept of mindfulness as well as to avoiding misunderstandings.

Fiction: Mindfulness is bound to a religious system; it is closely linked to the ritual practices of Buddhist monks and other related meditative practices. Undoubtedly, it is one of the major attainments of modern times to question self-deluding, alogical, and potentially wicked and pernicious epistemologies. *Fact: It is true that most authors locate the theoretical sources and practical roots of mindfulness in Buddhist psychology.* At the same time, there are astonishing parallels to Buddhist psychology in the lines of thought in e.g. Western philosophy, such as in the writings of Buber (2004) and the phenomenology of Husserl (Kockelmans and Husserl 1994). A similar method of personality development has also been employed, in Western psychology, most prominently, in the Gestalt approach of psychotherapy (Woldt and Toman 2005; Perls et al. 1980). Through the pioneering work of Kabat-Zinn in the 1990s, the spiritual underpinnings of mindfulness have been disentangled from the technique, thereby creating a secular technique of attention and awareness training (Kabat-Zinn 1991). Kabat-Zinn developed a mindfulness-based stress reduction program, called Mindfulness Based Stress Reduction (MBSR). In this 8 week group program, participants learn how to see stressors or distressing life events in a different light. With the help of mindfulness exercises such as observation of the breath and yoga exercises, participants learn to develop a stance of equanimity and acceptance toward aversive thoughts or emotions. Since the program has been established, it has been carried out in several hundred clinical settings in different countries. Empirical evidence, as stated above, is certainly not conclusive, but the data supports the effectiveness of the program.

Fiction: Mindfulness narrows down the variety of emotional experiences to nothing but neutral emotional states – such as a piano playing nothing but the middle C. It has been suspected that being a neutral observer and practicing a stance of acceptance and equanimity, particularly restraining emotional sensations, may severely restrict the richness of the human capacity of experiencing emotion. Moreover, one can ask whether it is at all desirable to suppress or even eradicate negative emotional states, even if they are negative. From the perspective of evolutionary biology, they may have "survival" value or, at least in the long run, positive and adaptive functions (Pöppel 1986). For example, grieving for a beloved family member who has passed away is likely to be healthy and adaptive. So why should one want to observe the grievance with equanimity? *Fact: Mindfulness does not argue for limiting the variety of emotional states or for ruling-out negative emotions.* Rather, mindfulness invites an individual to be very aware of whatever is going on in the present moment, regardless of the quality of the experience. While one can, for example, indeed be sorrowful and mindful at the same time – mindfully sorrowful – , the opposite cannot be the case: suppressing genuine feelings of sorrow and being mindful at the same time. A mindful attitude embraces the authentic experience of what is happening, be it positive or negative, wanted or unwanted. Thus, instead of constraining the human capacity to make experiences, being mindful actually enables the full experience of emotions. Paradoxically enough, this "full catastrophe living" as Kabat-Zinn puts it, enables one to live with and be contented with unwanted situations and even to face personal catastrophes (Hayes et al. 1999).

Fiction: Being constantly busy with observing inner states all the time precludes one's active involvement in a constantly changing world and its challenges. After all, life is about participating in the world's abundance of opportunities. Yet, observing seems to be the antidote to interacting and making choices. If that is the case, is a person who is not reacting but only observing what is going on not likely to fall prey to life's rudeness, not to mention the deliberate forming and shaping of one's environment? *Fact: Humans are much less active shapers of their lives and even less of their daily routines than they think; they are running on "automatic pilot mode" in a lot of circumstances. Mindfulness is a way of avoiding automatic responses.* This notion underlines the dialectical structure of mindfulness. Mindfulness aims at voluntarily suppressing the tendency to react to unwanted or desirable stimuli. However, at the same time mindfulness also invites one to observe consciously, with an attitude of openness and friendly attention, what is going on in the present moment. The capability of being aware of what is going on outside and inside enables one to respond in a way that is more reflective rather than reflexive. It is particularly helpful for an individual to consider important and long-term goals rather than expressing momentary, context related urges, inspirations or motivations. From a neurobiological perspective, it can be argued that mindfulness is strongly related to the use of the so-called "C-system" that has been associated with consciously controlled mental processes. The C-system consists of several neural regions including the lateral prefrontal cortex, lateral parietal cortex, medial prefrontal cortex, medial parietal cortex, rostral anterior cingulate, and the medial temporal lobes. Contrarily, the "X-system" is responsible for reflexive or automatic processes, which lie beyond instant conscious control. The X-system consists of several neural regions including the ventromedial prefrontal cortex, amygdala, basal ganglia, dorsal anterior cingulate, and lateral temporal cortex (Satpute and Lieberman 2006).

To conclude, it is not true that mindfulness is associated with self-deluding spiritual practices, with emotional restraints, and passivity. Rather, it is a simple way of being present and receptive with regard to the moment-to-moment inner and outer experiences. Mindfulness is not meant to stop participation in the real world, but to allow for reflective, rather than reflexive, behavior.

4 Mindful Leadership: How Mindfulness Can Help Leaders in Their Main Roles

It can be derived from the empirical and experimental studies that mindfulness has the potential to not only increase work performance, including the performance indicators for executives, but also enhance a person's leadership qualities. For example, a recent metaanalysis found mindfulness to be associated with personality factors known as the "big five" traits of personality. These five personality factors represent the best validated and most frequently investigated personality factors consisting of the traits (1) extraversion, (2) conscientiousness or diligence, (3) (low) neuroticism or (high) emotional stability, (4) openness to experiences and new situations, and (5) agreeableness or interpersonal skills. A recent qualitative and quantitative review on the influence of the big five personality factors on leadership effectiveness indicated strong support for the impact of the big five personality traits (Judge et al. 2002). This research shows that leadership performance is positively associated with all five of the big five personality traits, and most strongly with extraversion. Hence, indirect evidence exists for the beneficial effects of mindfulness on leadership attainment. However, there is still a lack of rationale and of an explanatory model that includes the psychological pathways from mindfulness to leadership performance. The Mintzberg model described above may be used as a basis for developing such a rationale as it offers a taxonomy for structuring the various leadership roles. As stated above, the main roles of executives can be summarized as information processing, interpersonal exchange, and decision making. How can mindfulness be of help for the executive in this regard?

4.1 Informational Roles of Leaders

These roles can be characterized as a threefold process: the acquiring of information, the processing of information, and the dissemination of knowledge. Most notably, executives are supposed to "be ahead of the crowd" in the sense that they understand factual issues not only better but also quicker, and derive solutions for practical problems. The main way for envisaging new solutions is to rearrange, rethink, and reconsider facts. This creative process of extending the matrix of possibilities for finding a solution to a given problem is also known as thinking out of the box. According to Langer, the very essence of mindfulness consists of "looking freshly" at things (Langer 1989). The habit of mindlessly falling prey to categorical thinking "This is A. Nothing new about that" may eventually lead to a rut or, worse, produce a standstill. Mindfulness is, in contrast, about trying to see things as if they are being seen for the first time. This mental attitude may prepare the way for creative out-of-the-box thinking. Langer gives an interesting example: Say a rich-looking man rings your doorbell late at night, saying that he is on scavenger hunt and desperately needs to find a $3' \times 7'$ piece of wood. He will give you $10,000 if you can help him. You think of a lumber yard, although you have no clue where one is and figure that nothing would be open at this hour, anyway. So you turn him down. It doesn't occur to you that the door you just opened is a $3' \times 7'$ piece of wood because you think of it as a category called "door," not "wood" (Langer 1989). This is an example of how mindfulness may help to foster processing of information by broadening the scope.

Furthermore, the second aspect of the leader's informational role – receiving information – involves an attitude of paying careful attention to another human being, being present, and being prepared to listen to what the other person wants to say. As Peter Drucker puts it "listen first, speak last" (p. 152; Maciariello 2006). This corresponds to the notion of mindfulness, highlighting the need for careful attention to the present moment. Empirical evidence supports the hypothesis that mindfulness may enhance limited attentional resources so that more mental capacities are available, which should also be of help in situations where listening and perceiving are crucial success factors (Jha et al. 2010; Slagter et al. 2007; Lutz et al. 2008; van den Hurk et al. 2009). Similarly, dissemination of information – the third aspect of the informational role of leaders – also builds on the capacity to be mindful. Naturally, interpersonal exchange is involved in the dissemination of information. This important aspect of relationship leadership is discussed in the following paragraph.

4.2 Interpersonal Roles of Leader

The most prominent interpersonal role is of course the role of leading people, especially in the context of organizational leadership. Much has been said about this topic (for a review, see Kotter 1998); perhaps this has even been more than excessive as many organizations are these days "overled", according to Mintzberg (Mintzberg 2009). To be able to lead people, the leader must have a (at least) basic understanding of the mindset of his or her subordinates. In fact, research suggests that narcissistic leaders lacking the ability to "cognitively put oneself in another's shoes" as well as the ability of being empathetic are less effective (Blair et al. 2008). Moreover, narcissists may appear cold, arrogant, and stubborn (de Vries and Miller 1985). This is likely a consequence of the fact that narcissists are unable to see issues from others' perspectives or to empathize with others' feelings. Consequently, coworkers are likely to view narcissists as displaying poor interpersonal skills. Any training that contributes to reducing narcissism would therefore prove to be of help in fostering leadership qualities.

To adapt a stance of empathy and receptivity, it is necessary to – temporarily at least – fend off distraction from one's own fears, plans, or sorrows. The tendency to get absorbed with one's thoughts, sensations, and interpretations (e.g., related to sorrows) has been labeled "rumination". The word "ruminate" is derived from the Latin word for chewing the cud, the process in which cattle grind up, swallow, then regurgitate, and rechew their feed. Similarly, human beings may mull over an issue at length. But while this approach might ease cattle's digestion, it doesn't do the same for people's mental health: Ruminating about the darker side of life may fuel depression, and it is certainly a major hindrance to being present in the situation (Teasdale et al. 2002). There is mounting evidence suggesting that mindfulness enhances the ability of being present (Brown and Ryan 2003), which can be seen as a prerequisite for developing a stance of acceptance (Grossman et al. 2004). The mental skill of standing back from one's own thoughts allows for a connection and, thus, an understanding with other individuals. In fact, this aptitude to "step back" from the sole focus on one's own self is a major line of personality development in humans, who learn even as toddlers that "I" and "You" are different, up to the stages of adult personal growth. Recently, Shapiro and colleagues posited that this capability to "step back", which they have dubbed "reperceiving", is the overarching pathway of mindfulness (Shapiro et al. 2006); preliminary results support this notion (Orzech et al. 2009). Furthermore, the notion that mindfulness directly fosters empathy is corroborated by recent evidence from Block-Lerner et al. (2007). To sum up, it is a viable option that training in mindfulness may reduce tendencies of narcissism in leaders, thereby increasing their interpersonal capacities.

Additionally, leadership, as well as all interpersonal behavior, is strongly related to emotional intelligence (Goleman et al. 2002). Emotional intelligence is a very complex construct, which cannot be pinned down to single brain areas (Bar-On et al. 2003). For example, the anterior cingulated cortex (ACC) and the prefrontal cortex (PFC) have been shown to play a pivotal role in the mechanisms of self-regulation of cognition and emotional regulation (Allman et al. 2001; Bush et al. 2000; Posner and Rothbart 2007; Tang and Posner 2009). Several studies suggest that brain areas that are deemed central in the regulation of emotional reactions can be influenced by mindfulness training. For instance, the team of Yi-Yuan et al. used brain imaging techniques to scrutinize the effects of mindfulness training in a randomized control trial with 40 Chinese students. They found that both the ACC as well the PFC, along with other brain areas related to emotion and attention regulation, were more activated after just 5 days of mindfulness training, with 20 min training per day (Fan et al. 2007).

Taken together, given the fact that the ability to work interpersonally with others is a vital part of nearly everything that a leader does, the potential benefits of mindfulness for leaders should be further scrutinized.

4.3 *Decisional Roles of Leaders*

Although a communication or PR expert might say that half of our life is communication, and a logistics expert might reply that the other half is logistics, it is surely true that both communication and logistics involve decision making as do most other activities in organizations and in people's everyday life. The last few years have seen increased criticism of decisions made by top leaders. As a response to the critics, economic scientists, especially from the domain of behavioral finance, have proposed different alternative decision making action models. Taleb, for example, has eloquently accused the current risk taking strategy in today's business, which is, as he puts it, very vulnerable to "black swans" – unlikely events that may exhibit high impact on an entire organization (Taleb 2001, 2007, 2009; Taylor and Williams 2009). As a remedy, Taleb recommends adopting the attitude and mindset called critical rationalism, which has been conceptually developed and refined by Popper (Popper 1965, 2002). This skeptical view of the world holds that one should be present when drawing conclusions that involve any kind of stereotype building. As a matter of fact, a lot of decision-making processes are based upon past experiences, thereby utilizing hindsight as foresight. Humans are caught in categorical thinking, which traps us in well-learned but past-oriented action tendencies. This backward oriented thinking style follows the idea that situations of type A were in the past always followed by reactions or new situations of type B. Hence, we conclude that as A was not the case, B will also not be the case. It may be a bitter lesson to learn that this sort of reasoning can easily lead to misinterpretations and erroneous predictions. Turkeys, for example, learn their lesson only the day before Thanksgiving. After a year or so of comfortable coexistence with humans, they suddenly learn that situation A – getting food and shelter from humans – is followed by an unforeseen situation C: becoming the Thanksgiving dinner's main dish (Taleb 2007). As discussed above, being aware, with a receptive stance towards one's own reasoning and categorization processes, allows for a – at least partial – decrease in categorical thinking although, of course, one is never protected against difficult market or social situations. This is why mindfulness may help in making decision making less prone to such biases.

4.4 Moral Behavior and Mindfulness

The roots of (im-)moral behavior have been discussed by philosophers for ages. Mindfulness may be seen as the cultivation of a state of mind that may not only enhance attentional performance but also, in a second step, acceptance. In other words, it seems that prosocial behavior and, ultimately, the capacity to accept a given situation despite negative inclinations emerges as a consequence of being mindful. In short, whereas being present seems to be a state characteristic of mindfulness, which may be exercised during meditation, the ability to accept a given situation is cultivated as a trait characteristic. Might there be a psychological explanation for the growth of altruistic attitudes and behavior that can be related to mindfulness? Behavior research suggests that some forms of so-called immoral behavior may be due to the lack of a capacity called "gratification delay"(Mischel 1974). This concept, which has some similarity with impulsivity (Fowles 1987), may be understood as the ability to await or delay gratification. It may correspondingly also be understood as the psychological counterpart to unrestricted wanting, or greed. Empirical research has shown that individuals show large differences in their ability to delay gratification (Carver and White 1994; Carver 2006; Carver and Scheier 1990). Interestingly, recent studies have shown that mindfulness can strengthen the capacity to delay gratification and to reduce impulsivity (Stratton 2009; Wachs et al. 2007; Bögels et al. 2008; Samuelson et al. 2007). This increased capacity to delay gratification through mindfulness training may possibly act as a functional pathway for explaining the impact of mindfulness on moral behavior. Notably, this explanation of moral behavior is independent of the types of personal values and ethical systems. Moreover, a second psychological process associated with mindfulness and accountable for immoral behavior can be envisioned. This process is called "experiential avoidance", and several studies converge on the idea that this process is a central base of mental imbalances (Hayes et al. 1999; Kashdan et al. 2006). Experiential avoidance is a deliberate attempt to change the frequency or the evaluation of unwanted subjective experiences such as unwanted thoughts, mental images, feelings, or emotional states. This suppressive mechanism, although meant to maintain inner balance and psychological homeostasis, may actually lead to distress and strengthen maladaptive behavior for several reasons: First, the notorious "pink elephant effect" comes into play. If you try to avoid the experience of thinking of pink elephants, you will end up forgetting everything around you because there will be only pink elephants running through your mind (Wegner et al. 1987, 1997; Wenzlaff and Wegner 2000; Wegner 1994). Also, it seems that verbal rules to escape unwanted inner experiences are ineffective as the underlying cognitive processes operate below the level of semantic reasoning (Chawla and Ostafin 2007). Preliminary empirical evidence suggests that a central pathway in which mindfulness conveys its beneficial effects may be a decrease of experiential avoidance. In one study, Baer and colleagues, for example, have shown that mindfulness is associated with the tendency to avoid unwanted inner experiences, measured on a self-report basis (Baer et al. 2004). Taken together, it seems plausible that mindfulness has an effect on both gratification delay and experiential avoidance. These two processes provide an avenue for explaining in psychological terms how mindfulness may improve the capacity of expressing high moral behavior, simply by observation of the needs and demands of the self without reaction.

Taking all these issues into account, there are both theoretical and empirical grounds to consider the beneficial effects of mindfulness on leadership effectiveness and moral behavior. These beneficial effects may manifest themselves in the three main task domains of leaders: information processing, interpersonal interaction, and decision making. We hold, in addition, that the mental capacity of exhibiting moral behavior may also be positively influenced by mindfulness practice. In research domains outside organizational or leadership studies, a substantial research body has been accumulated that points out the beneficial effects of mindfulness on many health and behavior-related parameters. In the leadership literature to date, only limited attention has been devoted to explaining the effects of mindfulness; psychology and brain research have, however, provided fruitful models, which leadership theorists and researchers may use as a platform for developing their theories and concepts further. Also, the intercultural differences in leadership need to be scrutinized with regard to how mindfulness may act as a way to foster effective leadership.

5 Building the Mindfulness Muscle Solves All Problems? A Caveat

In sum, it seems plausible that a dedicated and well-conducted mindfulness training may prove to be helpful in solving some of the problems today's leaders are facing. However, the assumption that "building the mindfulness muscle" may actually turn human beings into superleaders is a blatant misunderstanding of what mindfulness is all about. In order to understand it, it is important to recall the dialectical structure of mindfulness: If you want something very desperately, if you want it to happen at all costs, then it is very difficult to stay mindful at the same time. On the contrary, mindfulness is characterized by the systematic development of a certain "willingness" to acknowledge unwanted events that happen in a benevolent way. Thus, on some level, mindfulness can be compared to relaxing: It is impossible (or at least quite difficult) to relax on command. Worse, if fate depends on relaxing on command, this easy and basic act of not doing anything becomes surprisingly difficult, if not impossible. Hence, mindfulness should be regarded primarily as a way of living, paying attention to basic perceptional processes: Being fully present in each moment has intrinsic value on its own. Secondarily, improved health or better leadership capacities as well as the development of moral attitudes may well follow as a consequence.

Mindfulness primarily fosters emotional resilience toward unpleasant events (said to happen in most lives). The beneficial effects on health, concentration, and leadership capacities, for example, are mostly derived from this emotional resilience as a "by-product" and not from training the mindfulness muscle itself (Kohls et al. 2009). It is therefore crucial to avoid mixing up the basic concept of mindfulness, of developing a detached state toward life's ups and downs with a "meditate away all problems" mode of mind. In the last section, we discuss the implications of mindfulness for the work of leaders and draw conclusions as to how mindfulness can be of help in the work of executives.

6 Conclusion: A Very Old and Unspectacular Way of Being for Dealing with the Demand and Responsibilities of Modern Leadership

In this essay, we have analyzed the potential benefits of mindfulness for the work of executives. More precisely, we have outlined a general model of what leadership is and provided a taxonomy for the classification of executive responsibilities. In the next step, we have presented definitions of mindfulness. Building upon insights derived from neuroscience and psychology, we have outlined the reported effects of mindfulness. Sometimes, the term mindfulness has been used in questionable, and at times improper or even pernicious ways (Velting et al. 2004). For this reason, we have tried to shed light on what is deemed the very essence of mindfulness in current scholarly discussion, thereby contrasting it with common misconceptions and misunderstandings. We have used this as a stepping stone for theorizing how mindfulness may influence the informational, interpersonal, and decisional activities of leaders. We have tried to make the point that substantial evidence exists in favor of the potential benefits of mindfulness. It needs to be borne in mind, however, that the majority of the present research has not been conducted in the context of leadership activities, but rather in the context of day to day behavior or even clinical and medical settings. It seems to us that leadership scientists and practitioners alike should take advantage of the fundamental work accomplished by research colleagues of neighboring domains and unleash the potential that mindfulness has already demonstrated for other populations within their domain of interest. A major pitfall must not be overlooked, though. Mindfulness relies inherently on a dialectical or even paradoxical structure. That is, it is meant to make life more effective and healthy, but if the concept is pushed too hard, it will prove to be ineffective or may even exhibit a negative impact. This is due to the fact that mindfulness is a way of being. It conveys a sense of looking "freshly" at things, of attending to whatever occurs with an open and nonjudgmental attitude. It is neither a painkiller nor a steroid, and it is primarily not a technique for boosting performance, although it may strengthen an individual's resilience and ability to deal with difficult situations.

What does this mean for leaders? Leaders may be mindful because it helps them to be more effective in a healthier way. But at the same time, it is necessary to observe its essential qualities. This may include appreciation of the fact that drawbacks and failures do happen and need to be accepted. At the same time, one can encompass a balanced mind with strong proactivity and commitment to decisive action. Mindfulness combines equanimity toward the ups and downs of life with a receptive sharpness of mind. This is why the concept may be of value for leadership. Modern leaders willing to try the technique should make sure to invest some time at the beginning, for example, delivering a seminar with "formal" mindfulness exercises and concise explanation. "Informal" training can be conducted afterward on an individual basis.

Mindfulness is neither a new leadership tool, nor a new "management by technique"; nor is it a reformulated blend of last year's business literature. Rather, this technique is one of the techniques that have been employed since ancient times for developing the mind in the first instance. Nevertheless, performance enhancement, better health parameters, and formation of altruistically oriented, ethical behavior may arise as byproducts. Ultimately, any tool – in research, leadership, or otherwise – is "right" to the degree that it proves helpful for the individual. This is not something that science can conclusively give an answer to – science can only try to capture the effects for a defined population with methodological and statistical tools. Here practice becomes relevant – the appropriateness of this method for a certain individual must be experienced in practice, and it has to be stressed that mindfulness cannot be practiced on a theoretical basis. Considering the available data, mindfulness seems to be effective. The next step for leadership scientists now is to outline the applicability of this method to their current research questions and for intercultural scientists to reveal in which cultures and leadership styles mindfulness may be of help for leaders. Leadership as such, of course, is being lived differently in different cultures. Hence, mindfulness may be effective under certain conditions as opposed to others. Appropriate answers to the moderating role of cultural contexts in the mindfulness – leadership relation remain to be specified.

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