VOICE DISORDERS and their MANAGEMENT

Second edition

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Edited by

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Preface to the second edition

Since this book was first published, four years ago, there has been a considerable upsurge of interest in the field of both normal and abnormal voice production. Tangible evidence of this lies in the publication of the *Journal of Voice* in the United States, and in the UK the formation of the British Voice Association. This organization has attracted an increasing membership from professionals involved in all aspects of voice care and use – actors and singers, laryngologists and speech therapists, teachers and phoneticians. The Association holds regular study days, holds an annual two-day symposium, and publishes a Newsletter which attracts entries from this broad spectrum of professionals.

We have also seen an increase in the number of specialist voice clinics, and in the two final chapters in this book a contrast is presented between such a specialist setting and the more typical clinic that operates in the majority of general hospitals. This last chapter now contains a breakdown of voice referrals over an eight-year period, which must represent a unique published study in this country.

There still remains, however, little research into the management of voice disorders. There is clearly a need for more efficacy studies into specific treatment methods, and the single case-study designs developed in the field of aphasia would seem to be appropriate here.

Recent studies, notably in Japan and the United States, have continued to shed light on vocal fold structure and movement and the co-ordinated mechanisms of respiration and phonation. We have now included a chapter on the physiology of phonation, which looks at these developments and the extent to which they increase our understanding of voice production.

We have also included a chapter on technological support in the management of dysphonia, reflecting the increasing sophistication of the instrumentation available for presenting objective data on normal and abnormal voice use.

Developments in the field of phonosurgery over the past few years have certainly justified the inclusion of a chapter on this increasingly specialist area of ENT management.

The majority of the original chapters have either been rewritten or updated, and we hope that this volume will continue to be a useful source of reference for all those involved, in one way or another, with voice care.

Margaret Fawcus

Introduction to the first edition

> The great functional vulnerability of the vocal organs may, at least in part, derive from a paradoxical situation, for we use for the delicate task of self expression a set of structures that originally was not created for this purpose. The sphincteric origin of the larynx and the pharynx makes them more suitable for closure, for shutting off, than for emission.
>
> Brodnitz (1959)

Voice disorders, seen against the broad landscape of communication problems, are unique in a number of ways: in the first place, the management of vocal dysfunction has been something of a grey area where voice training and speech therapy meet in a mutual interest in voice production. This was demonstrated in a recent voice symposium at the Royal Society of Medicine where both singing teachers and speech therapists were in the audience. It must be remembered that the majority of early therapists came from a background of speech and drama training and practice, and these beginnings have obviously been influential in the techniques employed in remedial voice work.

Secondly, it has been an area somewhat bedevilled by a reliance on subjective judgements, both in describing the pathological voice and in attempting to evaluate the treatment. This has been true in spite of the feedback on the laryngeal condition provided by direct and indirect laryngoscopy. The therapist could hardly be blamed for this state of affairs, since until recently there has been little available in the way of a more objective approach to voice evaluation. The chapters in this book by Eryl Evans and Margaret Gordon illustrate the assessment procedures available in a specialist voice clinic compared to the rather more limited technological hardware available in the majority of general hospitals. The picture is gradually changing, but may be expected to change very slowly in the current economic climate.

While the emergence of more sophisticated and objective assessment procedures represents one of the most significant advances in voice management, the competent and experienced therapist may have to work quite effectively on a modest budget.

Thirdly – perhaps more than in the consideration of any other communication disorder – there is a 'blurring of the edges' in the concept of a simple functional versus organic dichotomy in the causation of voice problems. This has been highlighted in the chapter on causes and classification of voice problems, and in Margaret Freeman's view of psychogenic voice disorders. It has led to considerable problems in arriving at a satisfactory method of classification, which in turn has inevitably engendered a certain amount of controversy over their management. Nowhere is this more evident than in our approaches to the functional voice problem.

Finally, dysphonia is an area where co-operation between doctor and therapist is crucial, since no responsible therapist would work with a dysphonic patient – or indeed with any patient complaining of vocal fatigue or discomfort – without referring him to an ear, nose and throat (ENT) clinic for further investigation. While the majority of referrals in hospital speech therapy departments come from doctors, there is too often little contact at a professional level once the referral has been made. This is normally in sharp contrast to the situation which presents between speech therapist and laryngologist. An ENT examination is essential for both the diagnosis and continuing management of voice disorders – both in determining the precise nature of the problem at an anatomical and physiological level, and in determining the efficacy or otherwise of our treatment procedures. The chapters by Andrew Johns give proper emphasis to the role of the ENT specialist, reflecting the growing awareness of the need for an active and well-informed partnership between surgeon and therapist. The value of such a collaboration has also been stressed by Sara Collins, Tom Harris and Margaret Gordon.

Voice disorders are also unique in being associated with a degree of physical awareness or even physical discomfort not normally present in patients with other communication disorders. Such subjective sensations may be a sensitive index of the efficacy or otherwise of our remedial programme, and therefore present a parameter of voice production which should always be investigated before treatment begins and as it progresses. The literature has not always placed sufficient emphasis on this aspect of management, but its importance is dearly appreciated by Collins and Harris.

While there are an increasing number of papers and publications on various aspects of voice science, a survey of speech therapy and allied journals reveals remarkably little on disorders of voice. Even rarer is any attempt to evaluate the efficacy of treatment methods, which is in marked contrast with the increasing preoccupation with the efficacy of treatment in aphasia and stuttering. Such a paucity of research probably reflects, amongst other things, the relatively small number of voice referrals compared to other communication problems. It may also indicate the problems inherent in conducting research in an area where so much of our assessment has been essentially subjective.

Despite the lack of research, voice therapy has become an increasingly specialized area and we have seen the development of a number of voice clinics (Gordon, Collins and Harris) where an interdisciplinary approach has led to considerable progress in assessment and diagnostic procedures. Margaret Greene's unique achievement in producing the first comprehensive study of voice disorders in the United Kingdom has now become increasingly difficult to replicate. Only by gathering together a group of people with a special interest in voice problems was it felt that we could achieve the diversity and the depth needed to cover their management adequately. By doing so, it has been possible to give far more detailed consideration of some specialist areas which have previously been dealt with rather superficially in some previous texts. These include the voice problems in adult dysarthria (Sheila Scott and Brian Williams), the cerebral palsied child (Kay Coombes) the patient with vocal fold paralysis (Malcolm Stockley), the puberphonic male (Bob Fawcus) and the transsexual (Judith Challoner); Margaret Stoicheff has dealt with that most difficult and controversial subject, spastic dysphonia, and Sheila Wirz's chapter reflects the growing interest in the communication skills of the profoundly deaf.

Voice therapy is both an art and a science. The two should not be seen as incompatible. Even with a sound scientific training, and an appreciation of the anatomical, physiological, acoustic and behavioural aspects of voice production, there is still room for creativity and imagination in devising and implementing treatment programmes. This aspect is underlined in Elaine Hodkinson's chapter on the management of voice disorders in children. Equally important is the therapist's ability to establish a good working relationship with his or her patient. The most effective therapist is one who possesses the technical expertise, the ability to produce imaginative and interesting approaches to voice therapy and, perhaps most important of all, personality characteristics and non-verbal behaviours which enable her to establish a comfortable and reassuring environment. Collins and Harris have discussed the vital factor of patient satisfaction in evaluating treatment efficacy.

The idea for this book arose some years ago, and was born of an increasing concern that intervention strategies in dysphonia often seemed to have very little to do with the cause of the voice problem or the presenting symptoms of the dysphonic patient. Indeed, some clinical practice appeared largely irrelevant to the patient's real needs. Increasing experience has done little to change this viewpoint, and has acted as a spur in producing this volume. Whether the exercise will prove a worthwhile one for the reader will depend on the answers to the following questions:

Does the book meet the needs of those who are seeking to increase their own expertise in the management of voice disorders?
Will it lead the clinician to question the rationale behind some of the more traditional approaches to voice therapy?

More than any other area of speech therapy, therapeutic techniques in the management of dysphonia have their roots in a speech and drama model of training. We should develop what is relevant and worthwhile in that model, but remember that much of the expertise gained in working with the normal voice in order to obtain high standards of artistic achievement (as in acting or singing) is largely inappropriate to voice use in less demanding everyday circumstances. This point will be discussed more fully in the chapter on hyperfunctional voice use.

It is hoped that this book will meet a very real need in student training, since it is seldom possible to give that depth of clinical experience which is needed to produce a confident and competent therapist. Many qualified therapists, except those working in association with interested ENT surgeons, may have relatively few voice referrals and therefore limited opportunities to develop a tried and trusted repertoire of therapeutic techniques. This book will give them the opportunity to share the knowledge, ideas and understanding of therapists who have had the experience of working more intensively with both the prevalent and rarer causes of voice disorders.

In editing this volume, certain rather arbitrary decisions had to be made in omitting important areas of voice production – background information on the physiology of the larynx and disorders of resonance, for example. It would not have been possible to do justice to the latter, a rapidly expanding area of expertise, in the space available. There is no chapter on the voice of senescence, although the problems of the ageing voice are discussed in Chapter 12. Very few elderly people are sufficiently concerned or handicapped by the gradual changes in their voice to seek professional help, probably regarding the process as a normal rather than pathological one. It was, however, felt that a book on voice would be incomplete without a chapter on the acquisition of voice in the laryngectomised patient. The post-radiotherapy voice is also considered by Stoicheff, since this is an area which is assuming greater importance as radiotherapy is becoming an increasingly refined and successful form of treatment in laryngeal carcinoma.

We would like to place on record the help we have received in many forms from our colleagues and friends. Many of us have stretched the tolerance of long-suffering families, whose only reward is to know it is all over! Finally, we are inevitably indebted to the patients, who have undoubtedly taught us more than any textbook.

Margaret Fawcus

1

The physiology of phonation

Robert Fawcus

The elaboration of phonatory behaviour observable in the processes of human communication demands levels of physiological complexity which generally exceed those encountered in any other species. This represents arguably the most advanced sensorimotor system to be found in the human organism. To divorce phonation from the function of articulation is, however, misleading and highly artificial. It is in fact the coalescence of phonatory and articulatory behaviours which represent the advanced levels of evolutionary performance in perceptuomotor processing.

The basic process of phonation is well established and displays high levels of organization in many mammals and birds (Negus 1949, Kirchener 1988). In man, however, these activities have developed into a pattern of movements involving precise co-ordination of reflexive and learned behaviours resulting in accurate, intricate manoeuvres executed with flexibility and speed.

Lenneberg (1967) estimated that the production of a single phoneme could involve up to one hundred muscular contractions and adjustments. The majority of these adjustments form part of respiratory and phonatory activity, and the most subtle are those involving the complex lattice of intrinsic and extrinsic muscles of the larynx. In fluent speech this would represent over five hundred muscular adjustments per second within the speech tract. The control system specifications required to achieve the level of precision evident in even casual speech are quite beyond our imagination.

RESPIRATORY STUDIES

The primary source of power for phonation is derived from egressive respiratory air flow which is brought about by finely controlled contractions of the intercostal musculature. This contrasts markedly with the relatively passive process involved in quiet breathing (Widdicombe and Davies 1983, Nunn 1987). During speech the major contribution to the intake of air is achieved by contraction of the diaphragm, which produces a negative pressure in the thoracic cavity. In shouting, singing or public speaking the intercostal musculature is also employed to provide greater levels of air intake to satisfy the increased rate of flow required to sustain vocal intensity (Bunch 1982, Sundberg 1987).

In their seminal study of electromyography of the respiratory system, Draper, Ladefoged and Whitteridge (1960) showed the different functions of the external and internal intercostals. Figure 1.1 shows an oscillographic record of the repetition of the syllable [ma].

The first trace provides a time marker in *x* seconds.
The second shows a gradual decrease in the electrical activity of the external intercostals as each syllable is uttered.
The third trace shows the acoustic signal derived from a microphone – a sequence of nine syllables.
The fourth trace shows the gradual reduction in lung volume in the course of the utterance.
The final trace indicates increasing activity in the internal intercostals.

Electromyography of the respiratory musculature and other muscle systems in the speech tract tends to require the insertion of needle electrodes to detect electrical activity in individual muscles or small muscle groups. Surface electrodes pick up voltages from a range of contiguous muscles and therefore lack the precision afforded by needle electrodes.

Wilder (1983) and Baken (1987) discuss the findings yielded from pneumographic and related physiological studies of the contribution of

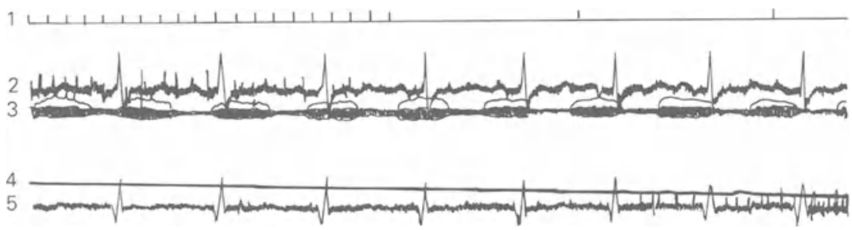

Figure 1.1 The electrical activity of several muscles of the chest during speech. The traces were recorded on an oscillosocpe during the repetition of the syllable [ma]: (1) time marker, seconds; (2) decreasing electrical activity of the external intercostals; (3) acoustic signal recorded by microphone; (4) volume of air in the lungs gradually decreasing; (5) increasing activity of the internal intercostals. After Draper *et al.* 1960.

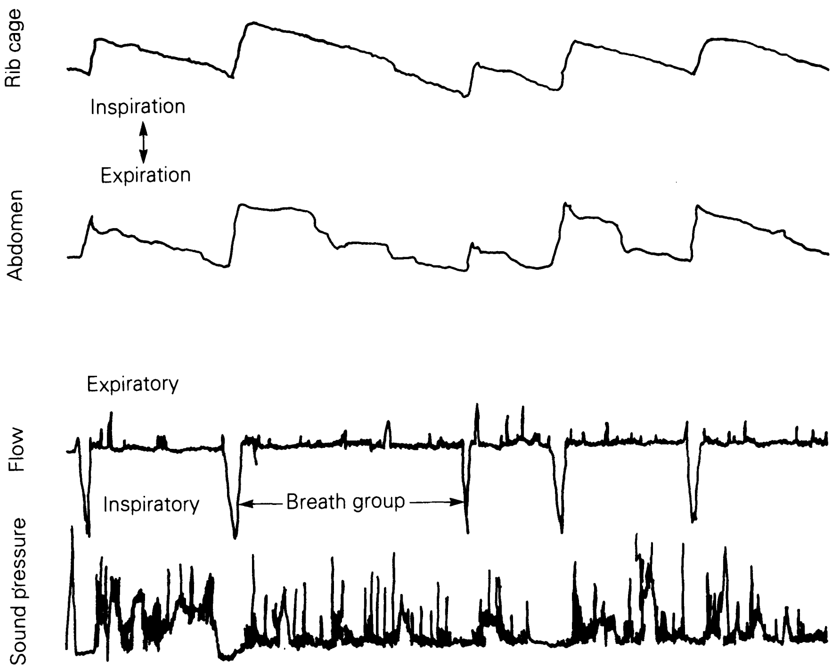

Figure 1.2 Pneumograph traces.

the respiratory system to phonatory behaviour. Wilder investigated movements of the rib cage and abdominal wall using Whitney gauges and electronic spirometry and found that there were significant differences between the respiratory movements detectable in male and female subjects (Figure 1.2). Her findings supported earlier claims that there is a precisely preprogrammed adjustment of the chest wall immediately prior to phonation onset (Baken and Cavallo 1981).

A wide variety of pneumograph devices have been constructed in order to detect gross respiratory activity. They all require some form of transducer, usually a strain gauge, which converts the stretching of a belt placed around different levels of the thorax and abdomen into electrical signals that can be displayed and recorded. More accurate data may be obtained from a pneumotachygraph, in which air flow is detected and measured during fluent speech or singing. This procedure requires the subject to wear a face mask, however, which increases the artificiality of the assessment.

Baken (1987) presents a meticulous examination of different methods of study of both respiratory and phonatory activities. He outlines the limitations and difficulties of each technique and provides examples of findings from a wide range of studies of both children and adults.

LARYNGEAL PHYSIOLOGY – VEGETATIVE FUNCTION

The primary purpose of the laryngeal mechanism is the protection of the airway to the trachea. The drainage of saliva and mucus from the oropharynx requires periodic reflexive closure to ensure the transfer of accumulated liquid to the oesophagus rather than the trachea, which would result in aspiration, with life-threatening consequences. Effort closure, which occurs during coughing, 'bearing down', and the fixation of the thorax during the lifting of heavy weights can involve a marked degree of muscular tension. Such closure can resist the maximal pressures generated in the thorax evident in the severe stutterer during a laryngeal block or the weight-lifter during a final effort. These pressures can reach levels in excess of 90 mmHg (Fink and Demarest 1978). Effort closure involves apposition of the cuneiform cartilages and vestibular folds, approximation of the thyroid cartilage and the hyoid bone with infolding of the aryepiglottic folds, and apposition of the median thyrohyoid fold to the lower part of the adducted vestibular folds. The closure which occurs during deglutition involves far less powerful contraction of the extrinsic and intrinsic laryngeal musculature. The juxtaposition of laryngeal contractions and high thoracic pressures can result in linear velocities approaching the speed of sound when the pressure is abruptly released during coughing (Nunn 1987).

LINGUISTIC DEMANDS

Birds, cats, dogs, primates and other mammals display complex levels of respiratory and phonatory control to achieve communicative ends, but it is in the movement patterns of the human larynx where one can observe the level of physiological complexity which is characteristic of man's communicative behaviour. The achievement of an acoustic power source by means of driving a respiratory outflow through contracted sphincteric membranes is a basic feature of both mammalian and avian communication. Some birds produce patterns of considerable complexity which can closely resemble human musical utterances, whilst certain species of whales are noted for extended vocal output that can last longer than most symphonies. In the human larynx the subtlety of the control available has been exploited in different ways by diverse language groups. The communication of meaning through tonal patterns in some African and Asian languages requires the precise tuning of laryngeal vibration with changes at each syllable boundary. This developmental skill tends to precede the associated articulatory patterns of the language even though the structure of syllables is generally less complex than typical Indo-European languages (Li *et al.* 1978, Gandour *et al.* 1989). Similarly the child learning English, Russian, or any other Indo-European language will normally learn to imitate the intonation patterns in his or her environment well before achieving accuracy in articulatory skills.

In Indo-European languages the patterns of intonation run in parallel with the structure of a sentence or phrase and are employed to convey emphasis, emotion, and overall meaning of an utterance. Speakers in tonal languages such as Cantonese employ meaningless 'tags', which are inflected to convey signals relating to emphasis and feelings (Ladefoged 1983, Ladefoged *et al.* 1988).

In addition to this important demand for control of intonation the laryngeal mechanism is employed to signal differences in intensity in order to impose patterns of rhythm and emphasis. Stress patterns are closely linked to variations in intonation in English and many other languages and these are brought about by precise adjustments of the internal intercostals.

The achievement of voiced–voiceless contrasts, the timing of aspiration, and voice onset all impose complex demands upon the function of the control system. To these must be added the requirement to produce glottal plosives and fricatives in many languages, and in some, such as Vietnamese, phonatory quality changes that are used to convey meaning (Ladefoged 1983, Ladefoged *et al.* 1988). It must not be overlooked that the system needs to revert to respiratory function about ten times in every minute.

PHONATORY REGISTERS – MODAL

Three principal types of phonation are claimed to occur during fluent speech. Modal register, described by Hollien (1974), occurs most frequently in normal phonation and consists of a pattern of vocal cord closure in which the mass of the cords is brought together with sufficient stiffness to interrupt the pulmonary air flow briefly. This results in a train of glottal pulses which occur at about 100 Hz in adult males and in the region of 200 Hz in female adults and children.

Daniloff *et al.* (1980) provide a cogent description of the Bernoulli effect, which plays a vital role in modal phonation.

> The lower edges of the vocal folds are more compliant than the upper edges. As a result, air pressure rising below the vocal folds first pushes aside the lower edges. As the lower edges move aside, they drag the upper edges with them toward the glottal opening. Once the folds open, air begins to flow through the slit. Due to an aerodynamic coupling effect, as the upper fold edges move apart, the airflow and the Bernoulli drop in air pressure become very large in the region of the lower edges. Because of their greater compliance and the fact that the Bernoulli pressure drop is greatest at the bottom edge of the glottis,

the lower vocal fold edges begin to move toward closure once again in advance of the stiffer upper edges which they pull along with them.

Glottal vibration generally does not begin with the vocal folds completely closed. Instead, the folds are brought toward the midline, but not fully closed. As air pressure rises, air flows through the small glottal opening. The Bernoulli drop in pressure causes the folds to move toward the midline. As the folds are pulled toward midline closure, elastic recoil increases and airflow is reduced. The folds recoil outward, airflow rises and the Bernoulli effect increases once again drawing the folds toward the midline. As momentum increases with each successive cycle of vibration, the vocal folds move nearer and nearer until they finally achieve closure.

LARYNGEAL CONTROL MECHANISMS

Wyke (1983a) describes a prephonatory inspiratory phase that occurs prior to each sequence of speech. The vocal cords are rapidly abducted and remain so until completion of an ingressive air flow, which provides the volume of air required for the ensuing utterance. Simultaneously the body of the larynx descends slightly in relation to the extent of the inspiratory tidal volume.

This process, he explains, is accomplished by simultaneous bilateral activation of a large proportion of neurons in the motor neuron pools serving the posterior cricoarytenoid muscles. These pools are located in the nucleus ambiguus in the medulla. At the same time the adductors of the vocal folds relax as a result of coincident inhibition of their motor neurons. The descent of the larynx referred to above results partly from the elastic traction applied from the trachea and in part from reflexly augmented motor unit activity in the sternothyroid muscles. Wyke then outlines the prephonatory expiratory phase subsequently initiated. This involves relaxation of the previously contracted diaphragm and inspiratory intercostal muscles, permitting recoil of the stretched elastic tissues of the lungs and chest wall. This is supplemented by augmented motor unit activity in the abdominal and expiratory intercostal muscles. The cortically evoked motor unit activity in the posterior cricoarytenoid muscles is abruptly (but only briefly) switched off, while corticobulbar activation of the vocal fold adductor motor neurons is switched on. Wyke's description of the neural and muscular events occurring in a few hundred milliseconds at the junction of every breath group does not include the important differences due to the presence or absence of voicing at the beginning of the ensuing syllable. Neither does it attempt to consider the influence of articulatory activities of the larynx.

Hollien (1983) discusses the contribution of both radiographic studies and electromyographic investigations to our understanding of the mechanisms underlying the control of vocal frequency. He concludes that frequency control is mediated by variation in vocal fold mass and stiffness plus changes in subglottal air pressure. He considers that vocal fold mass and stiffness plus the impedance to respiratory air flow in the glottis appear to vary as a consequence of changes in laryngeal physiology, which includes variation in vocal cord length. Such variation, he suggests, results from at least two mechanisms.

> The primary system (said to 'stretch' the vocal folds which have previously been shortened for phonation) results from contraction of the cricothyroid muscles. In turn these contractions operate to lengthen the vocal folds by increasing the distance between the thyroid cartilage and the vocal processes of the arytenoids. A second mechanism which functions to elongate the folds is one resulting from anteroposterior movement of the arytenoids – events that are mediated by co-ordinated activity among the interarytenoid and posterior cricoarytenoid muscles. This secondary process is most often seen to occur for the higher frequencies within the modal register.

Hollien prefers the term stiffness to muscle tension, as the latter is non-specific and rarely properly defined. He also emphasizes that the vocal folds are not in fact 'stretched' during phonation, as they are in fact longest during respiratory activity and are shortened for all types of phonation.

PULSE REGISTER

Creak, also known in the United States as glottal fry, was termed 'pulse register' by Hollien (1974) in his attempt to clarify terminology. It is a form of phonation that occurs briefly in almost every utterance in some speakers. It can occur to a greater or lesser extent in individuals according to mood, level of fatigue, or even degree of misuse of the laryngeal system. It occurs at lower frequencies than modal voice and is characterized by a relatively random rate of vibration in comparison with the high degree of consistency evident in normal modal phonation.

McGlone (1967, 1971) found significantly lower flow rates in speakers using pulse register at a comfortable intensity. The air flow for males producing vowels with pulse register ranged between 10 and 72 ml/s. Females producing similar phonation used from 2 to 63 ml/s. Creaky voice is a mixture of modal and pulse register (Table 1.1).

LOFT REGISTER

The third type of phonation occurring in normal speech, but tending to be rarer than pulse register, is commonly described as falsetto. Fawcus (1986) described the range of human vocal activities in which 'loft register'

Table 1.1 Mean air flow in modal and pulse registers in normal males*

Register	*F_o (Hz)*		*Flow (ml/s)*	
	Mean	*Range*	*Mean*	*Range*
Modal	107.9	87–117	142.2	74.9–267.8
Pulse	34.4	18–65	40.4	0.0†–145.3

* Nine young adult males

† Indicates a flow too small to be measured

is typically observed. These include the singing of the counter-tenor or male alto, and many types of popular singing styles from the traditional Irish tenor to the Beachboys. War cries in many cultures, including the shouting of orders on the parade ground at Sandhurst, frequently include an element of loft register, as do gentler activities such as yodelling, giggling, laughing, and the upper ranges of intonation in many male adults (Van Riper and Irwin 1958).

McGlone (1970) studied air flow during phonation in eight college-age women who sustained a vowel for 4 s at 10% of their intensity range and also 10% of their pitch range whilst using loft register. Flow rate was derived by dividing the volume of air used by the duration of phonation (Table 1.2).

Hirano (1975, 1982) presented electromyographic evidence on the activity of the phonatory musculature during the transition between different registers in singing. In speech the transitions are usually much faster and are rarely deliberately undertaken. The spectrographic and simultaneous laryngographic record (Figure 1.3) shows the shift from loft register through modal into pulse within 300 ms in a single syllable [no].

LARYNGEAL REFLEX MECHANISMS

Wyke (1983b) provides further information regarding reflexogenic contributions to the control of phonatory behaviour. He describes three sets of low-threshold mechanoreceptors which are embedded in the subglottic mucosa, muscle tissue, and laryngeal joint capsules. Afferent discharges from these receptors are relayed via the laryngeal nerves to the brain stem motor neuron pools serving the laryngeal musculature upon which they exert reciprocally co-ordinated facilitatory and inhibitory influences.

He goes on to describe a further three types of extrinsic modulatory reflexogenic system situated in pulmonary tissues, and a final one, the

Table 1.2 Mean air flow in the loft register: females (ml/s)

Intensity level (percentage intervals)	*Pitch level (percentage intervals)*									*Mean for intensity level*
	10	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	
10	92.4	96.9	91.7	87.8	100.8	132.8	130.7	121.9	131.8	109.6
20	121.1	120.6	114.4	123.4	133.9	149.2	154.4	151.8	158.6	136.4
30	162.0	158.6	138.0	154.2	144.3	165.6	167.2	159.1	180.2	158.8
40	185.7	187.8	177.3	164.6	148.7	183.3	169.5	173.9	186.1	175.2
50	208.9	200.5	174.2	203.1	179.4	184.1	198.4	182.0	188.5	191.0
60	207.5	217.4	183.9	216.4	188.8	200.5	227.8	190.1	188.8	202.4
70	242.4	232.0	194.3	224.5	205.5	220.6	229.7	215.2	206.2	218.9
80	239.8	240.4	211.5	246.4	202.6	237.8	242.2	223.1	216.4	228.9
90	266.4	249.7	223.9	249.0	198.4	232.9	268.7	213.3	224.0	236.3
Mean for pitch level	191.8	189.8	167.7	185.5	166.9	189.6	198.7	181.2	186.7	

From McGlone (1970). Reprinted by permission.

KAY ELEMETRICS CORP. MODEL 5500		
SIGNAL ANALYSIS WORKSTATION		
CITY UNIVERSITY LONDON CCS		
Date: AUGUST 07 1989	Rec. Off Time: 5:18:08 PM	
Analysis by: AH.RF		
INPUT SETTINGS	Channel 1	Channel 2
Source	LEFT CONNECTORS	RIGHT CONNECTORS
Frequency Range	DC – 4 KHz	DC – 4 KHz
Input Shaping	HI-SHAPE	HI-SHAPE
Buffer Size	4 SECONDS	4 SECONDS
ANALYSIS SETTINGS	Lower Screen	Upper Screen
Signal Analyzed	CHANNEL 1	CHANNEL 2
Analysis Format	WAVEFORM	WAVEFORM
Transform Size	75 pts (200 Hz)	75 pts (200 Hz)
Time Axis	50 ms (1 sec)	50 ms (1 sec)
Frequency Axis	FULL SCALE	FULL SCALE
Analysis Window	HAMMING	HAMMING
Averaging Set Up	NO AVERAGING	NO AVERAGING
DISPLAY SETTINGS	Lower Screen	Upper Screen
Freq. Divisions	0.000 Hz	0.000 Hz
Dynamic Range	66 dB	66 dB
Analysis Atten.	20 dB	20 dB
Set Up Options Set to: #50		
CURSOR READINGS:		
FC1:	FC2:	ˆF:
FC1: dB, FC2:	dB ˆF:	
ˆR1:	R2: dB	
ˆT:		
PITCH TC1:	Hz TC2: Hz	
AMPLITUDE TC1:	dB TC2: dB	
SUBJECT MATTER	Upper Screen : Sound Pressure	
	Lower Screen : Laryngograph Trace	
	– Male adult aged 52 years saying	
	/nəʊ/ emphatically.	

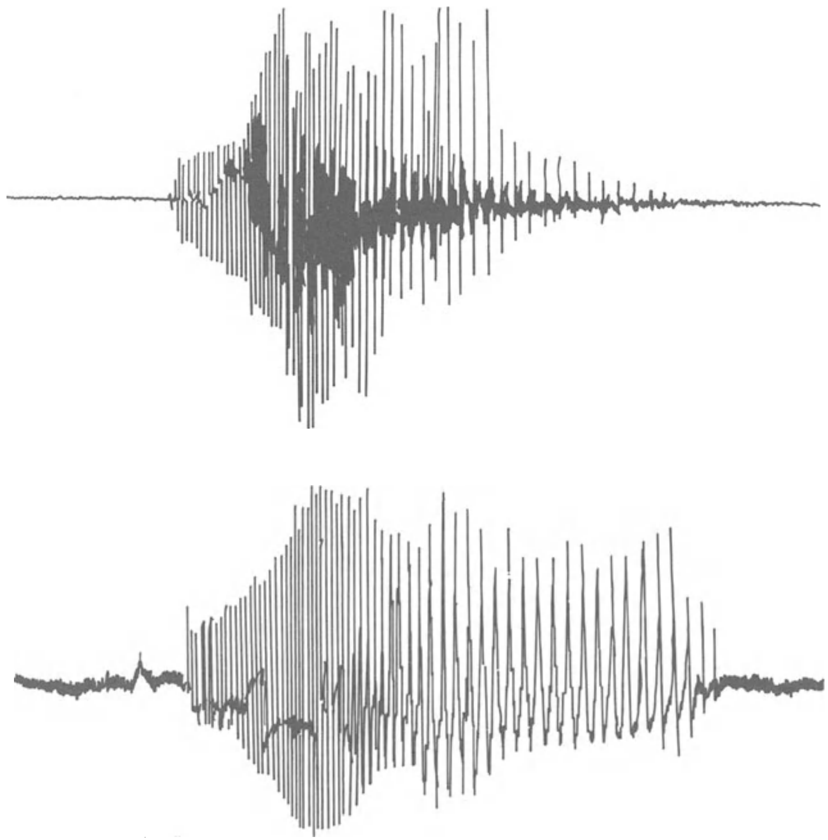

Figure 1.3 Laryngograph plus spectrographic trace showing a rapid progression from loft register through modal to pulse.

cochleolaryngeal, which, when stimulated, results in facilitation of laryngeal adductor motor neurons.

HISTOLOGICAL STUDIES OF THE STRUCTURE OF THE VOCAL FOLDS

The major contribution of Hirano (1977, 1981) to our understanding of the cellular structure of the vocal folds has introduced a completely new dimension to studies of normal and pathological patterns of phonatory behaviour. Hirano and his colleagues have described a five-layered structure (Figure 1.4):

1. A surface of squamous cell epithelium which has been described as a thin stiff capsule whose purpose is to maintain the shape of the vocal fold.
2. Lying below the epithelium there is a superficial layer of the lamina propria consisting of a matrix of loose fibrous components not unlike a mass of soft gelatin.
3. The intermediate layer of the lamina propria consists chiefly of elastic fibres and has been likened by Hirano to a bundle of soft rubber bands.
4. The deep layer of the lamina propria consists primarily of collagenous fibres and has been compared to a bundle of cotton thread.
5. Finally the body of the vocalis muscle makes up the bulk of the vocal fold and is said to be similar to a bundle of rather stiff rubber bands.

Hirano has further simplified the concept of the layered folds by referring to a mechanical classification consisting of a cover containing the epithelium and the superficial layer of the lamina propria, the transition consisting of the vocal ligament – the intermediate and deep layer of the lamina propria, and the body constituting the vocalis muscle. Hirano's studies have also involved examination of the different roles of pairs of muscles within the larynx. Table 1.3 summarizes the functions of the muscles in vocal fold adjustments.

LARYNGEAL NEUROMUSCULAR ACTIVITY

Faaborg-Anderson (1957) presented the results of his studies of laryngeal myography having inserted needle electrodes in the intrinsic laryngeal musculature via the oral cavity and further transcutaneous electrodes in the cricothyroid muscles via cervical tissues. Hirano (1981) comments that this approach led to difficulties in achieving normal phonation and this restricted its use in clinical examination.

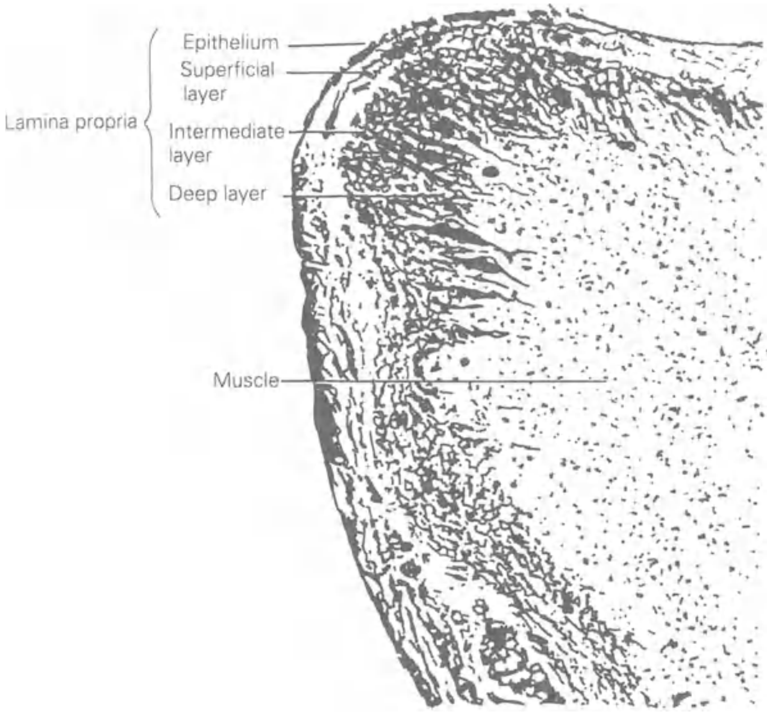

Figure 1.4 Frontal section of a human vocal fold through the middle of the membranous portion (Hirano 1981).

Hirano and Ohala (1967) extended earlier Japanese work (Hiroto *et al.* 1962) and reported the successful insertion of hooked wire electrodes into the major intrinsic laryngeal musculature. Hirose (1971) modified their technique and inserted needles into the cricothyroid space, through sub-mucous tissue into the vocalis muscle, avoiding the need to pass through the subglottic space. In order to insert electrodes into the posterior cricoarytenoid and interarytenoid muscles, Hirose employed the peroral route.

THEORIES OF VOCAL FOLD FUNCTION

The late 1950s saw the elaboration of a number of theories of vocal-fold function, some highly controversial. Husson and his collaborators had worked in Paris for over 20 years and proposed a revolutionary neuro-

Table 1.3 Functions of muscles in vocal-fold adjustments

	CT	*VOC*	*LCA*	*IA*	*PCA*
Position	Paramed	*Adduct*	*Adduct*	*Adduct*	*Abduct*
Level	Lower	Lower	*Lower*	0	*Elevate*
Length	*Elongate*	*Shorten*	Elongate	(Shorten)	*Elongate*
Thickness	*Thin*	*Thicken*	Thin	(Thicken)	Thin
Edge	*Sharpen*	*Round*	Sharpen	0	Round
Muscle (body)	*Stiffen*	*Stiffen*	Stiffen	(Slacken)	Stiffen
Mucosa (cover and transition)	*Stiffen*	*Slacken*	Stiffen	(Slacken)	Stiffen

0: no effect, ( ): slightly, italics: markedly.
CT, cricothyroid muscle; VOC, vocalis muscle; LCA, lateral cricoarytenoid muscle; IA, interarytenoid muscle; PCA, posterior cricoarytenoid muscle.
From Hirano (1981).

chronaxic theory, which suggested that achievement of vocal frequency was dependent upon direct cortical control rather than purely the result of the interaction of air flow, the gestures of the vocal folds, and auditory feedback (Husson 1953, 1957, 1962). Van den Berg (1958) strongly rejected this theory and propounded the myoelastic–aerodynamic theory, which has been the most commonly accepted view of laryngeal function for the past quarter of a century. Perhaps the most graphic form of his attack came in a film he made showing phonatory activity in an excised human larynx. By reversing the sequence of dissection in the film he was able to show a larynx constructed piece by piece from cartilages and muscles and finally able to vibrate in an artificial air stream without any neuromotor input. The muscles were contracted by means of externally applied tension (Van den Berg *et al.* 1960).

Lecluse (1977), working in Holland, compared electroglottograms derived from living human subjects with those from a series of excised larynges, and found consistencies between the results when air was pumped through the laryngeal preparations. The vocal cords were mounted between two clamps and a force transducer achieved either slow or rapid extension of the vibrating structures.

Smith (1954, 1957) put forward the membrane–cushion (mucosa–muscle) theory to explain the vertical phase difference between the upper and lower borders of the vocal-fold margins. He employed high-speed film pioneered by Bell Laboratories, laryngeal stroboscopy, and observation of ingenious rubber models of the vocal cords. Stevens (1977, 1988) postulated that the phase difference could be explained by a two-mass mechanical model of the vocal folds, and this has been developed by Titze (1981) and Ishizaka (1981) in the form of kinetic descriptions derived from computer simulations. Hirano *et al.* (1974) and Hirano (1982, 1988) have elaborated the 'body-cover' structure of the vocal folds and its mechanical contribution to phonatory physiology. Their findings tend to support Smith's membrane–cushion theory and are derived from both histological and physiological evidence.

PHYSIOLOGICAL STUDIES IN THE MANAGEMENT OF DYSPHONIA

The physiological processes underlying the production of normal voice and singing have received considerable international attention over the past three decades, and our knowledge and understanding are growing rapidly. Scant attention has so far been paid to the physiological study of dysphonia, but important work is in progress in Japan, the United States, and Europe, which is beginning to provide a firm scientific basis for the assessment and management of disorders of voice.

It must be emphasized that these studies cannot be confined to the realm of physiology because this would ignore the important contribution of anatomical, acoustic, clinical, and psychological investigations. The task of the voice therapist is to bring together these diverse factors, to establish a working hypothesis, and to devise regimes that will facilitate efficient and effective voice use.

To date the overwhelming majority of studies of laryngeal function and dysfunction have taken place in a few specialized laboratories in the United States, Japan, and Europe, and there has been a strong tendency for medical interests to dominate the investigations.

It is interesting to note that the first two major steps in the study of phonation came from a singing teacher in London (Garcia 1855) and a century later from a biological physicist in Lille (Fabre 1957). More recently the work of Hirano and associates has shifted the focus of laryngeal physiology to Japan and firmly into the medical field.

Three major levels of physiological investigation have a bearing on the clinical management of disorders of phonation. Few clinics would have the time, the staff, or the technical resources to attempt most of the investigations reported in current literature, even in the countries where considerable developments have taken place. This does not mean that laboratory-based physiological studies are irrelevant to the everyday problems faced by the therapist working with dysphonic patients, but merely underlines the differences between the levels of resource that are both practical and accessible. The top-flight laboratory capable of employing medical staff, physiologists, specialists in acoustic phonetics, and therapists skilled in the assessment and management of patients with phonatory disorders is likely to be a rare phenomenon in any country. The hardware alone would prove to be a prohibitive requirement, and yet most developed countries have at least one centre that approximates to this model. The most frequent manifestation is, however, a less formal arrangement involving co-operation between different interested departments in a University setting. The voice clinic (see both Gordon and Harris *et al.*, this volume) represents an intermediate level of activity. Both accounts, however, describe features which clearly converge with the first level. The more typical voice clinic would rarely offer physiological investigations as a routine, and accompanying acoustic analysis would probably be even less common. Advances in microprocessor-based assessment techniques, particularly non-invasive procedures, should lead to wider availability of measurement, display, and analysis of physiological and acoustic phenomena.

In a recent study at the Royal National Throat, Nose and Ear Hospital in London it was found that the proliferation of data acquisition devices interfered significantly with the normal running of the clinic and placed greater demands on the patient than could be reasonably justified. The principal mode of investigation was by means of a flexible or rigid fibre-optic endoscope connected to a miniature videocamera. The image of the laryngeal structures could be displayed on a large monitor and was recorded by means of a video cassette recorder. The addition of a microphone greatly enhanced the procedure, but when we started to require the patient to wear laryngograph electrodes we were clearly stretching patient co-operation to its limits.

Whilst some patients approach the situation with confidence and even enthusiasm, a large number find the technology baffling and even threatening. The laryngograph electrodes are non-invasive but can be the object of considerable suspicion and concern for a patient who is already finding the endoscopy something of an ordeal. Our original intention was to employ both the laryngograph and air-flow monitoring transducers but there is no satisfactory means available at the present time that would allow air-flow measurement to occur simultaneously with the insertion of a nasoendoscope.

For the voice therapist working in a hospital clinic the detection of laryngeal vibration by means of a laryngograph, with the possible addition of air-flow measurement and acoustic analysis, can greatly enhance the initial assessment of the patient. The possibilities for recording and analysing progress as well as providing appropriate feedback are now well established. Because of limited resources in the field such facilities continue to be rare in the United Kingdom. The Voiscope (Abberton and

Fourcin 1984, Abberton, Howard and Fourcin 1989) and the IBM Phonetic Workstation (Trudgeon *et al.* 1988), provide a tangible means to achieve more objective and effective monitoring of dysphonic patients, as both provide for simultaneous recording of a range of acoustic and physiological parameters. The inclusion of techniques for analysis of the recorded data means that for the first time a voice therapist has the opportunity to base therapy on hard evidence rather than subjective impressions.

Such developments represent the achievement of a third level of physiological investigation which will provide important benefits for the patient as well as underpinning much needed research. Baken (1987) describes the full scale of the currently available armamentarium of the voice therapist. He emphasizes, however, that none of the procedures individually or in combination can achieve a diagnosis 'that can be arrived at only on the basis of all the evidence – biological, physical, psychological and social – as interpreted by a professional who is well versed in theory and has wide ranging knowledge of how speech is produced.' Damste (1983), having made considerable contributions to our knowledge of the physiological processes in phonation and pseudophonation, reminds his colleagues 'In physiology we rarely discuss feelings; it is a hazardous subject we like to avoid because emotions cannot be quantified. However, since the voice is a very direct interpreter of feelings and a show-window of emotional states, in any complete discussion of voice it is necessary to spend some time analysing the relation between feelings and voice'.

When we understand more about the interrelationship between the physiological processes underlying learning and behaviour and the complex role of the emotions we will begin to have greater insight into the process of phonation and the ways in which it can deteriorate in the dysphonic patient.

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2

The causes and classification of voice disorders

Margaret Fawcus

INTRODUCTION

The chapter titles of this book indicate the wide range of causes of voice disorder. Basically, there are three conditions in which phonation can be affected.

1. The vocal folds may show structural abnormalities.
2. The folds may appear normal at rest but may demonstrate a disturbance of movement patterns.
3. There may be no apparent organic impairment in terms of either structure or function.

These three conditions will now be considered in more detail.

1. The larynx is vulnerable to physical stress which can result in the build-up of tissue reactions (vocal nodules, contact ulcers, or non-specific laryngitis). Physical vulnerability, upper respiratory tract infection and personality factors, as well as the demands of the situation, may all combine to produce a voice disorder. Where the vocal folds fail to present smooth vibrating edges, capable of full adduction along their total length, we may expect a voice characterized by air waste and a quality which may variously be described as 'rough', 'hoarse', or 'husky'.

As indicated, such changes in the smooth appearance of the vocal folds may be a direct result of inappropriate voice use. In other cases there may be changes caused by physical trauma such as intratracheal intubation during general anaesthesia, causing haematoma or granuloma, by infection, or by benign or malignant new growths (or the tissue changes that precede them). These are initially the province of the surgeon, although speech therapy may be needed in some cases following appropriate medical or surgical treatment.

Excessive alcohol consumption, smoking, chemical irritants, certain drugs, and hormone imbalance may also lead to tissue changes in the larynx. In many cases these factors occur in combination to have an adverse effect on voice quality.

2. The structure of the vocal folds may be normal but the movement of the cords may be affected. Disturbed vocal function may be part of the dysarthrophonic syndrome (Peacher 1949), where there is a disease process of the central nervous system, affecting both articulation and phonation. The dysarthrias associated with cerebellar, extrapyramidal, lower motor neuron and bilateral cortical lesions have associated voice problems involving all aspects of voice production (see Scott and Williams, Chapter 11 of this volume).

At a peripheral level there may be interference with the nerve supply to one or both vocal folds. The most common of these is a unilateral recurrent laryngeal nerve lesion (see Stockley, Chapter 12 of this volume).

3. Voice disorders can exist in the apparent absence of any physical cause, although this may reflect the present state of the investigation procedures rather than the true state of affairs. In some of these cases, more refined techniques such as laryngeal microscopy may reveal previously unidentified physical signs. This shift of emphasis from a psychogenic to a physical cause is demonstrated very clearly in the case of spastic dysphonia (see Stoicheff, Chapter 13 of this volume).

Generally speaking, however, wherever there are no apparent signs, the dysphonia is labelled as 'functional', 'psychogenic' or even 'hysterical'. Freeman (Chapter 9 of this volume) has indicated the complexities of the situation and the need for a careful evaluation of the variables involved. Despite the increasing sophistication in our approach to these functional voice disorders, one can still receive a referral which states: 'This lady has a tensor weakness of the larynx with no evidence of local lesion. I have explained that this is an emotional problem. . . .'

There are two other areas where the client has a normal voice mechanism but the voice is perceived as abnormal: in cases of significant hearing loss and in transsexualism. Increasing interest has developed in recent years in the indirect but often very marked effects of profound hearing loss for the frequencies of voice production (see Wirz, Chapter 14 of this volume). The speaker has a *potential* for normal voice production which is never realized due to his severely impaired auditory feedback mechanism and, in the case of acquired profound hearing loss, the continuous auditory monitoring that enables us to maintain consistent and appropriate intensity, pitch, and intonation patterns.

In the case of the transsexual (see Chaloner, Chapter 16 of this volume), we may indeed challenge the concept of a voice *disorder*, since the vocal pitch (the only aspect of voice with which the transsexual is normally concerned) may be entirely in keeping with the physical constraints of the laryngeal structure. There is, however, a mismatch between the modal range and the desired gender which the transsexual wishes to convey.

We must now consider what we mean by a voice disorder, and examine the ways in which interested speech therapists, laryngologists, and phoniatrists have attempted to classify the aphonias and dysphonias.

'A voice disorder exists,' says Aronson (1980) 'when quality, pitch, loudness or flexibility differs from the voice of others of similar age, sex, and cultural group.' It is on variants of these four perceived parameters of voice production that the listener judges the normality or otherwise of the voice he hears. Aronson considers that these judgements are made in relation to the listener's expectations regarding sex and age within a given cultural group. We must also consider the listener's individual preferences and biases, and his level of awareness of how voices sound and the differences between them. There is a continuum extending from the voice that is clear and audible to one which is unmistakably dysphonic.

Different listeners, asked to make a judgement about a speaker's voice, will not always place that voice at the same point on the continuum. For one listener, a voice may be acceptably 'normal', while for another judge the same voice may be noted as frankly abnormal. Wynter (1974) has emphasized the subjectivity of listeners' judgements, which has given rise to a confusing variety of terms to describe voices quality. 'Typically they are based on subjective auditory judgements rather than on objective observations of vocal function' (Reed 1980).

Rather little is known about the prevalence of voice disorder, and any figures available must be regarded with some caution: not all speakers with a hoarse voice would regard it as pathological, and would therefore not seek medical advice. Dysphonia may be regarded as a problem only if it causes discomfort or interferes in some way with their life style. We do, however, know rather more about the relative prevalence of the different causes of voice disorder (see Evans, Chapter 20). Herrington-Hall *et al.* (1988) carried out a retrospective study of 1262 patients seen by eight otolaryngologists over a two-year period. The total population was approximately 2.3 million. The purpose of the investigation was to look at the occurrence of laryngeal pathologies across three variables: sex, age, and occupation. They also looked at the residential environment of the patient population (rural or city).

Herrington-Hall *et al.* identified 22 laryngeal pathologies (Table 2.1). Of these the most common was vocal nodules (21%) followed by oedema (14%), polyps (11.4%), carcinoma (9.7%), vocal fold paralysis (8.1%), and dysphonia with no apparent pathology (7.9%).

Table 2.1 The prevalence of laryngeal pathologies and their percentage of occurrence

Total number (1262)	*n*	%	*Cincinnati (580)*	*n*	%	*Dayton (578)*	*n*	%	*Small town/ rural (104)*	*n*	%
Nodules	272	21.6	Nodules	110	19.0	Nodules	147	25.4	Normal on exam	41	39.4
Oedema	179	14.1	Oedema	97	16.7	Cancer	90	15.6	Nodules	15	14.4
Polyps	144	11.4	Vocal-fold paralysis	59	10.2	Polyps	86	14.9	Oedema	10	9.6
Cancer	122	9.7	Polyps	53	9.1	Oedema	72	12.4	Leukoplakia	8	7.7
Vocal-fold paralysis	102	8.1	Laryngitis	40	6.9	Vocal-fold paralysis	41	7.0	Polyps	5	4.8
Normal on exam	100	7.9	Leukoplakia	37	6.4	Normal on exam	28	4.8	Functional	4	3.8
Laryngitis	53	4.2	Normal on exam	31	5.3	Functional	16	2.7	Papilloma	4	3.8
Leukoplakia	52	4.1	Cancer	29	5.0	Vocal-fold paresis	11	1.9	Granuloma	3	2.9
Psychogenic	34	2.6	Psychogenic	22	3.8	Bowed vocal fold	11	1.9	Cancer	3	2.9
Functional	31	2.4	Bowed vocal folds	19	3.3	Hyperkeratosis	11	1.9	Laryngitis	3	2.9
Bowed vocal folds	30	2.4	Neurogenic	11	1.9	Laryngitis	10	1.7	Vocal-fold paralysis	2	1.9
Neurogenic	18	1.4	Functional	11	1.9	Psychogenic	10	1.7	Cyst	2	1.9
Hyperkeratosis	16	1.2	Laryngeal trauma	11	1.9	Leukoplakia	7	1.3	Psychogenic	2	1.9
Papilloma	15	1.2	Ventricular phonation	9	1.5	Neurogenic	7	1.3	Vocal-fold paresis	1	0.9
Ventricular phonation	15	1.2	Contact ulcer	9	1.5	Stenosis	6	1.0	Contact ulcer	1	0.9
Contact ulcer	14	1.1	Cyst	7	1.2	Papilloma	6	1.0			
Vocal-fold paresis	12	1.0	Granuloma	5	0.9	Ventricular phonation	6	1.0			
Granuloma	12	1.0	Papilloma	5	0.9	Granuloma	4	0.7			
Cyst	12	1.0	Hyperkeratosis	5	0.9	Contact ulcer	4	0.7			
Laryngeal trauma	11	0.9	Spastic dysphonia	5	0.9	Cyst	3	0.5			
Spastic dysphonia	7	0.5	Cricoarytenoid arthritis	4	0.6	Spastic dysphonia	2	0.3			
Stenosis	6	0.5	Hormonal	1	0.2						
Cricoarytenoid arthritis	4	0.3									
Hormonal	1	0.07									

Table 2.2 Distribution of laryngeal pathologies across age groups for the total sample and for males and females separately

	0–14 years			*15–24 years*			*25–44 years*			*45–64 years*			*Over 64 years*		
	Total	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*	*Male*	*Female*
Nodules	74	54	20	35	2	33	103	26	77	51	12	39	9	2	7
Oedema	5	3	2	17	8	9	67	29	38	57	21	36	33	15	18
Polyps	3	2	1	8	5	3	46	16	30	61	24	37	26	6	20
Cancer							2		2	60	46	14	60	46	14
Vocal-fold paralysis	2	1	1	3	2	1	13	7	6	39	15	24	44	22	22
Normal on exam	4	2	2	7	4	3	27	11	16	42	11	31	20	7	13
Laryngitis	1	1		4	1	3	21	7	14	17	7	10	10	4	6
Leukoplakia				2	2		14	7	7	29	22	7	7	6	1
Functional	2	1	1	2	2		9	2	7	11	3	8	7	3	4
Psychogenic				3	2	1	18	2	16	9		9	4	1	3
Bowed vocal folds				1		1	2		2	7	3	4	20	15	5
Neurogenic							1		1	4	3	1	13	5	8
Hyperkeratosis							3	3		7	6	1	6	5	1
Papilloma				2		2	6	6		7	3	4			
Ventricular phonation	1	1		2		2	2		2	7	2	5	3		3
Contact ulcer							7	4	3	4	2	2	3		3
Vocal-fold paresis				1		1	2		2	2		2	7	4	3
Granuloma				2		2	3	1	2	5	3	2	2		2
Cyst							2	1	1	5	3	2	5	3	2
Laryngeal trauma				4	4		4	4		2	1	1	1		1
Spastic dysphonia							4	2	2	3	1	2			
Stenosis	1	1								4	1	3	1		1
Cricoarytenoid arthritis										2	1	1	3	2	1
Hormonal													1		1
Total	93	66	27	93	32	61	356	128	228	435	190	245	285	146	139

In taking the variable of age into account, it is clear that laryngeal pathologies occur most frequently in the older age group (carcinoma and vocal-fold paralysis being the most commonly found causes of vocal dysfunction in the elderly). Females presented with laryngeal pathologies at a slightly younger age. In the total population, nodules and oedema were more common in early adulthood (25–44 years), with polyps and dysphonia with a normal larynx occurring in middle age (45–64 years) (Table 2.2).

It is interesting, but not altogether surprising, that nodules occur most frequently in males under the age of 14 years when we might well expect abusive vocal behaviour (ratio of males to females was 2.7:1). In contrast, nodules and oedema are found most commonly in females between the ages of 25 and 44 years. This is a period when many women are raising young children, and may also be facing the additional demands of being working mothers. Psychogenic voice disorders, perhaps for some of the same reasons, also showed an increased incidence in early adulthood.

When Herrington-Hall *et al.* looked at the influence of occupation, they found that the presence of laryngeal pathologies tended to reflect both the amount of voice use and the conditions under which voice was used (including noise and stress). Of the 73 occupations identified in the study, the ten most frequent were retired persons, homemakers, executives/managers, teachers, students, secretaries, singers, and nurses. Since we generally regard professional voice users as at risk of voice disorders, some of these occupations may seem surprising. The retired group are normally the elderly group, and we have already seen that laryngeal problems are more common in the ageing population, although the rarity of vocal nodules suggests that vocal abuse is seldom a cause of voice disorder in the elderly. Homemakers may be coping with a number of sources of anxiety and stress and, as Herrington-Hall *et al.* have pointed out, many more women are now working and therefore face additional pressures and responsibilities. We may therefore assume quite a complex of factors in any client described as a 'homemaker'. Eighty-five per cent of voice disorders described as 'psychogenic' occurred in women. Herrington-Hall *et al.*, in surveying a number of previous studies, noted a marked increase in the number of women presenting with voice disorders. Whilst this may be related to changes in life-style and the increased number of women now working, Herrington-Hall *et al.* mention studies showing that women are now more aware than men of the need for health care and may therefore be referring themselves for a medical opinion of their voice problems.

It is inevitable that problems occur in devising a satisfactory classification of voice disorders, because they so often represent the culmination of a number of predisposing, precipitating and maintaining factors. Perkins (1971) has commented that we are 'mired in a terminological swamp, with terms whose lineage is physiological, anatomical, acoustical and psychological.' While most writers are agreed that there is a need to strive for a greater objectivity, we must remember that descriptive labels may be important and meaningful to the voice user himself. As Thurman (1977) observes, the client's own terms may be inaccurate and difficult to define, but they may have more relationship to what he is doing vocally than the usual professional terms: 'The clinician should pick up the terms the client uses and attempt to identify the problem as the client sees it and to relate it to normal voice production.'

Dysphonia, Aronson (1980) reminds us, is a disorder of communication and has 'personal, social and economic significance.' In judging the normality of voice he poses the following questions:

1. Is the voice adequate to carry language intelligibly to the listener?
2. Are its acoustic properties aesthetically acceptable?
3. Does it satisfy its owner's occupational and social requirements?

The answers to these questions provide an effective way of judging, in the first place, whether the patient actually has a voice problem, and secondly, in helping us to evaluate the efficacy of our remedial procedures.

There is, however, one further dimension of voice disorders that has received scant attention in the literature: how does the voice *feel* to the patient? The degree of discomfort experienced is a vital and sensitive barometer of the condition of the larynx and the state of voice use. However normal the voice may sound to the therapist, or to anyone else for that matter, if it does not feel comfortable to the patient then we have failed in our task of vocal remediation. *Absence* of physical awareness of the voice is the target to be achieved.

Before considering some of the ways in which voice has been classified, we must remember that labels may be applied at a number of different levels. Brackett (1971) has discussed this problem in a very comprehensive contribution on the parameters of voice quality. Much will depend on who is applying the label: the patient describing his problem, the laryngologist reporting on the appearance or movement of the vocal folds, the therapist noting the perceived symptoms, or the physicist measuring certain acoustic phenomena of voice production. In other words, are we making some sort of classification on the acoustic, anatomical, physiological, or psychological correlates of voice disorder? As Brackett says, 'the nature of the disorder remains the same, although different labels may have been used in its descriptions.'

CLASSIFICATION BASED ON ACOUSTIC PHENOMENA

Wilson (1979) has observed that voice problems are 'traditionally' classified under the *aspect* of voice affected (quality, loudness and pitch problems). While this is a useful and apparently simple form of classification, we are immediately faced with the fact that in the majority of dysphonic patients all aspects of voice production are affected.

As Van Riper and Irwin (1958) observe, 'seldom does the abnormal variation exist along one dimension of voice alone.' Classically, the dysphonic voice is weak in intensity, restricted in pitch and 'hoarse' or 'husky' in quality. While we may encounter conditions where a single feature of voice is affected, such as the level of intensity in the early stages of Parkinson's disease, these cases are relatively uncommon. Furthermore, such a classification does not tell us all we need to know about the causes underlying the disturbed acoustic features. There are, of course, exceptions: the overloud voice in an elderly person may suggest a fairly marked degree of presbycousis, and persistent monotony may be associated with depression. Such exceptions are scarcely sufficient to justify the use of a classification system which is more appropriate as an assessment tool.

The majority of voice cases present as 'weak', 'hoarse', or 'husky' (or whatever we may choose to apply in place of these terms) and demonstrate a disorder along all parameters. It is also important to consider those cases who are referred with a voice that appears essentially normal, but where the problem may be one of vocal fatigue and discomfort, with as yet little effect on the way the voice *sounds*.

When we examine the many terms used to describe voice quality there are three that occur most frequently: harsh, hoarse, and breathy. While they represent an essentially subjective judgement of voice, there does appear to be surprising agreement in their use.

The term 'breathy' implies that there is a degree of air waste during phonation. Moore (1971) described the breathy voice as a combination of vocal fold sound and whisper noise produced by turbulent air. 'The quality of the breathy voice,' he says, 'varies over a wide range that is determined by the ratio of breath noise to phonatory sound.' Air waste occurs when there is incomplete adduction of the vocal folds, which may have an organic cause (bowing of the cords or vocal nodules), or may be a habitual pattern of voice in the absence of organic changes.

The harsh voice, by contrast, implies that the vocal folds are adducting normally, but that the speaker is employing excessive tension. A synonym for harsh is strident, again a term that occurs frequently in the literature. Van Riper and Irwin (1958) state categorically that the essential feature of the harsh voice is tension. They quote a study by Brackett (1971) in which inflammation of the vocal folds was achieved experimentally by the deliberate use of harsh voice. They state that the intensity of the harsh voice appears louder than normal, but consider that this may result from the effect on resonance of tension in the oral and pharyngeal cavities. It is commonly characterized by a hard glottal attack. Brackett (1971) has described this as hypervalvular phonation '. . . the vocal folds strike each other vigorously at the beginning of the closed phase and separate violently when the opening phase is initiated.' In addition, 'the vocal folds offer increased resistance to air flow with subsequent increase in subglottal air pressure'. The harsh voice has been described as generally lower in pitch than normal. Bowler's (1964) study found a mean fundamental frequency of 94 Hz for harsh voices compared to 127 Hz for normal adult male voices.

Depending on the physical vulnerability of the vocal folds, such habitual vocal misuse may eventually lead to tissue changes of chronic laryngitis, vocal nodules, or contact ulcers. The therapist hearing a voice which has this harsh, strident quality is alert to the risk of vocal abuse, particularly if the patient complains of vocal discomfort after voice use, or periods of vocal weakness and pitch breaks.

The majority of dysphonic voices, however, present as 'hoarse' and this is the label most often encountered. Wilson (1979) states that 'hoarseness in its simplest definition is a combination of harshness and breathiness, with the harsh element predominating in some hoarse voices and the breathy element in others.' In addition to the turbulence created by air waste, there is also an aperiodicity of fundamental frequency. Van Riper and Irwin (1958) describe an experiment in which a husky (breathy) and a harsh voice were blended in simultaneous recording of the same sentence. Eight of the ten judges listening to the resultant recording described the voice as hoarse. The tension present in hoarse phonation may represent the patient's physical effort to compensate for a weak, breathy voice. In some cases this tension may represent a long-term pattern of vocal behaviour (hyperfunction) which resulted in a weak (hypofunctional) voice (Brodnitz, 1959). On the other hand, tension may have been of more recent origin – for example, occurring after an attack of acute laryngitis, where the patient was trying to make himself heard. Boone (1977) wrote of these 'temporary laryngeal changes which cause compensatory vocal behaviours that persist and become the individual's particular *set* for subsequent vocal behaviour.'

As we have already said, one important constraint of a classification based on perceptual factors is the limited information it offers about the condition of the larynx in terms of muscle movement and tissue change, and the causes of the voice disorder. Clearly we have to look elsewhere for a more satisfactory classification, leaving the areas of pitch, intensity, intonation, and quality to be the focus of careful assessment and evaluation.

THE FUNCTIONAL VERSUS ORGANIC DICHOTOMY

The classical approach to classification is the broad one of a functional versus organic dichotomy, but as Van Riper and Irwin (1958) comment, 'both organic and functional factors are often present and it is difficult or impossible to weigh their influence properly.' Aronson (1980), who gives a comprehensive survey of organic voice disorders, describes the cause as organic 'if it is caused by structural (anatomic) or physiologic disease, either a disease in the larynx itself or remote systemic illnesses which impair laryngeal structure or function.' Brackett (1971), in discussing some of the theoretical difficulties involved in using such a classification, makes three important points: in the first place, a speech structure may be used in a variety of ways and therefore we may use the normal voice mechanism to produce a number of different acoustic effects; secondly, the way in which a structure is used may have an effect on that structure – it is well documented that hyperfunctional voice use leads to vocal nodules, inflammation, and oedema; thirdly, certain structural anomalies, such as laryngeal web, will place constraints on voice use. 'Present understanding,' says Brackett, 'does not permit a clear differentiation between the two terms functional and organic since both the condition and the use of the structure are determinants in the assessment of the disorder.'

The condition of vocal nodules is a very clear example of the oversimplification which the organic/functional dichotomy represents. The essential element in the development of nodules is the manner in which the patient is using his voice. Van Riper and Irwin (1958) provide a graphic picture of the 'repeated impact of highly tensed vocal cords hitting each other under conditions of excessive strain' which eventually leads to a tissue reaction in the epithelium of the larynx. It is these organic changes, in the form of small, bilateral, localized fibrous growths, that prevent full adduction of the free edges of the vocal folds, and result in a voice characterized by air waste, and, in most cases, by the hoarse quality that indicates the excessive effort the patient is making to overcome the vocal weakness. The organic problem is indeed having its effect on the voice, but initially it was the way in which the vocal mechanism was used which created the organic condition. This same patient may experience considerable anxiety about his dysphonic voice and its effect on his career or social activities. This can lead to still further localized or generalized tension. He may try to compensate for his weak voice by making greater vocal efforts, which inevitably lead to a worsening of the organic condition. This illustrates the complex interaction between functional and organic factors, and underlines the essential limitations involved in using this form of classification. As Wilson (1979) says, 'the continuum [between organic and functional] is a two-way path because a pathology can result in a poorly functioning mechanism, or a poorly functioning mechanism can result in organic changes or an organic condition.'

This brings us to a more careful consideration of the term functional. Brackett (1971) says that functional applies to the physiology or use of the structures in attaining particular objectives. Aronson (1980) takes a very different view in claiming that functional is a synonym for psychogenic, and that psychogenic voice disorders are caused by psychoneuroses, personality disorders, and faulty habits of voice use. The voice is abnormal 'despite normal anatomy and physiology'. Wilson (1979) uses 'functional' as an umbrella term to include both vocal misuse and emotional disturbances.

In using the word 'functional' in clinical practice, it is clearly important that we define our meaning. For many speech pathologists, the term implies a psychogenic voice disorder, in the apparent absence of vocal misuse. However, the concept of 'vocal misuse and abuse' (Van Thal, 1961) may also be properly regarded as a functional problem. It is obviously essential, in the management of voice disorders, to be clear what we mean by the term. To complicate the issue still further, functional is frequently used synonymously with hysterical, but as Van Thal observed, 'strictly speaking, hysterical aphonia is one form of functional voice disorder, and not all functional disorders are hysterical.'

The fact that the term hysterical is mentioned rather rarely in current literature on dysphonia, reflects a considerable shift in the appraisal of functional voice disorders and the changing attitudes on the subject of hysteria. It is interesting to note, for example, that Greene (1980) in the first edition of *The Voice and its Disorders*, wrote a chapter on 'Hysterical aphonia and dysphonia' (1964). In the third and fourth editions of the same book, the chapter is retitled 'Psychogenic disorders: anxiety and hysterical states.' Such changes in terminology represent a more careful approach to factors underlying so-called functional voice disorders.

It is unfortunate that the term 'hysterical' should still be applied by therapists and ENT surgeons, with all its negative implications and connections. Luchsinger and Arnold (1965) suggest that it is better to avoid the term hysterical 'because of its derogatory characterological and sociological connotations.' It is all too easy to label a condition as 'neurotic' or 'hysterical' when it fails to respond to traditional treatment methods. Three or four decades ago, there was a parallel in the 'neurotic' lisp (lateral sigmatism). This form of articulatory deviation was labelled as a symptom of neuroticism in the absence of any evidence more convincing than the difficulties encountered in trying to correct the error sound (neurotic resistance!), and perhaps because the aesthetic qualities of lateral substitutions tend to provoke negative reactions in the listener. Very few therapists at the time possessed the necessary expertise to evaluate the oral morphology and motor abilities of the child, or the knowledge of skills acquisition which might have made their intervention programme more effective. We have seen the same changes taking place in stuttering, which is now seldom regarded as a primary neurosis. Conditions that fail to respond to treatment create anxiety in the therapist, and it is easy to understand how failures came to be blamed on concepts such as secondary gain and hysterical states. There are undoubtedly parallels here in voice therapy – we need to develop our understanding of vocal behaviour and improve our expertise in both the assessment of voice disorder and in the evaluation of the many variables which tend to predispose, precipitate, and maintain it.

We have seen that the terms 'functional', 'psychogenic' and 'hysterical' have been used synonymously, and have been applied to those patients who exhibit a voice problem in the absence of any apparent organic symptoms on indirect or direct laryngoscopy. The use of the word 'apparent' is important: as Freeman (Chapter 9 of this volume) has stressed, increased knowledge of laryngeal function and the physical effects of stress have made us aware of the need to investigate for hitherto unexpected causes of laryngeal dysfunctions.

We know, for example, that dysphonia (manifest by a lowering of pitch and a roughness of quality) is an early symptom of hypothyroidism, which may be overlooked on laryngeal examination. Damsté (1967) has warned that the administration of androgens and anabolic steroids can result in vocal symptoms, such as 'unsteadiness of timbre', before changes are revealed by laryngoscopy or even stroboscopic examination. In a four-year period (1962–66) 10% of women referred to the ENT clinic at the University of Utrecht had disturbances of vocal function due to virilizing agents. It is not difficult to imagine that a label of psychogenic dysphonia could easily be applied to a group of menopausal women, with all the domestic and emotional problems associated with middle age! So the therapist must be aware of possible discreet physical changes which are not visible on what may have been a superficial examination (for example, indirect laryngoscopy of a patient whose larynx has been difficult to view).

In summary, functional is an umbrella term which can be used to describe a number of vocal behaviours.

1. It can refer to those cases where abuse and misuse of the vocal mechanism is clearly indicated.

2. We may propose that it is used for all 'learned' patterns of maladaptive vocal behaviour (for example, a compensatory mode of voice production which develops during a period of acute infective laryngitis).
3. The umbrella must be large enough to cover an apparently psychogenic cause where there is a cumulative history of emotional stress and tension, but the patient does not present with a recent history of vocal-fold pathology or evidence of misuse. Sudden onset can be associated with emotionally traumatic events.

We might further divide such apparently psychogenic cases into two groups.

1. Patients who present with a (sometimes long) history of psychosomatic conditions and a positive psychiatric history, who seem to be particularly vulnerable to physical and emotional stress.
2. Patients who appear to have a stable personality, and an absence of psychiatric history, but where the voice problem is a reaction to prolonged and increasing stress and tension in their domestic or work environment.

It is not within the scope of this chapter to discuss the possible mechanism of sudden or even more gradual voice loss in psychogenic voice disorder, or to consider the personality and physical variables involved in response to stress. It is obvious, however, that we need to be very clear in our own mind what we mean when we describe a voice case as functional, since this will inevitably have considerable implications for treatment. Quite apart from the problems involved in obtaining appropriate and effective psychiatric treatment, many patients would be distressed or defensive about such a referral. We must therefore be sure that we are not dealing with a case where careful management in terms of environmental modification, counselling, and vocal remediation by the therapist is not the more appropriate course of action.

It has been demonstrated that the functional/organic dichotomy is not an entirely satisfactory form of classification. As Murphy (1964) said, they represent 'an untenable dichotomy'. He went on to say, however, that it is a convenient classification despite the imprecision of the terms, since most therapists recognize that in many functional cases subtle organic factors exist, and that in most, if not all, organic cases functional factors can be found.

Figure 2.1 may help us to view this interaction more clearly and enable us to examine a patient's voice problem at any point on the triangle. With this concept of a triangle in which organic processes, misuse and abuse, and psychogenic factors interact, we may establish a kind of 'flow-chart'

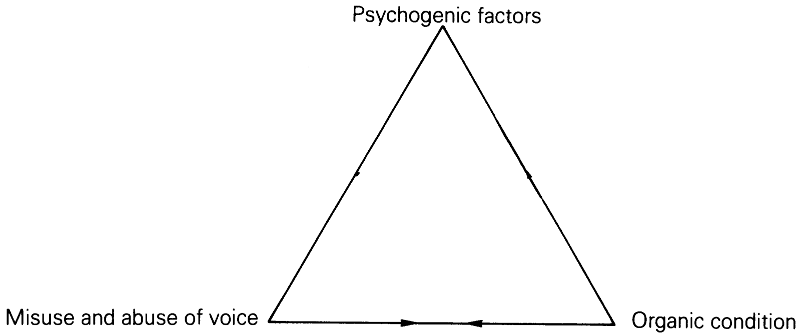

Figure 2.1 The interaction of aetiological factors.

which may aid our understanding of the several predisposing, precipitating and maintaining factors in all cases of dysphonia.

Greene and Mathieson (1989) have proposed an interesting and useful alternative to the organic/functional dichotomy by classifying voice disorders under the headings behavioural and organic. Changes in the laryngeal mucosa resulting from hyperfunctional voice use (e.g. vocal nodules and contact ulcers) are grouped within the behavioural category. Organic conditions are grouped under the four headings of structural abnomalities, neurological conditions, endocrine disorders, and laryngeal disease (Table 2.3). Greene and Mathieson stress, however, that whilst the classification is conveniently tidy, the clinical reality is likely to be more complex. Nonetheless, their classification is appealingly simple for the voice clinician.

HYPERFUNCTIONAL AND HYPOFUNCTIONAL VOICE USE

Some attempts have been made to classify voice on a continuum of overadduction or underadduction. Greene (1980) prefers the term hyperkinetic which she equates with vocal strain. Brackett (1971) introduces the concept of hypovalvular and hypervalvular phonation, which can clearly be used synonymously with hyperfunctional and hypofunctional and hyperkinetic and hypokinetic. He describes optimal laryngeal valving as a degree of valving which 'offers sufficient resistance to air flow to accomplish unhampered vibrations of the vocal folds at the desired intensity for speech.'

Luchsinger and Arnold (1965) use the term hypokinetic to describe inefficient laryngeal movements, 'reflecting the passive breakdown of laryngeal function.' Hyperkinetic refers to excessive laryngeal movements, which 'express the subconscious, aggressive protest of the patient

Table 2.3 Classification of voice disorder

Behavioural	*Organic*
1. *Excessive muscular tension* No changes in laryngeal mucosa 2. *Excessive muscular tension – changes in laryngeal mucosa* Vocal nodules Chronic laryngitis Oedema Polyps Contact ulcers 3. *Psychogenic* Anxiety state Neurosis Conversion symptoms Delayed pubertal voice change (puberphonia) Transsexual conflict	1. *Structural abnormalities* Laryngeal web Cleft palate Nasal obstruction Trauma 2. *Neurological conditions* Recurrent laryngeal nerve paralysis Pseudobulbar palsy Bulbar palsy Cerebellar ataxia Tremor Parkinsonism Chorea Athetosis Apraxia Multiple lesions, e.g. motor neuron disease, multiple scerosis 3. *Endocrinological disorders* Thyrotoxicosis Myxoedema Male sexual mutational retardation Female virilization due to adverse hormone therapy Adverse drug therapy 4. *Laryngeal disease* Tumour – benign/malignant Hyperkeratosis Papillomatosis Cyst Laryngitis – acute/chronic Cricoarytenoid arthritis Granuloma Fungal infection

against the difficulties encountered in his life.' They view both these problems as dysphonias of psychogenic origin.

Aronson (1980) uses the term kinesiologic for this form of classification, and comments that although this idea is not without merit, if used exclusively it 'oversimplifies the complexities of the laryngeal pathologies, placing excess emphasis on the degree of appropriation of the vocal edges rather than on the multiple causes of such approximation defects.'

THE AETIOLOGICAL CLASSIFICATION OF VOICE DISORDERS

A classification that looks at the causes of voice disorder 'encourages the deepest understanding of dysphonia or aphonia' (Aronson, 1980). Such a form of classification, based on the physical condition of the larynx, tends to have been developed by laryngologists. It implies the need for a careful investigation of the physical factors that may be involved, embodying such diverse disciplines as otolaryngology, neurology, and endocrinology. Indeed, while referrals normally come via the ENT department, both surgeons and speech therapists need to be alert to the possibility of both endocrine and neurological pathology as causative factors. Freeman (see Chapter 9 of this volume) emphasized that apparent absence of observable signs cannot always be assumed to indicate a psychogenic voice disorder.

Simpson's (1971) classification of voice disorders is given by Evans (Chapter 20 of this volume) and will therefore not be detailed here. It provides a systematic and comprehensive framework for the study of voice disorders and has clearly facilitated co-operation between laryngologists and speech therapists. Simpson wrote that 'dysphonia in the absence of gross laryngeal pathology has in the past received scant attention from the orthodox laryngologist, whose very training has concentrated his interest on gross pathology and life-threatening disease.' Such a statement has been less true in other parts of Europe, with emergence of the specialist area of medicine known as phoniatrics. Most, but not all, phoniatrists were originally otolaryngologists with a special interest in voice.

Luchsinger and Arnold (1965) give the following system of classification:

1. dysplastic dysphonia: voice disorders of constitutional origin;
2. vocal nodules and polyps: primary dysphonia and secondary laryngitis;
3. endocrine dysphonia: vocal disorders of endocrine origin;
4. paralytic dysphonia: vocal disorders from laryngeal paralysis;
5. dysarthric dysphonia: vocal disorders of central origin;
6. myopathic dysphonia: vocal disorders of myopathic origin;
7. the influence of neurovegetative system on the voice (in which they included vasomotor monochorditis and contact ulcers);
8. traumatic dysphonia: vocal disorders following laryngeal injury;

9. alaryngeal dysphonia: voice without larynx;
10. habitual dysphonia: vocal disorder of habitual origin;
11. psychogenic dysphonia: vocal disorders of emotional origin.

Aronson's aetiology of voice disorders is broken down under three main headings: organic, psychogenic, and those of indeterminate aetiology (under which he wisely places spastic dysphonia!). Under the organic heading he lists the following causes:

congenital disorders
inflammation
tumours
endocrine disorders
trauma
neurological disease.

The psychogenic voice disorders are listed as follows:

emotional stress – musculoskeletal tension;
voice disorders without the secondary laryngeal pathology;
voice disorders with secondary laryngeal pathology (vocal nodules and contact ulcer);
psychoneurosis;
conversion reaction – mutism, aphonia, and dysphonia;
psychosocial conflict – mutational falsetto (puberphonia), dysphonias associated with conflict of sex identification;
iatrogenic.

His classification of psychogenic voice disorders tends to assume causes which may not be demonstrated so easily – puberphonia may have a number of causes, and psychosocial conflict is not necessarily one of them! Not everyone would accept that hyperfunctional voice use should be classified as psychogenic. Aronson's classification remains, however, a useful and simple way of classifying voice disorders, devised by an experienced speech pathologist.

The aetiological classification attempts to locate the precise area of breakdown in the vocal mechanism, and the cause of that breakdown. It is the most essential aspect of assessment of vocal dysfunction, since we may find that there is a condition which requires medical and surgical treatment. Management of the voice disorder may therefore be irrelevant in some cases, or follows only after appropriate treatment from a laryngologist or endocrinologist.

CONCLUSIONS

Perhaps we have worried too much about getting the words right. Finally it is the patient, and those who have to listen to him or her, who will judge whether the voice is normal or not, whatever the 'experts' may say about the matter. The experts, however, continue to discuss the problem of describing voices, and continue to search for a more satisfactory way of doing so. We have seen that it is possible to look at voice disorders in a number of different ways: happily these are not mutually exclusive and each one may yield not only different information about the voice disorder but also a different way of looking at it. Perceptually we may describe the acoustic features of voice production in terms of pitch, intonation, intensity and quality; we recognize the variables involved in the development of voice disorders by attempting to describe the cause as functional or organic; the concept of underadduction or overadduction indicates the degree of tension involved, which has important implications for treatment procedures; and finally, it is the larynogologist and other medical specialists who give us a precise account of what is wrong (if anything) with the condition of the larynx and provide an essential opportunity to assess the efficacy of our treatment.

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3

Assessment of the dysphonic patient

Margaret Gordon

INTRODUCTION

Dysphonia is usually the first and most obvious symptom of laryngeal disease, but may also occur in a variety of disorders where vocal dysfunction is a secondary feature resulting from abnormality of the respiratory, nervous, endocrine, or psychological systems and, in many cases, with no organic disease present. Most dysphonias of short duration are of simple inflammatory origin caused by viral or, less commonly, bacterial infection and do not justify formal investigation and assessment, but where the main symptom of hoarseness persists for no apparent reason, expert opinion must be sought without delay to exclude serious pathology or permit its early treatment.

This usually means that the patient is referred to an otolaryngologist as it is essential that the larynx should be examined visually to exclude inherent disease of the vocal cords, or other evidence of organic malfunction. Where no disease that requires surgical intervention or medical treatment is found, the case is usually left in the hands of the speech therapist who assesses the functional disorder and is responsible for subsequent management and treatment. However, many hospitals in the United Kingdom now operate joint consultative dysphonia clinics using the combined expertise of a laryngologist and speech therapist, requesting assistance from a neurologist, endocrinologist, or psychologist when appropriate, perhaps as signs and symptoms of the underlying disease develop or become modified with time (Simpson 1971).

The laryngologist has, in general, received a training in his surgico-pathological specialty, which concentrates attention on gross pathology and life-threatening disease. The importance of dysphonia to him is essentially its value as an indicator to laryngeal and associated pathology, but the study of laryngeal physiology and its dysfunction has not been regarded as within the purview of the orthodox specialty other than simple referral of the case for speech therapy.

The speech therapist, with a multidisciplinary training which includes the study of pathology, physiology, linguistics, acoustics and psychology, is uniquely qualified not only to assess the functional disorder, while being aware of the pathological aspect of the dysphonia, but also to describe and grade the various characteristics of the perceived voice for the purpose of planning future management, as well as judging the results of treatment.

Most speech therapy clinics rely upon a purely subjective method for the description and assessment of dysphonia and in the hands of experienced therapists, using the same criteria, the results are surprisingly reliable and reproduceable, given the inexact terms such as 'harsh', 'breathy' and 'asthenic', which are open to different interpretation in character and degree (Kelman *et al.* 1981).

A few specialist clinics supplement traditional assessment with precise physiological and acoustical measurement techniques to investigate the various components of the dysphonic voice, allowing the clinical syndrome of dysphonia to be defined in terms of altered laryngeal or association function. Thus, the dysphonic voice can be analysed in terms of physical parameters which can be measured repeatedly and their validity subjected to the scrutiny of statistical examination. Serial measurements can be compared as an indication of progress or the lack of it in treatment.

Assessment of the dysphonic voice must therefore begin with clinical examination of the larynx and proceed to a full investigation of the presenting symptom with a history of the disorder, psychological evaluation of the patient where appropriate, subjective description and appreciation of the method of voice production, and scientific measurement of functional performance.

METHODS OF LARYNGEAL EXAMINATION

All methods of laryngoscopy allow good visualization of the larynx at rest, given a co-operative patient without gross congenital or acquired structural defects that might interfere with instrumentation, and all permit the ready detection of laryngeal pathology. Some of the methods can be used during laryngeal action, so allowing visual evaluation of phonatory function during selected phonation or continuous speech, and are thus of greater value for the detection of physiological dysfunction in the absence of gross pathology.

Indirect laryngoscopy

The standard clinical examination is by indirect laryngoscopy. This requires a round laryngeal mirror of about 21–25 mm diameter, angled on a long, slender handle, and a bright light source, which can be a light worn by the laryngologist on his forehead or more usually, an external light on a movable stand, which shines on to a head mirror worn by the laryngologist.

The patient is seated on a low stool opposite to and at the same level as the laryngologist. If the patient wears dentures these must first be removed. The patient is then instructed to open his mouth and protrude his tongue, which is covered by a swab and held by the surgeon. The mirror, warmed sufficiently to avoid condensation but not uncomfortably hot, is introduced into the patient's mouth and pressed gently but firmly against the soft palate elevating it to improve the view of the larynx. Light is directed via the head mirror onto the laryngeal mirror, illuminating it, and the laryngeal mirror can be manoeuvred to reflect the different structures of the larynx. The vocal folds are viewed in the abducted position during respiration and also when adducted during phonation of the vowel 'ee'. If the patient shows undue signs of discomfort, or a tendency to repeatedly gag, a Xylocaine spray can be used to anaesthetize the tongue and pharynx.

Gross abnormalities are readily identified by this means but, as the folds vibrate rapidly in phonation in the approximate range of 100–160 Hz for males and 220–290 Hz for females, the often associated inherent disorders of laryngeal function are not easily detected. Secondary functional disorders arising from abnormalities in tension or deficiency of respiratory support may go unrecognized if vocal-fold movement cannot be studied in sufficient detail to allow visualization of all phases of the glottic explosion. This is clearly impossible using continuous lighting but can be achieved if only a stroboscopic light source is employed.

Stroboscopic indirect laryngoscopy

The use of a voice-synchronized stroboscope as a light source for indirect laryngoscopy allows detailed scrutiny of the larynx. This enables detection of even slight abnormalities in structure or vibratory pattern by employing the optical illusion of slow motion or even the apparent stopping of the folds during phonation, so that all phases of the glottic explosion can be studied in detail.

The stroboscope works on the principle that an object moving rapidly and periodically is illuminated by an intermittent light with the same periodicity so that both are synchronous. Thus the object is illuminated at the same point in its trajectory on each flash and the eye cannot detect the movement, so the object appears to be stationary.

By synchronizing the light flash with the frequency of vibration of the vocal folds, the cords appear to be standing still. The moment of lighting can be changed in relation to the phase of glottic explosion and the cords examined serially throughout the period of a single vibratory cycle.

If the frequency of the intermittent illumination is then changed so that it is no longer perfectly synchronous with the folds, the illusion of slow motion vibration is obtained, so that the shape, position and excursion of the folds is seen throughout phonation. This can permit the early recognition of very minor degrees of organic disease or physiological dysfunction, which may be completely missed by steady-light indirect laryngoscopy.

The stationary image examination This allows scrutiny of the folds in any position of the vibratory cycle and thus scrutiny of any cord lesion. An imperfect stationary image with blurring results from asynchrony of vibration as seen in early oedema of the cord when the oedematous mucosa meets in advance of the true ligamentous cord and vibrates out of synchrony with the fold.

The amplitude of excursion of the vocal folds can be measured by noting the number of degrees through which the point of flash is moved when illuminating the folds, first in the completely adducted position and then at the point of fullest abduction. The amplitude of excursion varies significantly in disorders of function, and reduced amplitude is a reliable indicator of excessive tension in phonation.

The slow-motion effect The illusion of slow motion allows observation of the movement of the cords throughout vibration. In oedema of the folds the mucosa can be seen meeting in advance of the ligamentous cord, and with cord edge nodule the two portions of the cord can be seen vibrating at different frequencies by varying the speed of the intermittent light source to synchronize in turn with each part of the cord.

The new modified stroboscope from Bruel and Kjaer has a built-in automatic frequency tracking filter, a liquid crystal display (LCD) of fundamental frequency, and is supplied with rigid and flexible fibreoptic cables. The rigid light probe can be used with an endoscope and also incorporates a laryngeal mirror holder, thus allowing good visualization with the advantage of stroboscopic lighting without the need for an external light source. The flexible cable combines the advantages of fibreoptic laryngoscopy with stroboscopic lighting. The laryngeal view can be recorded and displayed on a video screen (Figure 3.1).

The mirror examination suffers the usual constraint of any indirect laryngeal examination in that phonation is limited to a restricted range of

Figure 3.1 Stroboscopic fibreoptic laryngoscopy using rigid endoscope.

vowel sounds and the larynx cannot be visualized during continuous speech – a disadvantage that is largely overcome when the flexible fibre-optic cable is introduced through the nares as described below.

Direct laryngoscopy

Direct laryngoscopy is of value to the surgeon in diagnosis of pathology of the larynx, affording a clearer view than can be achieved using a mirror in the indirect examination. It may be necessary with a patient who has an abnormality of structure such as an undeveloped mandible or overhanging epiglottis which restricts the view of the larynx.

A general anaesthetic is usually required for the introduction of the laryngoscope into the pharynx and phonation is therefore impossible, so this examination is of little value in determining laryngeal function, but is an absolute necessity when a biopsy is required.

Fibreoptic laryngoscopy

In certain cases, where it is impossible to obtain an adequate view of the larynx by indirect laryngoscopy because of structural defect, it may be desirable to use a flexible fibreoptic laryngoscope. The thin, flexible fibreoptic bundle is introduced through the nares and manoeuvred into position above the larynx, so that the image of the larynx is transmitted by the fibres to the eyepiece, thus giving an uninterrupted view. Phonation and speech are largely uninhibited, and this method of examination allows prolonged viewing and photography of the rapid vocal fold movements, but lacks the advantage of stroboscopic illumination. Some patients, however, find the introduction of the bundle difficult to tolerate even with a local anaesthetic.

Videoradiography

Videoradiography, which combines X-ray of dynamic function with synchronous sound, is of unequalled value for the recording and analysis of gross pharyngeal movements. Significant contributions have been made in the evaluation of alaryngeal speech (Simpson *et al.* 1972) using this technique.

Videoradiography provides good feedback for the patient, but the method has the disadvantage of cumulative exposure to radiation, which limits the technique as a routine form of therapy. The lateral viewing position and poor soft-tissue differentiation makes it inappropriate for detailed viewing of the larynx.

Xeroradiography

The term xeroradiography is applied to a technique that employs a comparatively high-kilovolt (kV) X-ray production to enhance contrast in soft tissue, which improves clarity of the image. There is a widespread misconception that the term is derived from the similar sounding prefix zero – thus implying a low-dose technique when in fact it is quite the reverse. The prefix xero is derived from the Greek *xeros* meaning dry. Xeroradiography is an X-ray imaging system in which an electrostatic image is produced on a xerographic plate by the effects of X-rays on an electrically charged plate, rather than on silver halide crystals or intensifying screens as in conventional radiography. Xeroradiography exhibits a specific type of image contrast called 'edge enhancement' in which a sharp demarcation occurs between two different broad areas of density.

A similar effect giving a clear definition can be attained by using a high-kV X-ray discharge with a filter at the tube to homogenize the beam and thus enhance contrast at a lower dose of radiation and without the unnecessary employment of an extremely expensive technique.

Xeroradiography has been used to investigate the vocal tract dimensions during phonation. Data on pharyngeal anatomical parameters are assessed in conjunction with laryngographic recordings, and the combined technique has been termed xeroradiography–electrolaryngography (XEL) (MacCurtain 1981).

It is claimed that aberrant vocal tract movements create aberrant sounds, but this has not been substantiated by sonographic analysis of laryngograph signals. Gordon (1977, 1980) and Kelman (1977) demonstrated by a comparison of sonographs of the LX and voice outputs that harmonic abnormalities in voice outputs were also detected in the LX outputs. The aberrant sound was thus shown to originate with irregularity of vibration of the vocal folds, which might on some, but by no means all, occasions be caused by variance in the configuration of the vocal tract caused by tension.

When XEL assessment was applied to dysphonic voice in a clinical setting (Berry *et al.* 1982) the findings confirmed subjective assessments made by speech therapists, but did not add to the knowledge of physiological function in deviant voice, and no evidence was produced for the modification of treatment.

Xeroradiography–electrolaryngography is potentially a useful research technique, but in clinical use caution must be exercised, as with all radiological techniques, to ensure that the patient is not exposed unnecessarily to X-ray dosage. The annual dose limit for members of the public to the thyroid area is near to 3 rad (0.03 Gy), and must therefore exclude repetition of the examination as is necessary for comparison at various stages of treatment. This seriously limits the application of the technique, for which safer and cheaper alternatives are readily available.

This procedure does not therefore meet the criteria for regular clinical use. Comparable information on the relatively gross pharyngeal movements studied can be obtained by using the high kV system described above or by using a 70-mm or 105-mm camera taking three to five exposures per second using conventional low-dose radiography. Good differentiation can also be achieved using medichrome film with orange and yellow filters to vary the contrast and this is often adequate for clinical use. In a comparison of methods of laryngography, Landman

(1970) concluded that disorders of laryngeal *function* can be most clearly visualized radiologically by means of cinelaryngography.

SPEECH THERAPISTS' ASSESSMENTS

Any assessment of the dysphonic patient must allow for flexibility of approach and an experienced therapist will continuously evaluate throughout the assessment session, varying the form of assessment and the time spent on individual sections according to the type of dysphonia presented. The assessment should be carried out in a relaxed and friendly atmosphere with, if possible, a pleasant environment and every effort should be made to put the patient at ease. The procedure described here is not intended to provide a rigid framework for evaluation, but is presented as a guide to the identification of the most distinctive and diagnostically differentiating features occurring regularly in association with dysphonic voice. The format for recording the information (Figure 3.2) was devised by the author and has been in regular use, with minor modifications, in the Victoria Infirmary, Glasgow, and associated hospitals since 1968.

For convenience, the assessment may be considered from three different aspects: the history of the dysphonia, the description of the dysphonic voice, and the physical production of the voice.

History of the dysphonia

Onset Upper respiratory tract infections amongst other physical causes and psychological pressures are recognized causative and perpetuating agents of dysphonias and the circumstances surrounding the onset of the dysphonia are, therefore, investigated.

Gradual onset Dysphonia of slow, almost imperceptible onset, is generally a symptom of habitual misuse or abuse of voice, in other words mechanical dysphonia.

Onset following a specific incident A common cold or other upper respiratory tract infection causing inflammation and/or oedema of the vocal folds (laryngitis) may result in a period of acute dysphonia, which will resolve when the inflammation subsides but can be the initiating cause of mechanical dysphonia if voice rest is not observed. By adapting voice production, the patient compensates for the irregularities in the cord edges and lowered pitch due to inflammatory thickening of the folds, usually by increasing tension and raising pitch, and so may develop a habitual faulty pattern of voice production.

Psychogenic factors   Misuse and abuse of voice   Organic condition

VOICE ASSESSMENT

Name .... Date ....

Number .... Age ....

Clinical History (Onset and Constancy)

Onset

gradual ☐	following specific incident ☐	sudden for no apparent reason ☐	

Constancy

	always present	increasing	intermittent	decreasing
History:	☐	☐	☐	☐
During Interview:	☐	☐	☐	☐

VOICE DESCRIPTION:

Pitch:	Normal	☐	High	☐	Low	☐	Unstable	☐
Pitch range:	Normal	☐	Diminished	☐				
Intensity:	Normal	☐	Loud	☐	Quiet	☐		
Breathiness:	Normal	☐	Excessive	☐				
Observed tension in voice:	Normal	☐	Excessive	☐	Diminished	☐		
Roughness:	Normal	☐	Excessive	☐				
Types of Hoarseness:	Tense	☐	Rough	☐	Breathy	☐		
Nasality:	Normal	☐	Hypo	☐	Hyper	☐		
Severity of Dysphonia:	Slight	☐	Moderate	☐	Severe	☐	Very Severe	☐

VOICE PRODUCTION:

Glottal attack:	Normal	☐	Soft	☐	Moderately Hard	☐	Very Hard	☐
Phonation time: on vowel [a]	Normal 8–16 secs	☐	Short 0–8 secs	☐	Long 16 Secs +	☐		
Air Support:	Normal	☐	Good	☐	Inadequate	☐		
Breathing Method	L/Costal Deep	☐	U/Costal Shallow	☐				
Environment in which voice is used:	Normal	☐	Noisy	☐	Quiet	☐		

Description of Larynx ______________________________

Any Known Medical Condition/Drugs ______________   Muscular weakness/ throat clearing ______________

Articulatory Deviations ______________   Personality and apparent emotional balance ______________

Figure 3.2 Case sheet report form used in the Victoria Infirmary, Glasgow.

A single episode of shouting, which ruptures a minor vessel in the mucous membrane covering the folds can have the same long-term results.

Sudden onset Dysphonias or aphonias developing suddenly for no apparent reason, or following an emotional shock, are generally of psychogenic origin.

Constancy In some types of dysphonia the symptom itself is extremely variable with periods of remission when the symptom is completely absent, or periods when the severity is diminished. The variability may not only be evidenced in the history of the disorder, but also extends to the clinical session.

Increasing severity A history of increasing severity is usual with mechanical dysphonia, but rapidly increasing severity during the clinical session may be a sign of fatigue in patients with neurological disorder.

Intermittent symptoms A history of intermittency of the symptom is a feature of dysphonia of psychogenic or neurological origin. The psychogenic dysphonic may report several episodes of dysphonia with complete remissions in between, and remissions also occur in some neurological disorders. In the dysphonia of psychogenic origin, the severity of the symptom often *decreases* during a sympathetic interview, whereas that of neurological origin increases, due to fatigue, as the interview proceeds. In evaluating the significance of constancy, the personality of the patient must be taken into account.

Relevant medical history

Past medical history may at times give a valuable lead to the nature of dysphonia and this is clearly more probable where there is a history of a disease affecting the respiratory tract or neck, although more generalized disorders of the endocrine and nervous systems may also prove relevant.

Chronic bacterial infections, such as syphilis and tuberculosis, may specifically affect the larynx, and bronchogenic carcinoma may cause recurrent laryngeal nerve paralysis with resultant dysphonia. Myxoedema characteristically affects the voice, as might imbalance of the normal sex hormones as a result of menopause, disease, or treatment with oestrogens or androgens as may be necessary in certain tumours.

A physiological dysphonia is of course well known and entirely normal at male puberty with the breaking of the voice, but where the transition is prolonged or inhibited by psychological pressure, dysphonia may become a permanent feature requiring correction.

A history of recurring colds and sore throats may predispose to mechanical dysphonia, and factors such as smoking and working in a smoky environment or in the presence of irritant fumes are clearly of relevance. Past history of psychological disorders might indicate continuing emotional instability related to the dysphonia.

Psychological evaluation

As the history of the disorder and the personality of the individual are closely linked and usually interdependent, psychological evaluation is of fundamental importance and is a continuous process throughout the assessment and any subsequent treatment. Some dysphonias are of purely psychogenic origin, and in all dysphonias the patient's personality is an important factor in the management and eventual outcome of the case. In a study carried out in the Victoria Infirmary, Glasgow, 15.6% of cases referred were aphonias found to be of purely psychological origin and therefore pure conversion symptoms, 12.8% were found to be of mainly mechanical origin, but with some psychological factor causing stress and contributing to the perpetuation of the dysphonia, while 44.7% were of mechanical origin only, and 7.3% of neurological origin (Gordon *et al.*, 1978). In the majority of cases where there is a psychological problem, this is successfully resolved through counselling by the speech therapist, although collaboration with a psychologist may be desirable when there is evidence of a behavioural disorder or phobia.

The patient's attitude to the voice is important, both diagnostically and in the planning of the treatment, and motivation for recovery is an important factor in prognosis.

Nevertheless, the contribution of a psychological element in voice disorders must not be overrated and must never be accepted as a diagnosis without first excluding as far as possible organic causes. Particular care must be taken in differentiating between disorders of psychological origin and those where early neuromuscular disorders present with dysphonia or dysarthrophonia as the first symptom. The speech therapist is perhaps in the unique position of recognizing the earliest stages of these disorders and can then alert the medical staff to the possible neurological nature and occasionally the specific diagnosis.

Environment

The patient's environment may be a primary or secondary factor in the acquisition of dysphonia.

Atmospheres which are over-dry, with high levels of dust, fumes, or tobacco smoke contribute to laryngeal irritation, as does excessive consumption of alcohol, which also irritates the pharyngeal mucosa.

Occupations involving teaching, preaching, and beseeching (street trading) predispose an individual to dysphonia unless care is taken to produce voice with adequate air support. Singers are another group prone to vocal abuse, either as a result of excessive demands made over a prolonged period, or of deviant voice production in some of today's pop singers, who lack a trained voice capable of withstanding the demands made in production of the ubiquitous falsetto and harsh cacophony of sounds comprising much of the pop scene.

Voice description

Habitual pitch The normal fundamental frequency for a male voice lies between 100 and 160 Hz and for a female between 220 and 290 Hz. Frequency can be measured in Hertz by using a frequency analyser or an appropriate tuning fork, but for the purpose of clinical assessment this type of measurement is not essential, as pitch anomalies are obvious even to the untrained ear.

Optimum pitch is usually the fourth note above the lowest comfortable note and can be gauged by asking the patient to hum up a scale from the lowest comfortable note. In many cases of mechanical dysphonia, by the time a patient is seen by the speech therapist a stage has been reached when the former optimum speaking level can no longer be easily attained and this type of assessment is unproductive. Natural pitch is readily established by asking the patient to phonate breathily on a vowel sound following a maximum inspiration as in sighing. This is the basis of the 'accent' method of vocal rehabilitation developed by Svend Smith (1980) and Kirsten Thyme (1980).

Lowered pitch In most cases of mechanical dysphonia the patient will give a history of a gradual lowering of pitch which has probably occurred as a result of some thickening of the cords. An increase in the mass of the cord causes it to vibrate at a lower frequency, as a result of which the patient may subconsciously increase glottal tension to raise the pitch again to that which his ear is accustomed. The increase in tension causes more damage to the cord, with further increase in mass and lowering of the pitch establishing a vicious circle of increasing severity and persistence. Deliberately acquired, or assumed lowering of pitch, is not uncommonly found, having been adopted by the speaker as a more 'influential' sounding voice and 'creak' is often a feature of this voice. Over a period this type of misuse can result in the development of contact ulcers or interarytenoid inflammation, but is rarely found in this country, although common in North America. Lowered pitch is frequently associated with low air-flow rate (personal observation).

Elevated pitch Conversely, habitual elevation of pitch above the optimum for the patient can also result in damage to the cords with accompanying dysphonia. This occurs more often than has been recognized in the adolescent male and is very easily corrected in the early stages. If, however, it is allowed to persist past puberty it can become associated with excessive tension and over a period can give rise to secondary organic effects of oedema or nodules and ultimately, tensor weakness with resulting bowing of cords. The patient with bowed cords often presents in late middle-age, having sustained a raised pitch mode of phonation since adolescence. Thickening of the cords may have 'masked' the abnormal phonation for a period, but with the development of tensor weakness the patient at last seeks help. Optimum pitch in these cases is often a resonant and beautiful bass which surprises no one more than the patient himself. The condition is associated with low air flow (Gordon *et al.* 1978).

Unstable habitual pitch Persistent fluctuation or frequent shifts in habitual pitch can be a result of neurological or psychological abnormality, injury to the folds, or a symptom of mutation in the adolescent.

Unstable pitch may also occur transiently in simple acute infective laryngitis, or when the subject is exposed to emotional stress.

Pitch range A reduction in pitch range can be an early indication of mechanical dysfunction and may be the first symptom the patient has noticed. This is especially so with singers. The amount of reduction in pitch range is often related to the severity of the dysphonia.

Pitch range may be estimated by asking the patient to sing or hum a scale accompanied by a piano or other instrument, or simply by the therapist. Some patients may feel awkward doing this, as singing scales is associated with musical ability and they might find it easier to follow a square wave tone which has itself a dysphonic sound. Visual feedback, such as is provided by the Royal National Institute for the Deaf (London) 'Visispeech' display is a useful aid to establishing pitch range.

Intensity Exact measurement of intensity is unnecessary as significant variations from normal accepted levels of sound will be obvious to the listener and can be readily brought to the attention of the patient.

Habitual excessive loudness results in an increase of tension in the larynx with a longer closed period in the vibratory cycle of the vocal folds. A sustained period of vocal abuse of this type can contribute to cord thickening, nodules and singer's nodes in children, through mechanical irritation.

A decrease in intensity can be significant for differential diagnosis, and can be of psychological origin, or related to neuromuscular hypotonia as in Parkinson's disease.

Breathiness Excessive breathiness is due to incomplete adduction of the vocal folds and can be a psychogenic, neurological, or other organic manifestation, such as a nodule or nodules on the cord edge interfering with the glottic explosion, a neoplasm restricting the movement of the vocal fold, or paralysis due to recurrent laryngeal nerve damage which may be a result of thyroidectomy or associated with bronchial carcinoma.

Excessive breathiness of psychogenic origin is associated with pseudo-adductor palsy or posterior glottal 'chink', i.e. incomplete closure of the cords in phonation.

Neuromuscular hypotonia can also result in excessive breathiness and is usually associated with restricted breathing pattern, particularly where the condition is of long standing and in the latter stages of a disorder such as bulbar palsy.

Excessive breathiness is rarely a feature of bowed cord phonation due to tensor weakness as, although incomplete adduction of the vocal folds is evident, air-flow rate is so reduced that breathiness is not observable, even if the voice sounds 'asthenic'.

Tension Hyperkinesia in voice can be simply a habitual increase of intensity or it can result from increased vocal effort of simple mechanical origin – a result of the vicious circle of vocal strain as previously described in connection with anomalies of pitch. Unconsciously, the patient tries to raise the pitch of the voice which has lowered due to cord thickening, thus increasing tension. In addition he may consciously increase intensity.

Excessive or fluctuating tension can also be of psychogenic origin (increased tension is clearly visible in body position, mandibular movements, shoulders, arms and neck muscles, and in elevation of the larynx on phonation) and can be the most disturbing feature of the dysphonia, as in spastic dysphonia where fluctuating tension gives the spasmodic bursts of 'creak' or 'fry' which typify this voice.

Hypokinesia, that is insufficient observable tension in the voice, is associated with:

1. bowing of cords, occurring as the end result of prolonged vocal misuse and usually habitual elevation of pitch;
2. psychological states;
3. neurological degeneration, producing neuromuscular hypotonia.

Roughness This is related to irregularities in the duration of sequential cycles of vocal-fold vibration, giving rise to frequency shifts and double harmonics. The loss of regular periodicity can be caused by asymmetrical mass distribution such as a lesion on one fold or by asymmetrical tension of the folds due to abnormality in the laryngeal musculature or nerve supply. Asymmetric vibration generates subharmonics, giving rise to the phenomenon of diplophonia, the double voice which can also be caused by overactive false cords pressing on and obliterating the ventricles. There is no way of accurately judging roughness without using acoustic measurement instrumentation.

Severity The severity of the perceived dysphonia should be noted and a record kept, either on tape or on a language-master strip or, best of all, a sonographic print, as a subjective estimation cannot be easily compared with subsequent assessment.

Nasality The presence of hypernasality should alert the therapist to the possibility of myopathic dysphonia such as myasthenia gravis, motor neuron disease, or bulbar palsy, as an early manifestation of these disorders can be hypernasal dysphonia with or without articulatory involvement. The severity of the hypernasality, the time since onset, and any change that has occurred may all be of significance.

The prime causes of *hyponasality* are nasal airway polyps, deviated septum, catarrh, and enlarged adenoids in children, all of which would have been noted in the laryngologist's report.

Voice production

Glottal attack Normal glottal attack is dependent on the maintenance of a delicate balance between the tension in the vocal folds and subglottic air pressure, so that when the folds are adducted at the onset of phonation, the pressure below the glottis is sufficient to overcome the tension in the folds and initiate vibration, normally reaching maximum amplitude after several cycles. Abnormal glottal attack can be either excessively hard or soft and, if not immediately obvious, can be assessed by asking the patient to repeat a list of words with vowels initially, or a sentence such as 'Arthur went out every afternoon with Amy, Olive and Ian'.

Hard attack This occurs when excessive tension in the vocal folds exerts a resistance that is too great for the subglottic pressure, causing delay in initiation of vibration until sufficient pressure is built up to overcome the tension. This results in a prolonged closed phase in the vibratory cycle, which can be heard as an increase in intensity or, when severe, as a stop. Hard attack is a common feature of mechanical dysphonia but can also be heard in hyperfunctional dysphonia of psychogenic origin, spastic dysphonia, and should not be confused with the strong vocal attack of a trained singer when the cords are extremely elastic and have an exceptionally fast closing time, perfectly balanced by a controlled air supply capable of generating the higher harmonics which give the extremely resonant pleasing quality to the voice.

Soft attack This results when there is insufficient tension in the vocal folds and occurs in psychogenic and myopathic dysphonias, in severe mechanical dysphonias when there is tensor weakness, and in senescence. It is often associated with asthenic voice quality.

Phonation time An individual's phonation time has been shown to bear an inverse relationship to the severity of some types of dysphonia and is, therefore, significant (Arnold 1955). It can be measured with a stopwatch and is the length of time phonation can be maintained without breaks following a maximum inspiration and may vary within a range of 10–35 seconds. It is dependent upon a combination of phonation volume, air-flow rate and elasticity of the folds. The norms for clinical assessment are considerably shorter than those obtained under stringent research conditions when subjects can be trained to maximize phonation time by increasing inspiration volume and reducing air flow (personal observation).

Short phonation time is associated with most types of dysphonia. Organic manifestations, which may or may not be secondary to the misuse of voice, inhibit vibration, causing voice break. Lack of air support or failure to maintain adduction of the folds due to psychogenic or neurological cause has a similar effect.

The exception to the rule is in certain types of mechanical hyperfunctional dysphonia when air flow is low and the patient is capable of habitually producing excessively long phonation times. Even when tensor weakness has occurred, flow may remain low and, in these cases, there is usually a history of prolonged use of elevated pitch.

Breathing method The patient's breathing method should be noted. The physiologically correct breathing pattern is lower costal/diaphragmatic, where inspiration is initiated by a strong contraction of the diaphragm resulting in forward extension of the abdominal wall and is accompanied by an upward swing of the lower ribs. Shoulders are relaxed and respiration even and rhythmic making full use of lung capacity. Expiration is effected by controlled contraction of the intercostal muscles and abdominal wall.

An upper costal breathing pattern is found in about 50% of patients with dysphonia of mechanical origin (Gordon *et al.* 1978). This method is usually accompanied by excessive tension. The shoulders are raised on inspiration and the rib cage elevated, allowing expansion of the upper one-third of the lungs only. This method cannot support professional or extensive use of voice and, if practised by serious singers over a period, can result in permanent deformity of the chest.

Air support Air support and vocal-fold tension are interdependent and inadequate air support can have far-reaching consequences, being the most frequently occurring causative factor in mechanical dysphonia. Poor air support results in hypertonicity of the vocal folds if the vocal intensity is maintained when air flow drops below the optimum level. Loss of the Bernoulli effect, where air accelerating through the narrowed glottis exerts a lateral force on the folds, drawing them together, results in slower cord movement in the closing phase and a reduction in generation of the higher harmonics, which shows as deterioration in voice quality. Available air support is closely related to breathing method and is assessed by asking the patient to take a maximum inspiration then to exhale on a sibilant, usually /s/ and measuring the time with a stopwatch (25–30 seconds). Functional air support is estimated by asking the patient to exhale on /s/ over a period of several respiratory cycles. If adequate, the patient will be able to sustain a moderately intense /s/ for at least 12 seconds on each exhalation, with little variation in the sound from cycle to cycle. Air-flow rate is directly related to resonance and deficiencies result in inadequacies in resonance.

Observations should be made of the patient's conversational speech during which persistent creak, use of low pitch, or breathlessness is an indication of poor air support. The use made of available air is more important than the volume that the patient can inspire.

Evaluation of air support is one of the most important sections of a voice assessment, but it is most unlikely to produce a reliable result when a subjective assessment is made. Where possible, observations should be supported by air-flow measurement.

Throat clearing Excessive throat clearing and reported globus hystericus with a feeling of a 'lump in the throat' are frequent symptoms accompanying dysphonia of mechanical or psychogenic origin. Smoking and alcohol, particularly if combined, can irritate the mucous membrane, causing the folds and pharyngeal lining discomfort, which can lead to throat clearing.

Articulatory deviations and muscle weakness Dysarthria, dyspraxia, and difficulty in walking and writing are all significant when arriving at a differential diagnosis. Difficulty in walking and articulation, slurring for example, may indicate a dysphonia of neurological rather than psychogenic origin when many of the other symptoms are similar and the dysphonias are easily confused.

In an assessment such as this the voice is described in terms that can be easily understood by each therapist and laryngologist who has to attend to the patient. A clinical description is necessarily subjective and must be made in terms such as described. Although reliable when carried out by an experienced therapist, the imprecision of these assessments is widely acknowledged and many attempts have been made to devise a universally acceptable system of voice description, and it is useful here to consider contributions that have influenced present-day thinking.

Pike (1943) isolated five significant factors of voice and used a system of opposites (bipolar factor system) to describe the condition: tension – tense versus relaxed; stricture – small throat opening versus large throat opening; pitch – normal versus falsetto; phonation – whispered versus voiced; sound – breathy versus clear.

Osgood *et al.* (1957) advocated a semantic method, essentially again a scale between opposites to measure the voice as described by abstract adjectival words often ascribed to voice, for example, soft . . . hard; dark . . . bright.

Much of the present-day work on vocal profiles is based on these early studies. Isshiki and Von Leden (1964) used a similar approach to isolate and highlight the four factors which are prime contributors to the perceived dysphonia. These factors are rough (R), breathy (B), asthenic (A), and normal (N) (or sometimes D for degree). The factor profiles were correlated with laryngeal disorders to produce a rule-of-thumb differential diagnosis, for example, a B(R) type was related to vocal cord neoplasm, while R(N) was associated with laryngeal nodule. Although the method has severe limitations in differential diagnosis it is a useful beginning because the number of descriptive terms is limited to generally recognized essential features of the dysphonic voice.

A five-factor analysis, introduced by Fritzell *et al.* (1977) is essentially an updated modification or variation on Pike's theme, with each factor representing a group of phonation types, thus: (I) steady/unstable; (II) breathy/overtight; (III) hypokinetic/hyperkinetic; (IV) light/coarse; (V) chest register/head register. Significant correlation was found by the authors between the factors and acoustic data. Differentiation between factors might prove difficult in practice, and with factor analysis there is a danger of oversimplification unless this is used in combination with a fuller assessment, taking account of other fundamental contributory factors.

Catford (1964) recognized this when he recommended a kinaesthetic auditory exploration technique to classify normal phonation types and took into account a wider range of factors, including type of stricture, location of stricture, vertical displacement of larynx, upper laryngeal constrictions, and vocal-fold length, thickness, and tension, with much of this being verified by laryngoscopic examination.

The vocal profile produced by Laver (1980) owes much to this early work. While bearing resemblance to the traditional speech therapists' assessment, the profile stresses supralaryngeal features, many of which are of little consequence when applied to patients with mechanical hyperkinetic dysphonia, or psychogenic dysphonia categories, which make up two-thirds of the case-load in a dysphonia clinic. A major part of the profile is a scale on which degrees of normality versus abnormality are scored for supralaryngeal and laryngeal features, with what are termed 'dynamic' factors, that is pitch and loudness, and what are called 'temporal organization factors', that is breath support, rhythmicality, and rate, included in a less well-researched section at the end. The profile falls somewhere between a descriptive profile and an assessment, giving a useful evaluation of aspects of dysarthrophonia, but is insufficient for a complete assessment. In common with all clinical assessments it is subjective and heavily dependent upon the experience of the assessor. Training courses are typically provided for therapists intending to use the Vocal Profiles Analysis (VPA) scheme.

The practising clinician's assessment must be succinct, selective, show high correlation when used by other members of the team (otolaryngologists and other speech therapists), and be sufficiently structured to provide for comparability of reassessment after a period of treatment, all of which criteria are met by the Victoria (Glasgow) assessment (Kelman *et al.* 1981). A diagnostic profile as suggested by Isshiki and Von Leden (1964) can be easily extracted from the Victoria assessment (Table 3.1).

INSTRUMENTATION AND OBJECTIVE MEASUREMENT

The use of instrumentation to provide objective measurements of voice production parameters is fully justified in that measurements can be repeated at intervals throughout treatment and an accurate record of progress can be kept. Areas requiring attention can be identified and therapy directed to these rather than using an empirical approach to treatment.

Certain criteria govern the regular use of investigative techniques in the clinic. The procedure must not subject the patient to discomfort or risk, must not be invasive, and the information extracted must be worth the time and money spent. The procedure must be easily carried out under clinical conditions and be readily repeated for evaluation of treatment. The research worker has slightly greater freedom than the clinician

Table 3.1 Suggested diagnostic profile

Assessment profile	*Diagnostic indication*
Breathy, hypotense: B + (T−)	Neuromuscular or psychogenic
Breathy, hypotense, quiet, hypernasal: B + (T−) + (I−) + N	Neuromuscular
Breathy, hypotense, decreasing or intermittent severity: B + (T−) + (S−)	Psychogenic
Breathy, rough: B + R	Neoplasm
Breathy, rough, tense, low pitch: B + R + T + (P−)	Vocal nodule, Reinke's oedema, etc.
Breathy, rough, tense, high pitch: B + R + T + (P+)	Hyperkinetic dysphonias

If increasing severity, these are likely to be of mechanical origin, and if fluctuating, of psychogenic origin.

and, on occasions, may use techniques that could not be permitted in the clinic, if no other method is available that can provide the necessary information.

The following investigative methods meet the *clinical* criteria.

Sonographic analysis

Analysis can be made of any voice output and can be carried out in the absence of the patient, using tape recordings of phonation.

Modes of display are varied and can be wide-band, narrow-band, contour, or section in any chosen frequency range and magnification (Figure 3.3).

In wide- and narrow-band display the intensity of the harmonics is shown as density and the frequency plotted against time. In section display the intensity of the harmonics is plotted against frequency. Using a narrow-band section, formants, subharmonics, and noise components can be clearly seen (Figure 3.4).

Harmonics can be easily counted and fundamental frequency established by dividing a given frequency by the number of harmonics. The section can be displayed with frequency inverted, thus allowing it to be superimposed on a wide- or narrow-band display and facilitating comparison.

Magnification of the first formant in wide or narrow band can drama-

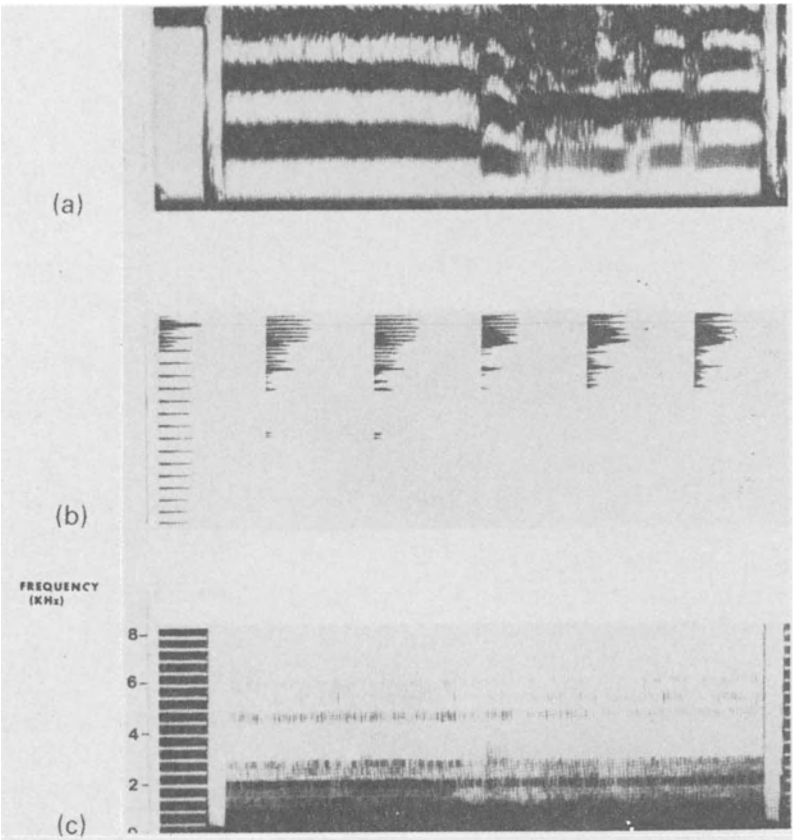


Figure 3.3 Sonograph display of phonation of sustained vowel: (a) magnification of narrow band showing 'shift', which is perceived as voice break; (b) section of same phonation with voice break shown as noise in the first formant with loss of distinction in harmonics; (c) wide-band display of the same phonation.

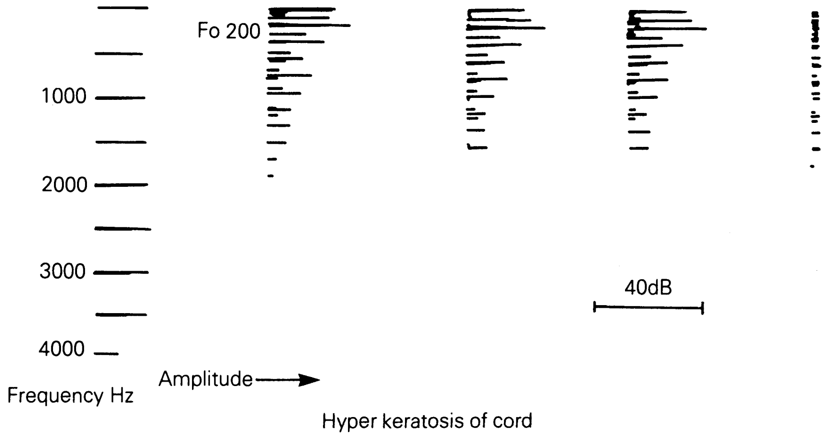


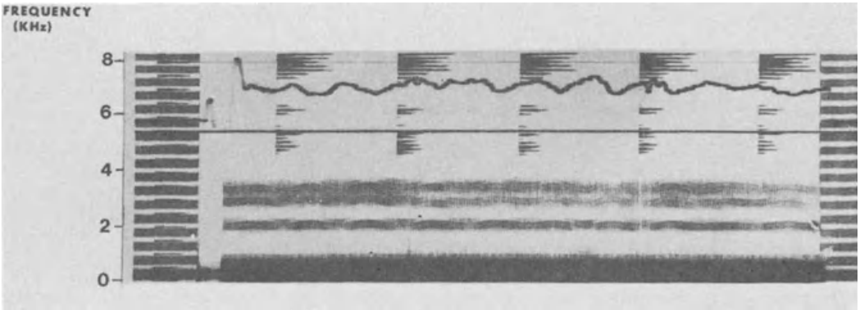
Figure 3.4 Section display of sustained vowel showing regular half-harmonics, which give the impression of diplophonia.

tically demonstrate frequency shifts, occurrence of subharmonics, and excessive tremulo (Figure 3.5).

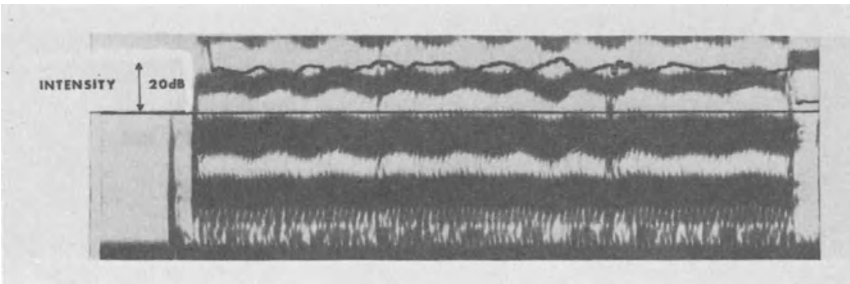
A purely objective method of classification of dysphonic voice using sonographic analysis was described by Yanagihara (1967) and warrants further exploration and use. Four degrees of dysphonia were classified according to degree of severity of dysphonia, the premise being that harmonic components disappear, to be replaced by noise, with the fourth formant being affected first and the lower formants as severity increases, with the first formant affected only in the most severe dysphonias (Figure 3.6).

Laryngograph and Voiscope

The laryngograph developed by Fourcin and Abberton (1971) is a completely safe and non-invasive instrument, ideal for routine clinical use. The instrument provides information on the vibratory pattern of the vocal folds (LX) for the clinician, and biofeedback information for the patient. The frequency/time mode (FX) incorporated in the Voiscope, shows fundamental frequency changes in real time, giving information on pitch. Two electrodes are placed externally on the neck over the wings of



a



b

Figure 3.5 Sustained vowel showing excessive tremulo: (a) wide-band display of excessive tremulo; (b) magnification of the first formant.

the thyroid and an AC current is passed between them. The impedance varies with the movement of the vocal folds, decreasing when they are in contact and increasing when apart. The electrical signal can be stored on tape and viewed on an oscilloscope, and consists of three parts: a sharp rise produced by a decrease in impedance while the folds are rapidly closing is followed by a gradual fall as the folds part and impedance increases, and a flattish base corresponds to the interval when the folds are out of contact (Figure 3.7).

Variations in the shape of the signal have been shown to bear a relationship to certain types of voice and pathological conditions (Fourcin and Abberton 1971) (Figure 3.8). Normally the closing phase is short when compared to the opening and open phases, and is of great

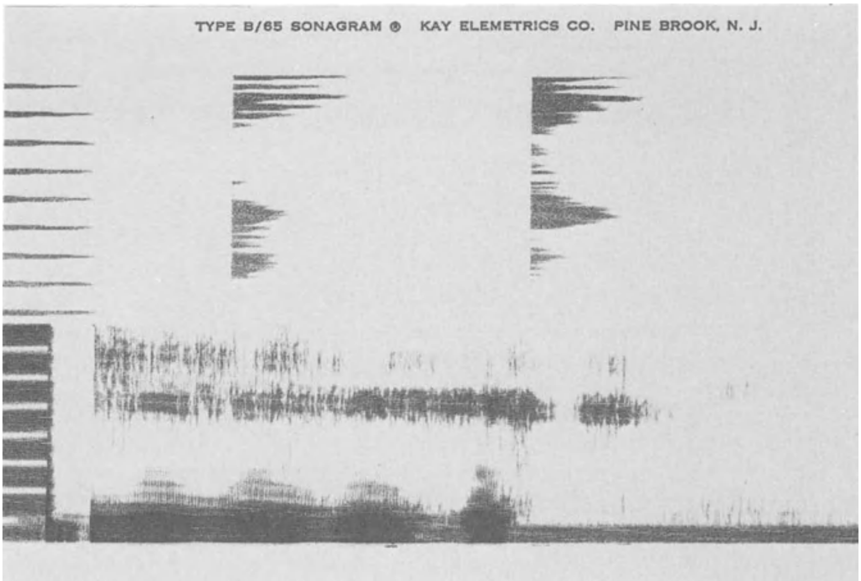


Figure 3.6 Sustained vowel; higher formants are affected early in phonation but the first formant only when the voice break occurs.

importance to the phonatory process as it corresponds to the time of maximum excitation of the vocal tract.

Spectral display of LX recordings using a Kay Sonograph in the section display mode

The frequency spectrum of the LX can be displayed in section using the sonograph, and the effect of the LX waveform on the LX has been investigated; the gradient of the spectrum is shown to be governed by the closing time. Thus closing time can be calculated from a knowledge of the gradient of the spectrum or from the fine structure of the spectrum (Gordon 1977, Kelman 1977; Figure 3.9).

A short or fast closing time, with *relatively longer period when the*

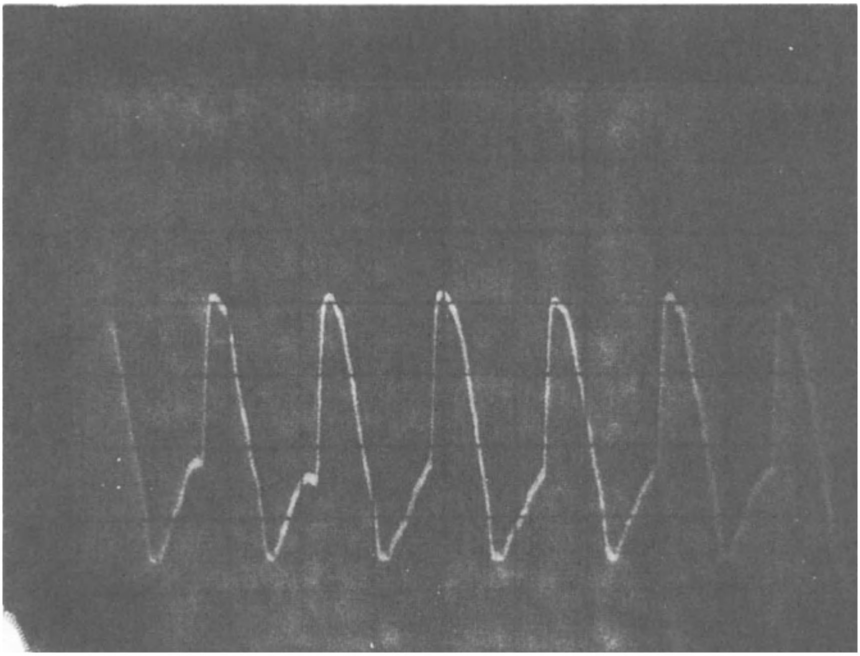


Figure 3.7 Typical LX output as seen on the oscilloscope.

cords are in contact, shows a steep gradient on the spectrum and generates more higher harmonics than a slow closing time.

The short closing time is, therefore, capable of exciting more response in the resonators and producing a more resonant voice. This should not be confused with the stiff, long closed period in the hyperkinetic voice.

Rapid closing is facilitated by the Bernoulli effect when air flow is adequate. Sonographic analysis of voice output and LX output during a voice break can demonstrate that the abnormality arises in the larynx as seen in the LX output, and although enhanced by the resonators is found to be virtually unchanged in the voice output when the two are compared.

The perceived break can arise from a shift in frequency of the lower harmonics with sometimes a loss of higher harmonics or the intrusion of half-harmonics or even thirds between the true harmonics in the first formant (Figures 3.10 and 3.11).

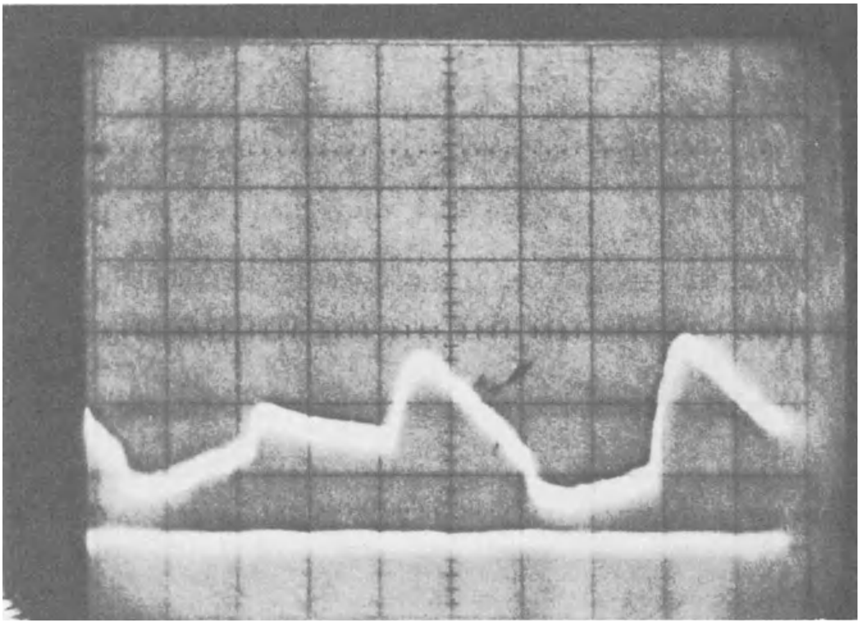


Figure 3.8 LX output from a patient with spastic dysphonia.

Visispeech

The Visispeech display was developed by the Royal National Institute for the Deaf and is now computer-based with visual display on a VDU monitor screen. The system operates by simple commands via a microcomputer keyboard (Apple II or BBC(B)) and provides the means of accurately measuring and describing aspects of dysphonia related to frequency, such as pitch range, habitual pitch, and optimal pitch. Measurements are also made of intensity and phonation time. This is an extremely useful adjunct to assessment, which also provides attractive feedback for therapy (Macgillivray 1984). Maximum and minimum frequencies and intensities can be plotted from hard copy to produce a phonetogram as described by Schutte and Seidner (1983).

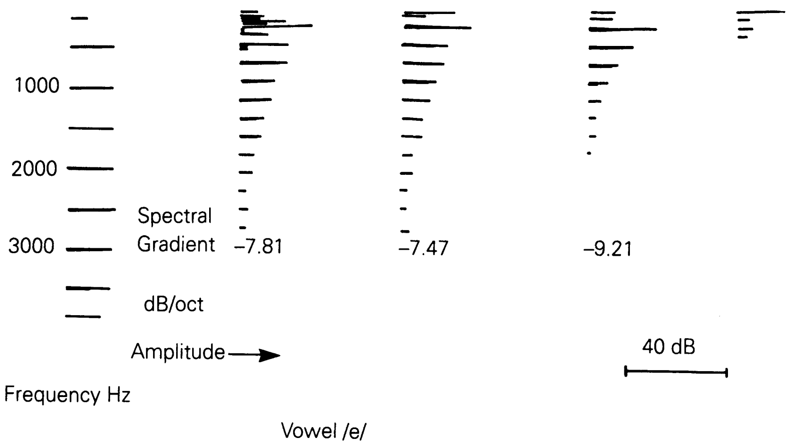


Figure 3.9 Section display of LX of sustained vowel showing decrease in gradient as the voice deteriorates.

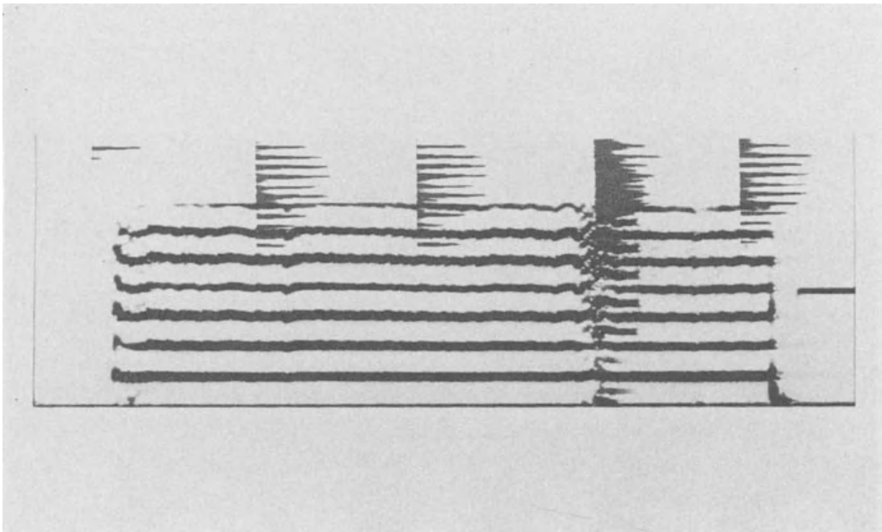


Figure 3.10 Voice output spectra showing half-harmonics at voice break.

Air-flow measurements using a pneumotachograph system

Air-flow measurement is widely used in assessment and is the most useful of instrumental measurement techniques, being non-invasive, easily

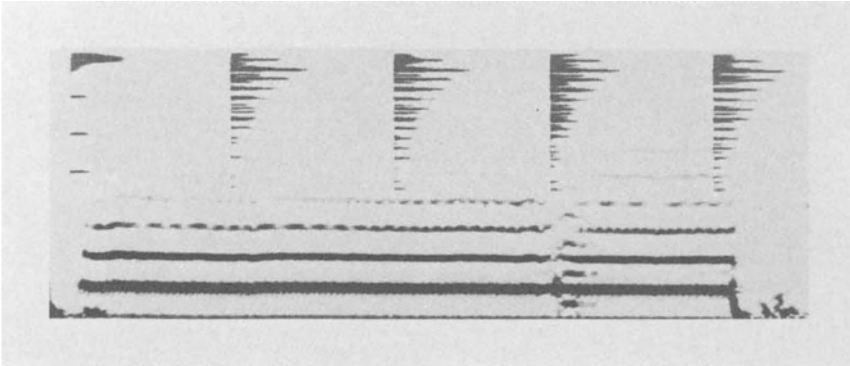


Figure 3.11 LX output of the same phonation as Figure 3.10 showing the break again with identical half-harmonics.

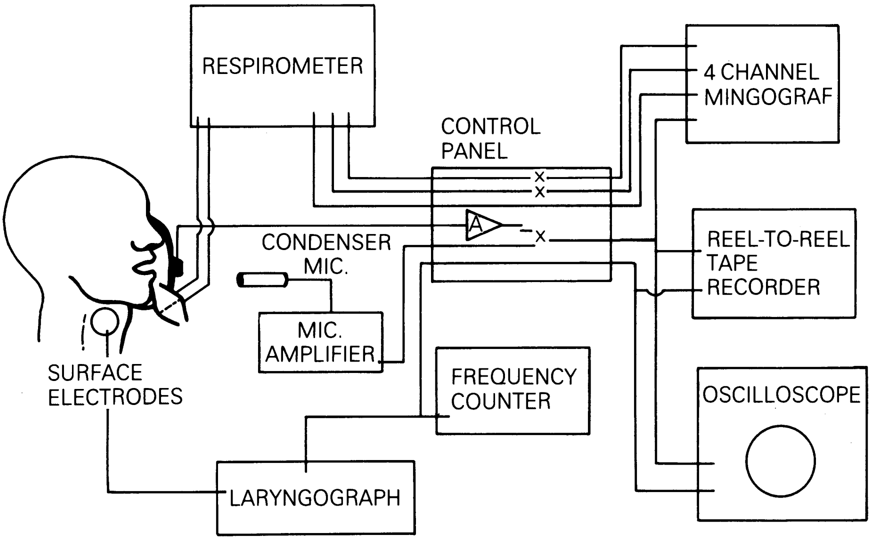


Figure 3.12 Air-flow measurement and voice-recording system.

repeated, and giving quantitative and qualitative information on the most important parameters of voice production. The pneumotachograph system incorporates a respirometer, a flow head with a wire gauze mesh separating the two halves, and usually a pen recording system with at least four channels; it has been described by the author elsewhere* (Gordon 1977,

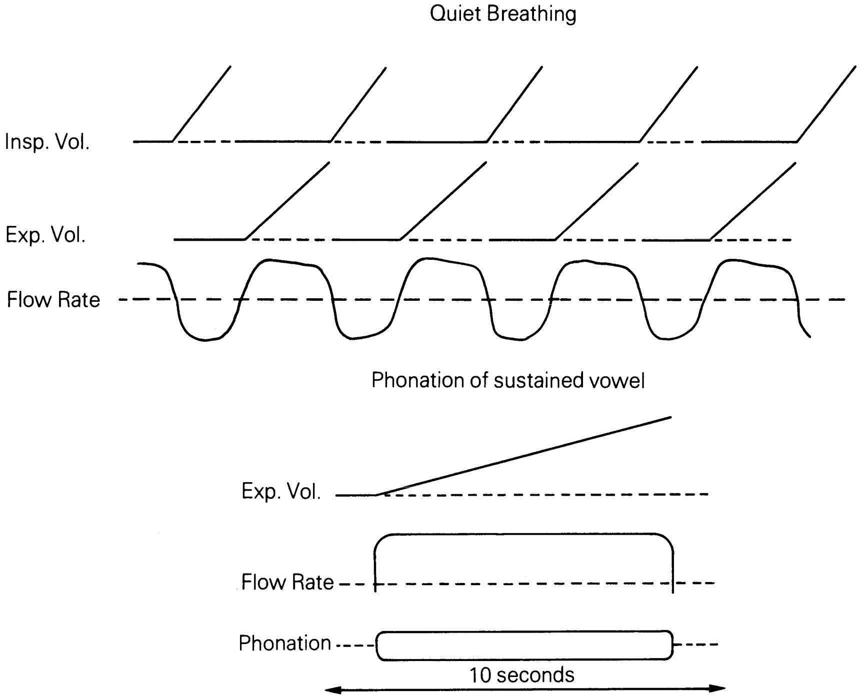


Figure 3.13 Diagrammatic representation of air-flow recording during respiration at rest and during phonation.

1980, Gordon *et al.* 1978, Kelman *et al.* 1975; Figure 3.12).

As the subject breathes into the flow head a pressure difference is generated across the gauze which is proportional to the air-flow rate. An electrical output signal is obtained using a differential pressure transducer. The flow rate is integrated with time to give volumes, and measurements can thus be made of tidal volumes and the time taken for each respiratory cycle and inspiration fraction of the cycle, so assessing the regularity and efficiency of respiration at rest (Figure 3.13).

During phonation the volume of air used on a particular phonation can be measured (*PhV*). The mean rate of flow of that volume of air (*MFR*) can be compared to the peak flow *M*/*P*, thus giving a measurement of the regularity of the expelled air and, therefore, regularity of vibration of the folds. A vocal velocity index (*VVI*), the ratio of *MFR* to vital capacity (*VC*), is computed (Koike and Hirano 1968) and used as a measurement of laryngeal resistance (tension) in the evaluation of laryngeal dysfunction.

* The pneumotachograph system can be used with an IBM-compatible computer or with BBC. Software supplied with the system compares the subject's output with previously-established norms (Gordon *et al.* 1991).

Name ____________________ Unit No. ________ Date ________

RESTING RESPIRATION ____________________

% VARIATIONS IN.	INSP.	EXP.	PERIOD	% INSP. TIME
(Normal Limits)	(16%)	(16%)	(14%)	(14%)
SCORE				

TOTAL __________

SCORE

MEAN TIDAL VOLUME ______	VITAL CAP. ______ B.V.C. ______	R $\frac{VC}{BVC}$ ______ (Normal Limits Above 0.70)

PHONATION

	NORMAL LIMITS	NPa SCORE	HPa SCORE	LPa SCORE
Pitch	Fo 120			
	Fo 240			
Phonation Time	12–16 secs.			
Phonation Volume	(See template) + 0.9			
Mean Flow Rate	5–11 l/min.			
Mean/Peak	Above 0.65. Low – Irreg. High – No irreg.			
Vocal Velocity Index	Low – Tense High – Phonatory loss			

	SCORE
VC/BVC	
PH.V	
MFR	
MP	
TOTAL	

SONAGRAPH ANALYSIS ____________________

____

STROBOSCOPE ____________________

____

DIAGNOSIS ____________________

____

Figure 3.14 Air-flow record used with binary score: 0 = within limits of normality; 1 = outside normal limits.

The efficiency of respiration and of phonation can thus be measured and compared with subsequent assessment of the same patient or with different patients. Abnormal patterns have been identified and quantified using a binary scoring system (Kelman *et al.* 1975; Figure 3.14).

The assessment has proved useful in monitoring the effect of therapy for all categories of voice disorder. Specific aspects of disordered function have been identified for treatment, thus avoiding a time-consuming empirical approach.

The significant measurements are regularity of tidal volumes and of rhythm of breathing at rest (period), the relative time spent on inspiration in each cycle (per cent inspiration time), vital capacity (*VC*), phonation volumes (*PhV*), mean flow rate (*MFR*), and control of flow (*M/P*) during phonation.

Breathing at rest Abnormally low tidal volumes for respiration at rest indicate that respiration may not be capable of supporting voice use.

Phonation Low phonation volume with low vital capacity indicates poor lung function, which may be due to lung disease, tumour or emphysema, or may be neuromuscular and should be investigated, particularly if associated with low tidal volumes and/or abnormally long expiration time.

A low phonation volume with normal vital capacity is suggestive of psychogenic origin and is usually associated with high flow rate on phonation. Tidal volumes in respiration at rest may be greater than *PhV* in extreme cases and is a certain indication of psychogenic involvement.

High mean flow rate

Normal phonation volume with normal vital capacity accompanied by high flow rate and abnormal mean-to-peak variations with uncontrolled flow indicates possible pathological changes in the cord which could be tumour, oedema, nodule, or paralysis. In cases of cord palsy where there is no compensatory movement of the opposing cord, mean flow rate may be so uncontrolled that it is unmeasurable; but measurement can be obtained from the very distinctive and transitory peak. The patient with hyperkinetic dysphonia of mechanical origin is likely also to show irregularity in tidal volumes in quiet respiration.

Low mean flow rate

This can result from increased glottal resistance or reduction in respiratory effort. Where *VC* is normal and phonation volume normal, this is most often found in hyperkinetic phonation, even when tensor weakness has occurred and cords are bowed. Low air flow results in poor resonance.

Although obviously of value in providing a differential diagnosis, the results of air-flow measurement procedures specifying aspects of respiratory performance that require modification also have a direct effect on treatment, particularly when evaluated in conjunction with the speech therapist's subjective assessment. A rule-of-thumb diagnostic profile can also be used to indicate areas for further investigation (Table 3.2).

With a complex disorder such as dysphonia, to which there can be many contributory factors, it is tempting to extend the history and accumulate a multiplicity of facts of varying degrees of relevance.

Accurate and easily applicable instrumental procedures for measurement and analysis of dysphonic voice are becoming cheaper and more available, and the speech therapist must welcome any technology which will increase his or her understanding of the disorder and thus enhance the patient's treatment. Nevertheless, discretion must be exercised in the

Table 3.2 Diagnostic profile for further investigations

Respiration at rest	*Diagnostic indications*
Tidal volumes irregular	Most frequently found associated with mechanical dysphonia or hyperkinetic psychogenic
Low volumes	Poor lung function with organic or neuromuscular origin; occasionally found in dysphonias of psychological origin
Timing irregular	Short inspiration time with long expiration time but otherwise regular indicates elasticity of lungs (e.g. possibly emphysema)
	The total score out of four indicates severity of disorder of respiration
Air-flow in phonation	
Low *VC* and *PhV*	Poor lung function – emphysema or neuromuscular in origin
VC normal and low *PhV* with possibly high flow rate	Psychogenic, especially when associated with high flow
MF high, *M/P* irregular, *VC* normal, *PhV* normal	Oedema, nodule, or other organic manifestation
MF low	Hyperkinetic phonation
	The total score out of four indicates the severity of the dysphonia

selection of useful techniques and care must be taken lest the patient is overwhelmed by a battery of tests that arouse anxiety and confusion where one has intended to heal.

History, subjective assessment, and physiological measurements should be confined to features significant to differential diagnosis and to the selection of treatment regimes. A combination of assessment procedures ensures that accurate diagnosis is made and effective treatment is selected and applied where malfunction has been clearly demonstrated.

In particular a combination of the speech therapist's subjective assessment and air-flow measurement have been found by the author to be effective in diagnosis disorders, and in formulating treatment in difficult cases.

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Visual feedback in the management of dysphonia

Allen Hirson and Robert Fawcus

INTRODUCTION

The diagnosis of dysphonia and a rational approach to therapy depends on notions of 'normal' voice, i.e. the distribution across several parameters within which voices may normally be expected to range. The specification of such norms is a primary requirement of research (Barry *et al.* 1990; Winstanley and Wright 1991), but until such time as pathologies are more rigorously defined in terms of these norms, the assessment and management of voice pathology continues to rely on what Reed (1980) refers to as 'authoritative opinion'.

One of the obvious advantages of introducing instrumentation into voice therapy has been to provide objective measures that support these clinical intuitions, providing baselines from which clinician and patient may assess progress in therapy, and a method of visual feedback for the objectification of voice production. However, this needs to be placed in perspective: visual feedback may play a part in therapy, and therapy in turn is only one component of the management of dysphonia. Nevertheless, we would argue that visual feedback constitutes an important element of the management of dysphonia, and deserves a full and critical appraisal.

Various devices available for visual feedback are evaluated in terms of the information they provide and their specific limitations. There are many commercially available feedback devices designed for use in clinic rather than as research tools. The development of this equipment has undergone an explosive evolution in the past decade, and we have tried to describe the uses of the various devices in their historical context. In particular, the changes resulting from the introduction of microcomputers into the field are discussed, as is the apparently inexorable progression from the early Apple and BBC computers to much more powerful systems based on the Macintosh, IBM AT or PS/2 technology. This evolution is a matter of fact: economic and political forces have ensured that earlier systems are replaced by more recent systems. However, we would not wish to imply that the more modern systems are necessarily superior to their predecessors, nor indeed that computer-assisted therapy is necessarily superior to so-called conventional therapy.

Effective voice therapy is dependent on a sound understanding of existing theory of voice pathology and good clinical practice. Therapy informed by poor theory, and 'administered' by good technology may nevertheless result in poor therapy. However, even good theory may not marry well with good technology. The computer may best be viewed as a tool used by the therapist as part of a therapy programme; it has little role, for example, in the psychological work that may be required in some voice therapy (Cook *et al.* 1986). Indeed, it may be that the delicate therapist–patient relationship could disintegrate if mediated by a machine. Conversely, the device may act as an effective focus for therapy, and this may be exploited by the therapist. The range of issues surrounding the use of computers in therapy has received little attention in the literature (Hirson and Chiat 1990) and this is in need of further investigation. In this chapter we address one aspect of computer intervention, namely visual feedback, and the theoretical assumptions underpinning this form of delivery. This approach to therapy rests upon some specific ideas about the way that patients may learn or re-learn the skills subserving phonation, and these assumptions need to be examined.

LARYNGOGRAPHY

The laryngograph, based on the electroglottograph (Fabre 1959, Fourcin and Norgate 1965), was one of the earliest effective visual feedback devices used in modern speech therapy and remains a widely used tool today (Fourcin and West 1968, Fourcin 1971, Abberton *et al.* 1989). Gold-plated electrodes are positioned externally on the wings of the thyroid cartilage and they detect impedance[1] changes across the vocal folds. The basic signal displayed by the laryngograph on a cathode-ray oscilloscope (CRO) is known as the Lx waveform. Evidence that the periodic changes in impedance do in fact reflect the underlying vocal fold vibrations has been demonstrated by matching points on the 'waveform' of larynx excitation with very rapid X-ray images of the folds themselves (Noscoe *et al.* 1983). Another approach that has been adopted in studies of the singing voice has been to utilize inverse filtering to reveal the

[1] A measure of electrical resistance to an alternating current.

glottal waveform by cancelling the effects of the supraglottal resonance chamber(s). High correlations between characteristics of the vibratory cycle measured by laryngographic and inverse filtering methods are compelling evidence that the Lx waveform is indeed related to the acoustic output of the vocal folds (Howard *et al.* 1990). Indeed, Davis (1976) has applied the inverse filtering method directly as a tool to evaluate laryngeal pathology.

At its inception the laryngograph claimed superiority to laryngoscopy in being relatively non-invasive, and had the advantage over the existing sound spectrograph in that the visual display was produced without any appreciable delay. It also laid claim to providing information directly about the vibration of the vocal folds, and linked to a minicomputer the signal could be stored and analysed. Unlike other well-established methods such as the 'cepstral' technique (Noll 1967), the laryngograph employs a 'peak-picking' device operating in the time domain (Howard and Fourcin 1983). The laryngograph has the ability to monitor regular and irregular vocal-fold vibrations, and in instances where the use of laryngograph electrodes is inconvenient or unsuccessful, the microphone-based peak-picking principle may be used. Subsequent development incorporated the laryngograph and an add-on PROM (programmable, read-only memory) into the BBC Master microcomputer, and this combination was dubbed the 'Voiscope'. More recently peak-picker hardware and software has been adapted for use on PC-compatible machines. The Voiscope produces a number of analyses of vocal-fold vibration (Figure 4.1). The fundamental frequency data are analysed to provide graphical representations of fundamental frequency, F_0 (or Fx, the period-by-period frequency), the so-called first- and second-order distribution graphs (Dx), and 'cross plots' (Cx). First-order Dx plots show the frequency of all F_0 transitions collected in 128 logarithmically equal 'bins' (30–1000 Hz); second-order plots show only those cycles whose frequencies occur in the same 'bin' as the preceding cycle (Barry *et al.* 1990). Second- (or higher) order plots eliminate irregular F_0 transitions; thus the difference between first- and second-order plots give some indication of the smoothness with which the voice makes transitions from one F_0 to the next, and is an index of fundamental frequency control, a feature involved in a variety of voice pathologies.

The Cx plot consists of each cycle frequency plotted against its successor, and is therefore expected to be aligned along the X–Y diagonal, with the densest distribution of points situated at the modal fundamental frequency. Points straying from the diagonal represent irregular cycles, and so give some indication of the smoothness of fundamental frequency transitions. Moderate vocal creak thus produces broadly distributed Cx plots, but rising and falling intonational glides and creak in normal voice, particularly at phrase-, or breath-group-final positions also produce Cx distributions that have strayed from the diagonal.

Variations from normal distributions of Fx, Dx and Cx would be excellent indicators of voice pathology, but it is only recently that these norms have been described. The distribution of fundamental frequency for defined 'normal' southern British male and female speakers, aged 19–24 years, and for different types of speech tasks have recently been compiled from analyses of relatively long portions of speech (Barry *et al.* 1990). For the given population ($n = 18$; 10 F, 8 M) this study corroborates American findings that women tend to have mean and modal fundamental frequencies about 1.7 times that of men, and that men tend to have a greater fundamental frequency range than women (0.60 versus 0.69 octaves). Both men and women have higher mean rising frequencies than falling frequencies, and the latter tend to be of a longer duration than the former. The form of Dx distribution (its skew and kurtosis) also indicate that in free speech both men and women make relatively few excursions into the higher frequencies of their respective fundamental frequency ranges. Such a detailed study reveals that the description of 'normal' is complex, but there are immediate and profound practical implications. As early as 1981, Leff and Abberton used calculations of Dx kurtosis to assist in the differential diagnosis of schizophrenia and depression, and a similar approach may help in the assessment and management of dysphonia.

Barry *et al.* (1990) also raise the problem of what constitutes a good or representative speech sample. Whether the speech is a 'free' monologue, how this is elicited, or even what type of text is read, and when, appear to affect the performance of each subject, with mean values for reading generally higher than for 'free' speech. The spread (kurtosis) of distribution appears to vary across different read texts, and these in turn engage more of the speakers' range than for a monologue. The skew of the distribution has been studied in a number of European languages (Barry *et al.* 1989) and this wider study suggests that there are differences between reading continuous text and isolated sentences. One factor that may be of relevance here is that reading aloud is not usually a taught skill in European cultures, unlike in Muslim cultures (Martin, personal communication). In any event, this problem suggests that absolute values of norms need to be carefully annotated with the form and context of the speech material, and the conditions under which the sample was collected. It may also be that more naturalistic samples of speech may be preferable to either read or pseudo-free speech.

The Dx plots also provide some indices for vocal creak. In the first-pass analysis, a smaller secondary distribution something over an octave below the main distribution is found in a significant minority of cases.

Collating these occurrences with the Cx plots may be a useful way of establishing clinical baselines.

The stability of the norms is also a matter of concern. A number of American studies indicate changes in mean Fx values with age, but corroborative studies of British speakers are still in their infancy. Initial indications for the female population are that the range may be stable over age, whereas the kurtosis may decrease, i.e. second-order Dx become less peaked after middle-age (Morgan 1990). Over a shorter time-scale, there appear to be consistent differences between the Dx plots of normal voices at different times of the day. This could be related to natural circadian rhythms of vocal-fold physiology or to levels of vocal fatigue. Mean F_0 values indicate a marked increase in fundamental frequency from morning to afternoon, and a rather less reliable shift from midday to mid-afternoon. The present authors have also observed consistent reduction in Dx kurtosis from morning to the latter part of the day as the voice becomes 'flatter' or less inflected.

To date, pathology has been related to a series of published exemplars of Lx, Dx and Cx regarded by various authors as typical of 'normal', 'whispery', 'breathy', or 'creaky', 'falsetto', and 'deaf' voices (King and Parker 1980, Abberton *et al.* 1989; electrolaryngograph interface manual). Such ideals are clearly inadequate: in order for laryngographic feedback to be clinically useful, the norms established by Barry *et al.* (1990) will need to be extended to the more extensive British National Database to include a wide range of British English dialects, and the fundamental frequency characteristics for voice pathologies carefully documented. It should also be noted that the disruption of normal voice in dysphonia involves 'pitch', 'intensity', 'quality', and 'flexibility' (Aronson 1985), and clinical approaches are manifold (Reed 1980). Psychological factors, and vibratory/acoustic factors inadequately represented the laryngograph (such as intensity and voice 'quality') may also be involved.

The usefulness of the Dx and Cx plots as visual feedback in therapy is restricted by the fact that they necessarily take some time to produce. Indeed it has been shown that between 90 and 120 seconds of speech is required to obtain a representative sample of voice activity (Barry *et al.* 1990) during which time there is little useful feedback.

The Lx trace, on the other hand, may be displayed in real time. Unfortunately, the trace can often prove unstable during speech, although it may be held more steady for controlled phonation on a single note. During normal conversational speech, variations of F_0 in voiced speech elements are an integral part of normal prosody, and this results in changes in the frequency of the Lx. Furthermore, even a good stable image of a normal trace has a complex shape, with characteristic

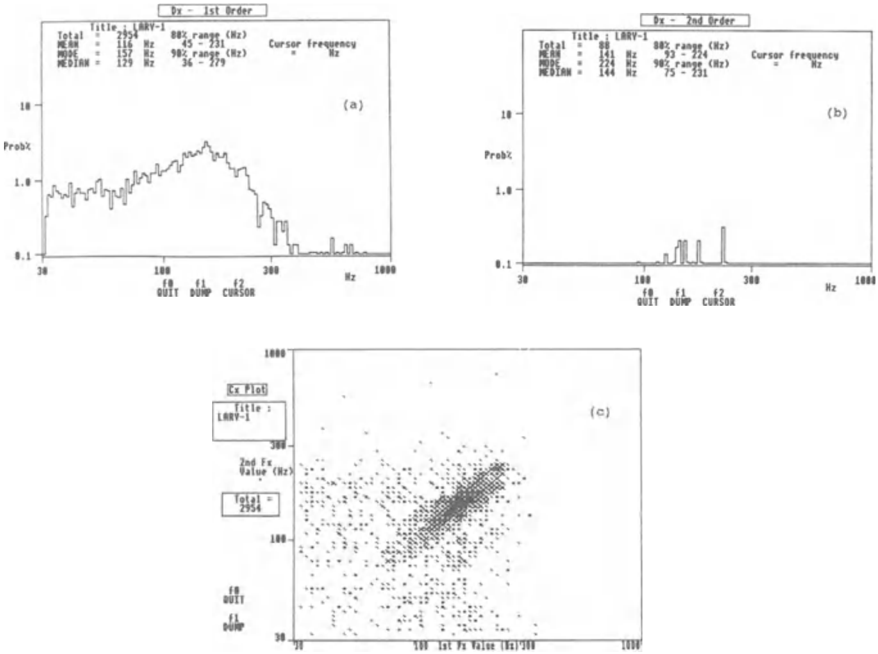


Figure 4.1 Voiscope: examples of data from dysphonic speech. (a) Dx (first order); (b) Dx (second order); (c) Cx plot. Note the very broad distribution of the Dx (first-order) plot, and the wide scatter of the Cx plot. These should be compared with normative data.

gradients, peaks, and troughs between peaks, and the usefulness of this type of feedback requires skilled interpretation. See Abberton *et al.* (1989) for a fuller description of the Lx waveform, and Winstanley and Wright (1991), discussed below, for some preliminary work on Lx norms. Problems are also reported with the positioning of the electrodes, particularly with children, primarily because of the difficulty in placing even small electrodes reliably over the larynx. Similar problems are sometimes reported in using the system where there is excessive subcutaneous fat tissue. These problems may be overcome in part by obtaining a maximal Lx amplitude with the aid of an oscilloscope and, in time, with the development of improved electrodes. Despite these problems, the device has widespread use in voice research and therapy around the world. Prototypes of the faster and more versatile IBM-compatible laryngograph are encouraging, and there is every reason to consider that this device will continue to be a valuable tool for the voice therapist.

LARYNGOGRAPH INTERFACES

The value of the laryngograph Lx trace in the management of dysphonia is diminished at the present time by the difficulty of interpreting the complex waveform. Furthermore, the signal tends to be more complex in cases of pathology compared to that produced for 'normal' phonation. There is also the problem of its transience on the oscilloscope. This latter problem may be solved with a freeze-frame oscilloscope, or other storage devices, but these solutions are expensive and tend not to be amongst the accoutrements of the clinical setting. Obtaining hard copy by the laborious process of manually tracing the waveform or photographing the trace with a Polaroid camera is also clearly unsatisfactory. Therapists also felt that the laryngograph failed to provide Fx data, and was less than ideal for monitoring changes in the patient's voice parameters through time (Cassidy 1988, unpublished). To achieve this end, printouts and disk storage of the Lx traces needed to be incorporated into the design of BBC–laryngograph interfaces.

To some extent the 'Voiscope' provided solutions to some of these problems, but it was also relatively expensive. The electrolaryngograph interface (ELI), and Datamed interface, consisting of software and add-on pieces of hardware (the interfaces) for the BBC or BBC Master plus laryngograph, were designed with specific clinical applications in mind to provide low-cost solutions to these problems. In both systems, the Lx waveform is digitized and displayed on the VDU, and this may be 'frozen' on screen at will by using the computer keyboard. The split-screen facility is provided for the Lx (ELI) and Fx (Datamed). Both systems provide the facility of making measurements from screen displays, of storing and retrieving short samples from disc, and printing traces and graphs via a printer or specialized plotter. The interfaces incorporate many excellent ideas, but as so often occurs with low development budgets, there are shortcomings in the software, the design of the displays, screen commands, and the manuals (see Cassidy 1988, unpublished). Nevertheless the interfaces (alone, or with devices such as Visispeech) have found applications in assessment and for visual feedback in therapy alongside the widely used perceptual Vocal Profile Analysis (VPA) which has been shown to be somewhat unreliable (Blaustein and Bar 1983).

Winstanley and Wright (1986) present a single case study of a dysphonic patient using ELI (with the Larycord software) and in so doing they highlight one of its central shortcomings. As the time-base of the display is short, each sample is not representative of overall vocal fold vibration. The ELI Lx trace has a time-base of 20 ms. For a male voice with a fundamental frequency of 100 Hz, this displays two cycles at any one time. Two waveforms may differ from one another, representing an unstable vibration, or it may represent a glide in normal intonational change. Unless some stochastic measure is provided, evaluation of individual traces will remain purely subjective. The same problem exists in the 'measurement' module of ELI, in which data about the fundamental frequency (Fx) or the period (Tx) are based on one or very few cycles. Measures from such small samples must be regarded with some caution.

Recently, the ELI software has been updated from the earlier Larycord to Wordplot, reducing some of the difficulties mentioned above. The major advance is that the system can now handle a signal duration of 1.7 s, through which one may scroll, viewing windows of 22 ms. Although this does not approach the 90 s established by Barry *et al.* (1990) for a representative sample, it is a significant improvement. The provision of five time 'markers' for making measurements of open, opening, closed, and closing phases (Abberton *et al.* 1989) of signals saved to disc, but without an algorithm for establishing the boundaries of the different phases (Howard *et al.* 1990), means that the measurements are unlikely to be reliable (i.e. they are not scientific).

The 'Datamed' interface addresses some of these problems with software that supplements the Lx trace itself with Fx traces (in a split-screen format), histograms of fundamental frequency distribution for up to two minutes of speech, and the more research-oriented spectrum analyser (Patterson *et al.* 1988). However, the Fx and histogram facilities recreate facilities available on Visispeech, and therapists appear to prefer the latter (see Cassidy 1988, unpublished). Visispeech (and Voiscope) provide mode and median values for fundamental frequency data, and these are considered to be valuable supplements to the mean values. On the other hand there is an advantage to deriving Fx data from Lx in that unlike the microphone input to Visispeech, it is immune to ambient acoustic interference. However there is a trade-off between providing data on fundamental frequency from the Lx waveform, which is rapid but possibly unrepresentative, and analysing chunks of speech, which takes time but is statistically reliable. The choice between these may be pragmatic, but in general research data will require statistical reliability, whilst the imperative of feedback is immediacy. It should also be stated that the Datamed and Visispeech histograms have been hamstrung to date by the lack of established norms; although some extrapolation from the Barry *et al.* (1990) norms may be possible.

The Lx displays have been hampered by the same lack of established norms. Winstanley and Wright (1991) describe a mixed population ($n = 100$; 66 F, 33 M analysed together) aged between 18 and 80 years. This rather heterogeneous population was selected on a number of criteria for normal voice, and Lx samples were collected with ELI from spoken stimuli elicited by presentation of the stimuli both visually and auditorily. The samples were of continuous phonation, single words, and phrases that could be uttered in the 1.7 s available for the system. Although nearly one-third (29%) of data were unanalysable, some 800 Lx cycles were analysed. Unfortunately the boundaries of the phases 'closing', 'closed', 'opening', and 'open' appear relatively arbitrary. Nevertheless the four phases described were 'clearly identifiable' in 68% of the waveforms, with 10% of cycles varying inconsistently. Unfortunately in this study the intrasubject 'regularity' of cycles is given no statistical confidence level. The Lx data for all subjects indicates that the 'closure' phase was relatively consistent ($x = 0.8$ ms, SD = 0.26); 'closed' phase was the briefest ($x = 0.34$ ms, SD = 0.27), and the 'open' and 'opening' phases were the most variable with the widest ranges ($x = 2.26$, SD = 0.85; $x = 1.33$, SD = 0.92).

The fundamental frequencies of the subjects were measured (80–367 Hz), and this was found to effect mostly the 'open' and 'opening' durations. Part of the study is purely descriptive, outlining the relative proportions of patterns for the different phases. For these norms to be useful a more objective (mathematical) description will be necessary. Descriptions of onset and offset of phonation patterns also appear somewhat arbitrary. It is nevertheless an important study in posing the central question: what does a 'normal' Lx waveform look like? This work needs to be continued, and further research may also attempt to substantiate the authors' comment that the Lx of patients presenting with functional dysphonia have a greater level of intrapersonal variability than normal.

As direct visual feedback the Lx waveform may simply be too complex to be useful as feedback (see discussion of the superabundance problem, p. 87), and until such time as its intra- and intersubject variability is understood better, the notion of an 'abnormal' waveform is at best subjective; at worst it is meaningless. In the Cassidy (1988, unpublished) questionnaire to therapists using the interfaces, a high percentage of respondents reported problems in interpreting the waveforms (100% for ELI; 40% for Datamed), and this problem is shared by users of the unenhanced laryngograph. The capacity to freeze the waveform is useful, but it should be unambiguously stated that at present the selection of periods of 'steady state phonation' is subjective.

Voice quality may be described in terms of Lx waveform 'open' and 'closed' quotients (see Howard *et al.* 1990). These are currently research metrics, but if they are indeed good indicators of pathology, they could be linked to easily interpreted visual displays in real time for use as visual feedback in the clinical setting. Indeed their value has already been recognized, e.g. in the changes of closed quotients changes with training in male singers (Howard *et al.* 1990), and the Datamed interface produces some data on these parameters for clinical use.

However, a more general problem relates to an assumption made about the usefulness of the Lx trace as visual feedback. The assumption is simply that it is the feedback itself which is mediating between the patient and their control of voice function. In fact there are at least four elements at play, viz:

1. Proprioceptive feedback, i.e. the patients sensations about how it 'feels' to alter aspects of his or her voice.
2. Motivational factors related to the status, in the minds of patients (and therapists), of computer technology, and to the function of a visual display focusing the attention on a representation of voice.
3. Except in cases of hearing impairment, auditory feedback by the therapist (or Voiscope).
4. The visual feedback itself.

Although the Lx trace is regarded by many as stock-in-trade for voice therapists, little attention appears to have been paid to the processes whereby a patient uses the complex visual image to adjust complex motor patterns to produce a more 'normal' trace, far less to the processes responsible for generalizing these skills to speech outside clinic. Until controlled experiments are performed to establish the relative importance of these factors and to disentangle their effects, statements about the visual feedback component must be regarded as uncorroborated. This said, however, the interfaces have some advantages over the Voiscope, not least their low cost.

VISISPEECH AND VISIPITCH

Visispeech is in many ways the model of clinical visual feedback devices in Britain: as one of the forerunners of the form, it set the pattern for many devices that followed. Designed specifically for the deaf community, it used the memory capacity of an undedicated microcomputer (rather than specialized machine or expensive and complex minicomputer) in order to display and record speech patterns over time rather than instantaneous measures from meters or oscilloscopes (King *et al.* 1982). Input to the system is via a standard microphone rather than neck electrodes.

Linked to customized hardware and using an ingenious combination of assembly language routines and a BASIC control program, Visispeech provides visual feedback of changes in fundamental frequency, energy, and voicing over time (Cook *et al.* 1986). Additional software was also developed to provide graphical and statistical information about the distribution of fundamental frequencies in a speech sample (Figure 4.2).

Following Cook *et al.* (1986) we will refer to the software as P1 and P2 respectively.

The analogue peak-picker and smoothing algorithm that underlie the fundamental frequency analyses, were also new developments, enabling the display of fundamental frequency contours extracted from the stream of speech. The microcomputer capabilities for storage and for printing the graphs were novel, and these proved to be invaluable for keeping records of therapy.

Visispeech utilizes a split-screen layout, one-half of which is for the clinician's model, and the other for the patient's attempts to reproduce this model. This was originally developed for the laryngograph, and is now widely regarded as the ideal form of visual feedback. However, the assumption that the clinician is able to produce an appropriate template for the patient is questionable. For example, 'correct' intonation patterns vary considerably across different dialects of English and it would be hoped that the norms currently coming on stream will replace or supplement this *ad hoc* solution to the template problem. The type of statistical information about F_0 distribution provided by Visispeech is also regarded as an essential part of any data set, and has been incorporated into other devices such as Voiscope and Visipitch.

The secret of the success of Visispeech is precisely its simplicity, displaying a single parameter such as voice 'pitch' or 'energy', in a readily interpretable form in real time. Further, the approach of concentrating for example purely on fundamental frequency as feedback has some compelling theoretical rationale in the work by Rosen and others (Rosen *et al.* 1981, Fourcin *et al.* 1984).

P1 has been widely used in providing feedback for hearing-impaired clients. For different reasons dysphonics may also have restricted pitch ranges, and therapists working with this group have also made use of the real-time feedback of 'pitch' contours. As Abberton *et al.* (1989) point out, there may be some compensation for the handicap of a restricted pitch range by full use of intonational nuclear tones; using Visispeech this may be a primary objective of therapy. Less satisfactory because the results are less consistent, pathological voice quality may give rise to more than one pitch trace, or a broken trace. Because the 'voicing' module is based on the spectrum balance of low and high frequencies, this part of the program may be used to provide feedback of 'breathiness' or 'hoarseness', which has significant high-frequency aperiodicity ('voicelessness'). Cook *et al.* (1986) also suggest that the P2 distributions may be indicators by which the quality of 'breathy' and 'hoarse' voice may be monitored through therapy. Their suppositions about the lesser distribution peaks (subharmonics) in hoarse voice are interesting, and have received some independent corroboration by Dejonckere (1990). Rosen and Fourcin (1986) refer to the phenomenon as a 'diplophonic' voice quality. However, spectrography may be more appropriate for feedback of these features.

Another current limitation of Visispeech is the BBC computer to which it is linked. The constraints of RAM memory restrict pitch contours

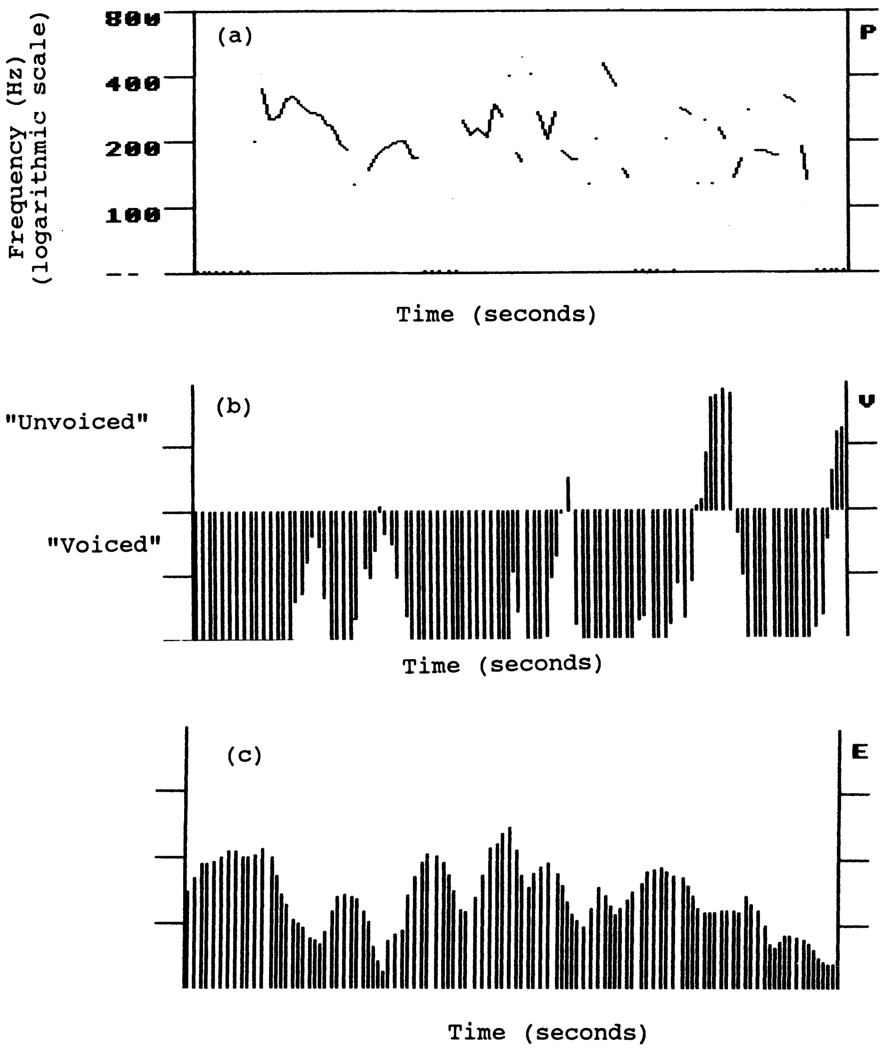


Figure 4.2 Visispeech (P1): examples of data from a dysphonic patient, showing (a) the intonation contours (F_0); (b) 'voicing'; and (c) 'energy' of a single read sentence. These traces show reasonable control of voicing and intonation, despite poor voice quality.

to a maximum of six seconds duration, and the processing speed, e.g. for 'scaling' histograms in P2, compared to currently available technology, is painfully slow.

Visipitch was based originally on a high-quality storage oscilloscope with a dedicated signal processing unit as an additional module. The display offers the therapist visual feedback of either a sound pressure waveform from a microphone input, or its simplified derivative of pitch alone. Fawcus (1970) reported on a similar device extracting pitch by the so-called zero-crossing method constructed by the Physics Department at Guys Hospital. Current versions of Visipitch utilize an IBM PC-compatible microcomputer for relatively rapid signal processing, and to provide similar statistical analyses and display facilities to those offered by Visispeech.

Because of its relatively high cost, Visipitch does not enjoy very widespread use in Britain, but some therapists, impressed by reports in the US literature (e.g. see Horii 1983), have invested in the system and have found it to be a valuable tool in therapy for dysphonia and dysarthrophonia. Unfortunately, accounts of its usefulness and limitations in therapy are not readily available.

SOUND SPECTROGRAPHY

Spectrography in speech therapy has many potential applications in voice therapy and some of these ramifications are explored elsewhere (Fawcus and Hirson 1990). The technique involves combing through the three-dimensional acoustic signal to identify features in the time or frequency domains. The intensities of different components are shown on the image by the darkness of the trace or from a palette of colours.

Until the early 1960s sound spectrographs were of little direct use in therapy because of the constraints on processing speed required to generate each spectrogram. They were, however, capable of establishing valuable baseline parameters which therapists could track through the course of therapy. Unfortunately, few voice therapists had access to spectrographic equipment, or the training to use them. Despite these obstacles the value of spectrography in dysphonia was demonstrated even in these early days, e.g. in the analysis of oesophageal voice carried out by Damste (1958).

There were hopes that the advent of the microcomputer would facilitate clinical developments, but until recently computers have lacked the processing power and memory to offer more than basic acoustic analysis. In recent years the Philips Acoustics Research Team at Eindhoven have produced an integrated system for the IBM PC (Elsendoorn 1984), which is capable of providing fast Fourier acoustic analysis as well as crude spectrographic analysis. Although it has been used extensively in acoustic research on speech and voice it has had little impact on voice therapy. The production of spectrograms is relatively rapid, taking a matter of seconds to produce the different visual displays, but this is probably still too slow for effective feedback for patients.

Loughborough Sound Images constructed the LSI Sound Spectrograph following the principles of speech analysis devised by Holmes (1973). Although it produces elegant sound spectrograms, the length of time involved in producing each spectrogram was reminiscent of the more ancient machines. The necessary breakthrough was a machine with real-time screen facilities, and this has recently been developed by LSI. The development of software to execute the fast Fourier transform, and the integration of digital and analogue parts of the process to perform this task in real time has opened the way for the development of real-time spectrographic feedback.

This is exemplified by the Kay DSP 5500 Sona-Graph (a term that has become almost synonymous with spectrograph), which digitalizes recordings from an audiotype or acoustic input directly from a microphone. The signal is processed such that a multiplicity of formats may be simultaneously displayed on a high-resolution screen. Optimal settings may be stored and recalled in a very straightforward manner to tailor this aspect of therapy for individual patients. This storage facility, as well as file management and manipulation may be extended further via links between the spectrograph and a controlling microcomputer.

With a tool of such complexity and potential we still have a great deal to learn about its value and use in voice therapy. Spectrography has undoubted value in freezing the fast-fading acoustic signal, providing a focus of attention in the therapy situation. An utterance can be scrolled backwards and forwards, held on the screen and compared with an earlier recording made by the patient or therapist. If more detail is required on a particular portion of the utterance, then the display can be reformatted using a different time-base or frequency scale. Cursors may be employed to make measurements or to provide targets.

The display may consist of two spectrographic channels, permitting direct microphone or recorded input, and allowing direct comparison of two separately recorded utterances or two utterances produced by the same individual. Possible formats for display of the acoustic signal include the cepstral analysis for extraction of the fundamental frequency, and spectral averaging to examine formant values, but these share at least one serious shortcoming for feedback in therapy. The speed with which the displays are processed is such that useful information can be on hand in a very short time, but the lag-time undermines the usefulness and efficacy of these displays as feedback. Furthermore, the current combination of cepstral analysis with amplitude and zero-crossing traces contains too much information for rapid interpretation. The 'pitch' displays of the Voiscope, Visipitch or Visispeech are smoother, and are produced without delay. The spectrograph also currently lacks the facility of producing statistical information about the signal.

The spectrogram, even for the experienced researcher, is something of a visual cacophony. In a study that claims to use unsimplified spectrograms as visual feedback for the hearing impaired (Maki *et al.* 1981), claims are made about spectrogram reading skills by patients which would do credit to any postgraduate speech therapy student. The superabundance of parameters displayed on the unsimplified spectrogram is daunting even to trained researchers, and this study may well prove unrepeatable. Furthermore, there is no need for the patient to have these rare spectrogram-reading skills. Feedback in voice therapy is likely to be beneficial only if the display is easily interpretable. It is this particular parameter of the acoustic signal which should be displayed.

Three major difficulties may be identified in using sound spectrography as feedback. The first problem is the need to produce the spectrogram without noticeable delay as the input is fed into the machine. This could be termed the real-time problem. The second concerns the sheer quantity of information conveyed by the spectrogram, and this we have dubbed the problem of superabundance. The third is a more general feature of visual feedback, which may be termed the carry-over problem. The real-time and superabundance problems are discussed here; the carry-over or learning problem is discussed in the section on the theory of feedback (p. 93).

There can be no substitute for perceived real-time feedback in active voice therapy. This has been demonstrated clearly in work on the laryngograph and other similar feedback devices (Fawcus 1970, King and Parker 1980). The dynamics of patient–therapist and patient–device interaction may deteriorate rapidly if there is any appreciable delay while the machine produces an image.

No machine is capable of transforming its input instantaneously. For the device to act as a feedback system it is important that the processing time for transforming the input does not interfere with the perception of the output. One criterion that a 'real-time' device must meet is that the output rate from the algorithm is no greater than that for the input rate; even a small lag-time will accumulate rapidly and the output will lag behind the input. The speed with which the algorithm may be processed will depend upon its computational complexity and the speed of the processor. Such is the speed of the DSP 5500 that in most cases the delays in displaying spectrograms are undetectable to the human perceptual system.

Acceptable delay in visual feedback relates to the speed of visual processing. This criterion determines, for example, the necessary 'refresh time' for television or cine film (20 ms). The demands this places on sophisticated software, and even rapid microcomputer technology, is considerable, and have been overcome only very recently on research-based equipment.

The second problem in using spectrography for visual feedback in a clinical setting is that spectrograms are complex, representing the three dimensions of sound (frequency, intensity, and time) on a two-dimensional surface. By representing the entire signal in a single image, sound spectrography provides a more complete picture of the acoustic signal than most other representations. This virtue for research applications, however, is also the major limitation for its clinical application.

The superabundance problem may be overcome in part by the versatility of the Kay Sona-Graph. Upper and lower channels may be used independently to provide visual representations of specific features of speech. Dysarthrophonic and puberphonic patients have been provided with real-time feedback of just the lower harmonics in the (narrow-band) spectrogram of voiced speech, providing feedback rather like the Visispeech intonation contour. The focus of therapy has been to prolong the duration, sustain the power of phonation, and to control the 'height' and movement of the first harmonic (Kerr and Hirson 1989, unpublished; Fawcus and Hirson, in preparation). The first harmonic display is not limited by the memory constraints of Visispeech (6 s) nor the time-delay in producing the Kay's own cepstral analysis. The results of these different courses of therapy are encouraging, and will be reported elsewhere. However, it is noteworthy that in both cases there was no indication that increased pitch control and improved awareness of pitch changes were 'imported' into the considerably more complex speech control systems for spontaneous speech. This contrasts sharply with the reported results using the laryngograph with deaf subjects where gains were achieved in the control of speech intonation and rhythm (Parker 1974). In these cases the carry-over was attributed to the role of kinaesthetic feedback (Fawcus 1980, King and Parker 1980). This carry-over problem is discussed on p. 94.

The use of the first harmonic visual for feedback highlights a particularly important problem in spectrography – both for voice analysis and feedback. The current state of the art makes it very difficult to identify a specific parameter or combination of parameters which are significant for any given voice feature. It may be that a complex set of parameters is the only way of representing the complex nature of phonation, particularly for relatively subtle disorders of voice. In this case, superabundant feedback may be necessary, and the onus rests on the clinician to make aspects of the feedback meaningful to the patient.

It is now a research imperative to identify, singly or in combination, the acoustic features associated with specific categories of voice pathology. It will then be possible to design software to selectively display in an appropriate form these features in real time, possibly in combination with a more complete spectrogram or other graphical representation of vocal-fold activity for the benefit of the therapist. Statistical measures of such parameters as fundamental frequency, 'noise', or proportion of voicing (periodicity) would also be useful. In time these features may be expected to be incorporated into an affordable clinically-based spectrograph.

SPEECHVIEWER

SpeechViewer, developed for over a decade in France and the US, and known originally as 'Vocalisation', operates on the most recent IBM PS/2 microcomputer, and has now entered the domain of clinic-based feedback devices used with voice patients in Britain. The system was originally designed for use with the deaf but now also claims applications with patients with language, cognitive, voice, fluency, and articulation problems (Maulet 1990, Winyard and McCurtain 1990, IBM Speech-Viewer Case Studies, undated).

Software modules designed for visual and auditory feedback in speech therapy are devoted to a range of sound parameters, and are organized into 'awareness', 'skill building' and 'patterning' sections (Figure 4.3). The modules themselves are impressive, particularly when compared to some of the BBC microcomputer devices with which they now compete. The system benefits from the rapid speed of the PS/2, and the games format of the 'skill building' modules is a welcome addition to voice therapy. The design of the 'front end' (the visible graphics in front of the algorithms working in the background) is excellent and the quality of the graphics is superlative. Careful design has also led to a clear presentation of information on screen, with useful 'help screens' for the therapist to adjust aspects of the display, or for help when difficulties are encountered. There are also valuable facilities for saving and retrieving material to and from disk.

However, the PS/2 computer, at the time of writing, has a somewhat uncertain future in the computing world. It is only partially compatible with the earlier IBM PC computers (on which SpeechViewer will not function), and it has not established itself as the 'industry standard' (What To Buy For Business 1989). Fortunately the new laryngograph will have a PS/2-compatible variant, and most standard IBM software will also run on the new machine. Unfortunately, most of the software written for speech therapy is still restricted to only the BBC microcomputer.

The IBM SpeechViewer Guide (undated; pp. 2–16) suggests that for organic and functional dysphonia, 'corrective intervention' with SpeechViewer might include work on 'inadequate or excessive loudness; inappropriate habitual pitch; inappropriate assimilated or de-nasal resonance; vocal hyperfunction, vocal abuse; voice onset difficulties; breathiness; harshness; and tension'. Several appropriate modules are then suggested for each of these disorders. The excellent manual (IBM SpeechViewer User's Guide 1988; Appendix A) also suggests modules which may be used for patients exhibiting aspects of voice pathology. Although this approach appears somewhat formulaic, it may be useful to some therapists. The range of modules is certainly impressive, and individual modules have a great deal to commend themselves, but the question of the mechanism for the 'corrective intervention' is one that requires serious consideration.

The modules vary greatly in the extent to which they may be considered useful for an individual dysphonic patient. For example, the module designed to provide visual feedback on 'frequency' is an innovative presentation of F_0, and its suggested applications are entirely appropriate. On the other hand the claim that the 'waveform patterning' module may act as feedback for problems of 'quality/resonance' and (vocal-fold) 'tension', as well as all the other itemized disorders associated with voice pathology is a little optimistic (IBM SpeechViewer Guide, undated; pp. 2–17). Further limitations of this module are the maximum duration of speech that may be analysed (11.84 s), considerably less than the 90 s minimum suggested by Barry *et al.* (1990), and the lack of modal values in the statistics which have been found to be very valuable by users of Voiscope.

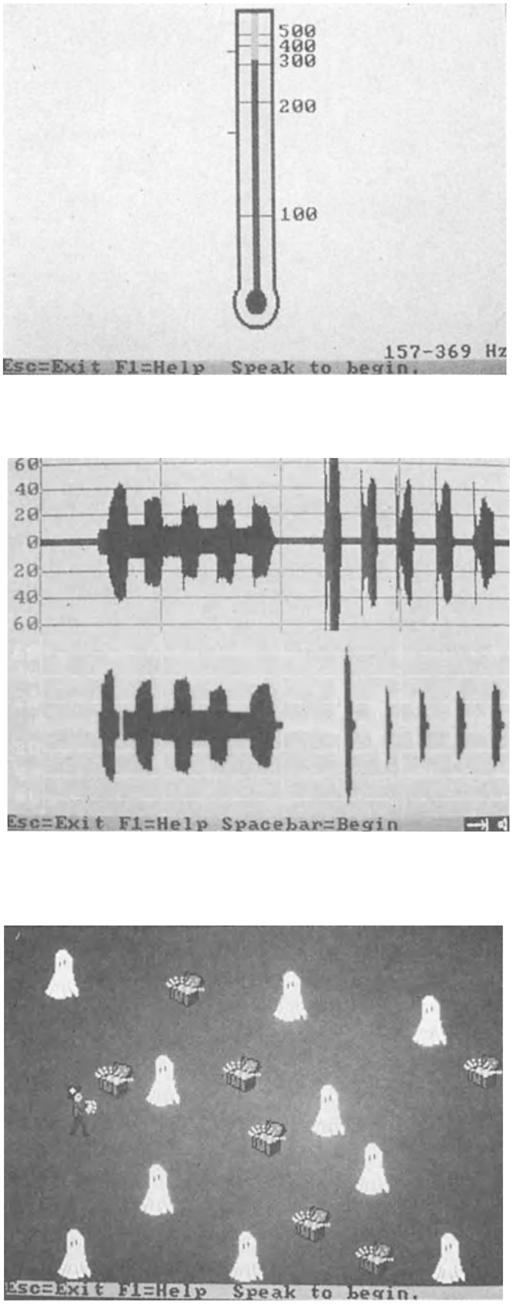
Indeed one of the failings of SpeechViewer is the implied claim that it is something of a cure-all. The clinical effectiveness of SpeechViewer with dysphonics still requires proper evaluation. The Riski and Horner (undated) case study of SpeechViewer therapy with a voice patient is anecdotal, with no systematic record of progress, and no controls; it also appears to accept uncritically that the 'norm' for the therapy is the therapist's voice.

The 'sound awareness', 'voicing onset', and 'amplitude awareness' modules are all likely to be useful visual feedback for dysphonic patients and are already proving to be useful with other groups of voice patients. However, one of the problems experienced by clinicians is that the modules appear either as very child-orientated, which may be off-putting to adults, or, in the case of the three 'patterning' modules, rather technical. Further, the 'patterning modules' (used in the Riski and

Horner (undated) case study) labour under the weight of the superabundance problem (p. 87), and the complex information conveyed as feedback, except in cases of severe pathology, is unlikely to be very meaningful.

The 'frequency skill building' module raises other far-reaching questions. The patient/subject moves a token through a set of obstacles by varying his or her fundamental frequency. This module has some similarity with the SINGAD system described by Howard and Welch (1989), discussed below. Howard and Welch (1989) employ the skills involved in their SINGAD system for singing training. In SpeechViewer the extension of voice pitch range, and development of fine control over pitch modulation control (IBM SpeechViewer User's Guide 1988; Appendix A) is concerned with features of speech such as intonational range and control. The question as to whether skills developed in the 'frequency skill building' module can then be integrated into speech raises a number of questions about the relative independence of prosody and segmental features of language, and the integration of skills in language. Current phonological theory suggests that at least some aspects of prosody such as rhythmic structure are intimately linked with segmental structure, and one could draw interesting conclusions about the pathology if 'pitch' could be trained separately and later incorporated into speech. It should be noted however that there is a difference between training the singing of a particular note (or even a group of notes) and 'training' a patient to use a particular intonation pattern. In the former the target has an absolute value, whereas for the intonation contour exact replication (in terms of frequency, duration or amplitude) is neither expected nor required. It is the general shape of the contour rather than the precise pattern which is desired. The idea of an exact replication is very clear in the 'frequency and amplitude patterning' module (mixed screen) designed for the patient to attempt to overlay his or her waveform pattern over that of the therapist (assumed 'normal'). This essentially behaviourist assumption is simply not applicable to language.

SpeechViewer includes advanced features such as speech recognition, and means of storing and accessing speech/voice samples which far outstrip those available to most other feedback devices. Unfortunately, published clinical trials to date have been poorly conducted, and refer to the earlier 'Vocalisation' version of the system (IBM SpeechViewer: Case Studies, undated). The experience of the current authors leads to suggestions of a number of minor alterations in design. Such alterations are possible as software developments (Crepy 1989), but require sophisticated expertise in real-time programming, debugging, acoustic processing, and signal analysis. It would be useful if this task was assisted by intermediary software.



a

b

c

Figure 4.3 Speech Viewer format for (a) 'frequency awareness' module; (b) 'frequency and amplitude awareness patterning' module; and (c) 'frequency skill building' module.

AIR FLOW AND CINEMATOGRAPHIC FEEDBACK

Air flow and other respiratory measures have held an important place in research into dysphonia (e.g. Draper *et al.* 1960). There has been little attempt to employ such techniques directly in voice therapy, but affordable systems that can handle multiple channels of data are likely to make use of such feedback. Anemometry linked into the BBC microcomputer has also been used in speech therapy (primarily for work on nasality) but it has been hamstrung by poor design of the sealed mask.

McCurtain, developing her earlier work on xeroradiography of the dynamic soft tissue during sustained phonation (Berry *et al.* 1982), has now begun to examine the possibilities of nuclear magnetic imaging as a method of direct feedback of the larynx and surrounding musculature (McCurtain 1990). This method avoids the harmful side-effects of xeroradiography, and although it currently produces only still images, in the near future one may expect dynamic images which can be matched with other non-invasive measurements.

Stroboscopy, using fibreoptic and video technology, produces cinematographic images and has also become a standard assessment tool used by otolaryngologists, but to date it has not found widespread application in voice therapy (Harris and Collins 1989). In part, this has been due to the expense of the equipment, and also because the fibreoptic probe may be considered too invasive to permit relaxed phonation. In addition, the visual image is often too complex to be of great use except in cases where there is a visually obvious abnormality of the vocal folds, or their vibratory movement (Bastian 1987). Nevertheless Bastian (1987) reports some successes using this technique particularly with patients exhibiting false vocal fold phonation and psychogenic dysphonia and aphonia, and there are glowing accounts of this 'larynx image biofeedback' (LIB) in singing training (Cleveland 1988, 1989).

We have presented details of a number of visual feedback devices providing information about the vocal-fold vibrations directly (stroboscopically), about the whole acoustic signal (spectrographically), or selected parameters of sound (peak-pickers, etc.). More physiological feedback includes air-flow and electromyographic information (Andrews *et al.* 1986). The success of all of these techniques relies on processes of so-called behaviour modification, and this requires some consideration.

THEORY OF VISUAL FEEDBACK

As discussed above, the minimal requirements for effective feedback are that the feedback is meaningful (i.e. it avoids the problem of superabundance by simplification) and that it is delivered in real time. A variety of different feedback systems have been attempted in voice therapy, including tactile feedback, feedback of the vocal-fold vibration waveform (Lx) using the laryngograph, and laryngeal image biofeedback. The most commonly used form has been visual feedback from the acoustic signal, but the methodology as a whole has rarely been subjected to any theoretical scrutiny.

Indeed, visual feedback is rarely discussed in the speech therapy literature (but see King and Parker 1980, Fawcus and Hirson 1990). However, it has received some attention in the psychological and musicological literature. Using a mirror to assist in mastering a motor skill such as a weightlifting technique (Sewall *et al.* 1988), or a microcomputer system displaying 'pitch' to train children to sing more in tune (Welch *et al.* 1989) both share the feature that meaningful information about an activity is displayed visually in order to assist in perfecting that activity.

Many activities, including use of the voice, are almost always accompanied by some form of feedback. This may be divided into feedback from the environment (exteroceptive feedback) and from the body (proprioceptive feedback). The feedback from the environment may, in turn, be of several different types, e.g. an echo, or someone's facial expression; and, crucially for the current debate, it is uncontrolled, and unscaled. An artificial and scaled response to the activity such as computer screen displaying an intonation contour through time, is what is meant here by the term 'visual feedback', and referred to in the psychological literature as 'knowledge of the results' or KR. It is hypothesized that the integration by the learner of internal and external feedback, and more particularly, the self-awareness of the activity via the scaled feedback, is the motive force of the learning (Welch 1985). Drawing upon ideas from cybernetics and knowledge of results (the feedback) is input to an 'error-labelling schema', and the mismatch between the actual and the desired production drives the learning process (Welch *et al.* 1989). The terminology used by those developing other feedback devices are equally revealing, e.g. in using the laryngograph '. . . [the patient/language student] can benefit from immediate correcting and reinforcing feedback from the visual feedback.' (Fourcin 1971: p. 176). In short, the theory is a behaviourist account of learning in which the reward (or stimulus) for a behaviour is the matching of a visual representation of the behaviour with a target associated with the same behaviour. For a fuller account of KR see Adams (1978) and Salmoni *et al.* (1984). Some of the feedback devices such as SpeechViewer, provide more explicit rewards: a starburst and rewarding sound-effects are produced for the successful achievements of tasks such as the 'frequency skills module'.

One of the casualties of this KR approach is that any cognitive representation or internal structure of the behaviour is lost by the wayside, and indeed this (anti-mentalism) was one of the prime reasons for developing this branch of psychology (Chomsky 1959). Adams (1978) sees this aspect of KR theory as dispensable, but it continues to exert its influence in thinking about visual feedback. The visual feedback device responds to specific acoustic or other stimuli, but *how* these changes are effected, is irrelevant to the device. This pragmatic approach may be all that is possible given the current state of theory about voice production, but this limitation of the methodology should be kept in mind when using visual feedback.

One of the questions hanging over the technique of visual feedback is whether there is any carry-over from the therapy with feedback to natural speech outside the clinic. KR theorists have debated this issue, and although it remains controversial, the predominant view is that the targets may be internalized so that the subject may continue to modify behaviour on the basis of the errors between his or her actual behaviour and the established targets. More controversial is the debate concerning whether the changes effected by KR are transient, or whether they constitute learning (see Salmoni *et al.* 1984).

Since KR research has applied to motor skills, it is appropriate to ask whether voice falls within this category. This question would receive different answers in different quarters. Simple phonation and aspects of singing may more easily be classified as a motor skill than voice as a prosodic feature of language. However, irrespective of the function of voice, its production undoubtedly involves a complex motor programme, which results in the vibrations of the vocal folds to produce the more or less melodic and distinctive characteristics of speech.

On the other hand, treating voice as a motor skill may be one underlying reason why there are reports of restricted carry-over from clinic to real life, and from voice exercises to speech. It may be that voice is indeed successfully trained as a motor skill, but this skill is not successfully integrated into more complex cognitive processes such as speech. Theoretical as well as clinical developments are necessary to resolve this issue.

A positive aspect of using visual feedback is that the voice production is externalized, and the patient's focus directed towards the objective representation on the computer display screen. In the few instances in which the method has been evaluated, e.g. in the SINGAD system for singing training, the results show that intervention assisted by visual feedback is significantly more effective than without (Welch *et al.* 1989). However, whether feedback of voice production may benefit dysphonic patients in a similar way is a question requiring serious investigation.

FUTURE DEVELOPMENTS

It remains a theoretical and empirical question whether visual feedback is of equal use for different types of dysphonia, and whether the effects of feedback are transient, or have more long-lived learning effects.

The type of information conveyed during feedback which is deemed to be useful will depend in part, on theories about normal and pathological voice production. For example there is evidence that the breakdown of the integrity of vertical striations in a broad-band spectrogram may provide us with an index of 'hoarseness' (Rontal and Rolnick 1975). The integrity of upper harmonics, the intrusion of noise components in the second and third formant range, bands of noise above 5 kHz, and short-term variations in the fundamental frequency may all be indicators of 'hoarseness' (Yanagihara 1967, Baken 1987, Dejonckere 1990). Software linked to real-time spectrography (or a spectrum analyser) could use these ideas to provide a simple visual feedback of the pathological voice.

Such software developments could also be open-ended, i.e. they could permit the clinician to adapt the precise form of visual display easily to the specific target of voice therapy, the age of the patient, and the severity of the pathology. Such open-endedness of software, drawing upon current theory of voice pathology, and going beyond predetermined and often limiting 'menu' set-ups, may well be the form of future clinical applications of visual feedback. Such flexibility will enable therapists to exploit new research in voice and to adjust settings for individual patients.

The multiple dimensions of voice, including degrees of aperiodicity, aspects of vocal fold vibration, control of intensity and fundamental frequency, etc. suggests that these could be monitored independently or in parallel via multiple input channels to a visual feedback device. Judicious use of the different channels could then enable therapists to choose those parameters which objective measures show are outside of normal ranges. Such flexibility would also help to integrate therapy and research.

The technology underlying real-time spectrography is formidable, and of an order that is difficult of compare with Acorn's BBC Master computer on which most clinical microcomputer applications in Britain have been based. On the other hand, the BBC, IBM PS/2 or Apple Macintosh are relatively affordable tools, albeit with less software or hardware developed for speech/voice therapy needs. With the fall in price of microchip-based technology over the past decade, there is every reason to believe that relatively sophisticated microcomputer-based visual feedback devices will become available to a greater number of speech and voice therapists in the field. Advances in theory will ensure that the use of such technology has firm foundations.

ENDNOTE

Further technical specifications of the devices mentioned in this chapter may be obtained from:

1. Laryngograph: Laryngograph Ltd, 1 Foundry Mews, Tolmers Square, London NW1 2PE.
2. Electrolaryngograph interface: Trafford Computing, 7 Trafford Road, Alderley Edge, Cheshire SK9 7NT, UK.
3. Datamed Limited, 39 Thorburn Road, Edinburgh EH13 OBH, Scotland, UK.
4. Visispeech: Royal National Institute for the Deaf, Gower Street, London WC1.
5. SpeechViewer: IBM Support Centre for Persons with Disabilities, IBM (Warwick), PO Box 31, Birmingham Road, Warwick CV34 5JL, UK.

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5

Laryngeal disorders in children

Andrew Johns

INTRODUCTION

The management of laryngeal disorders in children is as much the management of the child as it is the diagnosis and treatment of the laryngeal pathology. Close co-operation between specialists of varying disciplines ensures that both the child and the whole family environment are not ignored by too narrow a consideration of what may be a rare and fascinating disorder. Speech therapist, ENT surgeon, paediatrician and, for those children requiring hospital treatment, nursing staff and anaesthetist are the primary team members.

An important hallmark of childhood is growth and its accompanying changes. Development, at its most rapid before birth, continues apace and stages labelled as neonate, infant, toddler, child, and adolescent soon pass. This constantly changing and growing environment has important bearings on the manifestation of disease processes and calls for fine judgement in their management.

What follows does not consist of a list of the many varied conditions affecting the child's larynx. A detailed description of a particular condition can be found in other reference works. Rather it is hoped that the reader will obtain an overview of the presentation and management of the disordered larynx in children. Various conditions will therefore receive mention under the different section headings. Some will be given greater attention than others, the more common disorders being dealt with in most detail. Cross-reference should also be made to Chapter 7 on laryngeal disorders in adults, where, in order to avoid too much repetition, some topics are given greater emphasis.

PRESENTATION

In a textbook devoted to voice it is perhaps insensitive to assign priority to the functions of the larynx. It is often written that the oldest and primary function of the larynx is as a sphincter to protect the lower air passages, and that phonation is a secondary function which makes use of this sphincter mechanism. When both these functions perform without hindrance they assume equal importance, indeed the one carries on unnoticed while the working of the 'voicebox' is apparent to all. Rather than rank being given to the functions of the larynx, priority can clearly be assigned to disorders of these functions. An obstructed or unprotected airway has consequences not shared by an absent or altered voice.

The obstructed airway

Air passing through a narrowed or partially obstructed airway produces a noise. When the obstruction is in the pharynx the noise is rasping and bubbly-sounding and is called *stertor.* An example is the Pierre Robin syndrome. In this congenital condition the small lower jaw does not allow sufficient room for the tongue, which falls backwards to obstruct the pharynx, unless the baby is nursed in a prone, head-down position. Often there is an associated cleft palate.

Stridor is the name given to the noise when it is produced by an obstruction in the larynx or trachea. Some indication of the level of the obstruction can be obtained by assessing the phase of respiration in which the noise maximally occurs. Supraglottic and glottic obstructions produce stridor of somewhat musical quality maximal in the inspiratory phase. This is well-demonstrated by the condition of laryngomalacia, and when a baby with this congenital condition is examined under general anaesthesia the soft tissues of the supraglottis can be seen to fall inwards during inspiration and the stridor becomes audible as the anaesthetic lightens.

A noise produced in both phases of respiration usually indicates an obstruction in the subglottis or upper trachea. Congenital conditions occurring in this situation are subglottic stenosis and subglottic haemangioma. These lesions produce similarly obstructed breathing but the latter would be suspected if there is a cutaneous haemangioma present, usually found on the face or trunk.

An essentially expiratory noise occurs when the obstruction is in the intrathoracic portion of the trachea or the main bronchi and their subdivisions. The larger air passages may be blocked by inhaled foreign bodies, which most commonly lodge in the right main bronchus. The peanut is a notorious offender in young children and is particularly unpleasant due to the intense local mucosal inflammatory reaction to the vegetable oils in the nut. Other mechanisms of tracheal narrowing include compression by surrounding structures or collapse due to a deficiency of its cartilaginous support.

Varying degrees of airway obstruction occur. Severe narrowing will demand a much increased respiratory effort manifested by a raised respiratory rate and indrawing of the suprasternal and intercostal soft tissues. This extra effort can only be sustained temporarily and unless the obstruction is relieved the respiratory and cardiovascular systems will start to fail, as evidenced by the onset of sweating and cyanosis. Complete upper airway obstruction is incompatible with life unless immediately recognized and relieved. This situation can arise if a large foreign body impacts in the lumen of the larynx. Rarely a baby may be born with total airway obstruction due to failure of the formation of a lumen in the larynx called laryngeal atresia. Near total obstruction may be caused by bilateral abductor cord palsy, a condition usually associated with other neurological abnormalities. It must always be remembered that in a neonate with severe upper airway obstruction the obstruction may lie in the nose, usually due to posterior choanal atresia.

Lesser degrees of obstruction will often produce a loud stridor, understandably worrying to the parents, but without causing any constitutional upset to the child.

The unprotected airway

The larynx is not simply an air passage but it is the mechanism which prevents ingested liquids and solids from entering the lower airways. When the larynx is incompetent to perform this function, swallowing is impossible due to the risk of inhalation. This situation is rare in children but as described in the next section minor degrees of feeding difficulty often accompany laryngeal disorders. A posterior cleft larynx is a rare congenital malformation in which the larynx is incompetent due to a deficiency of its posterior wall.

Feeding difficulties

As a protector of the lower airway the larynx plays an important role in swallowing. The neonate is confronted with an entirely liquid diet, which the larynx must prevent from entering the trachea. Complex reflex movements are required, dependent on co-ordinated nerve and muscle function. Immaturity in this can lead to slow feeding and difficulties such as a tendency to cough and choke during feeds. Any laryngeal disorder in infancy may have an associated feeding problem, but a typical example is the commonest cause of congenital stridor, laryngomalacia, in which the stridor is often more marked during feeding. This can sometimes be overcome by thickening the feeds and the early introduction of a solid diet. The thicker food has less tendency to enter the laryngeal lumen and is more easily directed into the lateral food channels.

Dysphonia

Impaired phonation may be due to an irregularity in the larynx, especially of the surface of the vocal cords, which disturbs the airflow or which prevents the approximation of the vocal cord edges. It may also be due to vocal cords whose mobility is impaired by a neuromuscular failure or by fixation at the cricoarytenoid joints. Such abnormalities may manifest themselves as a weak or absent cry in a baby. The severe laryngeal disorders, in which the cry may be feeble, are likely to also give rise to the more serious problem of an obstructed airway.

Harshness, hoarseness and breathiness are qualities in the voice indicative of laryngeal pathology. A congenital laryngeal web may present with obstruction, if large enough, and also with dysphonia. The webs are most commonly situated in the anterior glottis and may consist of just a thin membrane or may extend down into the subglottic region (Wilson 1979).

PATHOLOGICAL PROCESSES

Diseases may be the result of genetic factors or the body's response to abnormal environmental influences. In any individual the particular manifestation of disease is the result of the combination of the inherited genetic constitution and the external influences. These factors may operate before birth, giving rise to congenital abnormalities – these are often multiple, so a baby born with a disordered larynx may have an abnormality of another system.

Abnormal development

It is out of place here to give a detailed account of the embryology of the larynx. However, in order to understand how some of the congenital abnormalities arise, it is relevant that early in its formation the entrance to the larynx ends blindly. Failure of canalization to occur would produce atresia of the larynx, if complete, and a laryngeal web or a narrowed subglottic lumen, if partial (Pracy 1983).

Growth and development of the larynx continue after birth until the adult structure is attained. The infant larynx lies higher in the neck than the adult larynx, being tucked under the base of the tongue. The epiglottis is often easily visible when inspecting the child's throat with a tongue depressor. The normal neonatal larynx is of a size adequate to meet the oxygen needs of the baby but the ratio of the glottic area to body surface area is smaller in the neonate than the adult. There is therefore less margin for narrowing to occur before the onset of symptoms of obstruction. On occasion the entire larynx is too small, but most often it is only the subglottic region that has failed to form an adequately sized lumen.

The most noticeable difference in appearance of the infant larynx from the adult, apart from overall size, is the shape of the laryngeal inlet. The aryepiglottic folds are short and the epiglottis more curled. The commonest cause of congenital laryngeal stridor is laryngomalacia; indeed, in early textbooks, the terms congenital laryngeal stridor and laryngomalacia are used synonymously. The name suggests that the laryngeal cartilages are soft and give inadequate support to the larynx. Compared to adult cartilage the cartilage of all infants' larynges is soft. The failure of development in laryngomalacia appears to be a delayed lengthening of the aryepiglottic fold tissue. Because this is short the edges of the soft epiglottic cartilage are pulled in, creating the exaggerated curve described as omega-shaped (Ω) and the arytenoid cartilages are tilted forward. On inspiration the arytenoid cartilages prolapse further forward and the epiglottis flops inwards. On expiration the flow of air pushes the same structures apart and hence this phase of respiration is quiet.

Some congenital disorders arise from the chance coming together of the particular sets of genetic material from the parents. Faults may also occur in the genetic material itself. One such example does affect the larynx to produce the *cri-du-chat* syndrome, characterized by a feeble mewing cry; there are other abnormalities which lead to severe physical and mental retardation.

Inflammation

Acquired disease is usually a response to damage from an external agent such as physical, chemical, living organism, or dietary deficiency. The most frequently encountered response to tissue damage is the inflammatory reaction, which attempts to nullify the damaging agent and initiate repair of the damage. The acute infections of the larynx demonstrate the inflammatory reaction. There is an increased blood flow through the inflamed tissues and the blood vessels become leaky, allowing fluid to enter the tissue spaces. Thus white blood cells, antibodies, and circulating antibiotics, if administered, reach the damaged area. One effect of this is to produce swelling, and within the lumen of the larynx there is little spare room. In the case of acute supraglottitis (acute epiglottitis) the inflammatory process is confined mainly above the vocal cords, where because of the lax mucosal tissues the swelling is marked and the obstruction to breathing is quick in onset. A temporary artificial airway is required to prevent suffocation. The inflammatory reaction in laryngotracheobronchitis is essentially below the level of the vocal cords, and as there is often less swelling of the tissues many cases can be managed without an artificial airway. If there is already an underlying congenital abnormality such as laryngomalacia or subglottic stenosis, even a mild infection producing little swelling may be sufficient to cause severe breathing difficulty. The parents of children with such disorders are warned of the potential danger of minor upper respiratory tract infections and the possible need for temporary hospital care.

Most acute inflammations are followed by restitution of the tissues to normal. When the damaging process is not quickly relieved or removed then the persisting inflammation leads to repair processes which do not return the tissues to normal. Scar tissue, consisting of dense fibrous material, is laid down. An illustration of this is trauma to the larynx from prolonged peroral or pernasal endotracheal intubation. Modern methods of ventilatory support requiring the use of endotracheal tubes have produced a dramatic reduction in perinatal and neonatal mortality, but this is sometimes at the expense of laryngeal damage. The trauma to the larynx by a tube remaining *in situ* for many weeks results in inflammation, ulceration, and subsequent scarring both to the glottis and the subglottis. This may eventually produce a web or an acquired subglottic stenosis.

Change in cell character

Under certain external influences the character and behaviour of cells may change. They may alter in appearance and change type and growth rate. This is dealt with in more detail in Chapter 7. Metaplasia and neoplasia are rare in childhood, but one condition that should receive mention is juvenile papillomatosis. In this the external factor is believed to be a virus. The papillomata, which have a warty appearance, consist of a core of vascular fibrous tissue covered by layer upon layer of well-differentiated squamous epithelial cells. The distressing feature of these papillomata is their tendency to recur after removal and to spread throughout the respiratory tract.

MANAGEMENT OF LARYNGEAL DISORDERS IN CHILDREN

Management consists of diagnosis and appropriate treatment. It is customary medical practice to delay commencement of treatment until the diagnosis has been made, but there are certain *symptoms*, severe stridor being one, that demand immediate treatment before the diagnosis of the cause of that symptom is made (Ferguson and Kendig 1972).

Urgent management

By this is meant cases where treatment takes precedence over diagnosis. When an assessment is made that the airway is severely obstructed so as to be life-threatening, urgent relief is required. This necessitates the use of an artificial tube to bypass the obstruction, and in the case of laryngeal disease this may be achieved by a tracheotomy or by a tube passed via the nose or mouth through the larynx into the trachea. Most obstructions can be temporarily relieved by this latter method of endotracheal intubation. This will be satisfactory for those conditions, such as the acute inflammatory laryngeal diseases, which are quickly resolved by appropriate medication. Children managed with endotracheal tubes do require the immediate availability of skilled nurses, anaesthetist, and a surgeon competent to perform paediatric tracheotomy.

Tracheotomy

Long-term relief of an obstructed airway is better achieved by a tracheotomy. This is usually performed under general anaesthesia and consists of an incision in the neck skin, separation of the tissues overlying the trachea and a vertical slit made in the anterior tracheal wall. The patency of this fistula is maintained by a tracheotomy tube.

Although tracheotomy has a morbidity and a mortality, the necessary nursing skills can be taught to parents so that these children can live at home. Vocalization will occur if air is able to escape around the tracheotomy tube through the larynx on expiration. Children learn the trick of partially occluding the opening of the tube with their chin or finger on expiration to increase this flow of air through the larynx. Alternatively a valved tube can be used, the valve of which opens on inspiration and closes on expiration. Provided the other parameters (such as normal hearing) are intact, language and speech will be acquired unaffected by the presence of a tracheotomy.

Methods of diagnosis

The only sure diagnostic method is inspection of the larynx. Some indication will have been gained from the mode of presentation. X-ray techniques may add useful information and a neonate or infant with stridor should have a barium swallow X-ray to exclude the presence of an abnormally placed blood vessel compressing the trachea and oesophagus.

Apart from this, diagnosis depends on visualizing the larynx, which in the neonate is possible without anaesthesia. This will be performed at the same time as an endotracheal tube is passed to relieve the breathing difficulty.

After the first few weeks of life, to inspect the larynx directly requires a general anaesthetic. This demands particular skills of the anaesthetist and surgeon, who are both seeking access to the larynx. The operating microscope gives a magnified view of the larynx seen through a rigid laryngoscope passed via the mouth. This is the technique of microlaryngoscopy. Attention is paid both to the size and appearance of the laryngeal structures and to movement. As the anaesthetic wears off the dynamics of the larynx are revealed allowing assessment to be made of the vocal cord movement in order to diagnose a vocal-cord palsy or view the characteristic appearance of laryngomalacia. If necessary, surgical procedures may be carried out as described below. The trachea and bronchi are usually inspected under the same anaesthetic.

It is surprising how young a child will allow examination of the larynx with a mirror held in the back of the throat. This method of indirect laryngoscopy is particularly useful where vocal-cord nodules are suspected. This allows the diagnosis to be made without a general anaesthetic and the child can be referred for speech therapy. Although technically easy to remove the nodules (by one of the methods outlined below), it is likely to be of little value unless the vocal misuse can be corrected. Once this has been achieved, should the nodules remain, surgery can be hoped to be worthwhile. The occasion will arise when diagnosis is made under general anaesthetic and the opportunity may as well be taken to remove the nodules, but unless vocal retraining is quickly learnt the nodules are likely to return.

General health and development

Attention must continually be paid to the development of a child with a laryngeal disorder. An airway that is adequate at birth may fail to grow to keep pace with the increased needs of the growing child and the demands of exercise. The result will be retarded physical and mental development.

The rest of the upper respiratory tract must not be overlooked and disease of the tonsils, adenoids, and sinuses may require treatment.

SURGICAL TREATMENT

Endoscopic surgery

Using the technique of microlaryngoscopy described above it is possible to perform surgical procedures. Various tools are used to do this. Microsurgical instruments such as scissors and forceps allow surgery in the traditional manner to be performed. This also supplies samples of the lesion for histological examination. Other modes for removal of lesions include freezing with cryotherapy, burning with diathermy, and vaporization with the laser. As mentioned above it is often unnecessary to remove vocal-cord nodules in children, but this can easily be performed by microdissection or by using the laser.

The laser offers the best method for the treatment of juvenile papillomata. They can be removed with the least risk of spillage of cells, thus reducing the chance of recurrence and spread. It also allows for very accurate removal of the papillomata with the minimum of residual scarring. In some cases this has to be repeated often and at short intervals in order to maintain laryngeal function. Tracheotomy is occasionally necessary but adds to the risk of dissemination of the papillomata into the lower airways. There is a natural tendency for the majority of cases to regress, but the condition remains one of the most challenging to the paediatric laryngologist and many alternative treatments to surgery have been evaluated. Chemotherapeutic agents having antibacterial, antiviral, and cytotoxic properties and the use of prepared vaccines have in individual cases proved successful but are not yet a universal solution to the problem.

Congenital subglottic haemangiomata have a life-cycle that leads to their regression by about the age of three years. Their situation, however, usually makes a tracheotomy necessary, and in order to allow earlier decannulation attempts may be made to remove the haemangioma with the laser endoscopically or they can be dissected out at open laryngeal surgery.

Open laryngeal surgery

It has long been held that to interfere with the cartilage of the growing larynx would lead to damage and deformity more troublesome than the laryngeal pathology that was being treated. A wait-and-see policy was adopted and the infant managed with a tracheotomy until such time as growth relieved the obstruction. In times past this policy had to be applied to relatively few children, as babies with severe laryngeal abnormalities did not usually survive long after birth. With the advent of neonatal intensive care units many more infants do survive with tracheotomies, and the need is much greater, in terms of numbers of children, to correct the lesion and so allow restoration of the normal airway. This particularly applies to the lesion of subglottic stenosis.

Methods have been devised to enlarge the subglottic lumen and may be carried out if examination under anaesthetic at three-monthly intervals has shown that there is insufficient growth occurring naturally. The surgery would then be performed at about the age of 18 months. The larynx is exposed through a neck skin incision. The thyroid cartilage is vertically split in the midline to open into the laryngeal lumen and the narrowed segment of the subglottis can be identified. This may be widened by slitting vertically through the narrowed portion and holding the two edges apart with a cartilage graft taken from a rib, or by performing a stepped incision through the narrowed segment and placing appropriate sutures to hold the edges apart (laryngotracheoplasty). In the latter case a supporting stent is placed in the lumen of the larynx and upper trachea and later removed after healing has occurred, usually six weeks postoperatively. By these means early decannulation of the tracheotomy is possible (Cotton and Evans 1981).

Laryngeal webs may also be removed by an open technique. The substance of the web is dissected out, keeping intact the epithelial edge, which is used to reconstruct the anterior portion of one of the vocal cords. The raw edge of the anterior portion of the other vocal cord epithelializes naturally. Accurate positioning of the two cords is essential to create the anterior commissure. Failure to do this leads to persisting dysphonia. The use of the laser to remove webs endoscopically is being evaluated. The timing of surgery for laryngeal webs depends on whether the web causes obstruction sufficient to require tracheotomy. If so, then early removal of the web is desirable to allow decannulation. If the laryngeal disorder is solely dysphonia, then treatment can be delayed, but it is preferable to attempt to improve the voice before the child starts school.

CONCLUSION

The work of those managing disorders of the larynx in children aims to restore normal laryngeal function. Judgement is required to balance active intervention against the natural processes of growth and repair. Failure to act promptly in the severely obstructed larynx leads to disaster. Failure to recognize that a partially obstructed larynx is not providing for the needs of the infant will have long-term effects on physical and mental development. Overenthusiastic surgical intervention may produce permanent laryngeal deformities with consequent effects on the voice.

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6

Therapy and management of the dysphonic child

Elaine Hodkinson

INTRODUCTION

The human voice reflects many aspects of a person's physical, social, cultural, and psychological development and background. From the birth cry to voice mutation at puberty, and voice stability during adolescence, there are many influences upon the child's voice development.

When a child is unable to produce a voice that is normal for the age, stage of growth, and maturation, the child should be identified as having a sign or symptom that requires investigation and assessment. In this way we can avoid, as far as possible, the child's use of vocal behaviour that can detract from the child's social and cultural interactions or psychological and educational development and achievement. Dysphonia can be described as disorder of voice, which includes phonation and resonance.

At birth some syndromes are immediately obvious and it can be deduced that the child is at risk, and that amongst various problems the child may have disorders of phonation and/or resonance. In other chapters of this book the cerebral palsied and the deaf are presented. However, the child who is mentally handicapped with Down's syndrome, who has cleft lip and palate, or laryngeal atresia is easily diagnosed.

Voice disorders can be caused by growths, structural laryngeal pathology or the child's voice can be abnormal because of neuromuscular weakness which interferes with the normal function of the larynx or resonators.

The speech therapist's work as a team member is to bring specialist knowledge about the production, development, and effectiveness of voice production to the parents, medical and social workers, and teachers. These interactions require knowledge and skills in counselling, informing, and teaching, and require that professional communication skills are essential to the therapist. In working with the child all these roles have to be used so that both child and therapist can relate at the level of contact and communication appropriate to the child's most effective learning.

When a potential problem is identified and the team require the involvement of the speech therapist, as much as possible should be done to minimize the effects of diagnosed conditions upon the child's voice production as well as all other aspects of development. Parental support and counselling throughout the infant's early years can help produce the most satisfactory climate, not only for assisting the child to develop most effectively, but for preventing some of the problems acquired, and demonstrated when parents are ill-informed, anxious, or unsure of how to help their child. Careful and informed observation about where, when, why, and how much information is required so that parents can absorb and understand what is happening. It takes a good deal of time for some parents to accept that their child has a particular problem. They must then understand the nature of the difficulty for the child and how they can assist in supporting and encouraging the child's progress. It may be that the therapist can be more effective in a preventive role when parents recognize the importance of human communication, and what is required of them to support the work of the multidisciplinary team of which they are a member.

Parents obviously are helped to understand that voice is part of the communication process and that speech, language, and behaviour are also considered when looking at how best to find out about and help the whole child.

IDENTIFYING PROBLEMS IN THE FIRST YEAR

In the first year of the child's life, the parents develop close contact with the baby, in holding, feeding, caring for the child and responding to his needs. Martin (1981) has spent some time in comparing the voices of babies as a significant feature in the child's development. The main signal used by the child is voice (Wolff 1969); the larynx is used for crying, coughing, and vocal play and the child's cries can be interpreted by the parents. It is an important agent in bonding. Wasz-Hockert *et al.* (1968) used spectrographic studies and listener judgement data based on 419 cries of 351 healthy infants. Four distinctive cries were identified from birth to seven months.

1. Birth signal: short duration with a flat or falling melody, always strained or strident and containing glottal plosives.
2. Pain signal: long duration, high pitched and strident with usually a falling melody.

3. Hunger signal: pitch rising/falling with frequent glottal plosives.
4. Pleasure signal: flat pitch with greater pitch variability than other types of cries, never strident and with rare glottal plosives.

Mothers appeared to have little difficulty recognizing the cries of their own babies as demonstrated by Hollien *et al.* (1971) and Muller *et al.* (1974).

Infant cries and other vocalizations are found to be inseparable from associated facial expressions and bodily movements. Young and Decarie (1977) coded the facial/vocal behaviour and bodily movements of 75 infants into positive and negative vocalizations. These vocalizations were then categorized into babbling, cooing, laughing and squealing, wail, soft wail and harsh wail. It is from these voice sounds that children develop the language of their culture, and Lenneberg (1967) made distinctions between the early appearing sounds of crying and vegetative activity and later voice behaviour of cooing and babbling.

It is obvious that parents are much influenced by the voice of the baby and that the family relationships and interactions are built up and affected by even subtle changes of phonation and resonances as infancy becomes childhood and then puberty. The parents have expectations of how this growing up should be achieved and deviations from an orderly process can cause tension and anxiety and other negative reactions.

VOICE PROBLEMS IN OLDER CHILDREN

Some children are particularly in need of special care which has to be monitored throughout their childhood, and the professionals looking after the child should share relevant information with each other of practical or theoretical importance. This information can range from research into environmental characteristics, considering cultural factors, attitudes and social influences on the basic competencies. In this way the total world of the child and its influence upon him, as well as his interaction with the environment can be considered.

Where the child has an obvious organic syndrome such as papillomata it is hoped that the speech therapist will be involved at an early stage for voice and speech assessment. Where the child has had early surgical intervention there will be investigative and supportive work to encourage the child to be an effective communicator. In the case of the child with tracheostomy there is a role in ongoing management in that the child learns to occlude the opening of the tube on expiration and projects air though the larynx. These children can be encouraged to be more effective in their non-verbal skills, so that eye contact, smiling, facial expression, and gesture can enhance their effective communication. It is important for the speech therapist to understand the medical and surgical treatment programme so that any information that needs to be passed on is accurate and relevant. If the child is on new treatment, such as interferon therapy for papillomatosis, the therapist is one of the members of the team who, in monitoring progress, can report on the child's attention, mood, behaviour, and general communication as well as specific laryngeal performance (Goepfert *et al.* 1982).

The work of the speech therapist with congenitally handicapped children is important in aiding development and effective use of voice as the child matures physically and cognitively. Each new situation requires voice to be adapted, depending upon the acoustics and the psychological variables influencing the child.

The child with structural change to the vocal tract will normally be referred to the speech therapist by the appropriate consultant surgeon or physician. Assessments and diagnoses will be made regarding the anatomical and physiological condition of the larynx and resonators. However, children are not so easily classified by having a diagnosis of 'vocal nodules', or 'misuse and abuse of voice' and much care in investigating the child and his life and behaviour is required to help him to unlearn the voice behaviour that has produced a traumatic result. Voice samples of voice disorders are found in Stemple (1984). A young girl with congenital web and monotonous pitch, and a hoarse and breathy dysphonia in a girl with bilateral nodules are found on the record in his book.

CLASSIFICATION OF VOICE PROBLEMS

Wilson (1979) classifies voice problems into (1) voice quality problems, (2) resonance problems, and (3) loudness and pitch problems. Aronson (1980) suggests that the following voice parameters are the elements of voice:

1. pitch: the perceptual correlate of frequency;
2. loudness: the perceptual correlate of intensity;
3. quality: the perceptual correlate of complexity;
4. flexibility: the perceptual correlate of pitch, loudness, and quality variations;
5. voice is described as audible sound produced by phonation;
6. phonation is the physical act of sound production by means of vocal-fold interaction with the exhaled air stream.

The causes of voice problems in children have been classified by Wilson (1979) as (1) organic, (2) organic changes resulting from vocal abuse and misuse, (3) functional, and (4) factors contributing to the voice problem.

He suggests that voice problems exist on a continuum with organic at one end and functional at the other. It is a two-way path because a pathology can result in a poorly functioning voice mechanism, or a poorly functioning mechanism can result in organic changes or conditions.

The four variables rated by Boone (1977) on a nine-point scale are (1) pitch, (2) phonation quality, (3) loudness, and (4) resonance quality. This is a voice-screening outline in which pitch level considered normal for the child's age and sex would be rated 1 or 2, and pitch level much higher and lower than peers would be rated 8 or 9. Phonation quality is rated according to the presence or absence of hoarseness, breathiness, or harshness with 1 or 2 rated normal and 8 or 9 with deviations in quality. Quality disorders require careful observation according to Boone as they often are the first symptoms of a nodule or papilloma. It may be that persistent quality disorders confirmed by parent or teacher will initiate laryngoscopic examination to confirm diagnosis.

Screening evaluation of loudness in an artificial situation is difficult as the testing environment inhibits the child. Sometimes the test can be carried out at the nursery group or school and rated when the child interacts normally with other children. It is easier to compare the voices of the peer group in this way.

The Buffalo Voice Profile of Wilson (1979) is considered a useful seven-point rating scheme indicating severity of phonation problems in 12 descriptive items. More recently a vocal profile analysis protocol was developed by Laver *et al.* (1982). This is particularly useful when a full evaluation of all articulatory as well as laryngeal parameters is to be assessed. Imaging techniques to demonstrate what vocal gestures are being performed by the vocal tract can give clear information of what the child is doing on phonation to the larynx and supraglottic resonators. The work of MacCurtain (1982) gives information not only to the doctor and speech therapist, but allows both parents and child to gain insight into what happens when the child uses voice.

CLINICAL EXAMINATION OF VOICE

A scientific approach to clinical examination of voice is outlined by Hirano (1981). Diagnostic procedures determine:

1. the cause of the voice disorder;
2. the degree and extent of the causative disease;
3. the degree of disturbance in phonatory function;
4. the prognosis of the voice disorder as well as that of the cause of the disorder;
5. the establishment of a therapeutic programme.

Hirano classifies ways in which direct or indirect assessment, observation and/or measurements can be made. Physiological and physical parameters are listed which regulate vibratory patterns of the vocal folds.

The following areas suggest the many investigations that may need to be made:

1. history-taking
2. physical examinations
3. neurological examinations
4. function tests
5. endoscopy
6. X-ray examinations
7. electromyography
8. aerodynamic measurements
9. histological examinations
10. microbiological examinations
11. endocrinological examinations
12. blood and serum examinations
13. observations during surgery
14. behavioural tests
15. psychological examinations.

The speech therapist uses this medical information to clarify organic problems. The site and extent of the lesion is noted as is the aetiology and pathology of any diagnosed condition. There will be discussion by the team of the preferred approaches to management and treatment policy, and careful follow-up to assess progress.

VOICE PROGRAMME FOR CHILDREN

A voice programme for children has been produced by Boone (1980). Two manuals are available which describe (a) screening, evaluation and referral, and (b) remediation. An additional help to the clinician are the forms available, which allow detailed analysis of the history of the disorder and the health of the child. Other sections allow evaluation reports on hearing, respiration, oral examination, and voice rating scales. The organization of the voice team and the various tasks each specialist should undertake are outlined by Wilson (1979). The speech therapist assesses vocal behaviour formally and informally when the child is alone with the therapist and aware of the evaluation. The therapist also observes group play and how the child uses voice either with abuse or effectively. The voice screening profile of Wilson and Rice (1977) is advocated in which laryngeal tone, voice pitch, loudness, and resonance with overall voice efficiency are rated from normal to mild, moderate, and severe problems.

Boone's remediation manual may be found helpful by clinicians who appreciate a clear and formal treatment structure.

The areas for new learning by the child incorporate ear training, yawn-sigh, new mouth movements, and altering tongue position. The facilitating approaches develop new kinaesthetic awareness in the child as well as improved auditory perception. The visual materials in the manual also hold the child's attention and interest and give guidelines for sequences in therapy.

An overall picture of the child in his family should be developed, and the help of the family encouraged and supported by the speech therapist. Once the child is at nursery or junior school, the class teacher or specialist singing or drama teacher may need to understand the overall management plan. In some school settings teachers who are interested in reinforcing good voice production can help the dysphonic child by planning class activities that allow the group to practise voice programmes that are beneficial to individual children in many ways. The careful rehearsal of reading out loud, singing, and role play can help the children understand what they are doing in performing these activities. Appropriate parts can be given to the children to practise different voices in a variety of characters in plays. There are many aspects of voice work that the teacher can support much more naturally at school than the parent at home or the therapist in the clinic. Once teachers see the need for healthy vocal behaviour they are only too ready to seek information on the many strategies open to them. They also begin to suggest seeing other children whose voice and speech they believe not to be normal. There are still problems to be overcome in promoting the classroom teachers' understanding of speech disorders (Wertz and Mead 1975).

SPEECH THERAPY

Parents and teachers have to believe that learning can be fun in therapy. Sometimes they think it is the serious work of the therapist, and they forget all they know in the normal context of the child's life that play or wanted activity is what best assists the child's desire to achieve or accomplish an aim. There are ways of communicating ideas to children that are appropriate to a particular age or stage of growth. Therapy should be tailored to the child's existing mode of gaining awareness, understanding his own present behaviours, and setting and achieving objectives. These cognitive factors should be represented in natural everyday activities chosen or accepted by the child. He should be encouraged to participate actively in the learning process (Bruner 1972).

Speech therapy can be described as the sharing of work which identifies and allows clear understanding of the communication problems to be dealt with, and strategies and techniques that will facilitate learning and change. All modalities of perception can be used and some children react to and prefer sensory experience from vision, taste, or smell at one stage to tactile or kinaesthetic at another time. Auditory perception and discrimination is often the latest to refine and requires maturity of the child before they can be self-monitoring. It is essential that the therapist has knowledge of a wide range of toys and equipment that can be called upon to illustrate an area of work that requires attention or can promote an activity. The practice of a game or the repetition of an interesting task gives the child an opportunity to develop awareness and skill. The therapist has to be able to provide appropriate materials, outline the possibilities that exist and can be created by the child in engaging in the process of therapy, and monitor with the child developments and future objectives.

Treatment approaches

The following ideas are examples of treatment approaches for the child with voice disorders that follow the well-described areas of what is required for effective voice production – relaxation, posture and movement, respiration, phonation, resonance, and articulation. The therapist's skills are first called upon to make the child feel comfortable and relaxed and encourage a relationship in which the patient trusts and enjoys what the therapist has to offer.

It is from the rapport that develops that aims and objectives can be negotiated with the child, and a contract outlined that identifies expectations on both sides. A sequence of activities or exercises can be described and noted. A variety of materials are shown and types of work agreed with the child. In this way a plan is discussed with the child and others and a time sequence organized with the objectives in mind. Therapy thus has a focus and clear aims and does not just proceed in an unstructured way.

Assessment of the child and the type and extent of voice disorder will continue throughout treatment. Most children enjoy activity and movement and it is necessary to observe how the child habitually responds when offered tasks. Each child reacts in his or her own unique way demonstrating habit patterns, imagination and skills. Some children respond to movement from observations of reality – swimming movements or dance or skating. Television has given pictures of free falling from aeroplanes or walking on the moon. Other children respond to the ideas of 'beaming down' in postures of all kinds, or aspects of movement such as slow motion or particular rhythms. Dramatic interpretation is often displayed when children work through postural changes from puppets on strings, statues moving, sea flowers opening, or interpretations of a variety of animals or objects standing, sitting, jumping, eating, or sleeping. Children loosen up and laugh in these 'dramas' and will take on new impressions and ideas for posture and movement that underpin improved relaxation and posture for efficient respiration and phonation. Music, mime, and drawing pictures and patterns give opportunities to listen and do things and take the emphasis off necessarily using voice. It is part of the work to give space for silence even though quiet activity, such as drawing, is in progress. Quiet time with the therapist is required for assimilation of ideas and new skills to take place.

The therapist may therefore be painting or doing a puzzle with the child, but the key task is to assist the child to relax.

For many overactive children with misuse and abuse of voice this is a new experience. From this baseline work can proceed to painting masks or mirrors with faces that depict mood or characterization. A well-tried favourite is a story painted or a collage depicted on a frieze. This allows a continuity of events in the child's life or a description of adventures of a chosen character in which a variety of sounds and voices are encouraged. Sweeney (1981) advocates 'encouragement' as an essential element in the helping process. He quotes the Adlerian model that in order for children to develop into self-confident healthy adults, they need to know that you have faith in their abilities and that you accept them for who they are, not only for what they do.

There are many natural phenomena to draw the child's attention to: the movement of the wind in the trees and the natural rhythm and sounds perceived; watching the way that water moves and perhaps fish swimming in water; imitating animal, bird, and fish movements and suggesting sounds and voices associated with them; describing the movements of mobiles and kites; and shaping ourselves into these objects and images allows for consideration of breathing exercises that encourage deep capacity of breath and easy respiratory control in set tasks. How do birds breathe? What do whales do? If clouds were full of air and floating across the sky what would they do? In a garden of enchantment what lovely smells would there be?

These imaginative approaches allow the child to enjoy themselves and 'freewheel' in new and interesting ways. The therapist needs to think about presentation of these ideas and his or her own involvement in the exercises to support the child.

The therapist, in using imaginative strategies, can be effective in enabling the child to feel and think about understanding and accepting new behaviour. Freedom to learn gives permission for involvement, and feeling and use of self from which support and trust will grow (Rogers 1969).

Following success in establishing appropriate posture and movement, imaginative work on breathing patterns can be developed. These activities require practice and can be essential elements in building up appropriate phonation. Continuous assessment of the child's developing competence and confidence is required so that voice exercises are selected in exactly the right situation to promote, reinforce, and be effective. Exercises and games can incorporate changes in loudness and pitch: these tasks can be as far apart as singing gently to dolls, chanting or using puppet voices to timing by stopwatch, or continuous phonation in high, medium, or low pitch range. Some children particularly enjoy the use of instrumentation to control their own work. The auditory training unit allows the patient close listening to his own voice. He may model sounds from the therapist, particularly intonation patterns, but often the child wishes to take the initiative and invites the therapist to copy his voice patterns. During these exercises it is helpful to enjoy vocal play that can be shared. In my own clinical work 'voice painting' can be utilized, and shapes and pictures drawn and coloured through voice sounds. It is in this developing voice work that changes of resonance can also be noted and used. Auditory perception and discrimination has to be further refined so that therapist and child are agreed about what are the desired sounds to achieve, how the voice manages to produce loudness and softness, high and low pitch, and changes in resonance. Kinaesthetic awareness can then anchor the ability to retain the skills necessary for a range of appropriate intonation patterns. Books and stories can give the child opportunities to utilize new voice skills. It may be that reading out loud assists the child in not only use of voice but in confidence and self-regard for his achievements.

INTEGRATION OF COMMUNICATION

As communication is a complex activity, it is necessary for the therapist to keep integrated all positive aspects of non-verbal communication with the developing voice. The use of eye contact, observation of gaze, and pupil dilatation can give clues to the child's involvement and excitement. Encouragement of smiling and easy laughter, with modification of facial expression according to context, can also give satisfaction and credibility to overall speech. The physical appearance of the child may change as he becomes more relaxed and confident. It may be necessary to decide with parent and/or teachers how to bring about these changes. Discussions with parents can cover a range of subjects. Not only can they discuss haircuts and clothes, but also bedtimes, pocket money, and how a child has learnt to blow his nose. With children who are dysphonic, it is often necessary to clarify the best ways to clear the throat or inhibit shouting.

This chapter has attempted to draw upon a general understanding of the treatment and management of the dysphonic child. The human voice is part of the unique characteristics of a person, and in this way it is the child who requires the care and commitment of all those involved in his education. Speech therapy offers understanding of the process of development of communication, and how lack of development or breakdown of good voice production alters relationships with those involved with the child. Participation in therapy through this educational and counselling approach increases the success of speech therapy intervention, allows for the child's own pattern of learning to be considered, and encourages the development of insight and self-esteem.

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7

Laryngeal disorders in adults

Andrew Johns

INTRODUCTION

The aim of this chapter is to present the ENT surgeon's approach to the management of disorders of the larynx (Ballantyne and Groves 1981). Chapter 5 has been devoted to the particular problems found in children. There is of necessity some overlap of the chapters as there is no clear division between pathology and its manifestations in the adult and child.

Disease processes affecting the larynx reveal themselves to a greater or lesser extent by disorder of the various functions of the larynx. As part of the upper airway and its role of protection to the lower air passages, the larynx has a vital function. Its use in phonation is essential for the chief method of human communication. When life is threatened by airway obstruction or by incompetence of the laryngeal sphincter, the surgeon can overcome the problem by way of an opening made into the trachea through the tissues of the front of the neck – *tracheotomy*. Indeed this 'essential' organ can be removed – *total laryngectomy* and respiration continues through a permanent opening of the trachea onto the neck – *tracheostomy*. The airway and food passages are thus completely separated such that a sphincter mechanism (that is, the larynx) is obviated.

Clearly such a major interference with the larynx will have profound effects on phonation. Communication by speech is one of the features that distinguishes man from the other primates, and its loss produces a severe alteration in customary way of life. The immense power of man's adaptability plays a large part in overcoming this handicap, aided by surgeon and speech therapist. Some diseases manifest themselves chiefly by alteration of the voice, and their management must be carefully tailored to remove causative factors and improve phonation without embarrassment to the other role of the larynx as airway protector. The balance between adequate removal of disease, the achievement of an acceptable voice, and the maintenance of a safe airway will be a theme pursued in this chapter. This theme is well demonstrated by bilateral abductor vocal-cord palsy. The two cords, immobile in the adducted position, produce a good voice but an inadequate airway. Surgery to widen the glottic opening to improve the airway will have a reciprocal detrimental effect on the quality of the voice.

PRESENTATION

A patient with a hoarse voice of recent onset, who visits his family doctor, will often be given treatment for an acute inflammation of the larynx. This is a presumptive diagnosis but a concurrent cold or sore throat makes the diagnosis probable. If the voice does not return to normal within two weeks, or if the dysphonia is of longer duration at presentation, a firm diagnosis of the cause must be made. The importance of the symptom of persistent hoarseness cannot be overstated because of the possibility of a malignant cause. Diagnosis requires adequate inspection of the larynx (which usually means referral to an ENT department) and, where necessary, the histological examination of a sample of tissue from any abnormal area.

A partially obstructed airway produces a noise called stridor. As a life-threatening situation it demands emergency referral to an ENT department for relief of the obstruction and diagnosis and treatment of the cause.

Most laryngeal disease presents with an altered voice. Stridor forms a small group; other symptoms that may be encountered are pain and discomfort, which may be experienced as earache (referred pain), cough, swallowing difficulties, or the feeling of a lump in the throat.

History

These symptoms, their duration, fluctuation, or progression will be elicited by a carefully taken and recorded history. Other relevant information will be obtained with regard to vocal use and abuse, smoking and alcohol consumption and the work and home environments.

Examination

Inspection of the interior of the larynx is achieved in most patients by the method of *indirect laryngoscopy*. The patient's tongue is grasped firmly and gently pulled forward, while a warmed laryngeal mirror is held in the back of the throat, pressed against the soft palate. The angle of the mirror allows visualization of the larynx and hypopharynx, illumination being provided by a lamp positioned above and behind the patient's shoulder and reflected from a mirror worn on the examiner's forehead. A patient who does not tolerate this procedure at first may do so after the application of local anaesthetic to the mucous membrane of the throat. The particular advantages of indirect laryngoscopy are the simplicity of the technique and the ability to observe movements of the vocal cords during respiration and phonation.

An alternative to mirror examination is the fibreoptic laryngoscope, passed through the nose into the pharynx, both of which have been anaesthetized. This method, which again may not always be tolerated, is useful when, for anatomical reasons, the mirror gives an inadequate view. It also has the advantage of allowing recording of the findings by still photography, or concurrent and future display by video recording, particularly useful for teaching.

The clinical examination is completed by palpation of the neck, paying particular attention to the mobility of the larynx and the presence of enlarged lymph nodes. The rest of the upper respiratory tract is inspected, noting the state of the teeth, mouth, throat, nasal airway, and any evidence of sinusitis. The general physical state is assessed for poor nutrition, weight loss and lung and heart disease. It may also be relevant to assess hearing.

As a result of this examination patients can be assigned to one of the following groups.

Group I	Inadequate view of larynx
Group II	Structural abnormality
Group III	Impaired vocal-cord movement
Group IV	Combination of II and III
Group V	Normal appearance of larynx

GROUP I. INADEQUATE VIEW OF LARYNX

For those few patients who do not tolerate mirror examination or fibreoptic examination, or in whom the larynx just cannot be seen, inspection will be performed under a general anaesthetic – *direct laryngoscopy*. A rigid laryngoscope is passed through the mouth and the larynx visualized through the lumen of the laryngoscope. The pharynx is also examined, and inspection of the trachea and bronchi (*bronchoscopy*) and the oesophagus (*oesophagoscopy*) may be indicated.

It is not easy to be certain of vocal-cord movement at direct laryngoscopy under general anaesthetic but usually patients can be classified into one of the remaining groups. Where endoscopic surgical procedures are required as discussed in group II, it will usually be possible to do them under the same anaesthetic as this diagnostic laryngoscopy.

GROUP II. STRUCTURAL ABNORMALITY

This group contains those patients in whom the inspection, whether by indirect laryngoscopy or direct laryngoscopy, has revealed an abnormality of the lining of the larynx. This may be a surface lump, irregularity, ulceration, or colour change, or a swelling of the subepithelial tissues. In many cases the appearance is so typical that a specific diagnosis is suggested. In the majority of cases it will be necessary to confirm this histologically and often the treatment of the lesion includes its removal. One exception is early 'classical' vocal-cord nodules, which may regress with vocal training, so avoiding surgery. To obtain the specimen for examination a direct laryngoscopy is performed and a sample (*biopsy*) or all (*excision biopsy*) of the lesion is removed. Where all the lesion is removed, as would be the case for some of the benign conditions such as polyps and cysts, the laryngoscopy is best performed with the aid of the operating microscope – *microlaryngoscopy*. This allows clear visualization of the laryngeal interior and the precise excision of the lesion using microsurgical instruments. The laryngoscope is held by a suspension apparatus, which releases both the surgeon's hands for the manipulation of the instruments.

The processing of the specimen takes a few days and usually the report confirms the clinical impression. Treatment is then planned on the basis of the pathology and the overall clinical picture.

Pathology

The most urgently awaited aspect of the histology report classifies the lesion into a malignant or a non-malignant type. The classification is not quite so clear cut and there has to be a third group to contain those lesions which, while not being frankly malignant, are recognized as having the potential to become malignant. Such patients must be maintained on a regular review list for frequent reassessment, including further biopsy as necessary.

Malignant lesions

The larynx is composed of structural tissues such as cartilage, fibrous connective tissue, blood vessels etc., and lining epithelium. Malignant change can occur in any of these tissues but by far the commonest (95%) are of the epithelium. These are the carcinomas, and irrespective of the site of the lesion in the larynx they are nearly always of the squamous-cell type. This indicates that in those areas of the larynx lined by respiratory-type epithelium there has been a change of cell type to the squamous cell.

The histology report also gives information as to the degree of differentiation of the malignant cells, that is how closely they resemble the normal cells. To a certain extent this is an indication of the aggressiveness of the cancer.

The behaviour of malignant cells is to spread, at first by local increase in number and invasion of the surrounding tissues. Eventually, if untreated, the cells gain access to the lymphatic channels and blood vessels, which leads to widespread distribution of the malignant cells throughout the body. In the case of carcinomas this distant spread occurs mostly via the lymphatics and the first clinical sign of this spread is the appearance of enlarged lymph nodes in the neck. This takes place most readily from those regions of the larynx richly supplied with lymphatics. These are the supraglottic and subglottic regions. The glottis itself has a surface epithelium that is tightly bound down to the underlying fibrous structure of the vocal cord, there being very little submucosal tissue space and therefore a relative deficiency of lymphatics.

The picture emerges that malignant disease of the larynx is not a single disease. Lesions of the vocal cord will give rise to a symptom, such as hoarseness, very early in their natural history and moreover this symptom is usually acted upon by patient and doctor. Second, distant spread by lymphatics is a late occurrence in relation to the onset of symptoms. Finally, they are usually well or moderately well differentiated and therefore not highly aggressive. Contrasting this with other sites in the larynx, hoarseness does not occur so early, spread takes place more readily and is more likely to have done so at diagnosis. These are the important factors in considering the prognosis, and it is not surprising that glottic tumours have a much higher cure rate than those tumours arising elsewhere in the larynx.

Malignant disease of the larynx is found mostly in males (in a ratio of males : females 8 : 1). It usually occurs in the later years of life and there is a definite relationship to smoking.

Benign lesions

Inflammation The majority of benign laryngeal lesions are due to inflammatory processes. Inflammation is described as acute or chronic. In the latter there is persistence of the irritative cause maintaining the inflammation, while the tissues also attempt a healing response with the formation of granulation and fibrous scar tissue. Typically acute inflammation of the larynx (acute laryngitis) is a viral infection, part of a generalized upper respiratory tract infection. The cardinal features of acute inflammation, redness, swelling, heat, pain, and loss of function are well demonstrated. The throat is sore, there is fever, aphonia or dysphonia, and indirect laryngoscopy will show red and swollen vocal cords.

Many factors are potential irritants to the larynx and include smoking, alcohol, vocal abuse, dirty and dry atmospheres, poor dental hygiene, mouth breathing, and chronic sinusitis. Following an acute laryngitis the presence of one or a combination of these factors may allow the persistence of inflammation into a chronic state, producing the clinical picture of chronic laryngitis. The changes in the laryngeal lining may be generalized and this is particularly seen in male smokers. The appearance is of a swollen, thickened, reddened mucous membrane coated with sticky secretions. Attention must be paid to any irregular, white areas as these are indistinguishable to the naked eye from early carcinomas. In the case of chronic laryngitis, histological examination after biopsy shows these white patches to be areas of squamous epithelium in which an excess of keratin is produced. This process is called hyperkeratosis, and where it is found in areas of the larynx not normally lined by squamous cells the change in cell type is called metaplasia. The significance of these changes is that they may represent early steps in the development of a cancer and hence these cases require careful follow-up examinations.

The localized lesions are polyps, nodules, cysts, and contact ulcers. Polyps are oedematous areas of the surface epithelium, particularly affecting the free edge of the vocal cord, often bilaterally. This lesion is more common in females and usually occurs after the menopause.

Vocal-cord nodules arise as a result of vocal abuse. This occurs in professional voice users if the voice is untrained or over-used, and in others with excessive use or misuse of the voice. There may be other irritant factors present, producing a more generalized change in the larynx, but most often nodules are seen as an isolated lesion within an otherwise normal-looking larynx. The nodules are usually bilateral and symmetrically placed on each vocal cord, one-third of the way back from the anterior commissure. They begin as an area of oedema but in time this becomes organized into a fibrous nodule.

Cysts develop when a mucus-secreting gland becomes blocked and the continued secretion produces the recognizable grey swelling.

A less common lesion is the contact ulcer. This is again a feature of vocal abuse, the trauma occurring at the point of contact in adduction of the vocal processes of the arytenoid cartilages within the posterior third of the vocal cords. There is superficial ulceration and attempts at healing may produce a granuloma.

Trauma External injuries to the neck may involve the larynx and this is most often seen as part of a road-traffic accident. The mechanism of injury may be a direct blow, a laceration or a whiplash. This may result in bruising or tears to the mucosa, fractures and disruption of the cartilaginous skeleton of the larynx, and injuries to the laryngeal nerves. Very often there are multiple injuries, any of which may take precedence for treatment, but these severe laryngeal injuries usually produce airway obstruction necessitating urgent relief by tracheotomy.

The long-term result of trauma is the formation of scar tissue, which can interfere with phonation by fixation of the vocal cords, or by formation of a web, and can narrow the airway (stenosis). These effects can best be avoided by the earliest possible repair of the mucosal tears and the accurate repositioning and fixation of fractured cartilage. In order to prevent stenosis some injuries require a stent or mould to be left in the lumen of the larynx while healing is taking place. The tracheotomy can be closed once the stent has been removed and the intralaryngeal swelling has subsided. Injuries to the laryngeal nerves are considered in a later section.

The larynx may also be damaged by internal injury. An endotracheal tube passed through the larynx is frequently used in general anaesthesia. The short duration of most general anaesthetics rarely traumatizes the larynx, but on occasion ulceration may occur with subsequent formation of a granuloma. Long-term intubation is part of the management of respiratory problems requiring mechanically assisted ventilation. Trauma is much more likely to occur, and to avoid this a tracheotomy is performed.

Surgical procedures on the larynx, particularly those performed endoscopically, require extreme care to avoid residual scarring. The use of the operating microscope makes such procedures more precise. Recently the advent of laser surgery performed at microlaryngoscopy allows pinpoint excision of diseased tissue with minimum damage to normal tissues. One area in the larynx to which special care must be applied is the anterior commissure. Trauma here may result in a web of scar tissue, a very troublesome situation to reverse.

Endocrines and ageing One feature of hypofunction of the thyroid gland (myxoedema) is a hoarse voice due to thickening of the submucosal tissues of the vocal cords. The appearances are similar to chronic laryngitis and the cause is suspected when other features of myxoedema are present. The condition is corrected by replacement therapy with thyroxine tablets.

The larynx is also under the influence of the sex hormones, obvious changes in the voice occurring at puberty. The development of vocal-cord oedema and polyp formation after the menopause has already been mentioned. Androgenic hormones are sometimes used in the treatment of gynaecological conditions and as a side-effect there may be an alteration in the female voice.

The ageing process affects the tissues of the larynx, such that they become lax and less elastic. The voice may change in pitch and lose its strength.

Papillomas The benign lesions so far described are not true neoplasms. Benign neoplasms are the non-invasive, non-spreading counterparts of the cancers. Symptoms are produced by the local effects of the swelling. They are rare in the larynx compared to the other benign lesions and the malignant lesions. The commonest true benign neoplasm is the papilloma, which has the appearance of a wart. In adults they are often solitary, making removal relatively easy, but careful follow-up is required for they may recur.

Benign neoplasms arising from other tissues such as glands in the epithelium (adenoma), fibrous tissue (fibroma), and cartilage (chondroma) are much rarer, and if large will require excision via a laryngofissure (see p. 133).

Congenital conditions These are described in Chapter 5.

Treatment of malignant lesions

First and foremost, patients with laryngeal cancer require sensitive, lengthy, and repeated counselling. There will be fears that need to be allayed, in particular that cancer has an inevitable and fatal outcome. Explanations of the effects of radiotherapy and surgery are not readily taken in and therefore need reinforcing by doctor, nurse and speech therapist. An excellent account of the management of laryngeal cancer is given in the book *Laryngectomy* (Edels 1983). What follows is a brief outline of the principles of treatment.

There are two modalities of treatment that may be used to effect a cure. They are radiotherapy and surgery. In this country the majority of patients are first treated by radiotherapy. This has the benefit of retaining the patient's normal method of breathing and speaking. The curative success with small glottic tumours is very high (more than 90%). Larger tumours in the supraglottic and subglottic regions do less well but some are cured with retention of laryngeal function. Very careful review of the patients is required during the radiotherapy and after to identify residual or recurrent disease at the earliest time. Radiotherapy itself has effects on the normal tissues of the larynx, in some cases producing marked oedema of the mucosa. The restoration of a satisfactory voice after radiotherapy may be helped by speech therapy, but the therapist must be on guard for any sign of deterioration of the voice. This could indicate recurrence of the cancer, and urgent referral to the ENT surgeon is needed.

A therapeutic dose of radiotherapy usually cannot be repeated as the effects are cumulative, even with a gap of years, and the neck tissues will be damaged excessively. Surgery is the choice of treatment for those cases that do not respond to radiotherapy, or that recur or are so advanced at outset of treatment.

Total laryngectomy The surgical procedure most widely used is the total laryngectomy, an operation which predates the development of radiotherapy. The principle that governs cancer surgery is that to overcome the invasive nature of the disease a sufficiently wide margin of healthy tissue surrounding the tumour must be removed. Applying this principle to the larynx requires an operation to be devised that will not jeopardize the adequate removal of disease, yet leave the patient able to perform the functions of respiration, swallowing and phonation. With total laryngectomy the first two are achieved at the expense of the latter.

This operation is usually well tolerated physically and has its major effects on the person rather than the body. It is this aspect of management that requires most sympathetic and optimistic counselling.

The operation may be performed through a U-shaped incision in the skin of the neck. The larynx is mobilized by division of the strap muscles, division and ligation of the neurovascular pedicles, and division of the thyroid isthmus. One or both thyroid lobes are removed with the larynx if to leave them would inadequately clear the cancer. Transection of the trachea and its suture to an opening in the skin of the neck creates the permanent tracheostomy. The final excision of the larynx leaves an opening into the pharynx, which is repaired. The patient is fed via a nasogastric tube for seven to ten days while healing of the pharynx takes place, and then normal swallowing can be re-established. This also heralds the time at which vocal rehabilitation can be started. Occasionally healing is delayed and a fistula between the pharynx and neck skin forms. This can take months to heal and may take several surgical procedures to effect closure. The commencement of speech therapy must await healing.

Vocal rehabilitation The standard method of vocal rehabilitation is the teaching of one of the techniques to produce a pseudovoice. These rely on the outflow of air taken into the pharynx to vibrate the pharyngo-oesophageal sphincter, so producing a noise that can be developed by the resonators and articulators of the remaining vocal tract. Because of the difficulties in learning the techniques, and the variable quality of the voice obtained, attempts have been made to overcome the problem surgically. Many of these have achieved little success due to the complexity of the apparatus, the introduction of infection, the inadequate removal of the cancer, and difficulties associated with swallowing.

A recent line of approach has been to create a tracheo-oesophageal fistula maintained by a prosthetic valve (for example, the Blom–Singer valve and Panjé button). This combines surgical speech rehabilitation with the techniques for acquisition of pseudovoice by directing air from the lungs into the pharynx for phonation. The one-way action of the valve is designed to prevent reflux of saliva or food from the oesophagus into the trachea. The simplicity of the idea and the relative ease with which the valves can be fitted bodes well for their success in aiding speech rehabilitation.

Other surgical procedures Other surgical procedures such as the partial laryngectomies, either supraglottic or vertical, and the reconstructive techniques of Staffieri and Serafini have found only limited application in this country. In many cases previous radiotherapy makes the healing after such operations suspect and other cases are too advanced to make anything less than a total laryngectomy possible.

Not all patients are cured. Professional skills are required to meet the physical needs of the patient, in particular the relief of pain. Special human skills are required of all members of the treatment team to maintain the patient's dignity during the terminal phase of the illness.

Treatment of benign lesions

The treatment of these lesions can be considered under three headings.

1. Excision of the lesion
2. Elimination of causative factors
3. Follow-up.

Excision of the lesion Many of the discrete lesions are easily recognized at indirect laryngoscopy. The majority require excision and this can be performed at microlaryngoscopy. The excised tissue is sent for histological examination.

Occasionally a large benign lesion is encountered that requires removal via a *laryngofissure*. In this procedure the larynx is exposed through the front of the neck and then split vertically along the angle of the thyroid cartilage. The inside of the larynx can then be inspected and the lesion excised. A tracheotomy is needed during the operation and for the postoperative recovery period.

A particularly difficult problem is the long-term scarring following trauma. The tendency is for the surgical excision of one scar to be replaced by another. The reconstruction of a stenosed larynx is one of the most challenging in laryngology.

Elimination of causative factors This largely is the role of the speech therapist and is described in Chapter 8. In the case of vocal cord nodules, speech therapy may precede surgical excision as some early cases may regress. However, if they do not regress, surgical treatment is indicated followed by further speech therapy. In many cases of benign lesions faulty voice production occurs and speech therapy is required even if vocal abuse was not the prime cause of the lesion.

The advice that would need to be given to correct the factors producing a chronic diffuse laryngitis is often not followed. It is unrealistic to expect a man to give up his pleasures and his work! A source of chronic infection in the upper respiratory tract such as the sinuses or poor dental hygiene can receive attention, as can a cause of nasal obstruction.

Follow-up It is mandatory that some cases are kept under long-term regular review. These are the patients with chronic laryngitis where the histology has shown changes that are premalignant.

In other cases, once the voice has returned to normal, the patients need not be seen regularly but can be asked to return if their symptoms recur. Unfortunately there is a high incidence of relapse in these conditions.

GROUP III. IMPAIRED VOCAL CORD MOVEMENT

Impairments of mobility of the vocal cords will affect the swallowing, respiration, and phonation functions of the larynx to a varying degree, depending on the movements that are paralysed and the static position adopted by the cords. The nerve supply to the larynx contains both motor fibres to the muscles and sensory fibres to the mucosa. The protective function of the larynx is equally dependent on an intact sensory input as it is on the motor response to complete the reflex.

Interference with the nerve supply is the major cause of abnormal movement of the vocal cords, but the rare muscle disorders and fixation of the cricoarytenoid joints need to be borne in mind. The former may be encountered in a generalized muscle disorder such as myasthenia gravis, and the latter as a result of trauma to the joints or as part of a generalized arthritis such as rheumatoid. Joint fixation may also develop after long-term immobility of a paralysed cord.

Management of patients with vocal-cord palsy consists of three aspects. Investigation to identify the cause, treatment of that cause, if possible, and correction of the laryngeal dysfunction. These will be considered in relation to the various clinical presentations.

Unilateral recurrent-laryngeal-nerve palsy

The commonest lesion is a paralysed cord that adopts a position in or close to the midline. This is the effect usually of a recurrent laryngeal-nerve palsy. There is no universally agreed explanation to account for the position taken up by the paralysed cord, but a reasonable explanation is that the position is produced by the unopposed adduction exerted by the cricothyroid muscle (nerve supply is external laryngeal nerve).

For many cases no cause can be found despite careful investigation. Some will recover spontaneously although this may take many months. In other cases the cause is obvious, such as those due to trauma. An unfortunate cause of trauma is that of surgery to the thyroid gland, but injuries to the neck or thorax may also damage the recurrent laryngeal nerves. The course of the left recurrent laryngeal nerve takes it into the chest, and being longer than the right this nerve is more liable to damage. In the chest the nerve may be involved in malignant growths of the bronchus or oesophagus, or malignant lymph glands at the hilum of the lung. In the neck, oesophageal, thyroid, tracheal, and laryngeal malignancies may paralyse the nerve. The investigation includes palpation of the neck, chest X-ray, a barium-swallow X-ray, and endoscopic examination of the larynx, trachea, bronchi, pharynx, and oesophagus.

Oesophageal and bronchial malignancies are usually so advanced when they produce a vocal-cord palsy that the chance of cure is small. Thyroid, and particularly laryngeal, malignancies offer a much higher success rate. Trauma to the nerve will recover if it were only bruised and the nerve sheath remained intact, although recovery may take many months. Complete division of the nerve is unlikely to recover.

The laryngeal dysfunction of this lesion is confined to a voice change of a rough quality with some weakness, air escape, and a tendency for the voice to deteriorate with tiredness. In cases where the paralysed cord is in the midline there may be virtually no alteration in the voice, and in others there is compensation by the non-paralysed cord, which overadducts to meet the paralysed cord in phonation. This compensation can be encouraged by speech therapy, but such treatment must not be expected to influence the recovery of movement in the paralysed cord.

Bilateral recurrent-laryngeal-nerve palsy

When the condition described above occurs bilaterally the clinical picture changes dramatically. With both cords in a position near to the midline, and unable to abduct, the airway is imperilled. This is an uncommon occurrence and the most frequently encountered cause is thyroid surgery. It is usually necessary to relieve the obstruction by tracheotomy, but on occasion the airway is not so severely embarrassed.

The situation is observed for at least 12 months as spontaneous recovery of movement of one or both cords may occur. If after this time there has been no recovery, a decision is made between the retention of the tracheotomy and a surgical procedure to widen the glottis. A tracheotomy tube fitted with a 'speaking valve' allows a good voice as in this condition the vocal cords are approximated and have smooth edges. The speaking valve must not be confused with a vibrating mechanism. It is simply a hinged flap inside the entrance of the tracheotomy tube which opens on inspiration and closes on expiration. The expiratory air is directed around the tube and out through the larynx, vibrating the cords for phonation. (Inspiration is not possible through the larynx as the attempt to draw in air sucks in the soft tissues of the larynx, exaggerating the obstruction.)

In order to close the tracheotomy the glottis must be widened by a cordopexy procedure. Various methods are available, from the complete excision of a vocal cord, the removal of one arytenoid cartilage, to the stitching of one vocal cord into an abducted position. It will be appreciated that this will have a detrimental effect on the voice, but for social purposes it may be acceptable. There is a large degree of self-decision by the patient as to the management, taking into consideration the importance of voice in work and the desire to lose the tracheotomy.

Vagus-nerve damage

Some injuries or disease processes affect the vagus nerve before it has given off its laryngeal branches. Tumours of the vagus nerve and related structures and their surgical treatment, and intracranial neurological conditions are some of the causes. The voice is often very weak and hoarse with air escape, and examination of the larynx shows the immobile cord to be in a more abducted position than is the case with a pure recurrent-laryngeal-nerve palsy. This can be explained by the added paralysis of the cricothyroid muscle, and the cord adopts a position midway between full adduction and full abduction. The mobile cord is less able to compensate, hence the more marked voice change.

Following investigation of the cause, treatment is first directed to that. Speech therapy may be given during the period of waiting for spontaneous recovery (although this rarely happens in these cases). If the voice does remain poor (and for those cases of recurrent-laryngeal-nerve palsy in which the voice is unsatisfactory), improvement can be gained by adding bulk to the paralysed cord to place it near the midline such that the mobile cord can now meet it. This is most simply performed by the endoscopic injection of Teflon paste into the substance of the immobile cord. Judgement is required neither to overcorrect nor undercorrect, but the procedure can be repeated as required to maintain a good voice.

There is some risk in this condition of a partial incompetence of the larynx due to the loss of a large area of sensory input from the epithelium and the inability to completely close the glottic sphincter. There may be some difficulty in swallowing, but this can usually be overcome if the patient takes extra care, and the situation will also be improved by the Teflon injection.

Bilateral vagus-nerve damage

A dangerously incompetent larynx results when both cords are paralysed in a semiabducted position. This rare occurrence is usually the result of a serious brain-stem lesion, for example a vascular accident or tumour. These lesions often have a fatal outcome, but the few patients who survive present a most difficult management problem. There is no stridor but the airway is compromised by the inability to prevent food and liquids entering the trachea and lower airways. This can be managed (temporarily) by a tracheotomy, using a tube with an inflatable cuff to protect the lower airways during swallowing. This is unsatisfactory in the long term and one drastic solution is a total laryngectomy, which separates the airway from the upper digestive tract. An alternative is to suture the epiglottis over the laryngeal inlet, thereby affording the necessary protection to the airway, but the tracheotomy may continue to be required for respiration.

External laryngeal-nerve damage

Following thyroidectomy some patients notice a voice change but indirect laryngoscopy reveals fully mobile vocal cords. This has been attributed to damage to the nerve supply to the cricothyroid muscle. The described appearance of a wavy edge to the vocal cord is rarely seen.

GROUP IV. COMBINATION OF GROUPS II AND III

Some cases are seen in which there is impaired movement of the vocal cords and in which a structural lesion is visible. Malignant laryngeal disease will be responsible for some of these, indicating advanced local disease with fixation of one side of the larynx. Second, as a result of trauma, there may be a combination of scarring within the larynx and paralysis of the motor nerve supply, or fixation of the cricoarytenoid joint. The principles of management are given in the relevant sections above.

GROUP V. NORMAL APPEARANCE OF LARYNX

In this group the surface lining of the larynx is normal in appearance. The cords appear to be fully mobile during the phases of respiration and they adduct fully on coughing. Adduction may not occur completely or be maintained for phonation, but this is often difficult to see and essentially the mirror examination shows a normal larynx.

Provided the examiner is confident in the indirect laryngoscopy findings, then it is likely that the voice disturbance, either aphonia or dysphonia, is functional. These conditions are seen most frequently in females, often in the younger age groups. Rarely is there a severe psychiatric condition but rather a superficial emotional upset, perhaps of a recurrent nature. It is, however, not often possible to elucidate the particular factors during a busy outpatient clinic, even though they may be suspected. It is of great benefit to the patient's recovery to be reassured that there is no serious pathology. A fear of cancer often superimposes itself and overshadows the original psychogenic disturbance.

Referral is to the speech therapist. A few cases do not respond, or the speech therapist may notice a deterioration in the voice. These cases must be re-examined by the ENT surgeon. In the rare instance where a deep-seated psychiatric disturbance is suspected referral to a psychiatrist is required.

Occasionally a pubertal or postpubertal boy is referred to the ENT surgeon for investigation of a dysphonia or the persistence of a high-pitched voice. These boys have usually developed normally in all other physical respects, as those cases with a definite hormone deficiency have had previous referral to a paediatrician or endocrinologist. Examination of the larynx is typically normal but in some cases of dysphonia the false cords are seen to take a prominent part in phonation. Again referral is to the speech therapist and in most cases the voice disturbance can be quickly corrected.

CONCLUSION

The causes of voice disorders cover the full range of pathological processes. Their management from diagnosis to treatment is an important aspect of the ENT surgeon's work. A close working relationship between speech therapist and surgeon is helpful. Joint consultation is particularly beneficial and the results of treatment are very rewarding.

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8

Hyperfunctional voice: The misuse and abuse syndrome

Margaret Fawcus

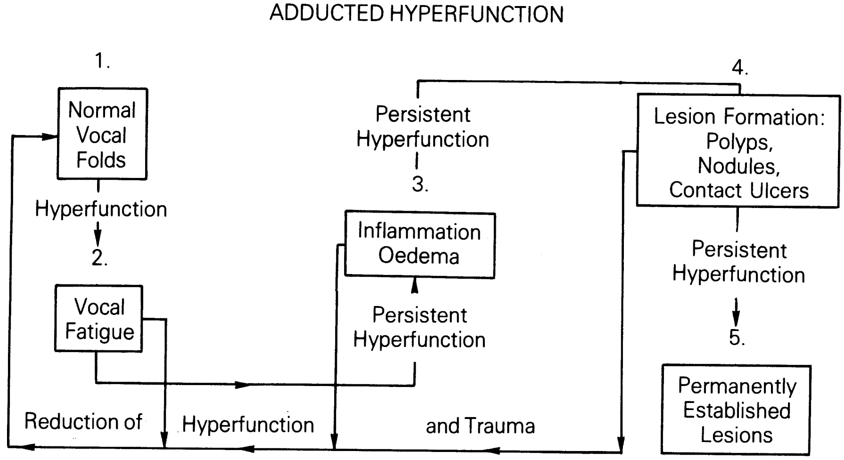
INTRODUCTION

The term *vocal hyperfunction* appears to have been first used by Froeschels (1943) and is characterized by a tense over-adduction of the vocal folds. It is generally regarded as the most common cause of voice disorder. Boone (1977) says, 'it is at the anatomical site of the glottal opening where the vast majority of hyperfunctional voice problems begin, because of inappropriate (inadequate or excessive) vocal fold approximation.' The resulting voice may be described as harsh or strident. Whether this type of voice use becomes a problem or not will depend on the relationship between the vulnerability of the vocal folds and the degree of hyperfunction involved in voice use. Not all strident voice users experience vocal problems, but where excessive tension results in vocal fatigue, discomfort, weakness or loss of voice and actual tissue changes in the epithelium of the larynx, there is clearly a situation which demands some form of therapeutic intervention.

The physical vulnerability of the larynx varies from one individual to another: using the voice against a high intensity background noise will lead to slight, temporary hoarseness in some speakers but not in others. Jackson and Jackson (1945) observe that 'there is great variation in the amount of abuse the larynx of different speakers will stand, but every larynx has its limit. To go beyond this limit means thickening of the cords, and a thickened cord means a hoarse voice.' The laryngeal mucosa may be resistant to a habitual pattern of overadduction for many months or even years, but an attack of acute laryngitis will often lead to the continuing condition of chronic non-specific laryngitis because the folds are now vulnerable to improper voice use.

The term *misuse and abuse* was used by van Thal (1961) and

Table 8.1 Cycle of events in which misuse of the voice can lead to physical changes in the larynx. (From Hillman *et al.* 1989)



distinguishes between the long-term habitual pattern of hyperfunctional voice use (misuse) and those situations where hyperfunction is on a situation-tied, 'one-off' basis (for example, speaking against loud ambient noise at a disco or shouting at sports events).

Excessive tension (that is, a state of muscular tonus over and above that required for efficient vocal-fold movement) is a common denominator in many cases of voice disorder. In hyperfunctional voice problems it is, by definition, the central feature. Brodnitz (1959) stated that 'the vast majority of functional voice disorders begin with excessive use of muscular force.'

Hillman *et al.* (1989) have commented, however, that whilst such qualitative explanations of excessive tension in vocal fold approximation may provide a reasonable, general description of hyperfunction, they do little to provide much needed objective insight into real cause-and-effect relationships. Their hypothesis, supported by initial research data, is that there are different mechanisms underlying the different stages and types of hyperfunctionally related voice disorders (Table 8.7). Using non-invasive aerodynamic and acoustic recordings, they are developing objective measures to look at glottal air-flow waveform, transglottal pressure, average glottal air-flow, glottal resistance and vocal efficiency, and finally, measures of vocal intensity and fundamental frequency. The study indicates that not only can hyperfunctional voice use be differentiated from normal voice production, but that hyperfunctional voice conditions can be differentiated from one another. Such findings will ultimately have their implications for the more sophisticated management of hyperfunctional voice disorders.

Tension may be manifest in a harsh or strident voice, in a hard glottal attack on vowel sounds, and in high and sometimes inappropriate intensity levels. The presenting symptoms will vary, and will depend on the condition of the vocal folds. In the early stages of hyperfunctional voice use there may be no abnormal signs on examination of the larynx. In these cases the vocal symptoms are probably intermittent and the main complaints are of vocal fatigue, episodes of vocal weakness, throat clearing, or pitch breaks. There may be slight reddening of the vocal folds when these occur. Voice therapy at this stage is an important prophylactic measure, since remediation is slower and may be less successful once the tissue changes associated with chronic inflammation, vocal nodules, or contact ulcers have taken place.

The causes of vocal misuse are complex, and frequently represent an interaction of endogenous and exogenous factors. Van Riper and Irwin (1958) have placed some emphasis on the personality of the speaker and regard the users of harsh voices as 'aggressive and antagonistic individuals, highly competitive and hypertense.' They commented on the difficulty of modifying such patterns of voice use because of the close affinity between voice and personality.

In addition to personality factors, the speaker's environment is a potential source of many causes of tension. At work there may be the burden of heavy responsibilities, relationships may be strained and difficult, excessive work loads, a highly competitive atmosphere, and nowadays the fear of redundancy. The interpersonal dynamics in the home environment may be even more demanding and complex.

There may, of course, be familial patterns of hyperfunctional voice use. Vocal misuse may arise initially from imitation of an adult model. Piaget (1952) and Greene (1980) have written about the vocal 'contagion' which takes place in the early months of the baby's life.

The patient's age may be a significant pointer, not only as an indicator of possible physical changes and associated problems (such as the menopause), but also of crucial changes in lifestyle. Within the family network there are many possible sources of anxiety, anguish, irritation and bitterness – all potential causes of physical tension and even lack of self-care. This holds true for both the single or the married person, for the young, the middle-aged and the old. Empathy and imagination are essential qualities if the therapist is going to evaluate the effect of the various sources of stress and tension. It is important that the presence of one obvious problem (such as overwork) should not blind one to other factors, such as poor interpersonal relationships, which may have more insidious effects and ultimately be more damaging.

The possible causes of stress and tension are endless; some may appear insignificant, but it is the cumulative effect of these causes that must be considered. Suffice to say that a systematic examination of the patient's total lifestyle, at home, at work, and at leisure, may reveal clear indications (if no easy solutions) for total management.

In addition to specific remedial techniques, the management of all such cases will involve an attempt to eliminate or modify adverse environmental factors. The emphasis in the treatment programme will obviously depend on a consideration of all possible aetiological and contributory factors in each case, and on the practical problems involved in implementing change. In planning what we may describe as the remediation package it is essential that we are aware of the physical and emotional stresses in the domestic environment, the work situation and leisure pursuits. Whatever can be done to reduce these demands should be discussed with the patient. The extent to which change can be achieved will obviously depend on the degree of co-operation we can expect from those in the patient's environment. More important still is the willingness and initiative shown by the patient trying to make changes. We are not only concerned with the question of whether the deaf relative is willing to wear a hearing aid, but also whether the client is prepared to approach the relative on the subject.

In many cases, the ultimate success of treatment will depend on the extent to which adverse environmental factors can be removed or modified, and in some cases this will depend on a balance being achieved between what is the ideal goal and what is practical. There are sometimes very simple solutions to vocal abuse – the purchase of a whistle, for example, may replace shouting to call the children in from the garden (and produce a more immediate response!).

THE REMEDIAL VOICE PROGRAMME

In very general terms, the remedial programme will be a two-stage process: the first step is designed to modify those habits of voice production that cause the vocal strain; the second step is the development of strategies to enhance voice production.

Traditionally, the approach to remedial voice work has been based on a singing and drama teaching model, with what would seem an inappropriate emphasis on certain aspects of the training. Improved breath control, for example, has occupied a central role in such training and has come to be considered as an essential part of all remedial voice work. In this section, we shall be considering the need to develop a treatment programme to meet the specific needs of those whose voices have been misused, rather than a training regime for those who are going to make more exceptional demands on their voices. In this context, it will be seen that improved breath control is not the most important aspect of retraining. It would seem far more important that the patient first learns to monitor his vocal output, so that he can make the necessary adjustments to improve his performance.

Auditory training

It has been suggested that a programme of auditory discrimination is indicated because those who abuse their voices demonstrate a poorer response on speech discrimination tests than their normal controls. Saniga and Carlin (1985) found that a group of 25 female voice abusers were significantly poorer on the Goldman–Fristoe–Woodcock test of selective attention than a control group of 25 female speakers with normal voice. They did not discriminate as well as the control group under conditions of noise. Saniga and Carlin suggested that vocal abusers 'unable to discriminate their own speech in a noisy environment consistently increase vocal intensity and thus increase the chronic abuse of the vocal mechanism.' They went on to suggest that these discrimination problems could also interfere with self-monitoring, thus identifying 'both an etiologic and maintaining factor.' Research, such as it is, has not conclusively shown that the listening skills of those who abuse their voices are less competent than their normal counterparts, perhaps because studies have been looking at different aspects of discrimination (e.g. pitch versus intensity or pitch versus quality). Whatever the findings, and even where a subject's discrimination abilities are apparently within normal limits, it would still seem essential to develop listening skills so that a client can monitor and evaluate his own vocal output.

Valuable as visual feedback devices (for example, Visispeech) may be, it is essential that the patient learns to develop his own monitoring skills. Bunch (1982) comments 'machines are important tools for research, but for the purposes of performance and the teaching of singing, the human ear and associated neural mechanisms provide a superb instrument for refined detection and analysis.' The same is equally true for the speaking voice. Nonetheless, visual feedback devices are an important adjunct in treatment in enabling the patient to compare his performance with the target model presented by the therapist. It is also important, however, that such instrumentation does not obscure the need for the patient to develop reliable listening skills.

Limited auditory monitoring ability may indeed be a poor prognostic sign in the dysphonic patient. Listening is the only tangible feedback channel since, as Boone (1977) says, 'no-one has much awareness of what he is doing laryngeally whether he is approximating his folds or shortening or lengthening them.' He goes on to discuss the problems this presents in voice work since the patient 'literally does not know what he is doing when he phonates.' This is in sharp distinction to the tactile awareness one can normally rely on in articulation work. Aronson (1980) considers that auditory discrimination and feedback 'occupy a pivotal position in voice therapy . . . because tactile and proprioceptive feedback is diminished in phonation and cannot be relied on.' A study by Fishman *et al.* (1971), in which the larynx was anaesthetized, showed that the deprivation of sensory feedback did not affect the subject's phonation. They concluded that sensory feedback from the larynx was not essential for phonation. This study underlines the importance of developing auditory feedback skills if the patient is to recognize and correct faulty voice production. The patient must become a critical and discriminating listener, and this is probably the single most important therapeutic goal. Unfortunately, concentration on breathing in the early stages of treatment – which is normally part of a more traditional approach – inevitably distracts the patient from the more important task of listening to his own voice.

Training in procedures such as the vocal profile analysis described by Laver *et al.* (1981) will give the therapist the knowledge he or she needs in order to:

1. Detect what the patient is doing.
2. Model what the patient is doing, providing him with an auditory 'mirror' of his own performance.
3. Be able to alternate normal and abnormal voice production in order to heighten the patient's awareness of the voice he is producing.

Aronson's (1980) statement that 'voice is ephemeral, lacking finite acoustic boundaries' underlines one of the difficulties on working with the dysphonic patient.

Van Riper and Irwin (1958) have described the process of 'hunting' in articulation practice and a similar approach can be used in achieving target voice. It is a form of exploratory oscillation about the target – in this case the most acceptable voice produced by the patient. Good voice may be used inadvertently on occasions and this must be recognized and reinforced by the therapist immediately it occurs. During a therapy session we may expect the patient to produce a number of 'different' voices, some nearer the desired target than others. The resourceful therapist helps the patient to place these different vocalizations on a sensitive rating scale from 'poor' to 'good' voice production. Aronson (1980) observed that 'the voice rarely changes from aphonic to dysphonic to normal without first passing through several dysphonic stages.' He goes on to say, 'in the early stages improved voice will break through suddenly and momentarily, milliseconds in duration.'

It is the therapist's role to help the patient evaluate what he is doing, with the aim of working towards the target sound, with the therapist and patient making careful judgements of the voice quality achieved at each stage. The patient becomes an active and informed participant, much less dependent on the therapist's judgement of 'correctness'.

The increasing ability to make reliable judgements for himself is essential for productive practice periods and voice use beyond the confines of the clinical situation.

Elimination of unnecessary tension

Implicit in the term hyperfunctional is the state of hypertonus or tension in the muscles of the larynx. It is not unreasonable, therefore, to assume that such tension localized to vocal function will be an integral part of a more generalized tension. From this assumption, general relaxation became recognized as an essential and early stage in the traditional approach to treatment. Such an approach seems logical enough in the circumstances, but closer consideration reveals flaws which would seem to demand a more specific approach. In the first place, one is aware that many very tense people do not necessarily abuse or misuse their voices. Secondly, degrees of considerable tension are a normal and indeed inevitable part of our daily living. Many professional speakers who use their voices well need the drive of adrenalin to achieve optimum performance. What is important, however, is that muscular relaxation is achieved through the ability to quite simply 'let go' in leisure activities and off-duty hours. The most effective and lasting answer to the problem of excessive bodily tension is to help the patient gain insight into the demands he is placing on his body. This lies in the realm of counselling more than relaxation, but if we are to achieve a more permanent solution in these cases, it would seem that we must address ourselves to these issues. There are a number of ways of attempting to make such changes in the person's total lifestyle.

1. Keeping a diary – an analysis of even a day's activities may demonstrate to the patient that there is little respite from a continuous pattern of tension and activity.
2. A personal 'brainstorming' session in which the client is asked to suggest anything which he/she thinks may result in tension. These items should be written down so that they can be discussed by client and therapist. An analysis of these situations may reveal patterns or 'groupings' which may have considerable implications for management.
3. Non-directive counselling (Rogers 1981) allows the patient to develop insights into sources of stress and conflict, and possible solutions to

them. It is a process that facilitates change, enabling the patient to choose between the options available to him. As the name implies, this process occurs without direct advice or guidance from the therapist (who, in any case, can view the patient's problems only from his/her own standpoint, however empathic he/she may be).

The state of general bodily relaxation is very far removed from the finely balanced tonicity required in phonation. Moore (1971) views relaxation as 'a dynamic balance, in which the opposing groups of muscles exert just enough reciprocal tension upon each other to accomplish the desired movement with perfect control.' Optimum functioning demands a dynamic balance between tension and relaxation. Boone (1977) sums up the goal of relaxation by describing it as a 'realistic responsiveness to the environment with a minimum of needless energy expended.' This same viewpoint is echoed by Brodnitz (1959) when he says 'alertness of mind and body and well-adjusted muscular tonus are characteristic for the normally functioning body.'

These statements represent a more realistic approach to relaxation, and emphasize the need to work on a more relaxed bodily state through activity rather than the more static approach of supine relaxation. The aim is freedom for action, with the elimination of unnecessary tensions which may inhibit easy movement and lead to muscular fatigue and even weakness. In the clinic situation van Riper and Irwin (1958) believe that 'the best relaxing agent we know is a good therapist' influencing the patient's mental and physical state 'by his own relaxed behaviour, by his permissiveness and competence.' This, they claim, can create 'the balanced tonicity out of which successful learning can come.' We need an active and not passive participant.

There are a number of specific approaches to general and localized relaxation available to the therapist.

General relaxation Boone (1977) and Greene (1980) have described approaches to general relaxation with the dysphonic patient, and readers are referred to the classic text by Jacobsen (1929). A state of relaxation may be achieved by a number of strategies. Suggestion may be used in which the therapist creates a restful scene for the patient to imagine. Used skilfully this can be a very effective technique. Some therapists use a similar approach, but the suggestion is directly related to a relaxed state of each part of the body. This is basically the method advocated by Jacobsen. An alternative method aims at heightening the patient's awareness of tension and relaxation by increasing tension in one part of the body and then releasing it. It is probably worthwhile trying all three approaches in determining the most efficacious with any given subject.

The acquisition of a balanced posture Laryngeal tension can result from a muscular imbalance caused by improper head/neck posture. Such postural problems may have interesting origins, which are not always immediately obvious to the therapist and may, in any case, be related to situations outside the clinic setting. Abnormal head/neck relationships may occur in those who spend a good deal of their working time on the telephone: it is not so much the amount of talking they do, but rather the continuously asymmetrical posture involved – particularly when the telephone receiver is tucked under the chin to free the hands! Occasionally we meet speakers who habitually cock their head to one side when they speak, which tends to create unnecessary muscular tension on the contralateral side. The following case illustrates the long-term effects of an abnormal postural problem.

The woman, in her mid-30s, had earned a somewhat precarious living from painting and occasional calligraphic assignments. She had no problems with her voice until she decided that she must take a part-time teaching post at a girls' secondary school. She had not received any form of teacher training, and had no experience of classroom teaching. She found the girls difficult to control, and under the circumstances did not enjoy teaching. She began to experience vocal fatigue and periods of voice loss and was referred to the ENT department of her local hospital. There were no abnormal laryngeal signs. She was not a particularly extrovert personality, her voice was not harsh or strident, and neither did she use it excessively outside the classroom. There seemed to be a clear case here of situation-tied vocal misuse, and a treatment programme was designed to improve the audibility of her voice without recourse to forcing it at high intensity levels. In implementing the programme it became clear that she was extending her neck, which involved the tilting back of her head, causing undue tension in the muscles of the neck and larynx. In discussing this phenomenon with her, it emerged that a fellow student at art school had drawn a cartoon of her, accentuating a somewhat underdeveloped mandible, making her look 'a chinless wonder' as she put it. She had attempted to compensate for this by sticking her chin out, which had become a habitual posture. This had not presented any problem until the tension it produced was compounded by the additional tension of using voice in the classroom for several hours a week at higher intensity levels.

A balanced posture in standing, sitting and walking avoids unnecessary tension and wasteful expenditure of energy. Alexander (1932) said 'freedom of alignment allows the body to use its energy far more economically and is especially efficient because no undue tensions are present.' Gould (1971) sums up the need for attention to posture both at rest and in action: 'posture is the dynamic interrelationship between muscular and skeletal tissues. The word dynamic is important; for alignment should be stable, but never static and fixed, if it is to be the prelude to easy flowing movement.' Barlow (1952) used the term postural homeostasis, to denote the 'state of steady motion which underlies all voluntary movement.' He felt that such homeostasis was 'primarily dependent on the correct equilibrium of the head/neck relationship.'

Speech therapists working with disorders of voice would undoubtedly benefit from a better understanding of Alexander's ideas and the techniques which have been developed to achieve improved postural balance. In the absence of such knowledge, they must at least be aware of the need to look for poor postural alignment that is producing tension and restricting freedom of movement. Willmore (1959) developed the concept of 'vocal homeostasis' in which 'the overriding aim of all voice therapy is the reduction of misplaced effort and tension.'

Reduction of intensity levels The majority of speakers probably use their voices at higher intensity levels than the situation absolutely demands. It is, of course, only the speaker who experiences vocal fatigue or dysfunction where this actually matters. Reducing the intensity level of the speaker's voice, to a level compatible with being heard by his/her listener, is probably the most practical way of achieving some degree of vocal economy. Aronson (1980) speaks of 'ill-advised prescription of vocal rest.' He contends that to advise a patient to whisper or remain silent for days or weeks is 'the most deleterious advice that can be given a patient with a voice disorder.' The risk of the patient adopting a forced whisper is considerable, and this can prove infinitely more damaging than quiet voice use. In addition complete voice rest can be a psychologically distressing experience, and one that it is practically difficult to implement. It is far better to advise the patient to adjust his level of intensity to meet the fairly precise needs of a given situation – to speak quietly whenever he can, with the full understanding that this takes some of the stress off the vocal folds.

Elimination of glottal attack A hard, glottal attack on vowel sounds may be characteristic of hyperfunctional voice use and represents a form of vocal abuse. This type of vocal attack can be heard in singers and, if used sparingly, does no harm. Associated with general laryngeal tension, however, it is another matter, and the speaker needs to be made aware of what he/she is doing. Fortunately it can largely be pinpointed to vowel sounds at the beginning of sentences, which makes it rather easier to modify.

The careful use of negative practice (Dunlap 1932) is a very effective technique in making the patient aware of a glottal attack. With fingers and thumbs resting lightly on either side of the thyroid cartilage, the patient is asked to produce a vowel sound with a tense initiation of voice. This is then followed by a soft, aspirate attack on the same vowel sound. The process is repeated, until the patient has had the opportunity of experiencing the contrast between the two approaches to vowel initiation.

This stage is followed by practice on the conscious use of aspirate attack on vowels, first on words:

arm – only – underneath – everywhere

and then on phrases:

arm in arm	every afternoon
all the afternoon	amber eyes

Appropriate reading material, which can be prepared to include a high proportion of vowel-initial sentences, can be used to ensure that the speaker can maintain a more gentle approach at the speed of normal speech.

Biofeedback techniques The use of biofeedback in the treatment of voice disorder has been described by Aronson (1980), Boone (1977) and Greene (1980). Aronson states that the importance of feedback cannot be overstressed because of the 'minimal tactile and proprioceptive sensation arising from the larynx during phonation.' The aim of biofeedback is to increase the patient's awareness of laryngeal tension and to give him a tangible way of controlling it. A study detailed by Prosek *et al.* (1978) investigated the use of biofeedback training and concluded that it would be most successful in those hyperfunctional voice cases where there was no permanent laryngeal damage. They found that biofeedback (electromyography) provided an accurate external monitor of laryngeal tension, thus placing fewer demands on the auditory system and freeing the patient to concentrate on developing methods of reducing such tension. Prosek considers that biofeedback techniques facilitate the vocal re-education programme but discusses some of the problems encountered in achieving reliable feedback. Undoubtedly, such an approach is a valuable adjunct to therapy in the hands of a skilful and experienced clinician.

A more recent study (Andrews *et al.* 1986) has looked at the comparative value of EMG biofeedback and relaxation in the treatment of hyperfunctional dysphonia. They concluded that both techniques were equally successful in reducing tension in the laryngeal area and in improving voice quality. This improvement had been maintained at a follow-up visit three months later. Andrews *et al.* comment that insight into the voice disorder seems to be essential in the acquisition and maintenance of 'less abusive vocal practices'. They considered that all subjects derived benefit from explanation of normal voice and the cause of their dysphonia. Interestingly, they also found a reduction in stress-related disorders such as migraine and sleep disturbances. EMG did prove to have its limitations in recognizing, for example, hard attack (which had to be eliminated by auditory monitoring). They stress that with the 'multitude of individual psychological, physical and personality components interacting on the voice mechanism, it is unlikely that even the most sophisticated combination of equipment could predict and supply exactly the most effective techniques.'

The chewing approach Detailed accounts of the chewing approach in achieving more relaxed phonation have been given by Boone (1977) and Wyatt (1977). The patient is asked to phonate whilst carrying out vigorous chewing movements. Because such phonation is not associated with abnormal patterns of habitual voice use, its advocates claim that the patient experiences a normal degree of tension while producing voice in association with a vegetative function. Aronson (1980) has suggested that the value of the chewing method may be limited because of the patient's embarrassment at carrying out the instructions.

Much will depend on the enthusiasm and skill of the therapist, and the ability to involve the equally enthusiastic co-operation of the patient. As with so many techniques employed in voice therapy, there appears to be no evaluative study of this technique.

Developing optimum resonance

Pershall and Boone (1987) have observed that past research has tended to focus on the vocal folds, with little apparent interest in supraglottic structures and their role in voice production. They reported on the use of videoendoscopy to study the supraglottic tract in eight professional singers. They found that each singer seemed to adopt 'a pre-phonatory setting consisting of a low laryngeal height, moderately dilated (as opposed to wide dilation seen in the yawn) round, tensed pharyngeal walls, and an elevated velum with a closed velopharyngeal port.' This position was maintained during singing, with a rise in laryngeal height and constriction of the pharyngeal walls only occurring when they used the upper third of their pitch range. Research seems to suggest that low laryngeal height, with a consequent long vocal tract, has a high correlation with subjectively good voice quality.

The work of Berry *et al.* (1982) has demonstrated the value of combining xeroradiography and electrolarngography in providing quantifiable visual information on soft-tissue changes in normal and disordered voice production. Xeroradiography provides characteristic clarity of soft-tissue detail with a low X-ray dose. Using this technique, they were able to demonstrate that voice-disordered patients constricted the supraglottic resonators during phonation. Obviously, such constriction will alter the quality of phonation. Whilst such changes can be discerned by the ear of both patient and therapist, xeroradiography allows objective visual feedback on what is taking place and gives invaluable insights into supraglottic behaviour.

Berry *et al.* stress the need for punctilious attention to detail in enabling patients to produce phonation with a relaxed and controlled vocal tract. This technique, combined with electrolaryngography, clearly has considerable potential, not only in voice therapy, but also in the evaluation of treatment procedures. It is not, however, easily available to the voice therapist and, because of the radiation hazard involved, does not permit the frequent monitoring of vocal performance which video-endoscopy allows.

It is reasonable to suppose that laryngeal tension in hyperfunctional voice use coexists with tension in the variable supraglottic cavities. As Bunch (1982) has observed, 'the hyperfunctional pharynx tends to be rigid and is constricted in such a way as to leave little resonating space.' Discussing the constricting effect of tension, Brodnitz (1959) said:

> hypertension at the level of the hypopharynx and the oral pharynx will produce a constriction of the muscles in the walls of the throat resonator. The tongue is thickened by contraction of its intrinsic muscles. At the same time it is pulled backward. The result is the creation of an acoustic bottleneck.

Tense, restricted jaw movement will further inhibit the optimum use of the oral cavity. The speaker may attempt to compensate for the poor carrying power of his voice by increasing the intensity of the laryngeal note, but the resulting tension is seldom justified by the increase in audibility of the voice. At the same time, the actual quality of the voice may deteriorate and the voice may sound 'constricted, strangulated and harsh' (Brodnitz 1959).

Bunch (1982) has described the pharynx as an adjustable, mobile muscular sleeve that can 'assume many changes of shape and variations of tension in its wall. These adjustments made by the muscles of the pharynx contribute directly to different vocal qualities.' The therapist may contract the muscles of the pharyngeal walls whilst producing /a/, or on speaking, in order to give a dramatic demonstration of the effects of tense resonators on voice.

Murphy (1964) has discussed the effect of both tense and relaxed surfaces on the quality of voice, and the need to achieve a balance if tone is to be enriched rather than 'muffled', and 'bright' rather than 'metallic'.

Relatively little attention has been paid to work on developing optimum resonance in patients with hyperfunctional voice problems. This is surprising when one considers those patients who have been struggling to meet the demands of teaching, lecturing, preaching, or just using their voices a great deal against adverse noise conditions. To instruct the patient to project or 'throw' their voice without a carefully structured programme is likely to do little more than result in increased tension which will be counterproductive in improving voice quality.

Zaliouk's 'tactile approach' (1963) provides a sound foundation for developing resonance, and forms the basis for the programme outlined below. The patient obtains tactile feedback from the facial bones, which focuses attention on oral and nasal resonance. In practice, the production of vibrations in the facial mask seems to be incompatible with hyperfunctional voice use and gives the patient a tangible experience of relaxed resonant voice use. This has the important advantage of ensuring that the patient can make use of such feedback in practice periods outside the clinical situation. Because there has been little reference to work on achieving resonant voice production in this way, the programme will be given in some detail. While the basic idea is Zaliouk's, the steps have been developed by the present author.

Stage I The patient sits down, with his elbows resting comfortably on the desk or table in front of him. His head rests on the palmar aspects of his hands, with fingers extended at the side of his face. He is then encouraged to produce a very quiet 'bm–bm–bm', on a continuous sung tone. He should be able to feel the vibration in the facial bones. If not, the therapist models the voice production herself, letting the patient feel the vibrations produced by the therapist. The same task can be practised by intoning 'bm' into cupped hands – this is particularly useful where the patient has some difficulty in achieving a sufficiently vivid experience of resonance. Variations on this task can be devised, providing they are carried out on a sung tone, at quiet intensity levels and with 'continuant' sounds which the patient can prolong and therefore experience adequate tactile feedback (for example: down, beam, doom, dine, barn). The patient is encouraged to imagine voice being made at the tip of the tongue (/d/ and /n/) and between the lips (/b/ and /m/), and to feel the vibration at the point of phonetic placement.

Stage II The basic posture and approach are maintained, but the task is extended. Phrases are now practised on a sung tone, each phrase containing only voiced sounds. Again the emphasis is on careful attention to tactile feedback, both in the facial skeleton and at the point of articulation. These consonant sounds should be prolonged to facilitate clear feedback.

moonbeam	nine men
down and down	one by one
no more room	down the lane
leaning down	ring round the moon

Nicholls (1973) found that holding pitch relatively constant in voice work reduced the complexity of vocal production, 'thus permitting perceptual awareness of the postures that produce optimal pitch and quality'. This has been described as 'chanting' by both Nicholls (1973) and Boone (1977).

Stage III Progress should now be made from a sung tone to a spoken tone, at a fairly quiet conversational level. At this point it is even more important to concentrate on the voiced 'continuant' sounds and the feedback provided by feeling vibrations in the facial bones.

Stage IV At this stage, provided that the 'feel' for resonance is well established, voiceless sounds can be introduced:

dream time	moon shine	love song
time to go home		one more time
climbing down		sing me a tune

Stage V There is no strict hierarchy to be observed, but at some point the variable of pitch change needs to be introduced. Intonation patterns are the first stage in this development:

Where've you been?	Who's that man?
I'm rather bored.	When are they coming?
Wait a minute.	Where are you going?

Pitch variations can also be practised on short three-note or four-note scales (for example on 'down', 'boom').

Stage VI While still using material carefully controlled for 'resonant' sounds, longer sentences are introduced:

How lovely to lie in the warm sun.
Nearly time to go home now.
Feeling the warm sunshine on my back.
Wandering down the lonely lane.
We shall soon see them again.
Lying down on the soft sand.

By now, the hands are held at the side of the face, as if to project the voice. Emphasis continues to be placed on the voiced sounds, but the speaker also concentrates on the movements of articulation, in a light, precise way.

Stage VII Still concentrating on light articulation and resonant sounds, work begins on more advanced material. It is important to avoid a hard attack on initial vowel sounds, encouraging a gentle, slightly aspirate initiation of phonation.

Obviously practice material must be chosen with the patient's interests in mind, but the following are two examples of suitable passages:

Rumbling in the chimneys,
Rattling at the doors,
Round the roofs and round the roads,
The rude wind roars.

Raging through the darkness,
Raving through the trees,
Then racing off again,
Across the great grey seas.

They were not all women, for there was one quiet little man in their midst, who, when not eating cake or drinking wine, was sucking the bone handle of a woman's umbrella, which he carried with him everywhere, indoors and out. He was in the custody of the largest and grimmest of ladies, whom the others called Aunt Martha.

From *The Hole in the Wall*
by Arthur Morrison
(The Folio Press, 1980)

Stage VIII In this final stage, the feeling of resonance is developed in spontaneous speech, 'anchoring' the voice on sounds such as /m/ /n/ /w/ /r/ /l/. The hands can be used to project voice if there is a need to increase audibility. This is the stage at which work on intonation, pause, and emphasis can be introduced, which will be discussed in a later section.

Filter (1980) describes a rather similar approach in which proprioceptive–tactile–kinaesthetic feedback is used in voice therapy. Emphasis is placed on the monitoring of tension, muscle tone, effort, pressure and movement, but this is extended from the laryngeal and pharyngeal focus to the thoracic and abdominal areas.

Nicholls (1973) commented that some of the most effective therapy was achieved in conjunction with resonance dynamics.

Modification of intensity and pitch

The question of reducing intensity levels to a more acceptable level has already been discussed in the section on eliminating unnecessary tension.

Suffice to say here that the patient needs to monitor his intensity level as carefully as possible, seeing the use of a quiet voice as a sensible way of conserving vocal energy. The practice is particularly important if the patient has an essentially extrovert personality, with a tendency to use an unnecessarily loud voice. Teachers, and others whose occupations require the use of voice at high intensity levels, need to ensure that this kind of voice use does not become habitual (in situations where the level is no longer necessary or appropriate). The effect of using a quietly resonant voice can be quite dramatic, but may initially be somewhat alien to the speaker until he becomes used to the sound of a very different voice.

The role of improper pitch levels in the aetiology of dysphonia is less clearly understood. Considerable controversy exists regarding pitch, which has been summarized by Reed (1980). Cooper (1973) claimed that 90% of some 2000 patients were using too low a pitch, and the remaining 10% were using too high a pitch. He therefore regards low pitch as a major contributory factor in most dysphonias. It follows, therefore, that adjustment to the optimal pitch level is 'a vital part of voice therapy in almost all cases.' He further claimed that the success of his therapy was proof of the appropriateness of this approach. Many practising clinicians would challenge Cooper's findings, and would agree with Mueller (1975) that the major focus of treatment should concentrate on the elimination of vocal abuse by effortless phonation, rather than any adjustment of habitual pitch levels. He reported on a study of 25 females (mean age 37 years) with hoarseness as a distinctive feature of their voice use. The mean fundamental frequency of this sample group was 204 Hz, which was 'well within the norms for women of this age'. 'In our opinion,' Mueller went on to say, 'raising of pitch is physiologically contrary to the elimination of laryngeal hypertonicity, which is the very core of our therapeutic efforts.' Mueller considered that if there were inappropriate pitch levels, these would 'stabilise perceptually and spectrographically following correct adjustment of laryngeal tension.'

Mueller's conclusions are supported in an interesting study by Murry (1978) in which the speaking fundamental frequency was assessed in 80 male speakers: 20 patients had vocal-fold paralysis, 20 had benign mass lesions, 20 had carcinoma of the larynx, and 20 had no laryngeal lesion. The subjects had a mean age of 52 years. Murry found that the speaking fundamental frequency for these organically based disorders was not lower than that found in normal voices. He concluded that 'clinical judgements of lower pitch in pathologic voices seemed to be caused by the confounding perception of voice quality rather than the perception of pitch alone.'

A more recent study by Hufnagle and Hufnagle (1984) lends still further support to the view that there is no difference between the speaking fundamental frequency of normal speakers and those with vocal-cord pathologies. They commented that the entire concept of an optimum pitch becomes 'highly suspect' when dealing with vocal-fold nodules, and came to the conclusion that manipulating pitch is not appropriate in the management of these cases.

If the hoarse speaker is found to be using a lower pitch, then it is probably a matter of effect rather than cause – a compensatory strategy to achieve a 'clearer' and more comfortable voice.

There may be evidence, however, that a speaker is not using his optimum pitch level, which can be described as an efficient pitch at which we produce voice of good quality and maximum intensity with the least expense of energy. There may be vocal fry (creaky voice) particularly occurring at the end of sentences on falling intonation patterns, or a habitual pitch level near the lower end of the frequency range. Fairbanks (1960) has suggested that the optimum pitch is approximately one-quarter from the bottom of the total scale, with the optimum pitch in females one or two notes lower. It is a pitch which must be compatible with the anatomy of the larynx, and a function of such variables as the length, mass, and tension of the vocal folds.

Any attempt to modify pitch towards a more efficient level should rarely be a radical one. One of the most effective approaches to pitch adjustment (towards a slightly higher pitch) is to establish a 'light' pattern of articulation. This is a method described by Chaloner (Chapter 16 of this volume) in helping transsexuals to achieve a higher pitch level. The idea of speech which is 'light and bright', with concentration on the voiceless, tongue tip plosive, for example, will be effective in raising pitch one or two semitones.

If pitch is too high, this may well be a byproduct of tension. Careful work on developing optimum resonance, with its resulting reduction in laryngeal tension, will lead to an automatic lowering of pitch.

If the therapist is faced with a hoarse voice, then it will be impossible to determine optimum pitch. As Aronson (1980) comments, 'the location of optimum is impossible to find in someone who has a lesion of the vocal folds causing the latter to vibrate abnormally.'

Working on articulation

The articulatory agility exercises recommended by some writers normally have no place in remedial voice work. There are cases, however, where improvement in articulatory precision can significantly increase the intelligibility of speech under adverse environmental conditions. This is particularly true where the speaker is coping with a background of noise or has to be heard over a considerable distance, for example in a lecture hall or theatre.

A more precise speech pattern may effectively supplement work on improving resonance. It must be stressed that in no way is one advocating an unnatural or exaggerated pattern of articulation: work is based on improving awareness, so that the speaker can feel the quick, light movements of tongue and lips, and aim for articulation that is distinct but not exaggerated. The adjustments to be made are very small – the analogy of bringing a photographic slide into focus is a useful one here – but may make a significant improvement in intelligibility.

Initially, therapist and client combine to devise phrases and sentences in which the movements of speech can be highlighted (for example: distinct articulation, intelligent participation, capital investment). Repeated practice drills are inappropriate: the purpose of the activity is to heighten awareness of light, precise, but natural articulatory movement, not to strengthen or speed up the muscular activity involved.

Increased awareness of what is happening in speech can be achieved by reading a short passage aloud several times, with emphasis on a different articulatory posture at each attempt (for instance, initial emphasis on tongue tip sounds marked thus /ṭ/, back of tongue sounds /k̭/ or lip sounds /m̱/). The aim is to heighten total awareness of articulatory movement, and although any adjustments to be made are probably very slight, they can make a significant improvement in intelligibility. It is the combination of improving resonance, together with a more precise pattern of articulation, that can facilitate improved audibility and help eliminate the need for effortful phonation.

At the same time, as we have indicated in a previous section, a clear resonant quality is usually incompatible with excessive tension and the concentration on light articulatory movements also tends to enhance the feeling of easy voice production.

Developing expressive use of voice

To aim for optimum resonance and clear articulation is clearly not enough – the effective speaker must also use the voice expressively. This is unfortunately not just a simple matter of making the speaker aware of more appropriate and lively intonation patterns – voice is intimately tied to personality and the speaker who is shy and diffident will not find it easy to project a more dynamic image with expressive use of voice. The therapist can model the required intonation, and give the client some idea of the range of available vocal expressions and the importance of such prosodic features in enhancing meaning and sustaining interest. This area of voice production needs to be approached with sensitivity and imagination in choosing practice material.

Effective use of emphasis and pausing will further facilitate effective voice use. Again, the use of suitable material, in line with the client's interests, is very important. It is far better to work carefully on one or two short passages, than to lose concentration on a longer text. The therapist models each phrase or sentence, discussing his/her performance with the patient. Given clear guidelines, the client has a good notion of what is required, and more confidence to attempt the task.

Work on intonation, pausing, and emphasis in spontaneous speech, needs even more ingenuity and imagination. Different emotional responses can be encouraged ('say something enthusiastic about the weather; make a sympathetic comment about someone's ill-health; congratulate someone about their promotion; be sarcastic about a colleague's late arrival').

The extent to which work is carried out on the prosodic features of speech will be determined by the end-product the client wishes to achieve. In the case of a young teacher, for example, it is important that he or she acquires a lively speech pattern which can attract and sustain the children's attention. Personality factors must be taken into account in setting goals which are acceptable to the client and in line with the demands of the situation. There are many clients where work on expressive use of voice is neither an appropriate nor necessary goal.

Breathing for speech

The need to improve respiratory control for speech remains an area of considerable controversy in remediation work. Greene (1980) stated categorically that 'the paramount importance of correct breathing in speech and song cannot be over-estimated. Permanent improvement in the voice cannot possibly be achieved without improvement in respiration.' Aronson (1980) considers that respiration is anatomically and physiologically normal in the majority of patients. He comments that 'exactly how important attention to respiration is in voice therapy is a matter of disagreement, primarily because the extent to which faulty breathing is implicated in voice disorders is unknown.'

The rationale for the emphasis on breathing exercises as an essential and often initial part of the rehabilitation programme rests on the assumption that people misusing their voices do so because they have insufficient or a poorly controlled breath stream for phonation. In actual practice, however, relatively few patients show such problems. They may, however, when instructed by the therapist to 'take a breath', demonstrate all the worst features of clavicular breathing (raised shoulders and shallow inspiration) in their anxiety to comply with the therapist's request. Van Riper and Irwin (1958) state their point of view quite clearly when they observe 'very little breath is used in the production of tone compared to the amount of breath potentially available' but in spite of this they say 'the myth continues that if you have a voice problem you should work on respiration.' There are clearly two opposing viewpoints, but in the final analysis the indications for working on breathing for speech must depend on an assessment of the needs of the patient.

Undoubtedly there are patients who have respiratory problems associated with asthma and bronchitis, for example. Inadequate habits of clavicular breathing may develop following a unilateral recurrent laryngeal paralysis, which may have persisted despite compensatory activity of the non-affected cord. Even in cases such as these, any problems in breath control can largely be resolved by a reduction in tension and some often minimal changes in postural balance. On the whole, however, Boone (1977) says 'while an actor or singer may require respiratory training the typical voice patient does not need special training in breathing.' Brodnitz (1959) says that most people speak and sing without paying any attention to their breathing. He goes on to say 'this is as it should be and serves the purpose as long as the natural co-ordination is not disturbed and the voice is used for ordinary conversation.'

Sundberg (1987) has suggested that attention may have been concentrated on breathing because the functioning of the respiratory system is visible to the naked eye where, in contrast, laryngeal function can be observed indirectly only, in terms of the acoustic output. Boone (1988) poses the interesting question of why our knowledge of respiratory function and physiology has had so little direct application to the patient with a voice disorder. He claims that more recent texts give only minimal emphasis to correcting faulty breathing patterns, with 'an aberrant respiration pattern often viewed as part of a total faulty phonatory set'. Boone goes on to say that 'many voice clinicians feel that to isolate and focus on one component in voice therapy, such as faulty respiration, may fractionalise the clinical process to the patient's disadvantage.'

It is interesting to note that the professional singers in the film made by van Lawrence (1987), must obviously know all about breathing techniques, and yet this does not prevent them showing marked abuse of the speaking voice. This must make one question the usefulness of 'teaching' breathing techniques to non-professionals who might be expected to experience even more difficulty in applying what they have been taught in the everyday speech situation. As Boone (1988) says 'our thesis might well be that the best respiration training for the patient with a voice disorder is the least amount of training.'

Boone quotes two interesting studies by Hixon *et al.* (1987) and Watson and Hixon (1985), which suggest that what actors and singers really do (in terms of respiratory kinematics) is certainly not reflected in the incongruous accounts they gave of their respiratory behaviour. As Boone pointed out, they had excellent conversational and professional voices, despite their relative ignorance about what they were doing to produce phonation. This surely has considerable implications for our therapy with patients whose approach to voice production is much less sophisticated. It is surely more important that we create the conditions which will facilitate or enhance the natural physiological movements of respiration, unimpeded by a self-conscious approach which is likely to lead to an inhibiting degree of tension.

Despite views such as this, exercises for improving breath control have played a central role in remedial voice work. The emphasis on such an approach almost certainly stems from the speech and drama model, which the present author would claim is largely inappropriate in the majority of voice cases referred for therapy. Nonetheless, one must recognize that there will always be exceptions.

1. Where the patient is demonstrating a markedly shallow, so-called clavicular pattern of breathing and, as a result, is 'running out of breath' before completing his utterance. He clearly needs practice in achieving more efficient and sustained breath support for speech.
2. There may be cases where the client consistently needs to place additional demands on his voice (such as acting, singing, or public speaking), and we may then need to concentrate some attention on improving voluntary breath control in developing 'maximum *use* of vital capacity' (Greene 1980).
3. Some patients may have a past or current history of respiratory problems which has resulted in poor habitual patterns of breathing, sufficiently marked to affect speech.

Even in such cases, breathing *exercises* are not indicated: much can be achieved by aiming for a relaxed posture, so that there is the minimum of interference with respiratory movement, and an understanding on the client's part of what is actually required in terms of breath support. Concentration on breathing may actually distract the patient from the more central aims of listening to his voice and producing good phonation.

Boone (1977) has suggested that 'the ideal respiration for conversational phonation is the easy tidal breath cycle, with a slightly extended expiration to match the length of verbalisation.' He goes on to say 'the patient's easy conversational phonation, coupled with the natural breathing that goes with it, is probably the most productive respiration "training" for the typical voice patients.'

Boone (1988) summed up his approach as working to extend respiratory control, matching target models and learning to renew breath effortlessly. Boone's therapy focus is on increasing the time of duration, not on encouraging the client to take a deeper breath. Boone says that 'by placing the individual's focus on an external target (time, verbal utterance), the breathing patterns often naturally accommodate the target production with no volitional muscle set or effortful preparation by the patient.'

Repeated studies by the present author have shown that the majority of young to middle-aged adult speakers can produce 100 syllables on a single breath (without any preceding practice period) and normal speakers can be expected to produce 50 syllables comfortably on a single breath. These tasks are, inevitably, carried out without the refinement of intonation, and with low intensity levels, but nevertheless demonstrate van Riper and Irwin's point that the normal, untrained speaker does not need special training in breathing for speech.

What kind of approach is appropriate where inadequate patterns of breath control are felt to be a contributing factor in dysphonia? Most breathing exercises seem remarkably unrelated to the demands of speech. Too often, instructions to 'breathe in' result in raised shoulders and an inhibiting degree of tension. Willmore (unpublished communication, 1948) suggested that breathing should be picked up on the exhaling phase to avoid interfering with the natural rhythm of breathing. It is probably sufficient to ensure that the speaker is sitting or standing in a balanced and comfortable way. If asked to sigh heavily (as if very relieved or fed up) the patient will experience the unrestricted thoracic movement that goes with a relaxed physical state. The most realistic approach in improving breath control is to remove the postural constrictions or muscular tensions which may be incompatible with easy thoracic wall movements. To put labels on the type of breathing is unnecessary. As Brodnitz (1959) observed 'unfortunately many of these methods [of breath control] defy physiologic fact, sometimes to the point of absurdity.' Aikin (1951) summed the matter up when he said 'the increased capacity of the lungs to be acquired by the singer must confine itself to the increased expansion of the lower ribs, and the proportionately increased contraction of the diaphragm, in imitation of ordinary physiological breathing, only on a larger scale.' The same holds true for an actor or public speaker, or indeed anyone who is making unusual demands on their speech, where increased breath control may need to be a focus of emphasis. A comprehensive study of normal respiration in speech and song has been given by Bunch (1982).

Considerable controversy exists (Reed 1980) regarding poor breath control as a causative or contributory factor in voice disorders. As Reed says, there is clearly a need for research here. The possibility exists, as Boone (1977) has pointed out, that disturbed patterns of respiration may be the effect of disrupted phonation rather than the cause. We have seen a parallel here in stuttering, where disturbed breathing patterns are the result of the abnormal valving behaviour of the vocal folds during the stuttering block. Breathing exercises designed to improve control for speech are as inappropriate here as they frequently are in vocal re-education. To suggest, however, that improvement in breath control is never required would be equally wrong – there are cases where poor breath support is clearly evident, creating an obvious imbalance between subglottal pressure and vocal fold tension which cannot sustain normal, easy phonation. One must ensure, however, that one interferes as little as possible with the normal, almost involuntary adjustments that are made in breathing for speech. Ideally the patient should be unaware of his breathing, leaving him free to concentrate on the far more important matter of an easy, relaxed approach to phonation.

Visual feedback techniques The use of visual feedback techniques such as Visispeech and Visipitch have become well established in voice therapy with many different client groups. They can, however, only represent what is happening by giving a graphic realization of vocal-fold activity. Laryngeal image biofeedback (Bastian 1987) represents a dramatic development in the management of voice disorder. Using a fibreoptic laryngoscope, videocamera and monitor, the patient can view his own laryngeal behaviour (having previously been shown a videotape of normal laryngeal movement). The patient is taught how to examine himself with both laryngoscope and camera mounted on a tripod. Instruction and feedback are given by the clinician as the patient attempts to 'normalize' vocal-fold posture. The client is then required to maintain normal phonation without the benefit of visual feedback. Bastian claims that from his experience of using this technique with twenty cases, it is particularly appropriate in psychogenic dysphonia and where the subject is using ventricular phonation.

He reports success where previous, more traditional, approaches have proved unsuccessful. It is clearly a technique holding considerable promise, and which may have applications in a wide spectrum of voice disorders. This view is supported by a remarkable film made by van Lawrence (1987) which demonstrates the use of such visual feedback in the management of hyperfunctional voice use.

VOICE THERAPY FOR SPECIFIC LARYNGEAL CONDITIONS

In this section we shall be considering some specific approaches to conditions that arise directly from vocal misuse (such as vocal nodules and contact ulcers). There are other conditions (such as polyps) where the connection with vocal misuse is much less clear, and a question of some controversy. Finally, we shall be considering the abnormal/maladaptive compensatory behaviour, which may arise not as a cause of dysphonia but as a result of laryngeal dysfunction of some kind.

Vocal nodules

In a retrospective study Hetherington-Hall *et al.* (1988) found that 21% of a total sample of 1262 patients presented with vocal nodules. Nodules were found to be significantly more common in females (1 : 1.8), occurring most commonly between the ages of 25 and 44 years. Under the age of 14 years, however, boys were more likely to have nodules (2.7 : 1). They commented that occupational hazards, combined with responsibilities as primary caretaker of home and family might be the predisposing factor in producing benign laryngeal pathologies. They were, however, almost equally common in factory workers, and were also found in a significant number of teachers, singers, and students. Factory workers are not traditionally regarded as at risk of vocal nodules, but as Hetherington-Hall *et al.* point out, they are often required to speak over noise, may suffer the effects of chemical and mechanical irritants in the atmosphere, and the need for physical exertion.

We have already indicated that there is some difference of opinion regarding the prescription of voice rest (see p. 148). Total voice rest may not only be impractical, but is a psychologically traumatic experience. The best approach is undoubtedly the recommendation that voice is used at quiet intensity levels, and as sparingly as possible. Such an approach, combined with a very carefully supervised remedial voice programme, should lead to the remission of newly formed nodules. Where surgery is indicated prior to voice therapy, it is equally important to initiate a voice-rest regime post-surgically. The advice to whisper is contraindicated, since this almost inevitably means the use of a forced whisper.

Aronson (1980) sums up the aims of therapy by stating that the patient 'should be taught to produce voice with less forceful stress or emphasis patterns and with easy onset of phonation rather than with a hard glottal attack.' He considers that vocal re-education is the therapy of choice and should be attempted before surgery is recommended. This is certainly an area where research is needed, since we have virtually no evidence of the efficacy of vocal therapy in the remission of vocal nodules at various stages in their development. Surgery is certainly the immediate answer to the problem, but treats the symptom and not the cause – at some stage the patient will need to learn how to use the voice in such a way as to prevent their recurrence. A remedial voice progamme has already been discussed in the previous section and will be appropriate in the case of vocal nodules, although modifications will have to be made if it is decided that the nodules are not to be removed surgically.

Contact ulcers

Contact ulcers have traditionally been regarded as more common in males: Cooper (1973) found that 77% of patients with contact ulcers were male, and Aronson (1980) regarded them as an essentially male disorder with the condition occurring rarely in women. In a recent retrospective study, however, Hetherington-Hall *et al.* (1988) found that eight of the 14 cases were female. A comparison with previous studies into the prevalence of voice disorders suggests that there appears to be a significant increase in the number of women demonstrating abuse-related voice disorders. This finding obviously has social and management implications.

The higher incidence of contact ulcers in the United States may, as Greene (1980) suggests, be a sociocultural phenomenon, in which the male cultivates a deeper voice to demonstrate his masculinity. This would suggest that attention to pitch level would be an appropriate point of departure in therapy, but if the voice is dysphonic it is impossible to determine either the patient's optimum or habitual pitch. It is generally agreed that surgical intervention is not indicated for all but the most severe cases. Boone (1977) has said that surgery may be necessary where there are large ulcers with surrounding granulations. He has emphasized that voice rest alone is only of temporary value, since vocal re-education will be needed.

Contact ulcers occur rarely in trained singers and actors. Luchsinger and Arnold (1965) have described the process of 'mechanical traumatisation' and, like Aronson (1980) point to personality as a significant factor in their development. 'The evidence is clear,' says Aronson, 'that these patients are hard-driving, competitive, angry and aggressive.' It must be noted, however, that these are essentially subjective impressions unsupported by objective measures. He suggests that interpersonal problems and environment stress both play their part.

In therapy, particular attention is drawn to the need to correct the hard attack, which is regarded as a causative factor in contact ulcer. Von Leden and Moore (1961) described the violent clashing action of the arytenoids during phonation, viewed in high-speed cinephotography. Boone (1977) recommends both the chewing method and what he describes as the yawn–sigh approach to counteract the problem of glottal attack.

He regards this second technique as an 'excellent facilitator of optimum voice' in all cases of vocal abuse. The method is based on a yawn, followed by a gentle exhalation with 'light phonation'. Boone claims that in doing this many patients experience easy phonation for the first time.

Aronson (1980) says that the quantity and intensity of voice use has to be reduced by approximately 50% for one month, and that smoking and drinking must also be abandoned for a similar period. Throat clearing and coughing must also be reduced as far as possible. He also recommends the use of an easy or aspirate vocal attack on vowels, and the need to feel the difference between hard and soft glottal attack. A case study by Bloch and Gould (1974) reports on the successful elimination of contact granuloma with a programme of psychological support and vocal therapy.

Laryngeal trauma

Under this broad and rather arbitrary heading we will be considering the voice therapist's role in cases where vocal abuse and misuse are not the primary causes of the dysphonic condition. These conditions can include the following.

1. External trauma to the laryngeal structure such as compression, fractures, and penetrating wounds, with resulting oedema, haematoma, dislocations and lacerations, and even laryngeal paralysis.
2. Laryngeal intubation, which can lead to mucosal ulceration and the formation of granular tissue. There may also be dislocation of the arytenoid cartilages.
3. Post-surgical problems may occur where the cords have been stripped (in cases of severe hypertrophic laryngitis), or where polyps or other benign lesions have been removed. Stoicheff (Chapter 13 of this volume) has described the effects of radiotherapy on laryngeal tissues.

Even where misuse has not previously been present, there is a very real risk that abnormal compensatory behaviour will develop and become habitual as the patient tries to improve on his dysphonic voice production. This is a very natural reaction, and it is advisable that any patient with an impaired laryngeal mechanism should be referred for speech therapy as soon as healing has taken place.

The aim of therapy is twofold – in the first place to prevent maladaptive behaviour as the patient tries to come to terms with the damaged larynx; secondly, to make optimum use of the available mechanism. Normal phonation may be impossible – the therapist must work with the patient to achieve the best possible results. This may mean settling for a husky or breathy voice rather than a hoarse one – as the patient is encouraged to use less effort. The use of clear articulation will help compensate for weak phonation. A balance has to be achieved between conserving voice and preventing vocal fatigue and further laryngeal damage, and the need to make voice audible. Where the patient has to make himself audible across space or above noise, then amplification may be needed. As far as possible, the remedial voice programme should be followed. There may need to be more emphasis on breath control, more attention to clear articulation and the prosodic features of pause and emphasis. The programme will have to be adapted to the specific needs of each patient. An essentially experimental approach will need to be adopted, in which patient and therapist together try out different approaches to voice production – manipulating variables such as pitch, intensity, breath control, and head–neck posture. It is essential that the therapist has an exact knowledge of the state of the vocal folds, both in terms of appearance and function.

Ventricular phonation

There are probably two reasons why ventricular phonation develops, with the false cords adducting over the true cords lying below: in the first place, it may, as Aronson says, be the extreme end-stage of hyperkinetic dysphonia. If this has continued over time, then there may be hypertrophy of the ventricular folds. Secondly, they may show compensatory activity where there is a failure of normal vocal-fold adduction. This can occur, for example, where there is unilateral paralysis of the vocal cords.

Ventricular voice is characteristically low in pitch, because of the larger vibrating mass of the false cords. Complete adduction along the entire length of the ventricular folds is difficult to achieve, and so there is air waste. Pitch variation is limited, and the resulting voice is monotonous, hoarse, and aperiodic. If there is hypertrophy of the folds, then the voice will be even more hoarse.

Where excessive effort is involved, the aim will be to achieve a more relaxed phonation, although this approach alone will be unlikely to achieve normal voice. A number of techniques have been reported to be successful in achieving normal vocal-fold phonation. Boone (1977) and others have reported on the use of reverse or inhalation phonation. The patient is instructed to phonate on the inspiratory phase of respiration. Once this has been established, he phonates on both the inspiration and expiration cycles. The rather high-pitched phonation produced is not consistent with ventricular voice. Van Riper and Irwin (1958) have recommended the use of glottal fry to initiate voice. They say that there is abnormal raising of the larynx in the production of ventricular voice, and suggest that a lowering of the thyroid cartilage should be achieved.

A diplophonic voice may occur in cases where true and false vocal-cord vibration occur concurrently. In such cases, the procedures described above may be used to try to eliminate the 'double' vibration. The use of a humming glide has also been successful: the patient is asked to produce a hum on the highest possible note in his repertoire (at a pitch incompatible with ventricular phonation), and is then asked to produce a phonatory glide down the scale until he reaches his optimum pitch. Once this has been carried out successfully on a number of occasions, he is instructed to sustain the note at the end of the glide, repeating words (down–down–down, dandelion) or phrases (more and more) on a sung tone at this pitch.

It has been suggested that the use of ventricular voice might be encouraged as a compensatory mechanism in cases of permanent laryngeal damage. Unfortunately the resulting voice will tire easily and the hoarse, low-pitch, and monotonous quality may not be acceptable to the patient.

Obviously, the final result – and the treatment methods employed – will depend on the patency or otherwise of the true vocal folds as a vibrating mechanism. Clinical practice suggests that the elimination of ventricular phonation is by no means easy.

Bowing of the vocal folds

The oval bowing of the vocal folds on phonation reflects a weakness of the thyroarytenoid muscle. The condition has been described as myasthenia laryngis or hyperkinetic phonasthenia. As the second term implies, the vocal weakness is caused by vocal strain, resulting in fatigue and weakness of the internal tensor of the vocal folds. The voice is characterized by air waste and is therefore weak and husky, lacking depth of resonance. Luchsinger and Arnold (1965) claim that the condition results from 'continuous over-exertion, particularly when tense phonation with hard attacks and poor respiratory support are at fault'.

A regime of quiet voice use, with a reduction in the amount of talking, will be needed in the initial stages of treatment. A programme of remedial voice work will follow, to encourage effortless phonation and prevent a recurrence of the condition.

Bowing may be seen as part of the ageing process, as the laryngeal muscles tend to atrophy. This is one of the several changes which result in the vocal changes associated with senescence.

The voice of senescence

Well-recognized changes take place in the voice during the normal process of ageing. The age at which these changes occur, and the extent to which the voice changes, will vary considerably from one person to another. The singing voice will be affected before the speaking voice, with a reduction in both power and range. In general, both the pitch range and the intensity of the voice will be reduced, and phonation may be characterized by what has been described as a senile tremulo. Luchsinger and Arnold (1965) claim that this particular feature is caused by an irregular pattern of expiration during phonation. The increased weakness of the voice is associated to some extent with a reduction in the older speaker's vital capacity, but there are a number of changes in the larynx itself which combine to produce the voice of senescence. Luchsinger and Arnold list the following factors: gradually increasing ossification of the laryngeal cartilages; a loss of elasticity in the vocal ligaments and arthritic changes in the joints; diminishing muscle tone; arteriosclerotic changes in the blood vessels supplying the larynx; reduced endocrine function, and a tendency to dehydration of laryngeal tissues. It is probably the gradual atrophic changes in the laryngeal muscles that give rise to an increase in fundamental frequency of the male speaking voice which has been noted in a number of research studies (Mysak 1959, Hollien and Shipp 1972, Honjo and Isshiki 1979). Interestingly this phenomenon does not appear to occur in women. Atrophy of the muscles may also lead to bowing of the folds on adduction.

Hollien (1987) reports on the aerodynamic correlates of ageing, and details the many studies describing the anatomical changes resulting in diminished respiratory output. These changes include the increasing rigidity of the thorax, the weakening of muscles, and loss of elasticity in the lungs. Hollien, in describing the reductions in respiratory function, nonetheless comments that it is not clear how or to what extent these changes affect voice. Hollien says that we must also take into account psychological, educational and sociological factors in the ageing process.

Deterioration in the intensity and quality of voice can be compounded by respiratory problems associated with bronchitis, to which the elderly seem particularly prone.

The ageing speaker may complain that talking is tiring. This may result from trying to make oneself heard to a peer group who are showing signs of increasing presbycousis. If an elderly person has to spend a good deal of time talking to a deaf friend or relative, it is well worth discussing the possibility of a hearing aid for them (although such a prescription is not always acceptable to the elderly deaf). Increasing loss of auditory feedback may account for the sometimes inappropriately loud voice used by some old people.

It is probably rather rare for the elderly to complain about, or even be aware of, the changes taking place in their voice, unless these are causing marked communication problems. It is even less likely that they would welcome the idea of speech therapy. It would certainly not be realistic to embark on a remedial voice programme unless the speaker was genuinely concerned about his/her voice and had specifically requested help. The emphasis should be on voice conservation, using it quietly whenever possible, and complementing any weakness by speaking as clearly as possible (particularly when talking to the deaf). Attention to phrasing may help to ensure that the reduced breath support available is used more efficiently. Unnecessary effort should be discouraged, since hyper-functional voice use can lead to only further fatigue.

The process of voice change is an inevitable one with increasing age, but to some extent compensatory strategies may be used to improve the quality of phonation if the elderly person is seriously interested in resisting the effects of ageing on the efficiency and effectiveness of their voice use.

VOICE THERAPY AS AN EFFECTIVE LEARNING SITUATION

Over the past few years there has been a 'quiet revolution' in the way many therapists approach their patients, in all areas of communication disorder. We have moved increasingly from a medical model in which the patient is a passive recipient in the therapy we think best for him. This changing philosophy is mirrored in many other areas of 'treatment' in which the importance of the patient as an informed participant is being increasingly recognized, even though the process may not always be a comfortable one for the therapist, physician, and surgeon. The following comment by Thurman (1973) sums up the current situation regarding our approach to the dysphonic patient:

> A brief statement of objectives at the beginning and a summary at the end of a session helps keep the client informed about what he is doing and why. If the clinician cannot provide such statements, he should examine and clarify in his mind his concept of the problem and his plan for correction. Each session, each procedure must have a specific purpose that contributes to the voice change desired. It is the client's right to understand, insofar as he can, what those purposes are and what progress is being made.

Thurman begs the question: How far can we judge what the patient is capable of understanding? Because the patient lacks a knowledge of our particular professional jargon, we must not underestimate his ability to understand a jargon-free explanation. The need for the therapist to explain often has the unexpected and beneficial effect of clarifying his/her own ideas, and as a result the therapy situation may become as much a learning situation for the therapist as for the patient.

Some of these same philosophies have been underlined and elaborated in Heinberg's (1973) systems approach to vocal behaviour modification. Heinberg has emphasized the need for what he terms 'cognitive competence' in vocal rehabilitation. He says that there must be a very clear specification of the product to be achieved. 'Once that has been accomplished,' he continues, 'alternative processes are considered for achieving that product, and each alternative is evaluated in terms of its relative productivity.' The patient must know the rules of each learning situation and the criterion of each learning system. Heinberg believes that the patient has to learn that his goal is to acquire a 'repertoire' of vocal strategies to meet the demands of different situations.

Goals must be clarified for the patient through explanation of the underlying rationale and, where necessary, the goal may be 'modelled' by the therapist. Furthermore, precise feedback must be provided on the patient's performance, each attempt being measured against the target voice. A precise numerical rating will help facilitate the learning process, since we are building up the patient's confidence in his auditory monitoring skills as we teach him how to listen and make judgements. It is essential that he learns to monitor his vocal performance reliably, otherwise self-supervised practice can do more harm than good. Furthermore, we are dealing with very fine differences, which are not obvious to the patient until his ear has been trained to listen. The therapist's role is to 'shape' voice production towards the target goal as he/she reinforces the patient's more successful attempts.

Drudge and Philips (1976) give an interesting and detailed account of voice therapy in which 'the behaviour is gradually shaped using procedures such as ear-training, negative practice and feedback until carry-over into spontaneous speech in life situations is achieved.' While the therapist provided feedback in the initial stages of each therapy situation, the client was given increasing responsibility for the evaluation of his own responses. They concluded that 'appropriate self-evaluations, that is, internalised knowledge of the desired behaviour, appeared vital to the consistent accomplishment of that behaviour.' They went on to say, 'when correct self-evaluations began to occur with consistency, the responses were observed to become consistently correct.'

The approach described by Drudge and Philips is in marked contrast to the areas of emphasis of more traditional approaches, and sums up the current trend towards a more 'behaviour orientated' approach in voice therapy.

Each session should be an optimum learning experience for the patient, a process of self-discovery, with the satisfaction of experiencing and correctly evaluating his own successful achievements. In order that he can experiment with his voice, it is clearly essential to create a comfortable and permissive atmosphere. He needs to develop confidence in his ability to bring about change, and to recognize those changes when they occur.

As therapy progresses, the patient becomes increasingly responsible for his own management – drawing up a list of realistic situations in which he can practise his new voice skills, noting the situations in which he is at risk of misusing his voice, being increasingly aware of aspects of his lifestyle that create conflict and tension, and being prepared to explore ways of bringing about change.

PROPHYLAXIS

It is interesting that so little has been written on the prevention of voice disorders, particularly when so many professional voice users are at risk of misusing their voices. With the exception of the majority of actors and classical singers, very few speakers who depend on their voice professionally have received any instruction in proper voice use or conservation. This means that many lecturers, preachers, and teachers have little idea of the demands they are making on their voices, and it is largely a matter of chance whether they use their voice effectively or not. Well-trained singers and actors should not experience voice problems, unless they continue singing or speaking when suffering from laryngitis. Greene (1980) reported that she had found vocal nodules only in untrained singers.

There are, undoubtedly, some singers battling against techniques learned through poor teaching methods. It is important to find out what these teaching methods were, and whether the patients' ideas about good voice production are compatible with easy phonation.

It would seem important to ensure that all those whose occupations may make excessive demands on voice use should have guidance during their training in using their voices effectively, with the minimum of unnecessary tension. An understanding of the vocal mechanism, and of how to use it efficiently, with an appreciation of the possible effects of vocal misuse and abuse, could go a long way to preventing disorders of voice. This would seem a cost-effective process in the long term.

CONCLUSION

A remedial voice programme has been described, appropriate to the needs of those who show evidence of hyperfunctional voice use. The weighting given to any one part of that programme will depend on a careful assessment of all parameters of voice use. It will also depend on the demands which the patient has to make on his voice. However, auditory training, the elimination of excessive tension, and the development of effortless, resonant phonation would seem to be the essential core of all vocal remediation work. The importance given to other aspects of the programme will be determined largely by the occupational needs of the patient. If the voice is dysphonic due to tissue changes in the larynx then work on developing resonance, intonation, and pitch flexibility will obviously be impossible, and indeed positively contraindicated in most cases.

It has been suggested that traditional approaches to voice therapy, still very much in current use, are based on an inappropriate model derived from singing and drama teaching. Not only are some of the techniques practised irrelevant to patients' needs, but they actually serve to distract from the real cause of the problem – the hypertonicity involved in voice use.

In other chapters very specific approaches and techniques for a number of dysphonic conditions will be described. Some of the principles outlined in the present chapter may be appropriate, particularly where the patient has developed a maladaptive response to some form of functional inadequacy. Laryngeal tension, with excessive and unnecessary vocal effort, is a very common symptom in many cases of voice disorder. Nearly all dysphonic patients need to develop the ability to monitor their voices during vocal re-education, and the acquisition of vocal habits that facilitate the easiest and most effective form of voice production. Some of the core elements described in the preceding pages will be found to be appropriate in many types of voice disorder.

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9

When is a voice disorder psychogenic? Some considerations for diagnosis and management

Margaret Freeman

Whether a physician is defining a disease, making a diagnosis, selecting a procedure, observing outcomes, assessing probabilities, assigning preferences, or putting it all together, he is walking on very slippery terrain. It is difficult for non-physicians, and for many physicians, to appreciate how complex these tasks are, how poorly we understand them, and how easy it is for honest people to come to different conclusions (Eddy 1988)

INTRODUCTION

Even a brief perusal of the literature on voice disorder reveals to the reader fairly general agreement that voice disorders can be influenced by various psychological factors. It is equally evident, however, that opinions about the nature of this relationship vary quite markedly, as does the terminology used to describe it.

In most textbooks of otolaryngology, for example, if a voice disorder occurs despite an apparently healthy larynx, it has classically been described as functional and attributed to either emotional stress or a personality disorder (Ballantyne and Groves 1981, Groves and Gray 1985). Although a number of laryngologists have argued that this is an oversimplified explanation (Arnold 1964, Brodnitz 1965, Simpson 1971), the traditional functional–organic dichotomy has continued to be used by many otolaryngologists.

In the literature of voice therapy we can identify three basic themes in discussions of functional–psychogenic voice disorder. Firstly, as Fawcus has pointed out (Chapter 2, this volume) the functional–organic dichotomy has tended to perpetuate a lack of clarity in the context of voice disorder (Boone and McFarlane 1988, Cooper 1973). In addition the term 'functional voice disorder' is in itself a problem. Perello (1962) listed eight commonly used interpretations of this diagnostic label. These range from absence of laryngeal signs and observations of physiological dysfunction to attribution of causes such as emotional distress.

In most other specialist areas of speech and language pathology, 'functional' has been rejected as 'a generous wastebasket term' (Darley 1978) – in other words it covers such a wide range of possible environmental, psychosocial, and psychological causes that it becomes almost meaningless. It seems relevant to point out that as more information has been gained through research into the nature of speech and language problems and fluency, the umbrella term 'functional' has become virtually redundant. It is hoped that the same trend may result from current and future research into voice disorders.

A second theme is that voice therapists have quite different views about the extent to which emotional factors, personality, and reactions to stress are at the root of voice disorders that do not have an organic cause. As Table 9.1 indicates, even when voice therapists agree that psychogenic causes of voice disorder are a separate entity, interpretations and descriptions of these causes are not the same. Aronson (1985), for example, has argued quite strongly that voice therapy should include attention to interpersonal factors as well as to direct remediation of physiological changes; his aetiological classification therefore reflects his conviction that voice disorder can reflect 'psychologic disequilibrium'. Greene (1980) and Case (1984) discuss vocal abuse/misuse and psychogenic voice disorders as separate groups, but both stress that there is a degree of interrelationship.

The third theme relates to change; Fawcus has already noted that attitudes to psychogenic disorder have changed over time (Chapter 2). In addition there is some indication that the pattern of voice disorders being presented at ENT clinics may be changing. Herrington-Hall *et al.* (1988) suggest from their study of over 1000 patients that the diagnosis of voice disorder presenting as symptoms of vocal abuse may be increasing. It is, of course, possible that this change in identified symptoms also reflects developments in the general approach to diagnosis. Since the 1970s there has been a major increase in information about the nature and causes of vocal abuse, particularly in American literature (Johnson 1984) and a general trend towards behaviour modification (Moncur and Brackett 1974) or symptom-based approaches to voice therapy (Boone 1983).

In this chapter it is recognized that one of the most confusing aspects of voice disorder is that symptom-based therapy seems to be effective for most people, even when the only apparent explanation is a suspicion of 'functional' or 'psychogenic' cause. The question in the title reflects an interest in trying to evaluate the broader context of psychological factors and vocal dysfunction, as much as in considering the factors that may allow us to identify the type of problems best managed by voice therapy,

Table 9.1 Usage of the terms 'functional' and 'psychogenic' in speech therapy texts

Author	*Term*	*Definition*
Aronson (1985)	Functional	See 'psychogenic'
	Psychogenic	Synonymous with non-organic Causes include stress and musculoskeletal tension, psychoneuroses, personality disorders, or faulty habits of use (i.e. includes categories such as abuse and misuse, puberphonia, vocal nodules, and contact ulcer)
Boone and McFarlane (1988)	Functional	Has no physical or organic cause 'Appears to be the product of both laryngeal and supralaryngeal shut down' May have an initial emotional cause, but generally responds to symptom-based therapy
Case (1984)	Psychogenic Non-organic	States 3 conditions apply: 1. Psychological disequilibrium 2. Voice is constantly affected 3. No physical or structural aetiology
Greene (1980)	Functional	'See psychogenic' (index) Suggests that anxiety may underlie vocal abuse Chronic laryngitis may be a psychosomatic symptom
	Psychogenic	Anxiety states can cause vocal strain and some laryngeal changes, e.g. bowing of the vocal folds. May also lead to somatic changes, e.g. globus hystericus 'Psychosomatic symptoms are endless' Strong association between hysteria/conversion symptoms/stress reactions and aphonia

Table 9.1 (Cont'd)

Author	*Term*	*Definition*
Wilson (1987)	Functional	'Poor voice and a normal mirror laryngoscopy' In children, due to 4 categories: 1. Disturbed mutation 2. Psychological causes 3. Imitation of 'important adults' 4. Faulty learning

or referral to or conjoint management with other professionals such as psychologists or psychiatrists. To do this it is important to consider both the background and history of diagnosis in voice therapy, as well as current practice. In addition, however, it seems that we can learn a great deal from considering current approaches to the management of stress-related disorders.

THE TRADITIONAL DIAGNOSTIC MODEL

The diagnosis of voice disorder has two identifiable functions. The first and undoubtedly the most important is to ensure that aetiologies such as life-threatening disease or conditions that will respond to medical or surgical treatment are identified and managed appropriately. The second function of diagnosis – the exploration of the causes of dysphonia which is not due to organic pathology – has until recently received considerably less attention from laryngologists (Simpson 1971, Bridger and Epstein 1983). This has partly been due to limited resources. ENT is a relatively small specialism, in which it is estimated that perhaps as little as 10% of referrals are for voice disorder of any kind. Of these, less than half of the cases will require direct primary management by the surgical team (Harris 1989, personal communication); diagnosis and management of the remaining group of 'functional voice disorders' has traditionally been handed on to speech pathologists, for example (Bridger and Epstein 1983, Simpson 1971). A lack of appropriate objective techniques for assessment has also been a problem (Gould 1981, Hirano 1980). Figure 9.1 reflects the traditional approach to management.

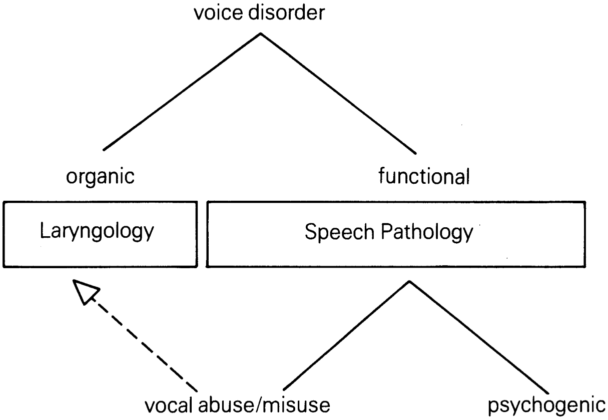

Figure 9.1 The traditional approach to management.

WHAT DO WE MEAN BY PSYCHOGENIC VOICE DISORDER?

The term 'psychogenic' is generally used as 'a qualifier of illnesses and symptoms assumed to be of mental origin' (Rycroft 1972). Rycroft goes on to warn that making such assumptions can be a real problem, especially in the context of psychosomatic illnesses, mainly because the judgement of personality, conflicts, and life-events 'can be fulfilled by enthusiastic speculation', and partly because of the difficulties in defining how these factors combine with subtle levels of physiological disorder. It seems that it is exactly this type of issue which faces us in voice therapy, especially when we are judging a level of disorder that might pass unnoticed by most of the general public (Graham 1983).

In general, speech therapists tend to use the term psychogenic to describe voice disorders that seem to present in conjunction with chronic or acute emotional stress, problems of life adjustment, use of symptoms for primary or secondary gain, neurosis, or depression (Aronson 1985, Butcher *et al.* 1987). For some therapists, however, the list is far broader, including for example, 'frustration, avoidance, reduced self-worth or lack of satisfaction with spouse, lifestyle, employment, financial status, family or sex-role (McFarlane and Lavorato 1983). Two further possible uses of the term include absence of overt organic laryngeal pathology and failure to respond to more standard approaches to therapy. Morrison *et al.* (1985) have recently suggested that the diagnosis of psychogenesis does not correlate with any specific pattern of laryngeal findings; they do suggest, however, that the vocal symptoms of psychogenesis tend to be less stable than symptoms of vocal abuse and may include some periods of normal voice.

THE INCIDENCE OF PSYCHOGENIC VOICE DISORDERS

Despite differences in attribution of symptoms and problems with diagnostic labels, most studies of voice-disordered populations seem to indicate that the incidence of predominantly psychogenic voice disorders is low. MacFarlane and Lavorato (1983) suggest that patients who require a predominantly psychological approach represent about 5% of the voice therapy caseload, a figure also quoted by Robinson (1988, personal communication).

Evans (Chapter 20, this volume) identifies a somewhat larger proportion (about 25%) of patients as having psychogenic aetiologies, but her discussion suggests that the classification was somewhat different. A similar figure, however, is also cited by Morrison *et al.* (1985) in their study of 1000 cases referred to a specialist voice clinic. It should be noted that both of these studies seem to be reporting a fairly specialized service; the Morrison *et al.* study in particular drew many of its subjects from secondary referrals from other ENT clinics, which tends to increase the probability of 'problem' cases.

THE PROBLEMS OF DIAGNOSTIC LABELLING

It has been recognized that the classic medical diagnostic paradigm which states that 'functional' disorders are mainly (or only) due to psychological factors can inhibit further exploration and understanding of the patient's problem. To put it bluntly, when 'functional' means 'it's all in the patient's head', then there is nothing physical to research!

One example of the problem of labelling can be seen in the diagnosis of spastic dysphonia; the classic description of this disorder included description of behaviours such as social withdrawal, facial tics, and avoidance of eye contact, all of which were attributed to personality characteristics. Spastic dysphonia was therefore considered resistant to treatment. After Dedo's (1976) introduction of surgical intervention for spasmodic dysphonia, however, some of the so-called personality characteristics were also reversed, which suggests that they were a *consequence* of the voice problem, rather than a cause.

A less dramatic but equally relevant issue concerns the use of a blanket term such as functional voice disorder. In their study of the results of voice therapy, Bridger and Epstein (1983) examined the case notes of 109 patients, all of whom had been diagnosed as having voice disorder despite healthy laryngeal appearance and function. The responses to therapy varied, with satisfactory results being achieved after several weeks in some cases, but some patients maintained contact with the speech therapist for over a year before discharge. This seems to confirm Reed's

(1980) view that there is a real need for clearer and more specific information, not only about the nature of voice disorders but also about the processes involved in voice therapy.

Brodnitz (1965) has described one of the basic problems in the diagnosis of voice disorder as a constant swing of the pendulum between approaches that emphasize physical aetiologies and those that are predominantly psychological. In fact, very few patients will fit into an either/or type of model of diagnosis or management. We need to develop a model of diagnosis that includes clearer definition of the grey area of mild/moderate physiological dysfunction as well as the recognition that vocal behaviour reflects a wide range of psychological behaviours such as learning, habit, cognition, perception, and motivation as well as emotional or stress-related problems.

Within this model we must include an examination of the process of therapeutic management. There is quite widespread agreement among voice therapists that most of our clients respond to a predominantly symptom-based approach, based on relaxation, control of respiration during speech, self-monitoring, and facilitating exercises (Moore 1977, Butcher *et al.* 1987). What is less clear is the way that speech therapists *generally* facilitate change through therapy (Eastwood 1988). We know even less about the framework we use for providing the emotional support and encouragement that seems to be a vital factor in effecting change (Brumfitt 1985).

In general medicine, this type of problem has been recognized for a long time, particularly in relation to the conditions classically identified as 'psychosomatic' and 'neurotic'. The following section draws on some information from physical medicine, which seems to be highly relevant to vocal dysfunction.

CURRENT MEDICAL APPROACHES TO PSYCHOSOMATIC AND STRESS-RELATED DISORDERS

Medical and social attitudes to stress-related illnesses have altered radically over the years. Whereas in the 1940s and 1950s these problems were attributed predominantly to neurotic personality, in the 1980s, the emphasis has shifted to the recognition that most of us are potentially vulnerable to stress-related illness (Cooper *et al.* 1988).

The themes explored in relation to stress-related illness seem to have direct implications for our understanding of voice disorder. In the broader field of medical disorders it is possible to examine trends and hypotheses in a much larger patient population, but the issues are very similar to those raised in discussions of causes of voice disorder. Research into the influences of lifestyle, personality, and the effects of various life-events, for example, has led workers in behavioural medicine to recognize that individual responses to all of these factors vary greatly.

Cooper *et al.* (1988) list a large number of symptoms that can be the result of long-term pressure. These include physical symptoms such as constant tiredness, changes to appetite or related gastric problems, and awareness of altered muscle tone such as aches and pains, as well as headaches, high blood pressure, etc. In addition, they also identify changes in feelings, including irritability with other people, generally feeling unable to cope, and other feelings of a lack of self-worth. It is worth noting that this latter list is very similar to that of McFarlane and Lavorato (1983) (see above). If a difference exists, it is one of interpretation; whereas Cooper *et al.* (1988) certainly suggest that these responses are *normal but potentially avoidable*, McFarlane and Lavorato's discussion suggests a deeper and more problematic level of disorder.

For many of us the circumstances provoking these reactions may in themselves be temporary, in which case the symptoms may be short-lived. In some instances, however, the steps we take to cope with stress can influence our future responses to similar or different pressures. A successful and adaptive coping strategy will prove a useful buffer against future stressful experiences. A maladaptive strategy such as avoidance, withdrawal, or denial may lead to vulnerability at a later time (Cooper *et al.* 1988, Dobson 1982).

Wadsworth and Ingham (1981, p. 353) identify four general categories of factors which can increase or decrease the chances of stress-related illness.

1. External physical agents such as infection, toxic substances, and nutrition.
2. Internal physical agents, such as genetic constitution, physical fitness, and immunity.
3. Psychological factors: the individual's personal resources and capacity for coping with threat – this interacts closely with:
4. External socioeconomic factors. Social resources include support from close confidants (see Brown 1976), which probably affords some protection against the adverse effects of threat.

It is generally agreed that when some of these factors combine or continue for a prolonged period, clinically identifiable symptoms are more likely to develop. Graham (1971) suggested this process was likely to be gradual; people take 'small physiological steps in the direction of full-blown illness.' However, if the individual is bolstered against changes in one of these elements by his or her own coping resources or by other factors such as social support, susceptibility to illness or symptom development is less likely. These findings have led to the conclusion that there is rarely a single cause of illness or symptom development; for the most part we should consider a multifactorial explanation (Bakal 1979, Cooper *et al.* 1988). This is certainly a view that is becoming more prevalent in the context of voice disorder (see below).

THE DEVELOPMENT AND IDENTIFICATION OF SYMPTOMS

From studies of the development of stress-related disorders it is also apparent that people can tolerate or ignore relatively minor symptoms for quite a considerable time. In some cases this will include self-treatment such as using non-prescribed medication; in others, if the symptom is not intrusive in one's daily life, it can simply be accepted. People appear to take these symptoms to the doctor for different reasons, including:

(a) the symptom may change, so that it becomes more intrusive;
(b) the symptom is validated by another person; that is, someone else confirms that this is a problem that should be examined by a doctor;
(c) a new significance is attributed to the symptom; this may be because someone else who becomes ill reports similar symptoms;
(d) circumstances change, so that the disorder is more noticeable;
(e) at times of stress, any of the above may combine with a general feeling of being unwell. In this case, the individual may go to the doctor as a coping strategy. It has been suggested that being declared unwell can be preferable to feeling unable to cope (Shuval *et al.* 1973, Winefield 1981).

This type of information may help us to explain some aspects of voice disorder. It is well recognized, for example, that change of voice particularly after a cold is rarely regarded as a significant symptom (Graham 1983). Johns (Chapter 7, this volume) notes, however, that people attending ENT clinics may express fears that their voice disorder is due to cancer. It seems that some additional element must account for the differences between these two well-recognized observations. Although speech pathologists and laryngologists may be aware that there are a large number of other possible causes, general public awareness of the causes of voice disorder is poor. This means that the potential patient with a voice disorder may delay presentation to the doctor until long after the original start of the symptoms, through lack of knowledge or any of the other reasons described above.

As referral from the patient's doctor to the laryngologist generally takes some time, it is likely that some of the natural history of the voice disorder may have been forgotten by the patient, or features that might have been relevant for diagnosis may be obscured by more recent events

(Wadsworth and Ingham 1981). Cooper (1973) suggests, for example, that patients often do not realize the significance of sensory symptoms, which are often the early signs of vocal misuse, such as pains in the throat or neck, voice that fades during the day, the need to clear the throat, etc. We also need to recognize that a potential delay of several months can occur between the onset of the voice disorder and the initial appointment for voice therapy. During this time, many patients will have attempted to adapt to the voice disorder or will have learned a faulty pattern of voicing that will probably need direct therapy. In addition it is possible that the initial stressor contributing to the onset of the vocal dysfunction may no longer be salient for the client (Rammage *et al.* 1983).

MULTIFACTORIAL MODELS OF VOICE DISORDER

An increasing number of voice clinicians have recognized that the multifactorial model is appropriate to our work. Kitzing (1983), for example, states that we should evaluate symptoms of vocal disruption on a number of different levels, which include physiological, acoustic, and psychosocial elements of voice. Rammage *et al.* (1983) suggest that various aetiological factors may interact with each other to predispose, precipitate, or perpetuate dysphonia. They advocate careful evaluation of both physiological and psychological factors, including the meaning of the symptom for each individual client, as the basis of all intervention.

Freeman and Schaefer (1982) have described an interactive model of cause in dysphonia. Here, it is recognized that phonation is a complex physiological activity that requires a competent mechanism able to adapt to the demands of conversation due to well-balanced auditory, kinaesthetic, and proprioceptive feedback. They identify potential alterations to the balance of the vocal mechanism or the feedback system including (a) infections and pollution; (b) allergies and vasodilating medication used for their control, gastric problems such as gastric reflux, hormonal changes, smoking, and vocal use; and (c) psychological factors, including conscious, volitional alterations of the voice as well as psychosocial issues. It can be seen that this list resembles the categories identified by Wadsworth and Ingham above. Figure 9.2 suggests a model of multifactorial causes of voice disorder.

BUT WHAT ABOUT PERSONALITY, LIFE-STRESS AND TENSION?

Personality and vulnerability to stress have generally been considered central to concepts of psychogenesis (Aronson 1985, Case 1984). As Aronson admits, however, studies of the relationship between voice and

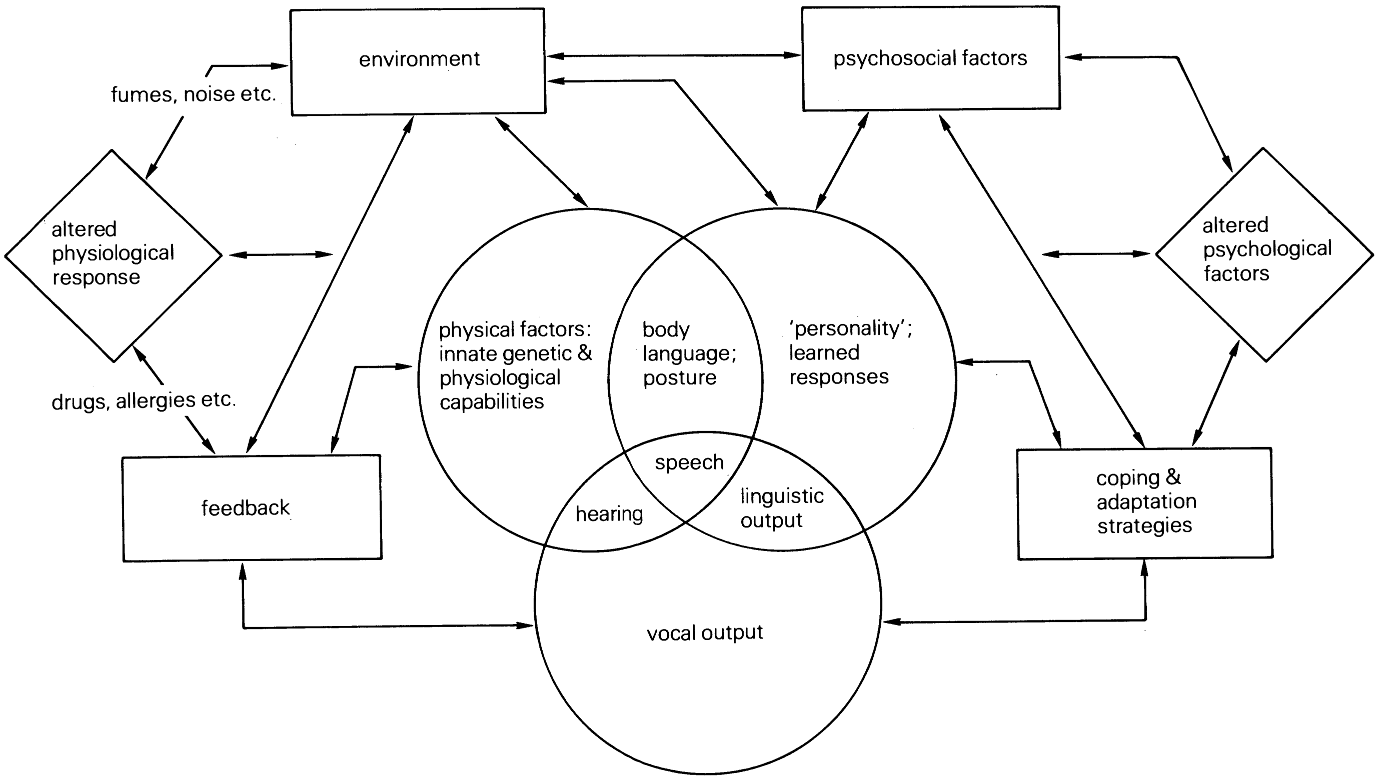

Figure 9.2 A multifactorial model of the influences on voice disorder.

personality are bedevilled by the fact that it is difficult to specify what we mean by 'personality'. In a review of the literature, Green (1988) confirms that although we can feel intuitively that there is a relationship between voice and personality, the research evidence is not conclusive. What does seem clear is that it may be helpful to consider three slightly separate aspects of voice as a reflection of 'self'.

It is fairly safe to presume that there is some interrelationship between personal, habitual style and vocal characteristics. Scherer and Scherer (1981) suggest that voice reflects personality in as much as 'personality' is agreed to mean both the individual's inherent biological make-up and acquired characteristics that reflect social learning. Laver's (1980) phonetic description of voice quality is also based on the recognition that most of us have fairly stable long-term habitual voice and speech characteristics reflecting sociolinguistic influences combined with physiological variables.

The second aspect of voice relates to alterations of the stable 'personality characteristics' at times of stress. Various studies have demonstrated that the 'fight or flight' mechanisms activated by fear, anger, or other immediate threats can be reflected in alterations to pitch and volume (Scherer 1981, Case 1984, Aronson 1985). The longer-term effects of prolonged psychological stress on voice have, however, been more difficult to evaluate (Green 1988).

The third issue is the suggested association between psychological disturbances and vocal characteristics. Studies of groups of patients with personality disorder or other diagnosed psychiatric conditions have demonstrated that changes in vocal characteristics can be part of the clinical picture (Weinberg 1983). It is evident, however, that these changes are not uniform across groups of people (Green 1988). In addition, the descriptions of the type of changes to 'voice' actually include characteristics such as speech rate, intonation patterns, and speech style, which speech therapists and linguists would classify as prosodic features rather than disorders of the vocal signal *per se* (Darby *et al.* 1984).

It seems that there is a need for further research into this area; to date, our conclusion must be that 'the extent to which psychological variables influence voice is neither clear cut nor simple' (Green 1988). In clinical practice we must be cautious about our 'intuitive' judgements of the person from his or her voice alone. Furthermore, the suggestion that there is a relationship between personality type or specific types of psychological disorder and the type of voice disorder has been called into question by a number of speech therapists (Cooper 1973, Boone 1983, Bloch and Goodstein 1971). Morrison *et al.*'s (1985) population study also showed that there was no specific relationship between the type of psychogenic problem and the type of laryngeal symptomatology.

POSTURE, PHYSICAL TENSION AND BODY LANGUAGE

It is here that two factors can be closely linked: the patient's level of physical tension can be interpreted as a sign of personality disturbance, anxiety, or as a sign of chronic life-stress (Aronson 1985). Although musculoskeletal tension can indeed be one response to life stress (Dobson 1982), it is also possible that the individual's habitual posture has been a precipitating cause of the voice disorder. The Alexander principle (Barlow 1973) originated from Alexander's observations that his own habitual stance and movement caused his voice problems.

Postural changes may also be influenced by attempts to force or control phonation. This type of compensatory behaviour has been suggested in relation to spasmodic dysphonia (Izdebski and Dedo 1981) and in relation to some neurologically based disorders (Ward *et al.* 1981). Changes in posture and tension levels can have quite marked influences on the mechanics of phonation (Simpson 1971, Wyke and Kirschner 1976).

The relationship between posture, tension, and anxiety states is a complex issue. Although it is recognized that heightened muscle tone can be a response to emotional arousal, there is quite a lot of evidence that individual levels of response differ greatly (Scherer 1981). Various studies have demonstrated that most people respond to acute stress with increased muscle tone, more rapid respiratory rate and higher vocal fundamental frequency, but longer-term changes are, in fact, more difficult to identify (Green 1988).

It can be seen that the observation of physical tension in voice-disordered patients, and the attribution of the cause of this, need to be considered as two separate issues. What we do know is that many of our clientele show signs of physical tension that is quite decidedly a maintaining factor in voice disorder (Morrison *et al.* 1985, Aronson 1985, Bridger and Epstein 1983). We also know that relaxation techniques can be effective and useful in reducing this tension (Boone and MacFarlane 1988; Fawcus, Chapter 8, this volume).

LIFE-STRESS

Again, the relationship between stressful life-events and the onset of symptoms, illness, or feelings of being unable to cope is not straightforward. Although some correlations have been shown between the onset of illness and significant life changes (Rahe *et al.* 1971), there are many factors that seem to mitigate against a clear-cut cause-and-effect relationship being established (Dohrenwend and Dohrenwend 1974). Winefield (1981) suggests that for people with an established pattern of illness susceptibility, episodes of illness may indeed follow significant social or interpersonal disruption. Many people, however, seem to experience similar levels of life change with little or no illness response.

Various explanations have been suggested for this. A degree of personal susceptibility is certainly implicated, as are the perception of the distressfulness of the life-event and the level of social or other personal support available to the person (Cooper *et al.* 1988). It has also been shown that people can adapt or adjust to quite a high level of emotional, physical, or financial stress as long as this is predictable; one relatively minor additional stressor may, however, be the final straw that leads to breakdown of physical health or coping strategies (Dill and Feld 1982). The patient who has been coping successfully with major problems may therefore present after a relatively minor straw has broken the camel's back!

LIFE-STRESS AND THE ATTRIBUTION OF SYMPTOMS

It is apparent that in evaluating the relationship between voice disorder and stress of any type, we should be wary of making automatic assumptions or judgements. We also need to remember that the patient may attribute the onset of symptoms to a given episode correctly or incorrectly. Alternatively, some clients may deny an association between stress and symptom onset either through fear of being judged as unable to cope (Winefield 1981) or perhaps because this does not feel like a feasible explanation. It may also be true that if the stress is ongoing, the person's denial is in itself a form of coping mechanism.

In some cases we should be aware that even when a specific event is identified as triggering the onset of symptoms or their recognition, the stress may have receded by the time the client attends for therapy (Rammage *et al.* 1983, Aronson 1985). This can mean that the patient is left with a residual pattern of vocal misuse which is responsive to direct therapy. It may also be important, however, to ensure that the patient is helped to develop strategies that may help him/her to cope with stress, for the future. Careful consideration of all these issues for each patient is the only realistic way to proceed in diagnosis.

PSYCHOLOGICAL FACTORS IN APPRAISAL AND MANAGEMENT

Appraisal

Working with adults who have voice disorders can have its own particular challenges. In the first place, the dysphonic or aphonic person is still able to communicate effectively, especially in comparison with other adult patients with acquired disorders such as aphasia or dysarthria. Again, unlike the stroke patient, most people with voice disorder are not in a typical 'sick-role'; throughout therapy, they will generally continue to live their usual, independent lifestyles and will need to incorporate the demands of therapy into the existing routine. Like most other patients, however, voice-disordered people want to know more about the causes of the problem and the possible outcome of therapy. In fact, voice-disordered clients have been known to question the relevance of speech therapy for their voice disorder – the cynic might wonder if this is one reason why they are labelled 'psychogenic'! For all these reasons, appraisal and management of the dysphonic person's communication may therefore require us to adapt our own approaches to interviewing and interaction.

If we take the view that the patient has to be a very active participant in therapy (Stimson 1974), the clinician's role as a communicator and persuader is vital. We need to be ready to listen and to explore with the patient the factors that are important to his or her specific case, *when the patient is ready to do this*. Several studies have shown that when patients feel the interviewer has taken a personal interest in their problems, they tend to be more responsive to subsequent guidance offered by the professional person (Ley 1977, Korsch and Negrete 1972). In addition, objective acceptance of symptoms and readiness to share information that helps to explain them, without judgement, has also been proved to increase compliance (Harris 1977).

The patient with voice disorder may quite realistically have developed an awareness that other people have judged their problem as insignificant or 'not real'. As well as the lay view that voice disorders are a symptom of 'nerves', some patients feel that the doctor's intended reassurance that 'there isn't a physical problem' can imply that the problem has been judged as neurosis. In such cases, even the subtlest hint of this from the voice therapist may lead to firm denial – in the first instance at least. To be viewed as unable to cope is still considered a stigma by many people (Brodnitz 1965, Winefield 1981).

Aronson (1985) advises that throughout the diagnostic evaluation the voice therapist should consciously separate the collection of data from the interpretation of findings. The objective description of visible signs such as posture, tension sites, and non-verbal behaviours, for example, will generally help to identify the relationship between these physiological components and the sound of the patient's voice; subjective interpretation of these characteristics purely as evidence of *psychological* distress may not provide the level of detailed technical information that will form the basis of voice therapy.

The patient's view of the problem

The client's view of the problem should be the starting point for diagnosis and management. It should be noted, however, that few people understand their own anatomy, are aware of anatomical or other technical terms, or recognize the relationship between symptoms (Winefield 1981). Speech pathologists are well aware that stutterers or their parents may (inappropriately) attribute the onset of dysfluency to a specific event or incident. It seems highly probable that the same process of attribution occurs in dysphonia – and indeed in patients generally, when they are trying to make sense of their symptoms (Mechanic 1972). We should also be aware that terms such as 'voice' for a lay person – or indeed a medical officer – can cover speech processes and accent; it is part of our role to clarify this issue.

Understanding and differentiating the symptoms

Brodnitz (1965) points out that the busy ENT outpatient clinic does not readily lend itself to the appropriate level of detailed discussion of the nature and cause of voice disorder. Unless the patient is referred to a specialist voice clinic, it is highly likely that the speech therapy interview will provide the first opportunity for the client to consider the background to the voice disorder in depth. Because clients tend not to realize the significance of some symptoms, we need to be ready to guide the discussion through examination of sensory symptoms such as pain in the neck or shoulder region, soreness or fatigue after talking, and the need to clear the throat, etc. which are often the first signs of vocal misuse (Cooper 1973). In the same way, the voice therapist needs to be ready to evaluate whether or not the client has a *voice* problem or a broader difficulty that may be more appropriately helped by referral to other colleagues.

The pattern of how and when the voice changes may also be an important indicator of the need for further exploration. A pattern that initially seems incongruent may sound warning bells of psychogenesis but might actually have an organic/physiological explanation. One example of this is the patient whose voice loss is specific to certain situations. Some patients may have an undiagnosed hearing loss that leads to problems with high levels of background noise. For others, allergic reactions to smoke, fumes, or airborne chemicals used in aerosols may lead to sudden voice loss. Freeman *et al.* (1987) describe a case of sudden episodic dysphonia that was eventually identified as hypersensitivity to insulation material, although the initial diagnosis was hysteria.

Aronson (1985) and Greene (1980) suggest that some voice disorders may be the first manifestation of neurological or other physical conditions.

This may only become apparent when other discrete signs are evident either in discussion of the development of the voice disorder or during the patient's attempts at therapy. Greene (1980) also cites a case in which her understanding of linguistic processes provided an explanation of a bilingual patient's difficulty in one language despite competent voicing in English. As Gordon (Chapter 3, this volume) points out, the multi-disciplinary education of the speech pathologist places us in a unique position for understanding voice disorder.

Making a diagnosis

In the majority of cases it will be possible to describe the physical features of the client's phonatory behaviour in some detail. Factors such as posture, the presence of tension in the neck, shoulder, or jaw region, and apparent problems with the mechanics of breathing such as raising of the sternum during inspiration are all readily visible. Use of the Vocal Profile Analysis system (Laver *et al.* 1981) can also provide additional useful data about the influence of vocal-tract settings on the vocal characteristics. It is also important to consider the patient's conversational style; subtle signs of vocal misuse may be identified in, for example, reduced use of pauses, speaking without adequate air support, voice breaks on emphasized syllables, and alterations to voice-onset times. Again, some features of conversational style may give an initial impression of aggressive or withdrawn behaviour (see Roger and Bull 1989, for example), which could be interpreted as personality traits but may equally be a symptom of incompetent motor control (Hadar *et al.* 1983). There is a need for further research in this area of voice use and vocal dysfunction.

Explaining the causes of the vocal dysfunction may not be quite so easy. The level of detailed questioning necessary to elicit a clear picture of symptom development may not initially seem coherent to the patient, and this may lead to ambiguous or unintentionally misleading responses. Many adults also resist invitations to self-disclosure from someone they have only just met, especially if they are not yet convinced of the necessity for this disclosure. It is for this type of reason that many experienced voice therapists initially offer a period of exploratory symptom-based therapy. In a fairly high proportion of cases, patients will respond to the techniques already described (see Fawcus, Chapter 8, this volume).

PSYCHOLOGICAL ISSUES IN VOICE THERAPY

The therapeutic relationship

The clinician and the client need to work in close partnership to effect the change. The clinician's job is to ensure that an appropriate target is set, that the client learns how to reach it, and to help the client to incorporate the behaviour into everyday communication. The client's work is to attain the target behaviour and to practise and self-monitor, in order to optimize the behaviour change. One of the factors that can be most influential in effecting these developments is the relationship which develops between therapist and client. The therapist who can identify and set attainable goals, who reassures the client that change is both feasible and desirable, and who is empathic and ready to listen, discuss, and explain therapy techniques, can best help the patient to make appropriate changes (Baker 1977, Harris 1977).

It is highly probable that the responsive therapist will also be more likely to be trusted with information about the client as a person. As with any therapeutic relationship, discussions of how the client relates and responds to others will arise, as will considerations about demanding or stressful situations which the client encounters during his or her daily life. As this information is disclosed, the voice therapist needs to balance the relevance of this information to the therapeutic process.

In many cases, at this stage, it is helpful to discuss the case with another professional, to re-evaluate the purpose and direction of therapy. As voice therapists our special expertise is predominantly in helping to resolve vocal dysfunction – if this is what the patient needs most, but we must be aware that referral to another agency may potentially deprive the patient of the appropriate strategies for vocal remediation. On the other hand, if the client's current social or interpersonal situation is preventing him/her from being able to change, it would be unreasonable to continue voice therapy when another type of support or help may be more beneficial. A common trap, however, seems to be one in which voice therapy takes second place to an unstructured sharing of problems which may be open-ended. The patient may feel better because he or she can air his or her problems, but there is a danger that no real change takes place, either in the voice problem or in the patient's long-term ability to cope without support.

Establishing a contract

There are a number of positive benefits from agreeing a trial period of therapy for a definite period. Firstly, the client is given a short-term goal in therapy, that is to re-evaluate progress after perhaps four or five sessions. Secondly, a contract that outlines times and dates of appointments and the consequences of not attending or not complying with therapy emphasizes the client's role in effecting change. Finally, by agreeing to review the situation at a given time, the therapist provides for him/herself the opportunity to evaluate progress and to consider the information gained about the client, which may lead to consultation with others or some other form of management direction.

The patient with special problems

Three particular types of problem seem to be most frequently identified. These will be considered separately.

The client who does not respond Lack of response to therapy can take various forms. For some clients there is a degree of resistance to voice therapy in general; it may be, for example, that the individual accepts referral to comply with the consultant's recommendations, but feels unready or unable to accept remediation. This can sometimes be related to lack of understanding of speech therapy itself, in which case explanation will help. If the client remains wary of therapy, however, it is his/her right to defer or refuse treatment; often, allowing someone to exercise this right may lead to a self-referral at a later stage.

For some clients poor response to therapy may reflect problems of teaching or learning. Adults with vocal dysfunction may find voice therapy is the first ever experience of learning in a one-to-one situation. This can be quite stressful, especially when voice therapy relies on heightened self-monitoring and self-awareness. The voice therapist needs to constantly be aware of the client's need for time, empathy, and encouragement, both in developing the appropriate changes and in extending these into everyday life. Some of the approaches used by cognitive–behavioural psychologists can be most helpful in this context; setting short-term specific goals between appointments and maintaining a log of how specific tasks were accomplished are often well accepted, for example.

For some clients, the pace of learning may need to be adapted. Intensive daily therapy has been used successfully, especially in conjunction with controlled voice rest (MacIntyre 1980). Use of biofeedback techniques, including work with the laryngograph on an intensive basis (Carlson 1988) can also prove productive. Filter (1980) has suggested that emphasis on sensory modalities other than auditory channels can be most effective; he advocates a stronger use of proprioceptive, tactile, and kinaesthetic awareness in relation to posture, relaxation and general awareness of laryngeal control.

For some people, transfer of techniques learned in therapy into everyday life may prove difficult. Again, the setting of specific goals may be required. Assignments, often used in therapy for dysfluency, may be useful here. Practise of use of the telephone, for example, extending to phone calls from the clinician to the client at home or at work, may effect change quite rapidly. Tape recordings of conversation with family or colleagues, or of part of one's teaching, may help a client to pin-point unsuspected vocal misuse or abuse.

In all of the above, it is recognized that one of the major problems for a person with habitual vocal dysfunction is the need to break down habits. This requires that the client alter his or her behaviour *every time the mouth is opened to speak*; this is an extremely demanding and potentially stressful expectation, which will require a lot of support from the therapist.

The aphonic patient The classic textbook description of functional or psychogenic voice disorder relates most directly to aphonia. Although several authors have suggested that there may be more than one cause for long-standing aphonia that has no apparent organic basis (Boone 1983, Boone and McFarlane 1988), the association between aphonia and conversion reaction remains the strongest – and often the only – theme in the literature (Aronson 1985, Case 1984). As Boone and McFarlane (1988) point out: 'Whatever the original cause, the [aphonic] behaviour is maintained by the reactions of people around the patient. Such patients develop a *no voice* set towards speaking and they develop habitual responses.' (p. 186).

It is generally agreed that some patients with aphonia relinquish their voicelessness with relative ease, in response to a consistent, empathic, and assured approach from the therapist (Greene 1980, Aronson 1985). In other cases, however, although the patient seems to be trying hard and expresses a keen desire to produce voice, the force of the habitual pattern seems to be resistant to therapeutic endeavour. It has been suggested that some cases of aphonia might have an organic explanation. Aronson (1985) has noted that there are some contexts in which the patient seems to lose 'the set of the voice' (p. 151), which he describes as possibly related to some aspect of praxis, occurring, for example, after prolonged voice rest or after the vocal folds have been stripped. Boone (1983) also advises that the sudden onset of aphonia should not be automatically assumed to be psychogenic and argues strongly for a careful evaluation of the client's medical history and physical status. Examination of the larynx using the fibreoptic stroboscopic laryngoscope may be most useful in cases of aphonia (Harris 1989, personal communication).

It is certainly evident that many clients with fairly long-standing aphonia present with signs of marked tension in the jaw, face, and neck (Aronson 1985). Morrison *et al.* (1985) include in their description a tendency to jaw-jut, tightness or near immobility of the mandible, retracted tongue, and palpable suprahyoid muscles, as well as some changes in breathing patterns, including breath-holding in speech contexts. Boone and MacFarlane (1988) suggest that a positive but firm approach in therapy can be successful in reducing these features. They advocate objective explanation that puts the focus on the vocal tract rather than on the patient. Discussion of what 'the vocal folds' seem to be doing can enable the patient to respond more readily than suggesting 'you should do . . . '. Included in their description is taking advantage of any change in sound and using this as evidence that the vocal folds are responding to therapy. The conviction that this will develop towards full voicing may in turn facilitate more phonation. Aronson (1985) describes the use of digital manipulation techniques to physically release the tension in the submandibular and suprahyoid musculature. Boone and MacFarlane suggest use of several techniques including inspiration phonation and the yawn–sigh techniques. MacFarlane and Lavorato (1983) suggest the use of various techniques such as imagery to encourage the patient to alter the vocal-tract configuration, such as making non-speech noises like air moving through a pipe or like wood being sawn. Most voice therapists now seem to advocate an intensive, firm, and direct focus on reduction of tension in the larynx and related structures, and gradual shaping of phonation. The use of what Greene (1980) describes as 'tactics' such as faradism or use of loud masking, which used to be employed to produce involuntary voicing, has fallen out of favour. As Tarneaud (1958) pointed out these produce involuntary phonation which generally 'are unable to restore the correct coordinations and synergies of the speaker's . . . voice' (cited by Cooper 1973).

The client with ongoing problems There is a small but significant minority of people who are unable to respond to voice therapy alone. Butcher *et al.* (1987) conclude from their experience of conjoint therapy that 'voice loss resistant to speech therapy seems to appear in a wide variety of patients, predominantly female, whose common condition is one of anxiety and who are experiencing psychological stress of one form or another' (p. 91). Although Butcher *et al.* admit that their study is somewhat anecdotal, their findings suggest that the predominant problems were often related to continuing family or interpersonal relationship difficulties, particularly when clients felt unable to express or assert their feelings. In fact, the association between weak or absent voice and a sense that the client still feels the need to 'choke back' emotions or hold back the tears is one of the strongest themes in current discussions of psychogenic voice disorder (Morrison *et al.* 1985, Butcher *et al.* 1987, Aronson 1985).

In this type of case, the most consistently successful management has been shared between the speech therapist and a psychologist (Butcher *et al.* 1987) or a psychiatrist (Rammage *et al.* 1983). Conjoint management has a number of benefits for client and therapists. For the client, the extension of therapy to exploration, and hopefully resolution, of emotionally based issues can be part of a continuous process, with the speech pathologist acting as the link between two potentially different styles of therapy. For the speech pathologist and psychologist, co-therapy provides the opportunity to extend areas of expertise, but equally important is the chance to share the burden of responsibility, which may be particularly stressful when helping a client to examine his or her emotions and interpersonal relationships.

Butcher *et al.* (1987) suggest that the use of cognitive–behavioural therapy also contributed to the relatively high level of success with patients who had been unable to respond to voice therapy. This approach has been increasingly used in stress management to help people to develop their own coping and problem-solving strategies, which can be generalized into everyday life (Dryden and Golden 1986, Brewin 1988). The experiences of the therapists in the Butcher *et al.* study certainly seems to suggest that the cognitive–behavioural approach is a useful framework for work with patients who present with long-standing problems.

CONCLUSION

It is evident that approaches to diagnosis and management of voice disorder are beginning to change. The availability of instrumentation-based techniques has extended the understanding of the complex nature of vocal function and has demonstrated how alterations to the fine-tuning of the vocal mechanism can produce quite marked changes. At the same time, developments in other areas of behavioural medicine have provided alternative ways of considering factors that were previously described as 'psychogenic', 'functional', or 'psychosomatic'. Both of these developments provide us with the beginnings of a framework for helping our clients to gain or regain competent vocal function in a supportive and therapeutic way.

In a sense, the themes within this chapter have challenged the long-held traditional view that voice therapy must strongly emphasize the emotional and psychological aspects of voice. This is not meant as a denigration of this traditional view, but rather, it is an attempt to de-mystify some of the many issues that come under the umbrella of 'psychological factors'. By drawing on recent research and developments by psychologists and other workers in behavioural medicine, it is hoped that we shall be able to work with our clients with an open, caring, and effective approach to therapy, which will fit each person's unique set of circumstances. In this way the ability to use voice as a reflection of self and as an effective, efficient tool should be made more available to the person who presents with voice disorder.

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10

Voice in people with cerebral palsy

Kay Coombes

INTRODUCTION

This chapter focuses on dysphonia enmeshed in other symptoms of cerebral palsy. The impact of current attitudes to disability on this area is noted. Symptoms are outlined and treatment aims described, together with some approaches to achieving them. The need to foster insight and provide long-term support for children and adults is emphasized.

The first edition (1986) brought responses from clinicians working with people of all ages who had cerebral palsy and from two adults with forms of cerebral palsy. I am indebted to them all for their comments. Some of the issues that were raised will be tackled here, but many questions remain to be answered by others elsewhere. Further research is needed to clarify some of the important areas that are currently controversial.

Clinicians requested more information about voice therapy techniques, and criteria for embarking on voice therapy and discharging patients. Those with cerebral palsy wanted ideas on how to help themselves. There were also questions about interrelationships between laryngeal symptoms in dysphonia and difficulties in swallowing (dysphagia). These enquiries reflect increasing concern about the treatment of people, including those with cerebral palsy, who have eating difficulties. The discussion is relevant and timely but largely outside the remit of this chapter. However, principal considerations are summarized (see 'The mechanism as the lowest common denominator' p. 212).

CONTEXT AND PARADOX

Recent years have seen people with disabilities increasingly able to take their place in mainstream society. An attitudinal revolution has taken place in the perceptions and expectations of people with disabilities and those around them. Sociological change has been facilitated by increased efficiency of mobility aids and technological advances that can make communication possible for people with severe motor impairment or learning difficulties. Enhanced medical care should provide for longer, healthier life expectancy.

The quality of life potentially available to people with developmental disorders such as cerebral palsy has never been so high. Yet ironically, a survey of young adults in south-east England (Thomas *et al.* 1989) reveals that handicaps persist and are likely to increase. This is due in part to the original disability, but more to restricted access to services and equipment and to inadequacies in the provision and management of resources. Examples include insufficient speech therapy provision and a lack of effective policy for supplying assistive communication devices. People with physical disability and impaired speech or language are unlikely to receive consistent and long-term help with any form of communication, let alone voice therapy. Additional problems arise from physical deterioration associated with inadequate physiotherapy. In summary, the absence of any national policy on standards of provision or priority areas of treatment for this client group makes it impossible to supply a co-ordinated and effective service of therapy or education. The recent DHSS working party on aids for communication is a welcome if overdue contribution to policy formulation. However it is regrettable that there are no statistics available on the numbers of children or adults with different kinds of communication abilities. Opportunities to gain a reasonable estimate of need for planning service provision, e.g. via central records on educational placement of children with special needs (Goacher *et al.*, 1986) have not been exploited.

The speech therapy profession must bear some responsibility for erratic service provision. Speech and language difficulties in those with developmental physical disability have not received consistently high-level specialist support. People with cerebral palsy are too often treated by junior staff. While newly qualified therapists are trained to understand the theoretical aspects of normal and pathological voice production, they are unlikely to have more than rudimentary skills in the application of laboratory-based voice research to the treatment of people with cerebral palsy and little practice in 'hands-on' work necessary for the treatment of patients with congenital or acquired disorders of the central nervous system. Posture and movement are directly relevant to respiration and phonation, and therapists need to understand how to manipulate muscle tonus for optimal sensation, movement, and voice production.

The central role of communication and the value of systems to augment or replace speech is repeated like a mantra throughout the professional literature, but there is too little discussion of treatment implications and different management approaches. For example, intervention needs to take into account the injurious effects that operating some alternative systems may have on developmental function over time. Speech therapists are right to respect the special skills of physiotherapist and occupational therapist colleagues. However, we may wrongly expect them to be solely responsible for 'posture' and 'positioning' and for decisions about switches to access communication aids. We talk about real-life activities and yet rarely provide speech therapy where children naturally spend their time, i.e. in the classroom or at home. Furthermore, many speech therapy activities are still carried out in a sitting position and may centre primarily on tabletop activities. Improved respiration and breath control is often a stated aim but patients are rarely sufficiently undressed to see their trunk activity (see Figure 10.4a,b, p. 228).

Currently there is an emphasis in the speech therapy profession on managerial and consultative roles. If these are pursued to the exclusion of direct clinical involvement, speech therapists are in danger of becoming 'de-skilled' and their place in the therapeutic team will be taken by others, or even more sadly, by no-one.

DISORDERS IN THOSE WITH CEREBRAL PALSY

Sensorimotor integration and cognition together with psychosocial factors determine language and communicative proficiency in all of us. Sensorimotor integration is always impaired in cerebral palsy, and other areas may be affected.

Movement disorders that characterize cerebral palsy are due to brain damage incurred in early life that affects any of the motor areas of the brain and may involve other parts, e.g. those concerned with hearing and vision. But the essential feature of the motor damage is a reduction of the cortical control normally exercised by higher centres over developmentally and geographically lower parts of the brain. Removing inhibition in this way releases tonic activity, reflex behaviour, and patterns of movement associated with more primitive brain activity. These release phenomena characterize cerebral palsy and this fact influences the theoretical basis of any valid treatment approach and guides effective intervention.

Any form of cerebral palsy is liable to involve diffuse neurological damage; predominant symptoms are taken as indicators of sites and combination of lesions. For instance, the impairment of extrapyramidal function is clearly evident in children with ataxia or athetosis where lesions primarily affect cerebellar and basal ganglia fibres respectively. Various symptoms often coexist: for example athetosis and ataxia may be evident in one child. Both these forms of cerebral palsy demonstrate clearly the disruption of the feedback loop that would normally provide continuous 'error correction' during voluntary movement. Hence the ataxic patient for instance, typically overshoots the target, where reaching to pick up something or depressing the mandible for speech or eating. While patients with athetosis can vary their muscle contraction levels over a wide range, with a velocity (rate of change) of muscle activity similar to a normal sample (O'Dwyer and Neilson 1988), there is a lack of selectivity of muscular action shown on electromyographic recording. This means that dysarthria in people with athetosis stems from a disruption of the physiological mechanism that provides for voluntary activity (rather than being essentially normal movement disrupted by involuntary movements). Those with spasticity are limited by the effect that unsuppressed tonic activity has on initiation of movement and the reciprocal contraction of agonist and antagonist muscle groups. Spasticity, athetosis, and ataxia are the three main categories of disorder, but the neurophysiological effects of the brain damage on patterns of movement for voice production may be seen in any form of cerebral palsy. In addition, 'psychological states can affect any aspects of the entire sequence of phonation' (Hirano 1981). This is certainly the case in many cerebral-palsied children. Effective treatment and management encompass physical and psychological aspects. Therapy is necessarily directed towards a child's family rather than merely attempting to teach the child techniques for obtaining improved voicing and speech.

Speech represents the highest level of sensorimotor integration. Some will have language disorders in addition to varying degrees of dysarthrophonia. It may be impossible for some people with cerebral palsy to learn to talk for various reasons.

The highest level in the neurological organization of speech production is the cerebral cortex, where sequences of sounds are programmed. These are conveyed by pyramidal fibres to respiratory, laryngeal, and articulatory muscles via the motor cortex and motor nuclei in the brainstem and spinal cord. Fine regulation of the system is normally facilitated by the extrapyramidal system (cortex, cerebellum, and basal ganglia).

CLASSIFICATION OF DYSPHONIAS AND TREATMENT CONSIDERATIONS

Conventional categories of cerebral palsy are principally those of spasticity, athetosis, and ataxia. Dysphonia in cerebral palsy is commonly subsumed under the heading of dysarthria or dysarthrophonia. Conventionally, dysphonias in the cerebral palsies are analysed and described in accordance with restrictions imposed upon respiration, laryngeal vibration, and vocal resonance by hypertonic, flaccid, or fluctuating muscle tone and distortions associated with tremor and involuntary movements, that is by manifestations of the 'release phenomena' described above.

Conventional descriptions of vocal characteristics include terms such as 'monotonous', 'effortful', 'laboured', prolongation of vowels associated with spasticity. Athetoid and ataxic children are described as having pitch breaks, and breathless and inconsistent voice. In other words their vocal performance is seen to mirror their varied and variable neuromuscular co-ordination. Such descriptions are clinical shorthand. They are not inaccurate but they are not precise or comprehensive either. They do not indicate the cause of any symptomatic feature nor reflect the combination of symptoms that might be evident in any one child, much less the way in which co-existing symptoms interact in different situations.

For instance, there is no indication of the significant effect that attempts to vocalize may have on posture and balance. This means that such descriptions as 'athetoid dysarthria' are not helpful in indicating a therapy approach or an appropriate point of intervention for any individual. It should be noted here that 'athetoid dysarthria' is not described in the literature as likely to include dysfluent hesitations and repetitions. Nevertheless, clinical experience suggests that many children and adults who have difficulty in controlling air pressures for speech demonstrate hesistancy and repetition as they repeatedly re-attempt words or phrases. The cause is likely to be instability of the trunk and an associated lack of diaphragmatic control. Careful diagnosis is clearly important, and the appropriate treatment in these cases is one that aims to increase stability of trunk and breath control during activities that do not involve speech before progressing to ones incorporating voice and speech (Figure 10.1a,b).

Intervention should aim to promote the most normal voice possible. This means voice initiated in a co-ordinated way that prevents wastage of air through the glottis either before onset of (delayed) vocal-cord vibration, or the other extreme when vocal cords are so firmly adducted that an enormous pressure of air is needed to blow them apart. Both of these characteristics can be heard in patients with spasticity. If intervention is successful, acquisition or maintenance of secondary symptoms will be lessened or avoided. Secondary symptoms include facial grimacing and concomitant movements of limbs accompanying speech attempts. These associated reactions impair the quality of the individual's overall communication and are likely to affect other functional behaviour such as eating. Secondary disability is superimposed when symptoms of primary problems are not modified by appropriate therapy. Appropriate therapy inevitably tackles the underlying problems of postural tone (muscle tone) and the postural control that it permits. At the highest level postural control comprises movements that are highly selective. Illustration of selective movement would include the automatic fine adjustments made to maintain balance as well as differentiated movement of tongue from jaw, for instance.

The prevention of abnormal phonation entails the individual child or

Figure 10.1(a) Voice therapy in children is typically combined with language work in a setting as normal as possible. This three-year-old child is unable to sit or stand alone. Here he is learning to use his trunk control while playing and talking.

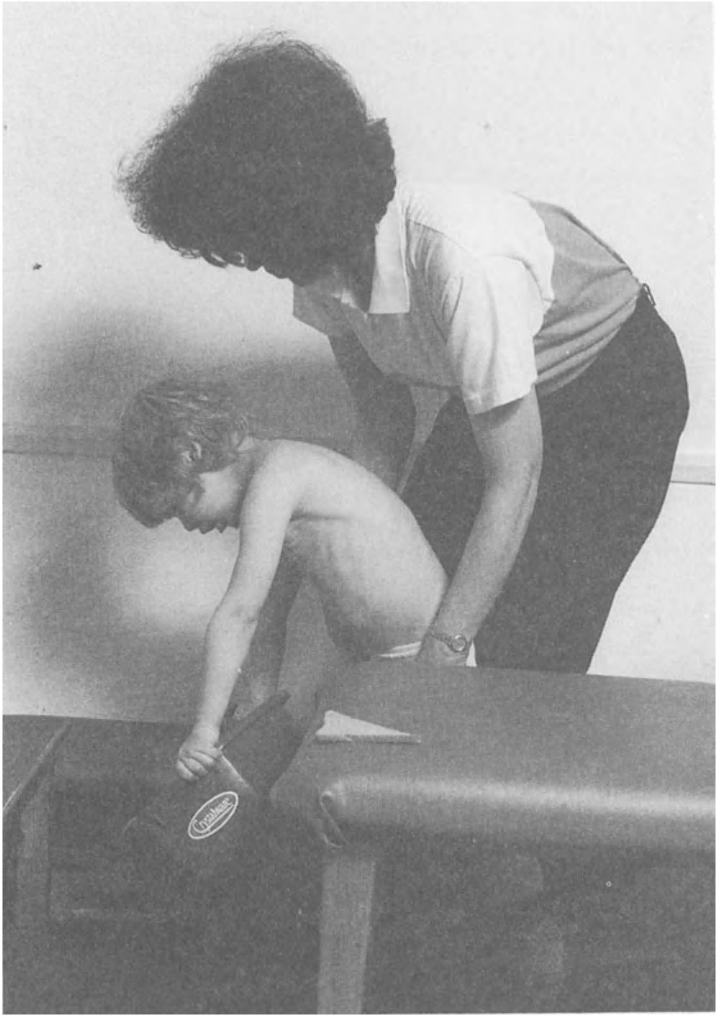

Figure 10.1(b) Note the demand on trunk control for flexion and rotation as the child lifts the bowl from the stool to put it on the floor.

adult learning how to control their own vocalization as well as phonation. Vocalization includes laughter and the sounds that we use conventionally to express surprise, disappointment, or agreement. Early intervention is essential if any form of voicing is not to become embedded in an abnormal sensory background. Tactile kinaesthetic and proprioceptive feedback is inevitable when individuals are trying to function using abnormal muscle tone, posture, and movement. Because the essential nature of speech involves emotion and cognition, together with the neuromuscular demands of a highly integrated group of synergies, it is likely that the most extreme distortions will be elicited by speaking attempts. In other words, it is during speaking attempts that children and adults with cerebral palsy experience their bodily movement most differently from those without physical disability. Attempts to consciously change the performance are not always successful. It depends upon the approach taken. Certainly, in these circumstances effort alone, the 'try again harder' approach (sometimes labelled a cognitive approach), is likely to exacerbate primary symptoms.

Motor learning of any pattern is obtained through practice, so the more that abnormal voice and speech have been experienced, the more likely it is that feedback will establish habitual routines as 'normal' for the person concerned. It follows that it will then be more difficult for any individual to unlearn undesirable behaviour and replace it with unfamiliar and therefore non-automatic patterns of movement. Moreover, some speakers, more or less intuitively, develop strategies for dealing with the limitations of their own neurophysiological system (see 'Compensatory approach', p. 222). They may adopt a telegrammatic speech style in an attempt to economize on air and muscular co-ordination, for instance. However, this maladaptive response tends to further reduce linguistic clues that would be provided by the redundancy and rhythm of normal voice and speech, and makes the individual's dysarthric speech less intelligible. Several authorities on voice disorders and their remediation have been pessimistic about achieving success in treating dysarthrias of any kind. While it may be true that some forms of dysarthrophonia are resistant to modification (Aronson 1980) it may be particularly important to examine:

1. The level of intervention: for instance, what is the postural basis for voice available to the individual?
2. The purposes of intervention at any one time, and associated with both these:
3. The criteria for success.

Overestimating the patient's level of postural control will be discouraging for everyone because initial tasks will be too difficult. On the other hand, starting with fundamentals such as breath control will not lead inevitably to improved speech unless the transition from sustained voicing of a vowel, for instance, to the production of phrases is carefully managed. The purpose of intervention is worth discussing with patients themselves or, in the case of a very young child, with the family. Goals and expectations of the parties involved may be very different. Inadequate discussion and negotiation can lead to unfulfilled potential. For instance, it is not unusual for families to reject communication devices that would augment severely dysarthric speech in their quest for more practise of voice production or word lists. This kind of situation is clearly related to criteria for successful outcome. It is most important that any programme designed to improve the speech of people with dysarthria is designed in small-step stages so that subtle changes can be monitored and recorded. As far as the treatment approach itself is concerned there may be a number of ways to effect improvement more successfully than those typically employed. There has been too little evaluation of clinical methods to evaluate significant factors. However, timing, consistency, and continuity of intervention may be as crucial as the selection of an appropriate clinical technique.

Treatment techniques and their objectives are necessarily dependent upon each clinician's view of neurophysiological and psychological processes operating in normal and disrupted speech production, together with their beliefs about potential opportunities for preventing abberant behaviour or modifying existing behaviour. Clinicians who share the currently accepted view of phonation as part of a valved air-stream system of speech production (Darley *et al.* 1975) will include articulatory processes in their assessment of function and try to examine the relationship between all levels of valving. It is easy to misinterpret phonetic features in patients with central lesions, mainly because there are often many interrelated patterns of impairment due to the nature of the damage. For example, some misarticulations or omission of phonemes may be manifestations of inadequate phonatory mechanism rather than the result of incompetent oral musculature. In turn, 'dysphonia' (impaired voicing) may stem from difficulties below the glottis, rather than from laryngeal malfunction (Hardy 1983). A six-year-old child with athetoid quadriplegia fails to make voice/voiceless contrasts: she voices all plosives, stops, and voiceless labiodental fricatives in initial positions. Other voiceless fricatives are omitted. Does this reflect hearing loss, phonological disorder, or an inability to inhibit voice by abducting vocal cords promptly? Does it demonstrate an automatic adaptation to economize on an inadequate supply of air pressure by reducing the demand? The picture presented possesses all characteristics of the classic chicken and egg syndrome. Part of the clinician's expertise lies in separating eggs from chickens in order to intervene in the right way at the right time. This must involve close liaison with other colleagues. Usually physiotherapists, occupational therapists, and teachers are involved. However, the speech therapist has a responsibility for (1) making a differential diagnosis of voice problems as well as assessing speech and language;

(2) incorporating appropriate physical management into the treatment of dysarthrophonia and monitoring progress. Satisfactory discharge of this responsibility demands a degree of communication and co-operation, both amongst professionals concerned and between them and the parents. Unfortunately, there is often too little contact between therapists to allow any real sharing of aims and attitudes, although this would seem essential for success.

Except at the most basic level it is not realistic to work on phonation without considering intonation and speech. Almost all children exhibit vocalization of some sort at times, and it is the speech therapist's responsibility to promote the most normal use of voice whatever the principal means of communication. It is increasingly recognized that parents have difficulty in accepting non-vocal systems as their child's sole means of communication. In particular, experience suggests that it is hard to come to terms with alternative forms of communication in non-speaking children when speech therapists and teachers have not appeared to give some thought to encouraging vocalization. This is not surprising. Vocal play and its role in interaction between baby and parents is recognized to be an important feature of early social development.

Children with any significant degree of dysarthrophonia have involvement of trunk and upper extremities and are likely to be diplegic or quadriplegic. They are therefore destined to be physically more dependent for longer than other infants. Their physical and emotional needs can be expected to bring forth one or more of a predictable range of responses, often labelled 'protective' (or 'overprotective'). These are merged with other recognized parental responses associated with grieving, anxiety, and exhaustion. This mix is to be expected in families who are coming to terms with disability. But there is a great divide between the awareness of the dynamics likely to be involved, documented theory, and delivery of practical help.

Current theories of communication development acknowledge the importance of prelinguistic vocal and non-vocal interaction and the formation of relationships within the family; developmental psychology papers describe 'motherese' (Gleitman *et al.* 1984) and the emotional comfort afforded by physical contact between a child and its parents. The underlying processes of interaction and language development would seem to be universal (if not universally agreed) and a primary aim of therapy should be the fostering of infant–parent interaction. Therapists' descriptions of parents as 'overprotective', 'defensive', and otherwise inept in 'adjusting' or 'accepting reality', probably testify to an inadequate supply of emotional support, information, and specific guidance on how they might play and talk with their child.

In working with children who have limited vocal ability it is still possible (and arguably very important) to develop some use of voice alongside the alternative communication system. Preventative treatment includes the inhibition of abnormal voicing as far as possible in order to prevent learning abnormal performance (see above). An example of learnt inhibition would be teaching the child not to phonate on inspiration. This abnormal technique is used by a number of cerebral-palsied children and adults and it can be spontaneously or deliberately acquired. The habit may be maintained because of its tendency to increase muscle tone, which is advantageous in children whose low or fluctuating tonus does not support normal voice, i.e. phonation on exhaled air, easily. This is because inspiration associated with increased extensor contrasts with exhalation, which induces a tendency to more flexion. Inspiratory voicing is not restricted to cerebral palsy. On occasions, children and young adults with tracheostomy providing airway patency have been encouraged to make 'voice' on inspiration because it had not been understood that a closed trachea or speaking tube facility is essential to produce laryngeal voice. In any event, voicing on inspired air is unpleasant for the listener and increases the likelihood of aspirating anything in the upper part of the alimentary tract, such as food or saliva in the mouth or pharynx.

THE MECHANISM AS THE LOWEST COMMON DENOMINATOR

Apart from aspiration during speaking attempts, those with cerebral palsy and dysphonia are likely to have eating difficulties of varying severity. These include oral motor dysfunction (Sochaniwskyj *et al.* 1986). In addition, there seems to be a number of people with cerebral palsy whose swallowing problems and vocal symptoms have become worse as they grow older. It may be that symptoms of incoordination are increasingly aggravated by distorted posture and movement over time and that this ultimately prevents useful function. There is a need to know more about such reported clinical observations. If there is consistency in the type of problems encountered and the degeneration of function, clearly there would be implications for specific assessment and treatment. It could mean minimizing abnormal movement arising from brain damage in order to preserve mechanisms of phonation and swallowing. In practice this could entail a greater concern for the quality of gait rather than the widespread philosophy of 'walking at all costs'. This would necessite providing treatment for all cerebral-palsied children with incoordination of oral and pharyngeal movement, including those unable to use speech. In such children, vocal symptoms could be used as a kind of 'barometer', providing an important contribution to the ongoing evaluation of influential factors influencing swallowing and phonation. In assessing pharyngeal and laryngeal activity, a significant symptom might be an abnormal 'at rest' position of the larynx associated with distorted head and shoulder posture. A typical pattern of neck extension with face tilted upwards and the back of the neck shortened is often seen and is likely to be associated with tongue thrust, dysphonia, and delayed swallowing movements of the pharyngeal musculature. This abnormal posture is reinforced by attempts to retain balance and to use sight, smell, and hearing. Consistently maintained, it impacts upon extrinsic laryngeal muscles and indirectly affects the vocal mechanism inside the larynx. An optimal relationship between head and upper trunk renders the vocal cords maximally mobile and allows extrinsic laryngeal muscles to alter the position of the larynx vertically, thereby changing the length of the resonating column and enhancing pitch changes. It seems likely that abnormalities tend to be exacerbated as the individual grows older and when habitual posture is reinforced by extended periods of sitting.

Not only phonation is affected, but swallowing is also vulnerable to disruption caused by abnormalities of muscle tone, head control, and trunk balance. Suspended between head and upper trunk, musculature of the pharynx and the larynx is inevitably influenced by the position of the head above and the body below. A normal head/neck relationship is the foundation for stability of the jaw and hyoid bone. These provide bony anchorage points for muscles that move larynx and tongue. These are principal organs in both swallowing and speech. Whether concerned to promote efficient swallowing, maximize safety via effective coughing and throat clearing, elicit voicing, or develop prosodic control including appropriate intonational contours, the speech therapist needs to be able to interpret symptoms accurately. An understanding of typical intuitive compensatory strategies, e.g. the head–shoulder position described above will help.

Patterns of respiration are also relevant to safe swallowing. While poor adaptation of the breathing cycle for speech is often very apparent, it is less frequently recognized that many children and adults with cerebral palsy have difficulty in the automatic adjustment of breathing for swallowing. Normally this involves protection of the airway by coordinating the interruption of breathing with passage of the bolus through the pharynx and into the oesophagus. The high incidence of chest infections (Skuse 1985) in children with cerebral palsy is probably associated, at least to some extent, with aspiration of food due to incoordination.

AIM FOR INTELLIGIBLE COMMUNICATION

Adult speakers with cerebral palsy frequently complain that it is the sound of their voice, quite apart from the intelligibility of their speech, that distresses and irritates them. They are undoubtedly justified in

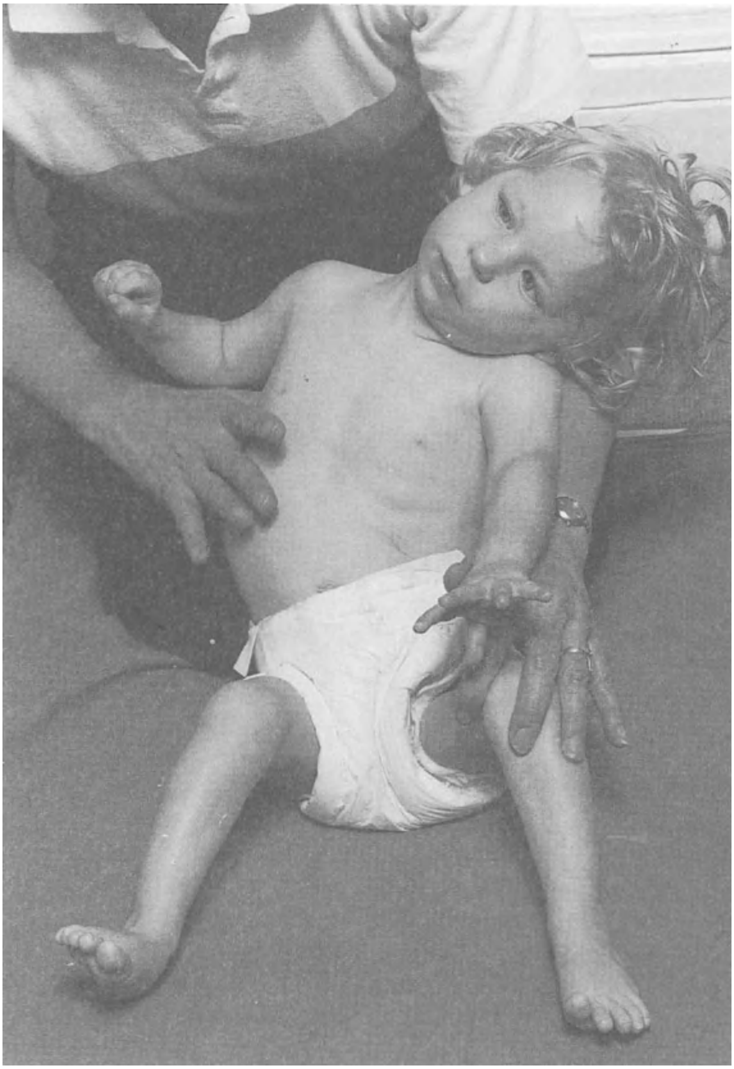

Figure 10.2(a) This child has to be fed on mother's lap and needs help with head and jaw control.

Figure 10.2(b) A modified jaw grip guides jaw movement during phonation in the prone position.

feeling misinterpreted. Dysarthric speech adversely affects listeners' perceptions of the speaker's personality (Lass *et al.* 1988). This is not surprising, given that vocal characteristics are part of an individual's personal identity. Resonance, pitch, pace, and rhythm can misrepresent speakers' moods and intentions (see later). Fortunately, working for intelligible speech is compatible with attaining enhanced voice.

Voluntary control may be severely limited. However, even small successes such as laughing without spasm of the whole body are valuable and the significance attached to calling 'Mummy', 'Daddy', or a sibling's name and producing a recognizable spoken 'yes' or 'no' testifies to the unique significance of human voice. Attempts to reach a level of at least minimum performance should not be abandoned lightly.

Aiming for intelligible speech means directing therapy towards goals of prosodic adequacy rather than articulatory precision. This is not a new idea. It has been emphasized repeatedly in print at least since 1949 (Peacher 1949). Phrasing, stress, and intonation, together with associated communicative gestures of body and facial expression are recognized to be more significant to communicative efficacy than precise and consistent articulation. This is not to say that working for some differentiated movement of jaw, lips, tongue, and palate is not a worthy aim. Production of isolated phenomes is not the goal. Remember that many children with 'delayed speech and language' who are not cerebral palsied demonstrate a delay in acquiring a full repertoire of consonants. Nevertheless, they are often intelligible communicators because they do not have restricted intonation patterns or because there is no specific impairment of movement patterns. These children 'get the message across' via appropriately intonated English vowel sounds and the occasional consonant and emphasize it by gesture (pointing, arm waving, and facial expression). In normal development non-verbal communication precedes speech, then proceeds to support and amplify it, and on occasion may take the place of speech. Although augmentative bodily gesture is likely to be impaired in cerebral palsy it may be possible to elicit basic vocal elements. Remember that voicing with intonation is heard normally rather early during the first year of life.

ASSESSMENT

As always, the therapist's essential tools are curiosity and observation. Assessment and treatment develop along lines determined by answers to a series of questions that therapists ask themselves. A typical question series is 'when?', 'what?', 'why?'. Each interrogative should also remind the clinician to check examined performance against the range of similar, target behaviour in individuals without impairment: e.g. when does this child vocalize? and when, i.e. at what age and in what situation would infants be *expected* to vocalize? Similarly what are the sounds, voice quality, and other phonetic characteristics produced by this individual? How do they differ from those expected? Why is this? Does perceived performance relate to maturity or pathology?

Embarking on the assessment and treatment of children with voice problems associated with cerebral palsy requires an understanding of the physiological processes of normal voice production, how these are affected by factors such as maturation, emotion, and social context, as well as the way in which they are likely to be affected by cerebral palsy. This entails the therapist combining experiential learning with relevant reading and an understanding of normal child development (Bax 1989). It is also important to remember that the eye only sees what the brain expects; similarly the ear, not only of patients but also of therapists, including those who write books on clinical practice. It is essential to keep an open mind, whether reading or treating. Predictably, it is easier to find literature on theoretical aspects: causes, symptoms, and classification are much less controversial than clinical intervention. The neurophysiology of the cerebral palsies is described by various authorities in journals and speech pathology texts. The latter tend to be littered with stereotypical descriptions of voice quality associated with types of cerebral palsy. The list of adjectives supplied (see 'Classification of dysphonias and treatment considerations', p. 205) can provide a comforting illusion of orderliness to undergraduates in pre-exam panic states, but clinicians must resist the temptation to replace clinical investigation with prejudice.

Mysak's neurophysiological speech index (1980) and the pre-speech assessment scales (Evans-Morris, 1982) are probably the most soundly based and comprehensive tools for assessing voice and related function. Their administration involves subjective assessment, but this is inevitable in clinical work. Both the Mysak and Evans-Morris assessment schedules are practical and they provide a clear rationale for the procedures employed in treatment. There remains a desperate need for rigorous clinical weaponry that will enable therapists to evaluate function precisely, plan effective treatment more easily, and also provide a method of measuring progress in subsequent reassessment. At the moment there is little available equipment for objective measurement by high-speed cineradiography, electrolaryngography, glottography, etc. outside research laboratories (Chapter 4).

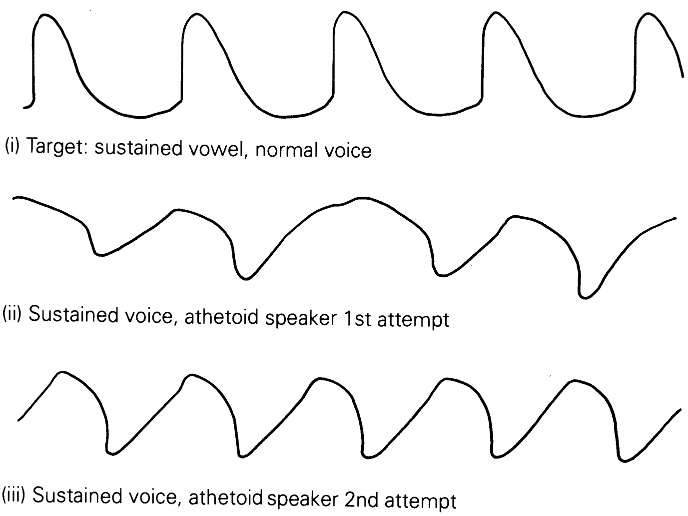

Figure 10.3(a) (Caption overleaf)

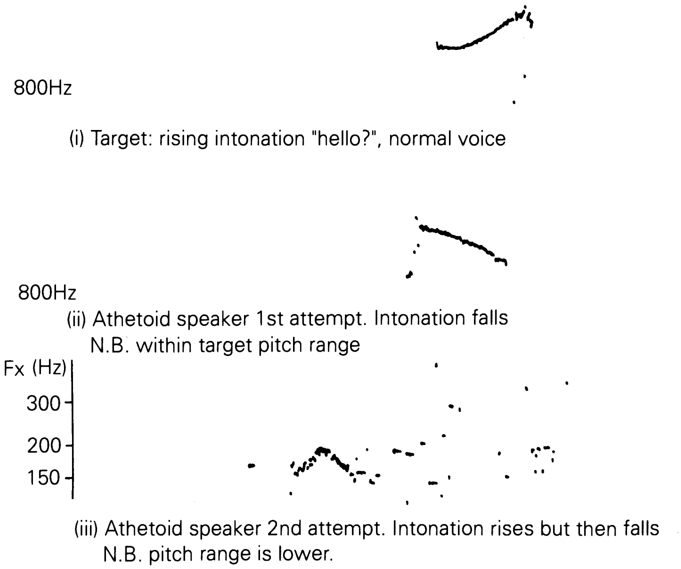

Figure 10.3(b) Laryngographic traces. The laryngograph provides objective evaluation of voice. (a) Athetoid speaker approximates target (trace (i)) at second attempt (trace (iii)). (b) Intonation falls instead of rising in this utterance of 'hello?' (This is a typical problem.) Subsequent attempt shows some rise, although it is still followed by a falling pattern.

Even if non-invasive technology for assessment and biofeedback (Fourcin 1974, Gibert *et al.* 1984, Guillemin and Nguyen 1984) were to be standard clinical equipment, many of the procedures involved would not be feasible for use with small, multiply handicapped people. With patients of any age, over-reliance on technology can invite isolation of parts of a complex whole in a way that confounds effective therapy. This can happen without technology. For instance, it is attractively straightforward to investigate the infant mouth for oral reflexes in the absence of food, using a manual examination of the child's face and interior of the oral cavity. The significance of elicited rooting and suckling is probably nil (Ingram 1962). It is almost always possible to elicit some primitive activity, but this does not translate to guarantees of functional feeding movements. Similarly with voice production: conventionally, vocal exercises include sustaining vowel sounds, but performance does not necessarily predict potential for producing useful speech. However, practice in making sustained vowel sounds may contribute to a useful therapy matrix (see below).

Assessment procedures appropriate for evaluating voice disorders in cerebral palsy are similar to those used with other aetiologies. They include examining phonetic characteristics, maximum phonation times, judgement of frequency range and intensity (Boone 1983, Darley *et al.* 1975, Hardy 1983). A major difference between dysphonia in cerebral palsy and dysphonia in people without other movement difficulties would seem to be the low expectations of many therapists about prognosis for cerebral palsy and dysphonia. Otherwise one would expect increased attention to be given to this area of work.

Well-structured assessments will include tasks of varying complexity and, sensitively administered, they should identify some successful achievement and be therapeutic in themselves. At the very least the assessment process should permit identification of dangers such as the unhelpful effect that speaking attempts have on the whole body (e.g. the speaker thrusting back in total extension on the initiation of speech). Evaluating performance requires teasing out the nature and degree of all contributory factors including hearing loss, anxiety, and pain. Speech therapy assessment and treatment are interwined. After initial assessment, further information about the nature of the disorder is provided by the patient's response to intervention, and monitoring treatment carefully provides continuous ongoing assessment. This is therapeutic because it increases insight of both therapist and patient into the nature of an individual's difficulties and ways to minimize them.

PHYSICAL METHODS FOR MOTOR PROBLEMS

Speech therapists tend to be practised in telling patients what to do. Typically, we excel in using verbal direction and explanation in treatment. Such skills alone are of little use in the treatment of developmental dysarthrias. These are sensorimotor disorders: therapists and parents have to learn ways to teach improved movement and the individual learns through movement and the sensory feedback it provides.

Physical contact and manipulation are required. It is a challenging business, which is frustrating when things do not work, but exciting and rewarding when they do. Some of the secret of success is to avoid continuing with techniques that are not working, while persisting with those that show signs of efficacy. Fluctuations in performance are likely but it should be possible to identify reasons for them.

Descriptions of the different philosophies and techniques employed in the physical management of cerebral palsy appear elsewhere (Mysak 1980, Scrutton 1984). It is essential that the speech therapist has a good understanding of the treatment approach used with children with whom he or she is working, and in addition some understanding of all the current principal approaches is required. These are based on the work of Fay, Kabat, Rood, Peto and the Bobaths. It is also valuable to have wide experience of working with patients who are not cerebral palsied but who have vocal difficulties. For instance the use of imagery in treatment and techniques taught by the Alexander School can be tremendously helpful adjuncts to the other therapies mentioned here, and some patients have found yoga exercises helpful for relaxation and improved breath control.

Head control and normal body alignment are principal aims in most physiotherapy regimes. Treatment that facilitates head control and normal head–trunk alignment will be beneficial for both swallowing and phonation. However, the pursuit of function often has an adverse effect, and so walking, manipulating, and speech attempts need to be carefully monitored. Not only must therapists (of various denominations) ensure that functional activities are carried out in a way that is as normal as possible, but everyone else concerned with the child must possess requisite understanding and practical skills. This is not easily accomplished, when children experience a number of different situations and encounter different people throughout each day. It is not surprising that regimes such as conductive education in which one individual, 'the conductor', is responsible for orchestrating the child's experience should be seen to achieve change. However, in any form of 'education' it is important to analyse all the factors involved and evaluate as objectively as possible. It is clear that many families whose children are receiving a form of conductive education in this country also seek specific help with voice, speech, and language.

Treatment approaches used by physiotherapists, occupational therapists, speech therapists, family, teachers, and care staff must be compatible. It is important to avoid 'cancelling out' the effects of treatment by injudicious mixing of different techniques founded on conflicting rationales. However, some apparent controversies can be disregarded. For example, given current theoretical knowledge, the debate over the relationship between reflexive vocalization and speech (see 'Facilitative approach', below) is only interesting at a philosophical level to therapists faced with a severely dysarthrophonic child. It is not dissimilar from questioning whether badminton skills assist or interfere with prowess in playing tennis. Both games involve developing skills that, although they differ from each other, share a common orientation. Importantly, there is a common background of knowledge about anticipating movement of the ball, holding the racquet, and so on. The situation of a cerebral-palsied child without a normal postural background, with no experience of normal primitive (albeit reflex-based) behaviours, is not dissimilar from the predicament of a candidate for Wimbledon Centre Court who has never held a racquet.

INTERVENTION ROUTES USED BY SPEECH THERAPISTS

There seem to be two main intervention routes used by speech therapists. They can be termed (a) facilitative and (b) compensatory. Implications for the treatment of children with dysarthrophonia (or who are believed to be likely to develop dysarthrophonia) are outlined below.

Facilitative approach

This assumes that vegetative movements of respiration and feeding underlie speech movements. Therapy, therefore, would be directed towards modifying abnormal at-rest breathing and promoting patterns of sucking and swallowing in infants. Biting, chewing and mature swallowing would be targeted as children grew older. But are vegetative functions and speech production directly related? Do movements of respiration and feeding impact on valving the vocal tract for speech? Can proficiency at this basic level predict or influence vocal performance?

Another assumption is that non-speech movements such as yawning and gagging, and also non-speech vocalizations, are associated with phonation and voice quality. Practising these non-speech activities is therefore expected to improve voluntary phonation. Again, however, it is not clear that such practice is helpful, although there is an intrinsic value in eliciting voice in terms of prelinguistic communication and enjoyment.

Finally, it is assumed that ability to produce isolated speech-type behaviours, such as consonant–vowel combinations, implies potential ability to produce and use intelligible speech. However, the extent to which practising isolated nonsense syllables, or even single words, may be expected to lead to improvement in the production of continuous speech is uncertain, although there may be some intrinsic value in rehearsing this kind of vocal exercise for other reasons.

The usefulness of oral exercises probably varies from individual to individual. Those with more involvement of oral musculature and less respiratory and phonatory paresis, or incoordination, may well benefit from an 'oral gymnastics' approach, and be able to incorporate learnt positions and movements of jaw, lips and tongue into their speech. Nevertheless, there are certainly individuals who are not able to generalize from such experience, and they seem to be those who have more (or equal) involvement of the thorax, pharynx, and larynx, that is, individuals with moderate or severe dysphonia. Here it appears fruitless to concentrate on oral movements for consonant production without first tackling the interaction between respiration and posture, which has been succinctly described as 'arrested movement' during any activity (Bobath 1980). Therapeutic methods employed to do this are more likely to be found in publications dealing with physiotherapy management of adults with acquired neurological lesions (Davies 1990). The interaction between respiratory, phonatory, and articulatory mechanisms are well described in speech pathology texts (Darley *et al.* 1975, Mysak 1980) but generally without recommendations on how to deal with the difficulties described.

Compensatory approach

In both these approaches speech production can be viewed essentially as a system in which air pressure is generated and controlled by a series of valves, although therapists adopting either approach may differ in their opinions about the origins and development of the system. The compensatory approach, however, assumes little overlap of any non-speech activity and propositional speech. Neuromotor programming of speech is considered unique and separate from the non-speech functions described in the facilitatory model. Thus, intervention is aimed at modifying dysarthric speech itself, that is, the entire vocal output, by teaching the speaker strategies which accommodate the neuromotor limitations.

Strategies would include accepting and adjusting to a short expiratory time, associated with low respiratory (tidal) volume and air wastage, by using short phrases. This contrasts with a facilitatory approach which would aim to first alter the breathing pattern. Paradoxically, a compensatory approach can become a form of facilitation. Deliberately slowing the rate of speech via pausing before stressed words and using phonetic approximation in place of those phonemes which are impossible for the speaker to produce are likely to be seen in treatment based on facilitatory or compensatory models. The strategies involved appear to influence breathing for speech, facilitate air flow and co-ordination of vocal-cord movement. Such phenomena are immensely interesting because they could imply availability of automatic adjustments between supply and demand routinely seen in intact neuromuscular systems. The way that this adaptation is brought about in people with cerebral palsy has not been satisfactorily explained, and indeed may vary between different individuals in various situations.

Merely providing the speaker with a strategy to use may reduce anxiety sufficiently to inhibit hypertonicity associated with psychological stress, which can overlay primary hypertonicity. Such individuals are particularly likely to make a tremendous effort to breath in before speaking. This forced inspiration results in hyperabduction of the vocal cords. It is counterproductive and any voicing obtained tends to be short and sounds effortful. The novelty of a consciously adopted manner of speech such as deliberately slow phrasing, may be a helpful distraction serving to maintain a reduction of tonus. Alternatively or additionally, improvement may be the result of acoustic and kinaesthetic feedback due to the induced behaviour having provoked changes in neurophysiological organization. Repeatedly breaking a stereotyped sensorimotor pattern may allow integration at a higher level; in this case true motor learning is taking place (Mysak 1980). Speakers who have previously used forced inspiration start an utterance with their vocal cords in a more normal 'at rest' position. A slower rate of speech is probably inevitable for dysarthrophonic speakers with spasticity, athetosis, or ataxia. However, variations in pitch and rate help to make slow speech acceptable. It is an even rate and limited pitch range that make it hard for listeners to accept the speaker's performance and truly listen to the content of his or her speech. Rather than presenting consciously slowed speech as a specific goal it seems to be more effective to emphasize reducing effort by teaching the speaker to use exhaled air efficiently through increased monitoring of the initiation of phonation, or contrasting voiced and voiceless sounds or exploiting pitch changes and pausing. This results in slowing speech in a more acceptable way than concentration on rate *per se*. The latter tends to produce a kind of syllable-timed regularity with a loss of aesthetic quality and reduced intelligibility.

A compensatory approach sounds attractively straightforward, since it implies that informed, motivated speakers should achieve speech which is at least intelligible. It also suggests that effective remediation is more likely when children can actively co-operate in therapy. Such conclusions are not always supported by observation of children with moderate to severe involvement of trunk and head control who are trying to speak. Typically they try too hard and aggravate symptoms as described. In addition, obvious difficulties in initiating and sustaining voice and controlling pitch and volume (often seen and heard) can result from a mistaken attempt at compensation based on the use of residual and abnormal movements. This will only lead to limited function and the effect is likely to be short-term.

INFANT BEHAVIOUR AND PRESPEECH THERAPY

The relationship between infant vocalization, voice and speech remains controversial. Developmental studies of vocal behaviour in normal and neurologically impaired children have been interpreted differently by various authorities. Advocates of a neurodevelopmental facilitative approach to cerebral palsy, exemplified by the Bobath School (Bobath and Bobath 1964, Mysak 1959, Evans-Morris 1982) view primitive reflex behaviours as natural precursors, and possibly prerequisites, of early speech development; neurological maturation results in suppression of reflex behaviours as higher brain centres are brought into operation. Differentiated and highly skilled movements result from the integration of earlier, more simple, activities. The process is facilitated by practice in combining and recombining sequences of movement similar to the way in which Bruner (1975) describes the acquisition of complex skills. Stark *et al.* (1978) would seem to support this view, observing that babbling and children's first words normally appear to be governed by the same 'natural phonetic preferences.'

Jakobsen (1968) disagrees: babbling is considered to be an essentially random activity; prespeech behaviour is seen as distinct and separate from first words. Lenneberg (1967) adopted a theory of compromise; he hypothesized that crying and vegetative sounds, such as coughing and burping, were unrelated to cooing and babbling, while conceding that the babbling might be a precursor of early speech development. However, two years later Wolff (1969) concluded that cooing incorporated vocal features of crying, and later Bosma (1975), suggested that babies' feeding movements influence non-reflexive oral activity.

For the first two months (and possibly for much longer in the case of neurologically impaired children), the vocal tract is controlled by primitive reflexes. The infant's vocal output comprises crying and discomfort sounds, vegetative sounds (such as burps) and various grunting noises that accompany movement. It is difficult to be comprehensive or precise in describing these sounds, although speech therapists treating babies suspected of having brain damage usually make an attempt to observe and record them. Stark *et al.* (1975) devised a classification system based on auditory and spectrographic information. This provided identification of primary features with various secondary characteristics that were dependent on them. Primary features were voicing, breath direction (egressive, ingressive, or changing direction), 'vowel-like', that is, open tract, or 'consonant-like' (when some form of closure occurred).

Analysis of various behaviours showed interesting similarities and differences. For instance, crying and discomfort sounds shared primary features; both were typically voiced and vowel-like and produced mainly on an egressive air stream. Vegetative sounds were different: they tended to be voiceless and ingressive, and intermittent closure of the vocal tract produced clicks, stops, and fricative noises. The infrequent consonant-like closures in crying and discomfort sounds on the other hand were usually nasal fricative sounds.

By the end of the second month, normal infants demonstrate increasing control over voicing. This development appears to be of paramount importance in the progression via vowel-like comfort sounds at about six weeks, to subsequent 'cooing' or early babbling at about eight weeks. At this stage however primitive reflex behaviour is unsuppressed. Early sound play is a mixture of crying, discomfort, and vegetative sounds; there is voicing, egressive breath direction, and consonant-type closure of the tract. A comparison of this performance with that of brain-damaged children reveals that many children with cerebral palsy continue to have difficulty in producing variations in their vocal play. Some neurologically impaired infants may only be able to produce voice when distressed, for example, in response to pain (Benjamin and Stark 1974, Stark 1978).

Children with any form of cerebral palsy are likely to have restricted and delayed development of early vocal patterns associated with delayed motor development. Their ability to initiate voice or experiment with pitch and rhythm in vocal play on their own, or in response to parents, will be enhanced by people handling them in a way that minimizes the effects of cerebral palsy and encourages a more normal postural reflex mechanism, in particular head control and balance (Bobath and Bobath 1964). By the time children are six months old they would normally possess a range of communicative behaviours that use voluntary control of head orientation and gaze (Martlew 1987). Retained startle responses, spasm, hypertonicity, or hypotonicity all disrupt the infant's communication.

Illustrations of the way in which infants combine prespeech utterances and non-verbal communication are recounted in the literature, together with comments on the similarity between some prespeech utterances and true words produced in parallel contexts. Stark (1978) cites the instance of an infant saying /ma/ /m/ /mae/ as he reaches for something he wants. All those utterances bear some resemblance to 'more' and 'mine', words that are produced later with (probably) similar intent. However, a cerebral-palsied child in such a situation is likely to have difficulty due to a lack of differentiated movement and incoordination. For instance the extension involved in reaching out an arm may induce associated extension elsewhere. This associated reaction might be hyperextension of the jaw or generalized hyperextension of the whole body. The involuntary wide-open oral position will proscribe making the bilabial sound /m/ and is likely to produce delayed production and distortion of the vowel sound(s). Treatment for this kind of difficulty would involve promoting selective movements by preventing, in this case, jaw movements being associated with arm extension, and then the facilitation of graded, controlled jaw opening.

So an initial aim of treatment might be preparation for phonation and would not involve directly working on voice at all. Where very young children are concerned, immediate goals might be eliciting voice whilst moving the child, e.g. during rolling from supine to side lying. Appropriate sounds would be those usually heard in early vocalization, primarily nasalized vowel sounds followed by consonant-like interruptions produced by movements of tongue (initially in association with jaw movement) and lips. It is important that the therapist is thoroughly familiar with the typical developmental sequence and range of sounds produced in infancy and the way this correlates with aspects of motor development. For instance, it is not until children are acquiring the head and trunk control necessary for unsupported sitting during the second half of the first year that vocalizations become organized into repetitive babbling and 'proto-words'. The neurological maturation that provides anatomical stability for articulators is presumed to be necessary for the increasingly precise phonatory patterns and this means that speech therapists need to know how to promote the development of head control as well as language learning experience in prespeech children with developmental motor disability.

It has already been said that although some authorities recommend teaching consonant production in isolation, it is difficult to believe that any skill developed in this way might be integrated into speech by a process of neurophysiological maturation alone. The theory is comforting but clinical experience is cautionary. Instead, developmentally based treatment would proceed to elicit vowel and consonant combinations. In this way vowels can be alternated with lip closure leading to the meaningful /ma/ /m/ /mae/ utterances described by Stark. This might be achieved via a route in which phonation for the vowel sound is initiated, then channelled nasally by assisted lip closure. The vowel–consonant sequence is repeated easily and rhythmically before attempting to initiate the utterance with lip closure for the bilabial nasal sound /m/. Obviously, this work is presented as a game for young children and rhymes or songs with a repeated vowel–consonant combination in them are used. Adults also benefit from using phrases and rhythm rather than rehearsing isolated phoneme production.

RESPIRATION AND BREATHING FOR SPEECH

Disordered respiration usually coexists with laryngeal and articulatory dysfunction in individuals with cerebral palsy. If this were not the case, speakers would probably be able to compensate in the way that those with lower-motor neuropathies such as poliomyelitis, are able to do (Hixon *et al.* 1983).

It is probably true to say that reduced respiratory control alone does not produce 'clinically significant' speech (Hardy 1983). Unfortunately, the central lesions of the cerebral palsies lead to disrupted patterns of movement, not to discrete paralysis of individual muscle groups. This fact does not preclude the possibility of different kinds of disruption being caused to different components, or subsystems of speech. However, at the moment it is difficult to translate hypotheses about regulatory control from contemporary research (Lesny 1980, Abbs *et al.* 1982), to clinical fingertips.

In the present state of clinical knowledge the description and interpretation of symptoms and selection of treatment methods are likely to be based on a concept of hierarchical neurophysiological organization and inevitably constrained by the feasibility of investigative procedures. As always, therapists need to understand the patterns of movement involved and their purpose, in order to assess malfunction and alleviate it.

In any consideration of respiration for speech in patients with a lack of postural control and co-ordination, it is important to evaluate control of eggressive air. This is much more difficult to measure than making crude estimates of capacity or peak flow. It demands taking account of the way respiration is influenced by different positions. One of the most difficult positions for many patients is sitting (see Figure 10.4a). An alternative position such as supported standing, may provide an improved background for breathing and phonation. This illustration of a child with athetosis and spasticity (Figure 10.4b) shows the advantages for trunk alignment. Supported standing facilitates abdominal musculature, which in turn supports more normal diaphragmatic and intercostal movement. It should be remembered that vast amounts of air are not required for phonation and attempts to obtain them by people with cerebral palsy are generally counterproductive and time-wasting; they should not be encouraged by clinicians, nor by parents who may intuitively, but erroneously, urge children to 'take a deep breath'. The importance of inspiratory chest expansion and the way that it seems to facilitate recoil contraction of expiratory muscles is not disputed. However, it is the control of egressive air pressure that seems to present the greatest problem for the majority of speakers with developmental dysarthophonia. This is particularly noticeable at the beginning and end of utterances. Phonation is rather like flying: skilled control is demanded at take-off and landing, both initiation of voice and its cessation require precise synchronization. The physical background for the highly selective skill of phonation is essential and demands maximum use of muscles of the trunk, including the abdominals (Davies 1990).

In normal phonation the outgoing air is obstructed by adducted vocal cords and by the organs of articulation. The sudden, rapid alterations in impedance that are caused, demand appropriate and prompt increases in subglottic air pressure. Typical problems of instability (associated

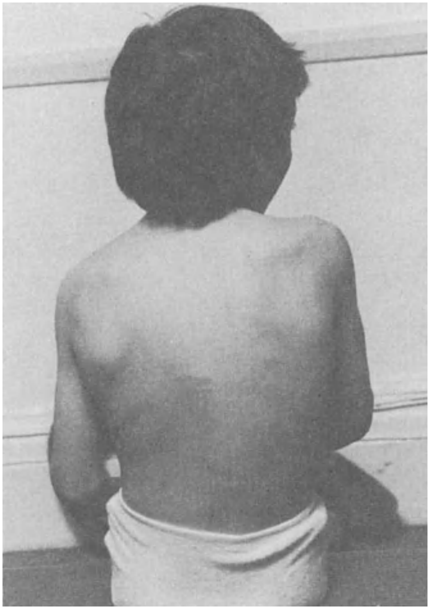

Figure 10.4(a) Spasticity and scoliosis in this eight-year-old boy severely impair respiration, phonation, and articulation.

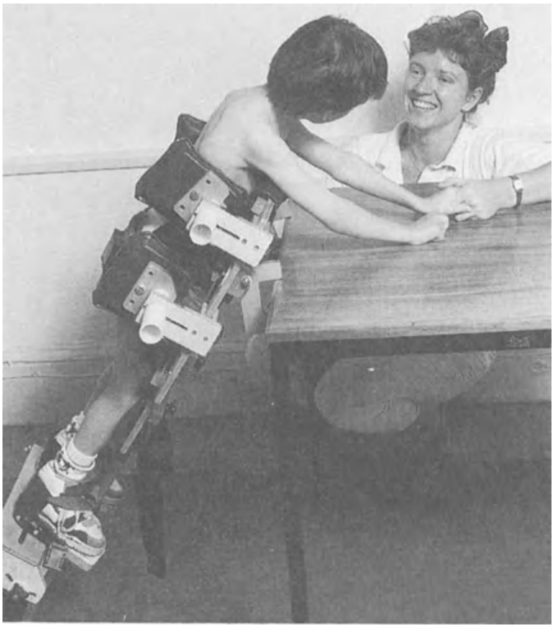

Figure 10.4(b) Upright positions promote symmetry and are preferable to sitting when speaking or using a word-processor.

Figure 10.4(c) A variation of the upright position.

with athetosis and ataxia), lack of mobility (associated with spasticity), and difficulty in obtaining graded muscular contraction seen in all types of cerebral palsy often result in breath being *pushed* out forcefully. This is done by simultaneously contracting ribcage and abdominal musculature, and it works up to a point. As Cavallo and Baker (1985) point out, it is an inefficient method of increasing air pressure. Success is limited since this mass effort cannot provide for speedy alternation between high and low pressures. The vocal symptoms produced by the strategy range from loud, uncontrolled voice at the onset of phonation, which becomes increasingly breathy and then aphonic, to delayed onset of voice and a low-pitched monotone. The basic problem remains a lack of co-ordinated muscle movement and this is exacerbated rather than improved by forced expiration when phonation attempts result in an increase in the irregularity of the bursts of air through the larynx. Using this kind of compensatory technique risks incurring abdominal pain or discomfort. This is certainly experienced by some adults with athetosis.

Early intervention would aim to prevent a child acquiring the habit of forced phonation in this way. If therapy is successful, speech will still be dysarthric, but it will be less abnormal than it would otherwise be. There will be fewer secondary symptoms associated with speech attempts, such as further disturbance of posture, balance, and facial movement, fatigue and pain.

As a general rule it seems unhelpful to work on respiration separately from vocalization. Facilitating automatic adjustments via careful positioning and movement, and controlling unwanted activity during voicing, seem to be more productive than attempting conscious regulation of breathing (which would be impractical anyway with young children). This, of course, represents an important difference from traditional approaches to acquired dysphonias. The traditional concept of therapeutic relaxation is also inappropriate. Attempts to invoke Jacobsen-style progressive relaxation (1929), which is consciously controlled, are usually doomed to failure unless they are integrated with more specific treatment. Exhortations to 'relax' are similarly doomed at least until the child has experienced muscle tone and movement patterns that are as near normal as possible, in other words, when treatment has facilitated 'neurophysiological relaxation' (Mysak's term). Older people may learn to use various methods of voluntary relaxation.

Inspiration and expiration can both be influenced by practising prolonged vowel sounds. For children this might involve using an extended neutral vowel in games where the vowel represents the engine noise of a car, for instance. Feedback from successive attempts to prolong the vowel (make the car travel further), should result in increasing both intake of air and control of output. The system responds to the demand more efficiently, providing appropriate techniques have been used.

Initiation of voice is often problematic for dysphonic patients of any age, and although humming and sighing exercises are still recommended in the literature they tend to be difficult for many individuals. Inefficient and intermittent voicing are typical problems and phonation tends to be accompanied by associated reactions such as generalized flexion in those with flexor spasticity.

Adopting a Bobath approach, therapeutic positioning would exploit extension and flexion, associated with breathing in and out respectively. Upright, weight-bearing positions make use of proprioceptive feedback to gain stability and to raise tonus in children with flaccidity or fluctuating muscle tone. This last group of children are those most likely to show symptoms of paradoxical or reverse breathing. In this pathological pattern the downward movement of the diaphragm on inspiration is not accompanied by simultaneous intercostal contraction to swing the ribcage upwards and outwards. This means that the chest wall is pulled inward by the descent of the diaphragm. These children have flared lower ribs and indented thoracic walls; sometimes the sternum is also indrawn. These deformities become fixed over time. Treatment involves inhibiting or delaying diaphragmatic movement, so preventing inspiratory intercostal movement being overwhelmed. Placing one's hands around the child's lower chest can stabilize the trunk and hold the rib-cage down (imitating the function of normal abdominal musculature). The manoeuvre can be carried out in infants while on their mother's knee, easily maintaining face-to-face contact and conversation. It is, however, difficult to ascertain generalization, or 'carry-over'.

LONG VOWEL SOUNDS VERSUS WORDS

Aim to control sustained voice for at least four seconds (personal clinical observation). Normal speakers can maintain a vowel sound for at least 15 seconds and Hirano (1981) suggests that less than ten seconds is pathological. This exercise might appear to be simpler than sustaining voice in connected speech. However, it is not necessarily the case and vowel sounds should not be practised to the exclusion of other utterances at any stage in treatment. Clinical reports have shown that persistently short phonation times, intermittent voicing and uncontrolled pitch changes are not only discouraging for patients but paint an unnecessarily pessimistic picture of the possibilities for acceptable voice and intelligible speech. The laryngographic tracings (Figure 10.3) of an adult with athetosis show an acceptable and improving performance on a task requiring control of articulation and intonation. The same speaker was unable to produce a consistent and sustained vocal note on vowel-only tasks and his performance degenerated with effort and frustration. Having achieved a range of intonation patterns in phrases and longer utterances it was easier for this speaker to sustain a vowel sound, although voice was still unsteady. Patients typically underestimate their own performance, and using objective measurement such as laryngographic feedback not only enables older children and adults to work independently but can help to establish a 'benevolent circle' of self-confidence and neuromuscular control.

VOWEL-TO-VOWEL PHONATION

At the same time it should be said that some of the disappointments experienced by clinicians and their clients may be caused by trying to transfer too quickly to meaningful speech with excessive phonetic demands. Consonant–vowel combinations require a degree of co-ordination that may be beyond a patient's current capability. If this is the case, proceeding from neutral vowel to other vowels and diphthongs without interrupted voicing is indicated. Demand is increased gradually and can be monitored using electrolaryngography, providing this is feasible for the individual concerned.

Ideally all the vowel sounds should be elicited as early as possible so that children acquire a wide vocabulary of vowels. If voice can be initiated without exaggerated jaw movement, and the child has a repertoire of vowel sounds with some pitch control, there is an excellent basis for intelligible communication.

VOWEL–CONSONANT (VC) COMBINATIONS

Some children have less difficulty than others, so practice in VC combinations might precede or accompany vowel-to-vowel exercises. It is often helpful to interrupt nasalized vowels with facilitated movement of jaw and the back of the tongue and then progress forward to front sounds. Some would say that this follows a normal developmental sequence, in fact, as it mimics the consonantlike sounds of early infancy.

Eliciting the transition from vowel and consonant combinations may follow a sequence like this: 1, nasal neutral or open-back vowel elicited (facilitated by positioning with movement and possibly jaw control and vibration of the chest); 2, vowel interrupted by facilitated velar nasal /ŋ/; 3, followed by continued phonation on the same vowel. It is important that voicing is maintained during transition to the second target sound of each pair of vowels. In this way a staccato delivery and intrusive neutral vowel-like grunts can be avoided. At first, movements are slow and sounds are prolonged. With practice, normal and acoustic changes are accomplished more quickly, although duration of diphthongs is usually longer than normal.

PARENTS AND EARLY INTERVENTION

Voice is essentially a vehicle for speech or spoken language. Parents' intuitive behaviour is increasingly acknowledged, by 'experts' like psycholinguists and speech therapists, to be the most effective catalyst in the development of a child's language (Bruner 1975). The way in which parents of children with learning problems accommodate their children's language difficulties has been described as conversational 'buffering' by Stanhope and Bell (1981) and illustrations of this behaviour appear in descriptions of mother–child interactions (see, for example, Bryan *et al.* 1984). Intuitive behaviour of parents whose child is cerebral palsied can appear to be inhibited or depressed because the child's spontaneous signals, which would normally help to elicit parental behaviour, are absent, infrequent, delayed, or distorted. In addition, parents are likely to lack confidence and be self-conscious, and anxious about the best way to manage when a persisting disability is suspected or confirmed.

Confirmation of cerebral palsy in early infancy is only likely when children are severely disabled, or when they show obvious hemiplegic asymmetry. Therapists should be involved before confirmation. As soon as any degree of disability is suspected there should be careful monitoring of progress. Early intervention might include counselling parents, explanation, demonstration and practice in interactive play. Physical handling of the child facilitates the most normal and pleasurable experience of movement.

Handling must also permit and promote eye contact with mother, and hand-to-face contact, as well as inhibiting abnormal physical responses to the exciting stimulus of the parent's voice. Such reactions interfere with early listening and associated behaviours, such as turn-taking.

Understanding the way in which extension of the trunk promotes inspiration, and that subsequently flexing the child's legs (at knees and hips) particularly while leaning over the baby with a smile is likely to produce vocalization, is not only helpful in giving the child experience of vocalization and social interaction, it also enables the parents to feel successful and confident in their parenting ability. Vocalization that is as normal as possible and disrupts muscle tone as little as possible, contributes to more normal family relationships. Just as the child learns from sensorimotor practice, parents need opportunities to put learning into practice under supervision.

Sensory input should include combining this kind of interaction (that is, mother's speech, and the child's early speech or prespeech vocalizations), with daily activities, in particular those that would be typically accompanied by mother–baby conversation. These include nappy changing, washing, dressing, and mealtimes. Positioning and moving the child therapeutically during these activities can exploit patterns of trunk extension, flexion, and rotation. All these increase thoracic movement for respiration. Also, because the child is not static there tends to be more spontaneous automatic vocalization than when children are held in fixed positions. This is not surprising: small children are normally noisiest during active movement, whether lying supine and kicking their legs, playing with their fingers, or engaged in rough and tumble play. Experience of automatic voicing is reduced or missing in many cerebral-palsied children. Yet it is usually easy to elicit a variety of vowel-like sounds by making use of active movement, or if this is not possible, perhaps moving the child passively. In both cases the therapist or mother accompanies the facilitated movement with her own vocal cue or model, and inhibits undesired associated movements or reactions. It is essential that primary carers (usually the parents) learn to handle the baby in a way that facilitates vocalization during daily activities.

CONCLUSION

The management of dysphonia associated with neurodevelopmental spasticity or dyskinesia cannot be separated from the management of all coexisting symptoms. Consideration of vocal function must be made in the context of each individual growing child and neurological systems which have been damaged during development. Each client presents a new challenge to the clinician; therapy has little hope of success if it is not founded on careful and comprehensive assessment, and then carried out with at least a modicum of determined optimism. Optimism is more easily sustained when the clinician has developed a rationale for the approach employed based on a good understanding of phonatory mechanisms and syndromes of cerebral dysfunction.

The preventative aspects of treatment are important. Once faulty vocal habits have been acquired, and particularly if they are associated with abnormal posture or movement that becomes fixed by contractures, improvement possibilities become increasingly limited. It should be noted that intensive work with young adults with athetosis and no fixed postural deformities has indicated that change may be brought about even in adult life.

As stated at the beginning of this chapter, the whole area of voice, speech and communication in people with developmental disabilities suffers from a lack of policy and service organization. Services vary across the Health Districts and speech therapy resources are universally depleted. All cerebral-palsied people with dysphonia would benefit from periodic review of symptoms followed up by appropriate treatment. In some cases this might involve self-help programmes. These might include using biofeedback (Abberton 1989) and 'emancipatory' assistive technology for communication (Odor 1984).

To date, the statutory changes that are bringing about desegregation of children with special needs are inadequately funded. Long-term provision would be more feasible if there were to be a central agency or association responsible for child health care. Additionally, long-term provision of remediation would be more feasible if there were to be a comprehensive health care programme for those with physical disabilities as recommended for instance by Thomas *et al.* (1985). Without a policy of service provision for people with cerebral palsy that addresses the range of difficulties experienced by people in this group, in which communication is weighted as heavily as walking, it is difficult to see how the needs of people with cerebral palsy and communication difficulties can be met.

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11

Voice problems in the dysarthric patient

Sheila Scott and Brian Williams

INTRODUCTION

Speech therapy for voice disorders of neurological origin used to be considered as unrealistic and of limited value, particularly in progressive disorders (Peacher 1949, Sarno 1968). This attitude has gradually changed with reports of successful research and case studies (Canter 1965a,b, Rosenbek and La Pointe 1978, Scott *et al.* 1984). There are a limited number of type-specific treatments available, but the same kinds of therapy can be applied to many types of dysarthria, the emphasis of treatment altering for each individual.

Earlier definitions described dysarthria as 'defective articulation of speech'. This traditional approach is frequently adopted in medical textbooks despite being imprecise and inadequate (Peacher 1949, Darley 1984). Yet as far back as 1911, Gutzmann (Berry 1984) indicated that dysarthria could encompass not only defects of articulation, but also respiration, voice quality, vocal pitch, and rate of speech.

Peacher (1949) suggested that in describing those neurological speech disorders in which articulation and phonation were involved 'dysarthrophonia' was a more appropriate clinical term. Grewel (1957) proposed that this term should be extended, for accuracy, to include the defective respiratory component and coined the phrase 'dysarthropneumophonia'. The implication was that this might influence therapists to consider such voice problems holistically and encourage treatment of the 'whole problem' rather than focusing attention upon one feature to the detriment of others (Greene 1980).

Such terms are useful as a means of clinical description, and thereby in the direction of therapy, but they could be taken to extremes – for example, 'dysarthropneumoreasonoprosodophonia'. Fortunately we have not reached such extremes, and today it is generally agreed that the term refers to a group of speech disorders arising from neurological causes and affecting all motor and temporal aspects of the vocal tract (Darley 1984, Netsell 1984). Rarely does one encounter disorders of articulation and phonation occurring in isolation in such neurological disorders (Hardy 1967).

The problems of voice described in this chapter are classically described by Darley *et al.* (1975), as being included in a group of related motor–speech disorders resulting from disturbed muscular control over the speech mechanism, arising from disorders of the central or peripheral nervous systems and encompassing coexisting motor disorders of respiration, phonation, articulation, resonance, and prosody. Thus the use of the term dysarthria rather than dysarthrophonia is generally accepted and strongly recommended.

Our knowledge about the prevalence and incidence of the dysarthrias is limited. Statistics published usually relate to those individuals who have sought doctors' or speech therapists' help. However, epidemiological aspects of certain diseases associated with dysarthria are well known and thus the prevalence of the speech disorder may be recorded (Table 11.1). Dysarthria may complicate a wide variety of neurological disorders (Table 11.2).

CENTRAL DISORDERS

Dementia

It is somewhat controversial to consider dementia as a cause of dysarthria and much research is needed before the picture is clarified. However, while dysarthria can obviously be associated with dementia, it is important that the speech disturbances characteristic of dementia are mentioned and borne in mind with therapy.

Table 11.1 Prevalence of dysarthria in four neurological disorders

	Study	*Prevalence of dysarthria (%)*
Multiple sclerosis	Darley *et al.* (1972)	49
Parkinson's disease	Merritt (1977)	50
Motor neuron disease	Kurland (1977)	25–30
Stroke disease	Kurland (1975)	8.8

Source: Enderby 1985, personal communication.

Table 11.2 Neurological disorders associated with dysarthria

Central	*Upper motor neuron*	*Lower motor neuron*	*Extrapyramidal*	*Cerebellar*
Dementia	Congenital diplegia	Disorders of cranial nerves	Parkinson's disease	Multiple sclerosis
	Stroke			
	Motor neuron disease	Bulbar palsy	Chorea	Hereditary ataxias
	Head injury	Poliomyelitis	Wilson's disease	
	Tumour	Syringobulbia		Vascular lesions
	Multiple sclerosis	Tumour		

Dementia is associated with a global loss of intellectual function that is usually irreversible. It affects about one in ten of the population over the age of 65 (half of them severely) and one in five of those over 80. Both sexes are equally affected, but more women survive into old age and therefore female cases predominate. Senile or non-vascular dementia of Alzheimer type accounts for most cases of dementia and most of the others have vascular or multi-infarct dementia. A small number of cases (less than 5%) may, however, have a remediable cause for their dementia, such as thyroid disorders or vitamin B_{12} deficiency. In the more severe cases management problems will include a tendency to wandering, nocturnal disturbance, and an inexorable deterioration in self-care in association with worsening confusion. Support for relatives is a prime consideration and full-time institutional care may be necessary. Numerous drugs have been developed in an attempt to improve intellectual function, but none has shown more than minor symptomatic improvement.

Speech disturbances are characteristic of the dementias. Features of voicing difficulty are manifested as disordered rate and volume with disturbed rhythm and pitch. Difficulties in initiating and maintaining speech are also common (Critchley 1970, Espir and Rose 1970). One of the most significant voicing characteristics is habitual use of high-pitched vocal quality.

Improvement in vocal production may be observed following intensive reality orientation treatment procedures, particularly in mild dementia. It is an area currently receiving much-deserved study.

UPPER MOTOR NEURON DISORDERS

The articulatory muscles on both sides are innervated by both cerebral hemispheres. A unilateral corticospinal lesion (such as vascular lesion in the internal capsule) may cause temporary but not usually permanent dysarthria, although an extensive unilateral lesion involving the motor cortex may cause persistent dysarthria.

Pseudobulbar palsy

Bilateral corticospinal lesions may be due to congenital diplegia, vascular lesions of both internal capsules, motor neuron disease, tumours of the midbrain, or multiple sclerosis. This syndrome is usually associated with dysphagia and impaired voluntary control over emotional expression. The tongue is usually smaller than normal because it is spastic, but the muscles are not wasted.

One of the most distinguishing features of voice production by such patients is 'laryngeal hypervalving'. Darley *et al.* (1969a) categorized this through two perceptual dimensions of voicing: 'harshness' and strain-strangled voice quality, produced with effortful phonation. Excessive nasal resonance is present where there is palatal weakness. There has been little research into the breathing patterns of such patients but the Mayo studies observed excessively short phrasing. The lack of laryngeal control and synchrony have considerable effects upon pitch and intensity variability (Darley *et al.* 1969b). Although Kammermeier (1969) found pitch variability to be reduced he concluded that it was not more significantly reduced in pseudobulbar palsy than in other types studied. He did note, however, that in measuring vocal frequencies the pseudobulbar-palsy subjects had considerably lower fundamental frequencies that were more in keeping with the levels achieved by Mysak (1959) in a normal sample (65–70 years); yet the pseudobulbar-palsy subjects were on average more than ten years younger.

Aten *et al.* (1984) have reported the benefits of modified palatal lifts. Pseudobulbar-palsy patients with dysarthria showed a minimal change in phonation time with the lift, reduced hypernasality, and improved overall intelligibility.

If the harsh vocal quality occurs in conjunction with extreme tension, relaxation of the supralaryngeal musculature may prove effective. Facilitation techniques, massage, or electric brush vibration in the area of geniohyoid and digastric muscles may be valuable (De Jersey 1975, Rosenbek and La Pointe 1978).

Combining forces with the physiotherapist is invaluable in these cases. Specific respiratory stimulation through excitatory cold and respiratory resistance exercises are often found to be of benefit (Goff 1969). However, Hardy (1968) suggested the removal of the demands on respiration, as reduced vital capacity is less crucial than we commonly imagine. Therapists should emphasize an efficient use of the exhalatory air stream, by teaching the patient to make the best use of his residual respiratory support. The pursed lip breathing techniques described later are also recommended with speech phrasing and prosody. Voice therapy must co-ordinate respiratory flow with phonation (Greene 1980).

As with other dysarthrias, therapists should aim to improve posture for speech, swallowing, and communication techniques. The exercises described above are of no value if they are carried out in isolation.

LOWER MOTOR NEURON DISORDERS

These disorders include cranial polyneuritis, progressive bulbar palsy (MND), bulbar poliomyelitis, syringobulbia, and brain-stem tumours. True bulbar palsy presents with wasting, weakness and fasciculation of the tongue muscles. The labial muscles are affected first and thereafter the muscles of the tongue and soft palate, producing a nasal quality in the voice. Similar dysarthric features may present in the myopathies, for example, myasthenia gravis, polymyositis, and muscular dystrophy.

The speech characteristics are well described in Darley *et al.* (1969b). There is muscle weakness, with flaccidity and atrophy of individual muscles, breathy voice quality, audible inhalation, abnormally short phrases, monotony of pitch, imprecise consonants, and monoloudness. Suggestions for therapy follow in the general treatment section (p. 248).

Motor neuron disease (MND)

This is a disease of late middle life and usually begins between 50 and 70 years of age. Variants of the disorder include amyotrophic lateral sclerosis (ALS), progressive muscular atrophy, progressive bulbar palsy, and motor system disease. Degenerative changes occur in the anterior horn cells of the spinal cord, the motor nuclei of the medulla and the corticospinal tracts. More common in the male, the condition is of unknown aetiology and clinical manifestations may include either upper motor neuron lesion signs of corticospinal degeneration, with weakness and spasticity in the legs, or lower motor neuron lesion signs of weakness and wasting of muscles, or a combination of both. The patient experiences increasing difficulty in speaking and swallowing. MND is progressive and treatment is symptomatic.

The function of all the muscles used in speech may be impaired. Vocal symptoms cover the entire spectrum from none to complete aphonia. Darley *et al.* (1975) considered that the speech gestalt of ALS consisted of grossly defective articulation of both consonants and vowels, often rendering speech unintelligible, laborious speech production, marked hypernasality, and poor adduction and abduction of the vocal cords. The inefficiency of valving results in short phrasing, but the overall effects are of breathlessness, audible inspirations, and severe vocal harshness. Recent studies by Putnam and Hixon (1984) support the concept that chest-wall muscle weakness and wasting curtail the inspiratory and expiratory extremes of the lung volume range; they have stressed that despite this, however, subjects may still be able to produce enough volume displacement and compression to support conversational demands.

There is little specific speech therapy treatment. In the early stages of swallowing difficulty, brushing and icing can be of some assistance. Similarly, tongue movements are reinforced by head positioning. Flexion and extension of the neck facilitate depression and elevation of the tongue. Head rotation can also stimulate lateral tongue movements.

EXTRAPYRAMIDAL DISORDERS

Parkinson's disease

Parkinson's disease (PD) is one of the more common neurological disorders and it has a number of causes, but only those due to drugs (mainly phenothiazines) or of the idiopathic form are numerically important. The incidence increases with age, and at any one time approximately half of those affected are over 70 years of age. The underlying cause of PD is a degeneration and loss of neurons in the substantia nigra and elsewhere in the brain, with an associated decline in dopamine synthesis. Typical clinical features include rest tremor, muscle rigidity, and bradykinesia. Effective drug treatment with dopamine agonists such as levodopa or bromocriptine has modified the natural history of the disease and improved the quality of life for most patients.

Half of Parkinson's disease patients have speech disorders (Scott *et al.* 1985), and there is no apparent relationship between the duration of the disease and the degree of speech involvement. The parkinsonian speech disorder includes hypokinetic dysarthria, and dysphonia. Levodopa effectively improves speech intelligibility in most patients (Mawdesley and Gamsu 1971, Wolfe *et al.* 1975). However, despite otherwise optimal drug responses, speech difficulties may persist (Scott and Caird 1983).

The phonatory aspects of speech are often considered to be the salient feature of hypokinesia (Darley *et al.* 1975). The vocal levels of pitch are considered to be more characteristic of an older age group. Pitch variability is limited and often monotonous.

The respiratory function of parkinsonian speakers is restricted, in keeping with the other musculature involved. De la Torre *et al.* (1960) noted irregular and inflexible breathing patterns and a marked reduction in vital capacity.

Kim (1968) and Mueller (1971) considered that the reduction and monotony of vocal intensity were attributed to the loss of amplitude and rigidity of chest musculature. However, Ewanowski (1964) noted that parkinsonian subjects performed as well as normal controls during sustained phonation, under strictly controlled conditions, when verbal reinforcement was given to them.

The vocal quality and intensity studies of Canter (1963, 1965a,b) are well known, as is the work of Darley *et al.* (1975). However, Cisler

Table 11.3 Traditional methods of speech therapy in parkinsonian speech disorder

Method	*Method aim*	*Technique*
Chewing therapy (Froeschel 1948)	Improving voicing Correct pitch placement	Chewing vigorously while simultaneously voicing
Eurhythmic approach (Smith 1951)	Improving breathing Improving voicing	Relaxed total body movements in rhythmic sequences during vocalization
Forcing exercises (Butfield 1961)	Improving vocal-fold adduction	Synchronized pushing with voicing
Syllabic speech (Andrews and Harris 1964)	Reduce tension Improve speech rhythm	Speech is timed to a slow and regular tapped syllable
Amplification (Greene and Watson 1968)	Reduce tension Increase voice volume mechanically	Patient's voice is amplified by a mechanical aid
Metronome therapy (Wohl 1968)	Improve speech rhythm Improve voice onset	Syllable timed speech using a metronome aid
Group therapy (Allan 1970)	Improve voicing, rate and clarity	Group practice of selected articulation exercises, speech phrases, and conversation practice

Source: Scott *et al.* (1985).

(1927) noted that the limited closure of the glottis in Parkinson's disease, in conjunction with a loss of synchrony with articulatory movement and vocal cord movement, caused a breathy vocal quality.

The treatment of vocal disturbance in Parkinson's disease has recently been considerably modified. In the past many methods were considered; these are summarized in Table 11.3. Perhaps the most commonly encountered method was the use of amplification as advocated by Greene and Watson (1968) which was found to increase the voice volume mechanically, thereby reducing tension. However, the patients were dependent upon a mechanical aid and, although there was some carry-over in the therapeutic situation, there was often very little carry-over beyond

Table 11.4 Speech therapy techniques in parkinsonian speech disorders

Method	*Method aim*	*Technique*
Pacing board (Helm 1979, after Luria)	Reduce rate Inhibit initiation difficulties	Patient feels along a stepped board The physical barrier met by the hand is transferred into speech
Delayed auditory feedback (Downie *et al.* 1981)	Reduce rate Overcome onset difficulties	Mechanical feedback masks the patient's speech, causing reduced rate and sound prolongation
Proprioceptive (Scott and Caird 1981)	Improve rate rhythm, intonation, vocal expression, vocal intensity	Exercises emphasizing the affective and prosodic aspects of speech
Residential holiday therapy (Robertson and Thompson 1983)	Social and conversational improvement	Intensive group therapy
Visual feedback (Scott *et al.* 1983)	Social and conversational improvement	Individual, intensive and group
Auditory feedback (Johnson 1987)	Gains in intelligibility	Individual treatment
Pitch analysis (Robertson 1989, personal communication)	Gains in intelligibility, alleviation of monotony	Individual therapy

this. Syllable timed speech, with the aid of a metronome advocated by Wohl (1968), was found to improve speech rhythm and voice onset time and was also a popular method of therapy for Parkinson's disease patients. This method also relied upon a mechanical aid, however, and carry-over without the aid was limited. More recent methods of therapy are summarized in Table 11.4. The prosodic method advocated by Scott *et al.* (1984) highlights the necessity to focus the treatment away from the improvement of respiratory, phonatory, and articulatory components, and shifts the emphasis to suprasegmental and prosodic features of speech. Prosodic variables make a significant contribution to the intelligibility of speech, and therapeutic efforts directed at these features improves intelligibility of speech. Clinical practice suggests that articulation also improves. For too long dysarthria therapy has focused solely on attempts to improve segmental production and, although this is important, equal emphasis should be placed on the suprasegmental and prosodic features.

Description and treatment are well documented by Rosenbek and La Pointe (1978). However, Rosenbek emphasizes that the goal of testing should focus on treatment and not merely label the type of dysarthria. Classification is not the primary or even a necessary goal with dysarthric patients. Treatment of dysarthria is important as it can improve the patient's life both socially and functionally.

Tests Methods of testing are wide and variable. There are specific approaches such as that of Scott and Caird (1983) for prosodic abnormality in Parkinson's disease, or more general methods, such as one outlined by Rosenbek (personal communication 1984, Robertson 1982, Enderby, 1983); see also Scott *et al.* (1985). One tests non-speech and speech stimuli alone and in combination.

1. Muscles of respiration

(a) (i) Command the patient to sniff (if the patient can sniff then the diaphragmatic movement is intact).
(ii) Command the patient to pant (if co-ordination of movements of the diaphragm and the abdominal muscles are synchronized and in control, then the patient can pant).

(b) If the patient can prolong a sustained vowel such as [ah], quietly and abruptly, and then louder over several repetitions, the patient has the effective use of laryngeal, diaphragmatic and abdominal musculature.

(c) Listening to connected speech one should be examining overall loudness, the appropriateness of loudness change, and the function of the respiratory muscles in producing loudness. If any of these functions are impaired, the first treatment target is working upon impaired respiratory mechanisms and improving respiratory function.

2. The larynx

(a) Command the patient to cough and observe the patient's cough reflex spontaneously, if possible, and on command.
(b) Listen to the quality of voice (if it has a mucosal or salival quality, then it suggests a weak larynx).
(c) Examine pitch function to determine fundamental speaking frequency and the appropriateness of pitch change (this determines if the larynx is well used in combination with other structures).
(d) One should always judge the quality of phonation, the presence of tremor, hoarseness, harshness, and if the patient has voiceless/voiced distinctions (is the patient dysphonic?).

3. The nasopharyngeal sphincter

(a) Examine the soft palate or velopharynx, which is instrumental in the production of correct nasal balance.
(b) Examine drinking – does the patient get water up his nose while drinking?
(c) (i) Listen to the speech stimuli [/u/ and /i/] while occluding the nostrils and listening to the change in resonance. When occluded, is the resonance adequate or inadequate?
(ii) One would note if there was consistent nasality or inconsistent nasality in connected speech (words such as smoke, snake, snooker are very difficult to produce if velopharyngeal competence is inadequate).

4. The tongue and jaw

(a) Finally one examines the tongue and the jaw, the upper airway and orofacial system, and evaluates the swallowing mechanism. Watch the movements during chewing. Is there adequate lip seal? Is there symmetrical jaw movement? One examines diadochokinetic movements, asking the patient to repeat ppp, ttt, kkk, as fast as he can. Some patients can produce these adequately at fast speeds whilst some are only intelligible at a slow speed. Some patients talk better with the jaw stabilized and some are worse. A bite block might be a means of improving consonant production and articulation in some cases. Traditional observations of articulatory production are made, and then judgements of why speech has gone wrong. Is it because of consonant imprecision, weak range, velocity, or directional difficulty of the articulators?

There are a number of specific measurements that can be made. Robertson (1989, personal communication) reported on the glottal frequency analyser as an assessment tool with Parkinson patients. This measures the fundamental frequency of the voice during speech, giving objective and reliable measurements of mean pitch and range of the voice.

This study is providing valuable information regarding the monotonous nature of PD voice. It gives evidence that for 60–80% of the time PD speakers use a maximum range of half a semitone. The equipment has also been used as a means of helping patients maximize their potential pitch range and thus alleviating their monotonous vocal quality.

GENERAL TREATMENT AIMS IN DYSARTHRIA

The goal in treatment is seen as maximizing the level of speech function available (Schow *et al.* 1978). Darley *et al.* (1975) summarize the aims as enabling the patient to learn to make the best of his remaining speech potential and to compensate for the impairment that has altered his lifelong speech habits.

Respiratory function

Attempts at increasing vital capacity are rarely justified. Seldom is function so restricted that it alone limits speech production (Darley *et al.* 1975). Rather, the limiting influence is considered to be inadequate respiratory control or inefficient valving on expiration (Hardy 1967).

There are three classes of management according to Rosenbek and La Pointe (1978).

1. Prosthetic
2. Instrumental
3. Traditional phonatory.

Prosthetic The prosthetic means of improving respiratory structures might utilize the respiratory plunger, which is a paddle placed against the abdominal muscles acting as a surrogate belly muscle. A substitute for this is to get the patient to put a hand on the abdomen inside the waistband of the skirt or trousers and press in on the expiration with speech. This is particularly useful in the treatment of patients suffering from multiple sclerosis. It is important to note that the amount of pressure and the amount of air produced is not emphasizing overbreathing. Similarly one should remember posture for breathing, and mechanical or prosthetic aids to improve posture, may well improve respiratory function.

In voice therapy with dysarthrics concentration upon the controlled flow of expiration is an important therapeutic aim. Initially the assessment of the patient's posture should be made, and where necessary corrected or supported to encourage an adequate range of movement and symmetrical pose.

Position the patient in a supported sitting position with the head slightly flexed in a midline position. The patient should be relaxed and comfortable.

Bearing down through the arms onto a table top or the arms of a chair, along the ulnar border of the hand, helps to fix the shoulder girdle and strap muscles of the neck. This simple position promotes symmetry and can alone increase vocal intensity.

When the patient is adequately positioned, facilitation of respiratory control and flowing expiration can begin against this background of increased effort.

The proprioceptive neuromuscular facilitation techniques of diaphragmatic breathing are recommended; for example, gentle resistance to the intercostal musculature during the expiratory phase is beneficial. Other techniques are described by Langley and Darvill (1979) although sternum facilitation and rib springing have been found to have little value in a speech facilitation. However, they are valuable as a dramatic means to initiate respiration in a life-saving situation.

Pursed lip breathing techniques have been found to be extremely beneficial and useful for all of the dysarthrias and particularly in Parkinson's disease (Scott *et al.* 1984, 1985).

1. The patient is instructed to count to ten and the therapist notes the ease or difficulty involved.
2. The patient is then instructed to blow the next breath out through pursed lips as though trying to cool the soup! Gentle blowing is required, *not* forceful blasting or puffing as in blowing out a candle.
3. The patient is instructed to let each subsequent breath out this way for three to four expirations.
4. The patient is asked to count to ten again on the next breath out. If done properly respiratory flow is more relaxed, breath support stronger and vocal intensity and phrasing greater. All emphasis is removed from inspiration, the patient naturally breathes in, and following a pursed blowing out inspiration is greater as the blowing relaxes the chest musculature.

Instrumental or biofeedback methods For improving respiratory function, the use of manometers is often popular with the patient. Placed in an adequate posture, and with the increased background of effort already described, the patient blows into the manometer and tries to generate at least 5 cm of water up the tube for 5 seconds. This helps the patient to recognize the degree of control associated with moving that volume of water for that length of time, and Rosenbek suggests that the patient then learns to transfer that control to speech. The therapist then counts how many syllables a patient's respiratory mechanism can support, helping the patient to learn to identify and produce only the number of syllables that he can support with ease.

Phonatory techniques In many cases brushing and icing may have a facilitatory effect upon voicing intensity. A neck wrap or the use of light pressure on various parts of the larynx may well improve voice intensity. For some patients the use of a prosthetic palate reduces the palatal dome and hence reduces the muscular movement, increasing intelligibility. Similarly, a palatal lift may also facilitate improved intelligibility of speech. A bite block or jaw sling may improve upper airway function.

Gradual voicing is co-ordinated with controlled expiration. Short phrase units are generally the end aim achieved by working through improving the glottal attack, speech sounds, rhythms, and inflexions. Emphasis on well-supported easy speech groups, with inflexion, stressing, and volume variation is more important than concentration on articulatory accuracy.

Netsell (1984) suggested that 'chewing' therapy may facilitate speech not least because the neuromuscular stimulation involved in chewing is similar to that of speech.

Utilizing laryngeal valving, as involved in lifting or exerting pressure with the arms during phonation, may help hypoadduction, and 'breathy' voice onset techniques may benefit hyperadduction (Wertz 1978).

Rood (1962) suggested that light pressure to the sides of the thyroid, moving it up and down, 'releases' the vocal cords. During this movement patients are requested to phonate.

Generally modification of respiration, resonance, prosody, and articulation influence intelligibility more than exercises designed to improve phonation (Wertz 1978).

Other methods are also mentioned in Tables 11.3 and 11.4 from Scott *et al.* (1985).

The amplification methods described by Greene and Watson (1968) in the management of Parkinson's disease patients, and the use of auditory feedback, are thought to modify vocal intensity, overall rate, and the stress patterns. If the patient talks better when he attempts to talk more slowly, then delayed auditory feedback (or DAF) may be a suitable method of therapy with the parkinsonian patient. However, in clinical experience, delayed auditory feedback is only useful if it is used by an experienced therapist, accompanied by extensive explanation, and it is only functional with certain patients and certain stimuli, so is perhaps best used as part of a total behavioural-type therapeutic programme. Similarly the amplification device had little carry-over either outside the therapeutic situation, or when the aid is not in use. The pacing board described by Helm (1979) is based on Luria's theory of motor interruption and is an artificial way of improving rate and timing. Again the authors' experience with parkinsonian patients has not found it useful (although the use of pacing board with dyspraxic patients can be most effective).

Utilizing traditional methods the therapist might link gesture and speech. A simple task would be counting using finger pointing and speech, and then building up to using contrasting stress drills with a question-and-answer format, gradually increasing the complexity of material and finally fading gesture. Work on stress and improving prosody often improves overall intelligibility and articulatory accuracy.

Table 11.5 Drugs that may produce dysarthria

Group	*Approved name*	*Proprietary name*
Antiarrhythmic	Mexiletene	Mexitil
Anticonvulsant	Phenytoin	Epanutin
Antipsychotic	Chlorpromazine	Largactil
	Haloperidol	Serenace
	Promazine	Sparine
	Thioridazine	Melleril
Mood regulator	Lithium	Camcolit
Sedative/hypnotic	Barbiturates	Amytal
		Seconal
		Soneryl
		Tuinal
	Chlordiazepoxide	Librium
	Meprobamate	Equanil
Tricyclic antidepressant	Amitriptyline	Lentizol
	Dothiepin	Prothiaden
	Imipramine	Tofranil

EFFECTS OF DRUGS

Tables 11.5–11.7 indicate the effects of drugs including those that may produce dysarthria, affect taste and cause a dry mouth.

Table 11.6 Drugs that may cause abnormality of taste sensation

Group	*Approved name*	*Proprietary names*
Antiarrhythmic	Amiodarone	Cordarone X
	Procainamide	Pronestyl
Antibiotic	Ceftazidime	Fortum
	Lincomycin	Lincocin
Antidepressant	Amitriptyline	Lentizol
	Doxepin	Sinequan
	Imipramine	Tofranil
	Nortriptyline	Allegron
Antihypertensive	Captopril	Acepril, Capoten
	Enalapril	Innovace
Antileprotic	Ethionamide	
	Prothionamide	
Antimicrobial	Metronidazole	Flagyl
	Tinidazole	Fasigyn
Hypnotic	Flurazepam	Dalmane
	Triazolam	Halcion
Treatment of Paget's disease	Calcitonin	Calcitare
	Disodium etidronate	Didronel
Other drugs	Allopurinol	Zyloric
	Aspirin	
	Carbimazole	Neo-Mercazole
	Cisplatin	Neoplatin
	Clofibrate	Atromid-S
	Disulfiram	Antabuse
	Ethambutol	Myambutol, Mynah
	Griseofulvin	Grisovin
	Gold salts	Myocrisin
	Levodopa	Larodopa, Brocadopa
	Lithium	Camcolit, Priadel
	Metformin	Glucophage
	Penicillamine	Distamine, Pendramine
	Phenindione	Dindevan
	Propantheline	Pro-Banthine

Table 11.7 Drugs that may produce a dry mouth

Group	*Approved name*	*Proprietary name*
Analgesic	Nalbuphine	Nubain
	Nefopam	Acupan
Antiarrhythmic	Disopyramide	Rythmodan
	Nadolol	Corgard
Anticholinergic	Atropine	
	Dicyclomine	Merbentyl
	Emepronium bromide	Cetiprin
	Flavoxate	Urispas
	Hyoscine	Buscopan
	Pirenzepine	Gastrozepin
	Poldine	Nacton
	Propantheline	Pro-Banthine
	Terodiline	Teroline
Anticonvulsant	Carbamazepine	Tegretol
Antidepressant	Amitriptyline	Lentizol
	Clomipramine	Anafranil
	Desipramine	Pertofran
	Dothiepin	Prothiaden
	Doxepin	Sinequan
	Imipramine	Tofranil
	Iproniazid	Marsilid
	Isocarboxazid	Marplan
	Lofepramine	Gamanil
	Maprotiline	Ludiomil
	Nortriptyline	Allegron
	Phenelzine	Nardil
	Tranylcypromine	Parnate
	Trazodone	Molipaxin
	Trimipramine	Surmontil
	Viloxazine	Vivalan
Anti-emetic	Nabilone	Cesamet
	Prochlorperazine	Stemetil
Antihistamine	Azatadine	Optimine
	Clemastine	Tavegil
	Cyclizine	Valoid
	Cyproheptadine	Periactin
	Diphenylpyraline	Lergoban
	Phenindamine	Thephorin
	Promethazine	Phenergan
	Trimeprazine	Vallergan

Table 11.7 (Cont'd)

Group	*Approved name*	*Proprietary name*
Antihypertensive	Clonidine	Catapres
	Indoramin	Baratol
	Methyldopa	Aldomet
	Prazosin	Hypovase
Antiparkinson drug	Amantadine	Symmetrel
	Benzhexol	Artane
	Benztropine	Cogentin
	Biperiden	Akineton
	Bromocriptine	Parlodel
	Levodopa	Brocadopa
	Methixene	Tremonil
	Orphenadrine	Disipal
	Procyclidine	Kemadrin
Antipsychotic	Chlorpromazine	Largactil
	Fluphenazine	Moditen
	Haloperidol	Serenace
	Methotrimeprazine	Veractil
	Oxypertine	Integrin
	Promazine	Sparine
	Thioridazine	Melleril
	Trifluoperazine	Stelazine
Anxiolytic	Chlormezanone	Trancopal
	Clobazam	Frisium
	Clorazepate	Tranxene
	Hydroxyzine	Atarax
Appetite suppressant	Diethylpropion	Apisate
	Mazindol	Teronac
Bronchodilator	Ephedrine	
	Ipratropium	Atrovent
Diuretic	Amiloride	Midamor
	Triamterene	Dytac
Other	Allopurinol	Zyloric
	Busulphan	Myleran
	Dexamphetamine	Dexedrine
	Etretinate	Tigason
	Isotretinoin	Roaccutane
	Ketotifen	Zaditen
	Penicillamine	Distamine

CONCLUSION

Changes in the motor aspects of speech communication are well documented in Darley *et al.* (1969a,b, 1975), and Rosenbek and La Pointe (1978). However, too often the management of these problems is given a cursory assessment, and treatment usually consists of articulatory exercises and phonemic drill, building up to longer speech unit practices. Recent studies have indicated the success speech therapy can have in the management of voice disorders of neurological origin, and that they are no longer unrealistic in their aims or of limited value in the management of progressive disorders. Therapy has come a long way from considering dysarthria as merely a defective articulation of speech, and as such the treatment should look beyond this and utilize the many varied instrumental and biofeedback techniques that are readily available to therapists nowadays. The management of dysarthria in the elderly remains limited and research opportunities, although still limited, provide an exciting and much-needed opportunity for examination.

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12

Vocal-cord paralyses

Malcolm D. Stockley

INTRODUCTION

Vocal-cord paresis (weakness) and paralysis (inability to stimulate contraction of muscle) are the results of a number of related neurological conditions that affect the movement of the vocal cords. Other conditions may also affect the movement of the cords; for example, arthritis of the cricoarytenoid joint, although uncommon, may occur in patients with rheumatoid arthritis, or after trauma. In addition the various myopathies such as myasthenia gravis, polymyositis, and the muscular dystrophies may cause varying degrees of wasting and hence weakness.

This chapter, however, will be mainly concerned with lesions of the vagus (Xth cranial nerve) occurring at some point between its origin in the nucleus ambiguus and the laryngeal musculature. The major division of the vagus concerned is the branch known as the recurrent laryngeal nerve (RLN), which supplies all the laryngeal muscles except the cricothyroid. Hardcastle (1976) gives a clear description of the action of the intrinsic laryngeal muscles and their effects on the movements of the vocal cords. Any condition affecting this nerve can produce weakness or immobility of the vocal cord on the affected side (more often the left, due to its longer course), giving rise to dysphonia or, exceptionally, aphonia when both recurrent laryngeal nerves are paralysed and the vocal cords adopt a paramedian position. Lesions of the superior laryngeal nerves, which part from the vagus just below the inferior ganglion and provide the sensory innervation of the supraglottis in addition to motor supply to the cricothyroid, may also occur. Both unilateral and bilateral lesions may occur and are frequently accompanied by a recurrent laryngeal nerve paralysis. The clinical features of these conditions are described below. Cord palsies are a fairly frequent problem in ENT practice; they are usually unilateral but bilateral palsies are not uncommon.

As McKelvie (1979) states: 'No more contentious subject exists than vocal cord palsy, and positions of the cord in such states, since they can come to rest in any position between full abduction and adduction.' Semon (1881) bequeathed his famous law, which described the positions adopted by the affected cord(s). Although the exact explanation has still not been elucidated, the gist of Semon's thesis was that an incomplete lesion of the recurrent laryngeal nerve results in an *abductor* paralysis, whereas a complete recurrent laryngeal nerve lesion results in both an *abductor* and *adductor* paralysis. That is, progressive damage would result initially in an adducted cord followed by a slow migration to an intermediate position. Negus (1931) proposed that phylogenetically speaking the larynx was primarily a sphincter to protect the entrance to the lower tracheobronchial tree, later acquiring an opening mechanism, which remains more vulnerable to neuromuscular damage.

Greene (1980) discusses the behaviour of the laryngeal muscles and concludes that 'the position of the vocal cord is not subject to any fixed neurological laws, evolutionary or otherwise, but is determined entirely by the interaction of a combination of neuropathological and anatomical factors.' These factors include the effects of unaffected muscles, for example the cricothyroid in the case of recurrent laryngeal nerve paralysis and the interarytenoideus in unilateral paralysis; the angle of the cricoarytenoid joint (frequently the affected cord lies at a lower level than the contralateral cord); the balance of forces between the abductors and adductors (that is, their respective bulk); and the final amount of atrophy and fibrosis that ensues. Nevertheless, the puzzling fact remains 'that the abductors of the vocal folds often appear to be most susceptible to paresis after partial injuries of the recurrent laryngeal nerve.' (Bowden 1974). For a review see Kirchner (1982).

With the advent of improved systems of videostroboscopy by fibreoptic laryngoscopy, laryngeal appearance and function can be better investigated and demonstrated to the mutual benefit of surgeon and voice therapist. The work of Williams *et al.* (1975) is a good example of the type of research needed.

AETIOLOGY

There are many possible aetiologies, but the common causes of these conditions are infranuclear and include injury such as road-traffic accidents, surgical trauma (thyroidectomy, endotracheal intubation, and bronchoscopy); pressure or stretching due to contiguous disease, for instance cardiovascular and neoplastic disease; and peripheral neuritis, for example toxic (lead poisoning), infective (influenzal and herpetic viruses, streptococcal and other bacteria).

Since malignant lesions such as carcinoma of the bronchus or upper lobe of the lung, or mediastinal growths, may affect the recurrent laryngeal nerve, laryngologists assume this to be the case until proved otherwise. Carcinoma of larynx, pharynx, nasopharynx, thyroid, or oesophagus, and secondaries in the base of the skull, neck, or hilar lymph nodes may also give rise to palsies, as may aortic aneurysms and other lesions of the heart and major blood vessels. Accidental surgical trauma, for instance during thyroid surgery, is still a common cause. Around 30% of cases are idiopathic (of unknown/spontaneous origin), some are congenital and perhaps associated with birth trauma, and many of acute onset are associated with a flu-like illness. Blau and Kapadia (1972) believe idiopathic unilateral vocal-cord paralysis to be a cranial mononeuropathy in which nerve function is impaired or lost, with the site and aetiology of lesion unknown, and having a generally high rate of spontaneous recovery within a period of a year. Most common is the condition of unilateral and incomplete (abductor) paralysis. In the author's experience of a specialist ENT hospital in London, patients present at a rate of approximately one each month.

Nuclear level causes include Parkinson's disease, stroke, Guillain–Barré syndrome, multiple sclerosis, primary or secondary brain tumours, and infections such as polio, meningitis, and syphilis (Holinger *et al.* 1976). Such lesions more often result in a bilateral rather than a unilateral paralysis.

RECURRENT LARYNGEAL NERVE PARALYSIS

The four conditions that may be distinguished are unilateral incomplete paralysis, bilateral incomplete paralysis, unilateral complete paralysis, and bilateral complete paralysis. They are described in Figure 12.1a–d.

Unilateral incomplete (abductor) paralysis

A common presentation of this condition is as an idiopathic mononeuritis, but it may also be a sequela of thyroid surgery or caused by carcinoma of the left lung due to the more extensive course of the left recurrent laryngeal nerve (Figure 12.1a). Injury to the nerve during thyroid surgery may be temporary, due to oedema, typically developing within seven days postoperatively. Intubation with an endotracheal tube in which the inflated cuff lies within the larynx rather than the trachea is also a possible cause of this condition (Minuck 1976, Cavo 1985). Since the affected cord remains in the midline there may be little in the way of

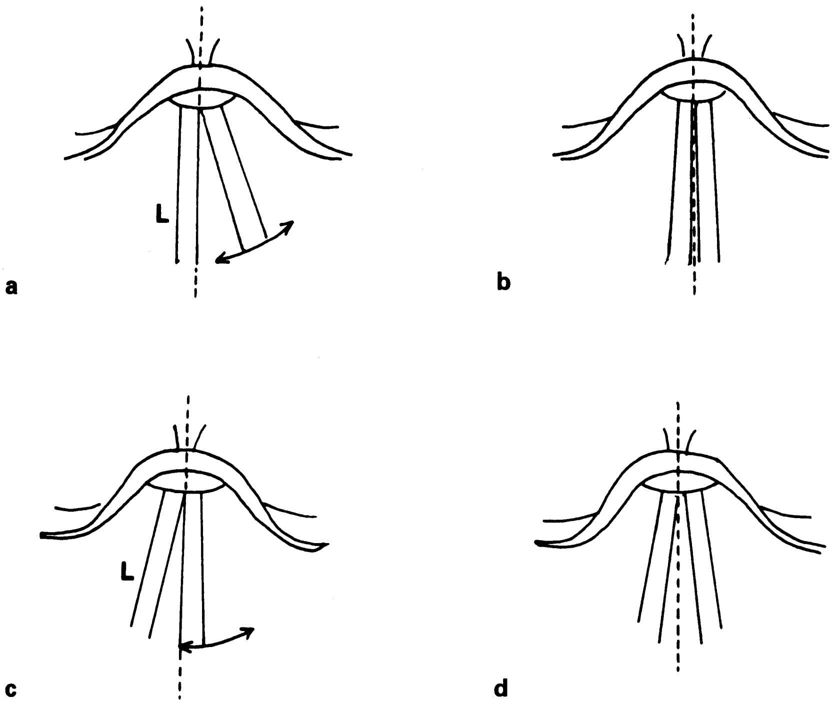

Figure 12.1 (a) Unilateral incomplete (abductor) paralysis (left cord); (b) bilateral incomplete (abductor) paralysis; (c) unilateral complete paralysis (left cord) and (d) bilateral complete paralysis.

symptoms except slight dysphonia (worse when singing), vocal fatigue, and breathlessness, and many patients learn to compensate spontaneously. An intensive burst of therapy is frequently efficacious in promoting better adduction of the cords and eliminating breathiness.

Bilateral incomplete (abductor) paralysis

This condition, which may be an unfortunate result of thyroid surgery, is the most serious form of vocal-cord paralysis (Figure 12.1b). The voice can be good, because the vocal cords adopt a position near the midline, thus obstructing the airway, but patients may complain of dyspnoea and stridor. If the patient is not overweight and is relatively inactive it is possible to survive without surgical intervention. Exertion or an acute upper respiratory tract infection results in obstruction, which needs to be alleviated by emergency tracheotomy. Currently the best solution is a permanent tracheostomy, so that the patient is assured of a good airway, with a speaking valve. The usual plan seems to be to wait for about 12 months to see if any spontaneous recovery occurs.

If it does not, another solution is to carry out a cordopexy. There are several varieties, which involve fixing one vocal cord in a position slightly lateral to the midline with a stainless-steel suture. This solution requires intensive vocal rehabilitation, since the other cord has to be trained to cross the midline to approximate with the fixed cord. Once the muscles of adduction relax, the natural elasticity of the tissues usually help the free cord to abduct slightly. The procedure is undertaken in such a manner as to create a permanent posterior glottic chink, adequate enough for normal respiration but not so large as to markedly impair the voice. A similar result may also be obtained by cordectomy (endoscopic excision of one vocal cord) using a CO_2 laser and with or without excision of the arytenoid. For the future, the ideal solution lies in reinnervation techniques. As long ago as 1927, Colledge and Ballance showed that reinnervation of the paralysed larynx could be achieved experimentally in monkeys and baboons. However, results in humans have been disappointing so far and the early success of Tucker (1976) has not been widely reproduced. For some recent case examples see May and Beery (1986) and Fernandes *et al.* (1987).

Unilateral complete paralysis

The left vocal cord is more commonly affected than the right due to the greater vulnerability of the left recurrent laryngeal nerve (Figure 12.1c). Damage during thyroid surgery used to be one of the commonest causes, despite the surgeon's attempt to preserve the nerve. In a review of 262 cases treated with Teflon injection (Sadek *et al.* 1987), the commonest cause was carcinoma of the lung with 203 cases (77.5%), while thyroidectomy, the second commonest cause, was responsible for only 13 cases (5%). However, 118 cases had undergone thoracic surgery where the left recurrent laryngeal nerve may have been deliberately sacrificed to 'ensure clearance of the mediastinum in those cases where the disease is found to be extensive at operation.' (Sadek *et al.* 1987). The affected cord assumes the cadaveric position somewhat lateral to the midline, with the result that there is a marked degree of air wastage and the voice is weak and breathy. Patients frequently complain of fatigue due to the physical effort involved in their attempts to approximate the cords. Other problems include overspill from swallowing and an ineffective cough, rendering the patient liable to aspiration and recurrent lung infections. If the dysphonia is resistant to voice therapy, good voice may be obtained with vocal rehabilitation following Teflon paste injection after allowing sufficient time for spontaneous recovery to take place.

Bilateral complete paralysis

Fortunately rather rare, this condition may result from the severance of *both* recurrent laryngeal nerves (during thyroid surgery) or if one nerve is damaged in the presence of an unrecognized palsy of the other nerve (Figure 12.1d). Both vocal cords assume a paramedian position initially and the patient is aphonic. Aspiration of fluids may be severe and the patient may eventually need a laryngectomy to protect the lungs, for if the condition is permanent both cords assume the more lateral cadaveric position after about 6–9 months. The cadaveric position is half-way between midline and moderate abduction, and is so called because the muscles are inactive as in death. With great effort an audible whisper is possible in time, as the flaccidity of the cords give way to stiffening with fibrosis and contracture.

SUPERIOR LARYNGEAL NERVE PARALYSIS

Both unilateral and bilateral paralyses may occur from lesions of the external branches, which innervate the cricothyroid muscle, although these conditions are much less frequent than recurrent laryngeal nerve paralyses due to their shorter course and 'rarely occur without a recurrent laryngeal nerve paralysis' (Simpson *et al.* 1967).

Unilateral superior nerve paralysis

This condition results in an unequal rocking of the cricoid and thyroid cartilages. A slack, flabby cord is produced due to the failure of the backward-bracing action of the cricoarytenoideus muscle so that the arytenoid cartilage tips forward, thus allowing the cords to overlap. Patients complain of vocal fatigue, which results from the effort to phonate and produce sufficient intensity. The voice is quiet, lacks intonation, is breathy, and singing is impossible. There is no effective treatment for this problem. Such patients need the support of the voice therapist to explain the mechanics and implications of the pathology, to reduce general and specific musculoskeletal tension, and help to obtain optimum voice.

Bilateral superior nerve paralysis

When the lesion (for example, carcinoma of the nasopharynx) affects the vagus at a higher level than that at which the superior laryngeal branch is given off, this condition occurs together with a recurrent laryngeal nerve paralysis. The relatively wide cadaveric position of the glottis greatly exacerbates the dysphonia. The voice may be low in pitch and so restricted in range as to render singing impossible and to affect intonation. Aspiration of fluids is usually a distressing added complication. There is no effective treatment for this problem other than tracheostomy (with insertion of a speaking valve) should this prove necessary to protect the patient from inhalation pneumonia.

TREATMENT

Surgical intervention such as a Woodman's procedure may be necessary, or a Teflon implant as described below. Vocal rehabilitation consists of so-called forcing or pushing exercises to encourage the active cord to compensate for the paralysed cord by crossing the midline so as to approximate with the affected cord. Voice production work should be undertaken with Teflon implant cases to ensure that full benefit is made of the surgical result. Although this aspect cannot be dealt with here, counselling is frequently of great importance: not infrequently emotional, social, and economic difficulties compound the vocal problems.

SURGICAL INTERVENTION

Cordopexy

Several types of procedure are in use – the best-known being the Woodman operation (Woodman 1946). In cases of bilateral abductor paralysis of sudden onset, due to surgical trauma, both cords are fixed in the midline, causing stridor and dyspnoea, and a tracheostomy is indicated. A special cannula with a flapped valve (a speaking valve) is inserted to allow the eggressive air stream to pass through the larynx and provide a satisfactory, even good, voice. If there is no spontaneous recovery (after at least a year) cordopexy may be undertaken. This frees the patient from living permanently with a tracheostomy with its attendant restrictions and hazards – respiratory infections and water being the chief ones. However, as McKelvie (1979) points out, 'Tracheostomy remains an option for the very aged, those who have had one for many years and cope well with it, the obese and frail, those . . . with no wish to swim, those with a brief but vital need to talk via a valved tracheostomy tube . . .'.

The Woodman procedure (which requires an initial tracheostomy) comprises the following: arytenoidectomy with retention of the vocal process, which is moved laterally and, together with fibres of the thyroarytenoid muscle, is then sutured to the inferior cornu of the thyroid cartilage. This fixes the cord in a more advantageous position of abduction. Cicatricial tissue formation during healing may change the position of the cord and voice therapy is required to achieve adequate adduction.

Teflon injection

Teflon paste (polytetrafluorethylene) is injected into the paralysed cord to add bulk. The increased bulk has several effects: 1, the cordal margin becomes smoother; 2, the bulk adds thickness to the cordal edge; and 3, the cord is moved slightly towards the midline, all three of which aid both adduction and vibration when the other cord moves to close the glottis and produce phonation.

As early as 1911, Brünings, a German ENT surgeon, introduced a method of intracordal injection of paraffin into the affected cord. However, paraffinoma, embolization, and sloughing led to its abandonment. The technique was reintroduced by Arnold in the mid-1950s, at first using particles of cartilage in an emulsion and then Teflon paste (Arnold 1962). By the early-1970s Teflon particles (7–100 μm in size) in a suspension of glycerine had become the substance of choice. Teflon, it was claimed, 'had proven to be well tolerated by human tissues' (Montgomery 1979), and has had no carcinogenic effects (Lewy 1976).

The usual procedure involves direct laryngoscopy under general anaesthesia supplied by a small lumen tube, and the use of a microlaryngoscope (see, for example, Kleinsasser 1968), an operating microscope and a Brüning syringe (Figure 12.2). Gentle injection of approximately 1.00 cc. of the paste (Teflon granules in a 50% glycerine base) may be accomplished by using a manual or motor-driven mechanism that gives a controlled dosage (for example, the Lakatos' Teflon injector by Richard Wolf UK Ltd.). The paste is deposited approximately 3 mm lateral to the vocal-cord margin. An excellent postoperative voice for the first 24 hours may deteriorate a little as the oedema resolves and the glycerol is slowly absorbed. Improvement should occur in about a week and reach a permanent level in two weeks. The technique works best with a unilateral recurrent laryngeal nerve paralysis. Sadek *et al.* (1987) in their review of 262 cases report a 96.9% success rate. Bilateral injections to adduct the cords in the case of bilateral flaccid, paralysis (accompanied by a tracheostomy with speaking valve) have produced somewhat unpredictable results thus far and are not in common use. The aim of this latter technique is to prevent overspill and provide a useful voice.

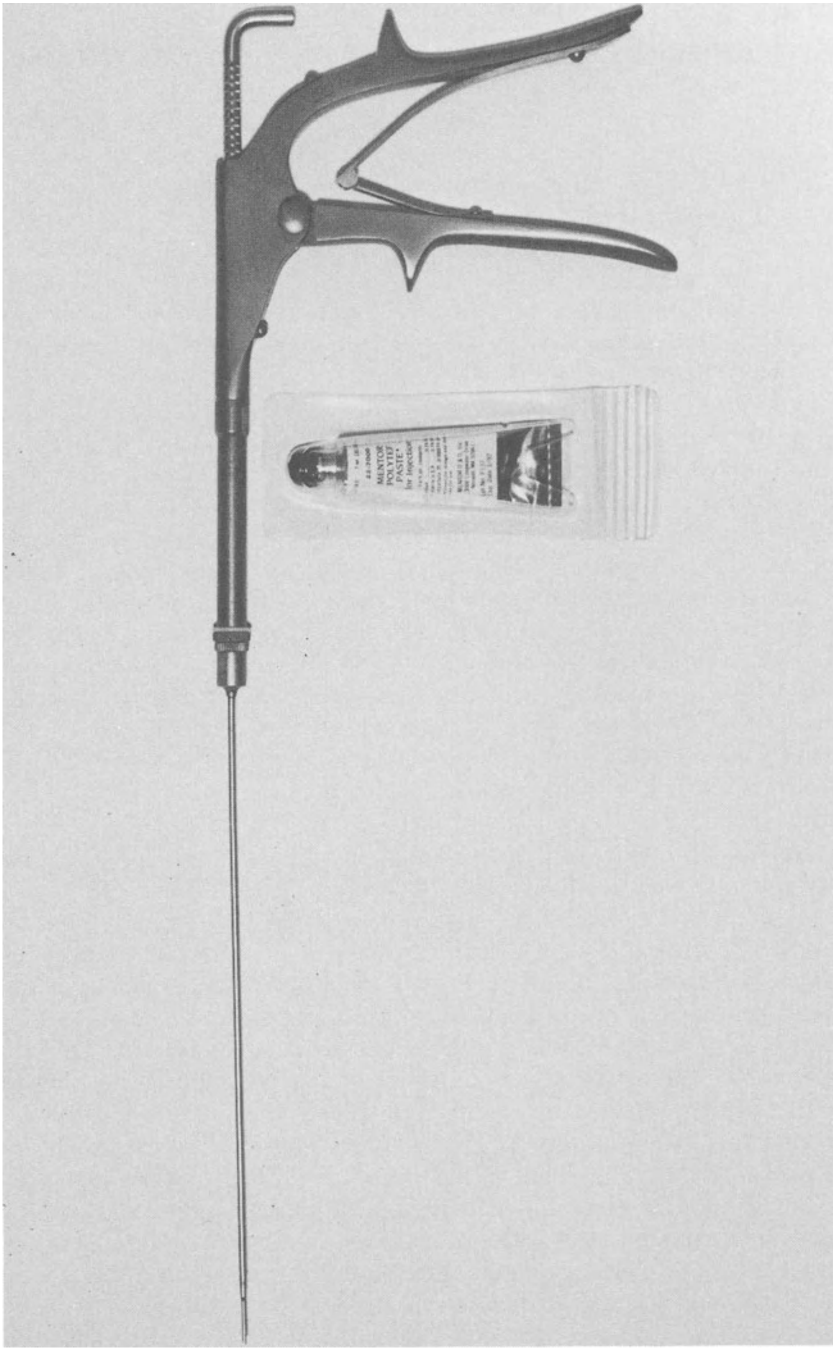

Figure 12.2 A Brüning syringe

VOCAL REHABILITATION

Vocal assessment is indicated for all patients with a cord palsy. Most patients will also require some form of therapy; this may involve counselling and explanation, and usually some form of voice therapy to encourage optimal voice production. Although patients with an idiopathic palsy may recover spontaneously within 9–12 months, longer periods of up to three years are not unknown (McKelvie 1979). During this time unsupervised patients may develop poor vocal habits and even worsen their dysphonia.

The common element is habitual musculoskeletal tension that affects breathing, for example, which may become upper costal and hence shallow. The rate of breathing increases (tachypnoea) to compensate for the insufficient volume of inspired air and the air wastage through the open glottis. Some unsupervised patients even develop the habit of phonating on an ingressive air-stream mechanism. Specific tension in and around the larynx may produce all the usual signs and symptoms of vocal strain: tightness and aching in the throat, fatiguability of the laryngeal muscles (myasthenia laryngis) and disturbance of balance of resonance. The apparent paradox is that the vocal exercises used to encourage the active cord to compensate by crossing the midline to approximate with the affected cord rely on increasing laryngeal tonicity. This is certainly an area where art meets science. The aim is to exploit the natural sphincteric action of the larynx, such as occurs when fixing the chest to lift heavy weights. Thus, it is perhaps better to foster the idea of 'pushing', as first advocated by Froeschels *et al.* (1955) and 'lifting' exercises rather than 'forcing' exercises.

Depending upon the patient's age and physical condition there are a variety of ways of producing sufficient physical effort. The aim is repeated, rapid muscular tensions accompanied by attempts at vocalization. Controlled coughing and grunts (that is, a glottal plosive) followed by a vowel or nasal such as [ʔɑː] or [ʔm], and a voiced glottal fricative accompanied by bilabial or alveolar closure and nasal release [ɦm], [ɦn]), should be followed by rapid muscular relaxation. No more than 60% of total strength is required. Although some authorities advocate pushing against furniture, etc. (Bull and Cook 1976), it is important to bear the safety aspect in mind! Isometric exercises, such as interlocking the hands and trying to pull them apart whilst producing [iː] sufficiently involves the muscles of the neck, thorax, and arms to encourage compensatory adduction. This procedure also encourages better lateral expansion of the ribs and therefore greater inspiration than, say, pushing with the arms held forwards, or downwards on the arms of a chair. The vowels [uː] and [ɔː] seem to have particular value once adduction begins to improve. As soon as possible, progression from stressed syllables, to words (beginning with a stressed vowel, such as /'eg/, /'Iglu:/), phrases, reading, and spontaneous conversation should follow. Not all patients require 'pushing' exercises; encouragement to use hard glottal attack on short stressed syllables may well be sufficient. Turning the head to increase tension and digital manipulation of the thyroid cartilage have also proved useful adjuncts to the above procedures.

Relaxation exercises are frequently essential to reduce general musculoskeletal tension, and thus indirectly improve breath capacity and control, and to reduce specific neck tension following each attempt at achieving compensatory movement. The present author is an adherent of the Alexander technique (Barlow 1973, Gelb 1981) but recognizes the difficulties of trying to *write* guidelines for students and clinicians who have had no experience, or access to a qualified teacher, of a technique concerned with muscular re-education in a much wider context. However, the procedures described by Mitchell (1977) can be readily understood and applied in therapy and represent an acceptable approach. To some extent the amount and type of relaxation work reflects the personal interest and therapeutic style of the clinician. Some clinicians are advocates of massage (for example, 'digital massage', see Aronson 1980), others of music, or biofeedback (Stemple *et al.* 1980). Patients frequently find such work of lasting value and should be encouraged to incorporate the practice of relaxation into their lifestyle.

CONCLUSIONS

Voice pathologists find this a rewarding area in which to work as the majority of patients (who have a unilateral cord palsy) normally achieve a very satisfactory voice. Satisfaction is enhanced by close collaboration with the ENT surgeon and the use of fibreoptic endoscopes, which facilitate viewing and documentation of the state of the vocal cords.

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Adductor spastic dysphonia: Diagnosis and management

Margaret Stoicheff

INTRODUCTION

Spastic dysphonia, which has been recognized as a voice disorder for over a century, was thrust into prominence by Dedo's surgical management procedure (Dedo 1976). This was the first general treatment approach to demonstrate substantial changes in vocal symptomatology. For a number of years surgical resection of the recurrent laryngeal nerve became the popular approach to management of this devastating voice problem. As the limitations of this procedure began to surface, the resurgence of interest in the disorder was evident in the rapidly expanding research and clinical literature. This renewed vigor in seeking to understand the nature of spastic dysphonia and the implications for management have provided the speech pathologist with more information and direction in working with individuals with this vocal problem. In this chapter the issues of diagnosis and management are presented using the data available as well as personal clinical experience.

WHEN TO APPLY THE LABEL 'SPASTIC DYSPHONIA'

Pathophysiology

There is unanimity in the literature that spastic dysphonia has as its basis an abnormal adductory movement or spasm of the vocal folds during phonation (Fox 1969, Aronson and De Santo 1983) and that this movement is involuntary, momentary, and intermittent. There is also consensus that this abnormal movement may extend to the false vocal cords.

In some patients with spastic dysphonia, it appears that the spasmodic movement may extend beyond the larynx and into the hypopharynx and oropharynx (McCall *et al.* 1971, Parnes *et al.* 1978), into the oral cavity (McCall *et al.* 1971), and may even occur during respiration as well as speaking (McCall *et al.* 1971, Parnes *et al.* 1978, Salassa *et al.* 1982). Using electromyography, Schaefer *et al.* (1987) found evidence of disrupted neuromuscular activity in the levator veli palatini muscle as well as in the thyroarytenoid muscle in three of four patients, suggesting that spastic dysphonia is not a peripherally focal disorder.

The sound of the voice

This abnormal spasming or hyperadduction of the vocal folds is perceived by the listener as a phonatory spasm – as a squeezed or strangled quality or even a choking-off of voice. This qualitative change may be very brief and widely spaced among otherwise normal phonation, or it may occur so frequently that the overall impression is of a strangled voice interrupted only occasionally by more normal voicing. Other audible features include a low-pitched, harsh voice with hard glottal attacks (Aronson *et al.* 1968). The listener is also aware of the effort that the patient is putting into forcing voice through a constricted glottis. These vocal symptoms are often accompanied by visible signs of struggle such as grimaces, eye-blinking, and contraction of thoracic and abdominal musculature. Patients without exception confirm this effort and the fatigue that comes with extended speaking.

Voice tremor is found in a percentage of patients with spastic dysphonia, although its frequency of occurrence is not clear. In 1968 Aronson and his associates found that in 31 patients with spastic dysphonia, 58% had a voice tremor in contextual speech, and 71% had a voice tremor on prolongation of /a/. A similarly high percentage of voice tremor on vowel prolongation was found in a series of 33 patients on whom surgery was performed (Aronson and De Santo 1983). Dedo and Izdebski (1983b), on the other hand, report that vocal tremor occurred in only 20–25% of their 300 patients.

Onset of the disorder

The patient typically reports that the onset of the disorder was insidious and barely noticed (Aronson 1980). Hoarseness or roughness began to appear in the voice, but there remained periods of time lasting hours or days when there were no symptoms. Usually the patient does not seek help during this period, because he does not perceive these minimal symptoms as sufficiently serious. It is only after the patient begins to experience interruptions of voicing, with some consistency, that help is usually sought some months after the initial voice symptoms. Once this stage is reached, typically there are no extended periods of time when the individual is free of the problem. The patient may experience greater or lesser difficulty when speaking, depending on fatigue level, emotional state and speaking situation, but he no longer experiences cessation of symptoms. The only occurrences of normal voicing are very brief and occur (for a word of phrase) in asides, during laughter, when taken off guard, sometimes when angry or shouting, and when speaking at a higher pitch.

Aetiology

From 1871 to 1960 spastic dysphonia was considered by most clinicians to be a psychogenic disorder and was usually classified as a conversion reaction (Aronson *et al.* 1968). Since Robe *et al.*'s (1960) findings of disordered function of the central nervous system, the evidence appears to be mounting in favour of a neurological basis in at least some of these patients.

The presence of voice tremor in a high percentage of patients with spastic dysphonia and the similarity of the voice signs in spastic dysphonia to those of essential (voice) tremor, a known neurological disorder, prompted Aronson and Hartman (1981) to conclude that 'the presence of voice tremor or rhythmic voice arrests on clinical examination, despite the absence of other neurologic signs of tremor, should arouse suspicion of essential tremor.' Aminoff *et al.* (1978) reported associated coexisting disorders of idiopathic torsion dystonia, blepharospasm, postural tremor, and familial tremor in five of twelve consecutive patients with spastic dysphonia evaluated clinically by a neurologist. They suggested that spastic dysphonia should be regarded as a focal dystonia of the laryngeal musculature. The appearance of abnormal laryngeal movements during breathing in three patients some months after recurrent laryngeal resection for spastic dysphonia led Salassa *et al.* (1982) to the conclusion that these patients had a focal, isolated form of dystonia.

In a recent article, Schaefer and his associates (1987) have concluded from their extensive investigations, which included magnetic resonance imaging of the brain, auditory brain-stem response (ABR) testing, visceral vagal testing, and laryngeal electromyography, that 'spasmodic dysphonia is a neurogenic disorder predominantly localized above the brain stem (i.e. upper motor neuron), involving perhaps cortical or subcortical structures.'

Faulty labelling

Dedo and Izdebski (1983a) have indicated that a major problem with spastic dysphonia is misdiagnosis, that spastic dysphonia is confused with voice disorders with some similar voice features. In this writer's experience, incorrect applications of the label 'spastic dysphonia' have generally involved patients presenting with severely strained voices associated with hyperfunction, and have been made by inexperienced clinicians.

The characteristics that distinguish a dysphonia associated with hyperfunction from spastic dysphonia are continuity of the strained quality, no evidence of involuntary phonatory spasms, complaints of throat pain associated with the straining to produce voice, presence of excessive tension in extrinsic laryngeal musculature producing the glottal constriction, and the possibility of triggering normal voice with an altered laryngeal set.

Since misapplication of the label, as well as failure to apply the label, may lead to fruitless or inappropriate management approaches and considerable hardship for patients, it is important for speech pathologists to recognize their limitations and to make referrals to colleagues or centres specializing in the diagnosis and management of spastic dysphonia.

Spastic dysphonia as a voice sign

An important point made by clinicians and investigators is that the term spastic or spasmodic dysphonia should be used as a voice sign rather than as a diagnosis (Salassa *et al.* 1982, Aronson and De Santo 1983). Schaefer *et al.* (1987) have also indicated the need to discontinue viewing spastic dysphonia as a pure disorder and to use the label to signify a vocal behaviour having multiple aetiologies.

At least the following possibilities are involved in using the label 'spastic dysphonia' in this way.

Spastic dysphonia associated with psychologic disorders of conversion reaction and depression In spite of the evidence supporting a neurological basis, there are patients with this vocal symptomatology where the basis is psychogenic (Aronson and De Santo 1983). The patient with a psychogenic spastic dysphonia usually reports a sudden onset to the voice disorder, as well as periods of remission lasting days, weeks or months. This is not the case with neurological and idiopathic types.

In patients with psychogenic spastic dysphonia it is also possible to trigger near-normal voice in the voice testing situation.

Spastic dysphonia associated with neurological disorders of essential (voice) tremor, spasmodic torticollis, blepharospasm, pseudobulbar *palsy, dystonia* The presence of tremors in the limbs, jaw and tongue, or of involuntary movements of the head or neck, or of dysarthric involvement should alert the speech pathologist to a possible neurological condition requiring a neurological consultation. The presence of a voice tremor or of regular voice arrests without tremor elsewhere is also a suspicious sign (Aronson and Hartman 1981). In an organic disorder, there are no brief instances of normal voicing during laughter, asides, singing, or use of a falsetto (Aronson and Hartman 1981).

Spastic dysphonia on an idiopathic basis The use of the term spastic dysphonia has traditionally been associated with this type. Aronson (1980) has summarized the characteristic features of idiopathic spastic dysphonia. These are:

1. presence of intermittent strained and/or strangled phonations and breaks in the voice;
2. no laryngeal lesions or paralyses;
3. no abnormal speech signs in the rest of the peripheral speech mechanism;
4. brief periods of normal voicing during singing, laughter, shouting, or anger;
5. resistance to treatment. The cause of the voice disorder cannot be found in this type.

MANAGEMENT

What constitutes successful management of spastic dysphonia has been undergoing change since 1976. The less-than-normal production capabilities of patients following recurrent laryngeal nerve resection and the increasing evidence for a neurogenic basis in many patients have contributed to this change. It has become apparent that the goals or expectations for management are not complete remission of vocal symptoms. A *reduction in severity* of the vocal manifestations is now rightfully becoming the measure of successful management.

It has also become apparent that each patient's management must be considered on an individual basis. Although no one management procedure can or should be applied to all cases presenting with this vocal symptomatology, there is a need for all patients to be given information concerning the current knowledge base of spastic dysphonia and to receive concerned understanding of what this devastating vocal disorder means to them socially and occupationally (Freeman *et al.* 1985). These authors also advocate patient support group meetings as well as individual counselling to assist patients in their adjustment.

Surgery

Surgical resection of the recurrent laryngeal nerve, which reduces or eliminates the hyperadduction of the vocal folds by paralysing one vocal cord in a paramedian position, was used extensively to manage spastic dysphonia up to 1983. In this year Aronson and De Santo reported on the long-term vocal results of surgery for a group of 33 patients, 70% of whom had essential (voice) tremor. By the three-year period 64% of the patients had voice disorders which were at least as severe as prior to surgery. Tape recordings were used to make these judgements. The authors attributed the failed voices to a progression of the patients' original neurological condition. Dedo and Izdebski (1983a) on the other hand, using patient self-assessment questionnaires, reported that 90% of 212 patients managed surgically considered their surgery results to be satisfactory; voice tremor was present in a small percentage of these patients. The authors indicated that 80% of the sample found their voices to be too weak to communicate adequately in noisy surroundings and that approximately 50% reported that strangers frequently commented on their unusual postoperative voices. Thus we do know that many of the patients in this sample had improved but not 'normal' voices. Dedo and his colleagues have indicated throughout their reports that voice therapy is needed postsurgically and that this therapy should emphasize elevation of pitch, avoidance of vocal fry, and avoidance of efforts to push the voice to achieve loudness. It is not clear whether the differing results of these two studies are due to patient population differences or to the imposition of voice therapy following surgery (Dedo and Izdebski 1983a, Shipp *et al.* 1985).

Although there are conflicting reports in the literature on the long-term benefits of surgical resection of the recurrent laryngeal nerve for all patients, there are a significant number of patients who have benefited from this procedure. Based on the available data, it is defensible to consider this approach when:

1. the patient has had spastic dysphonia for a number of years;
2. the voice symptomatology is sufficiently severe to present an obvious obstacle to communication;
3. voice therapy has failed to bring about sufficient relief; and
4. there are no medical contraindications.

Schaefer and Freeman (1987), who support the use of surgery in some instances, stipulate that a trial with a lidocaine-induced paralysis provides both patient and professionals with the opportunity to preview the possible benefits of such surgery.

Botulinum toxin injection

The use of botulinum toxin injection to create a vocal-fold paresis (Miller *et al.* 1987), now in its experimental stages, appears to be a promising approach in that it is not a permanent procedure. The paralysis lasts approximately 3 months with repeated injections purported to produce the same results.

Voice therapy

Increasingly the literature is portraying a more positive outcome with voice therapy. Schaefer and Freeman (1987) have reported that voice therapy can significantly improve performance. This improvement, however, requires continued practice of control techniques for maintenance. Following are some of the approaches used to reduce severity of phonatory spasms.

Breathy voicing In 1969, Fox presented some positive therapy results with a case of spastic dysphonia. Therapy consisted of teaching the patient to speak in a breathy voice so that the vocal folds would make minimal, if any, contact. Fox reported that the woman was able to eliminate the tremulous strained quality 75–80% of the time in daily life. This was the first reported account in the literature of success in **reducing** spastic symptomatology through therapy. It was ahead of its time in presenting reduction rather than complete remission of symptoms as successful treatment.

Elevation of pitch Shipp *et al.* (1985) have presented electromyographic data to support the clinical observation that an increase in speaking fundamental frequency reduces phonatory spasms. The range of frequencies selected for a patient must provide a measurable reduction in phonatory spasms while falling within an aesthetically acceptable pitch range. Since patients' voices are typically excessively low-pitched and guttural in quality, this elevation promotes an improved voice quality overall.

Easy voice onset and easy articulatory contacts In many patients hard voice onsets are characteristic and trigger or coincide with phonatory spasms. Initiating voice more easily, although difficult for patients, is an effective way to reduce spastic symptomatology (Allison and Stoicheff 1986). There is often an associated need to work on easy articulatory contacts to reduce the level of effort put into the speaking process.

Breath support In most patients therapy must be directed to ribcage and/or abdominal–diaphragmatic support for voice production. Such support is essential to the controlled voice production which these patients must learn and maintain.

Relaxation therapy Patients require instruction in relaxation procedures that will enable them to control voice in a variety of situations. In this writer's experience, use of yawning to relax oral, pharyngeal, and laryngeal musculature has been particularly valuable.

Inspiratory phonation Although it has been noted that patients with severe spastic dysphonia may resort to inspiratory phonation to get their message across, instruction in the use of inspiratory phonation has only recently been reported in North America (Freeman and Shulman 1988). The successful use of this as a method for speaking in patients with spastic dysphonia, pioneered by Shulman (1989, personal communication), appears to offer an effective approach to the management of some severely disabled patients. Shulman has also been experimenting with the use of inspiratory phonation as a relaxation technique for mild and moderately severe spastic dysphonic patients speaking on egressive air. Patients under her care report that this is one of the most effective ways of relaxing laryngeal musculature. Shulman has cautioned that inspiratory phonation must be done easily and with the throat open, otherwise the patient will experience discomfort from the drying effect of the ingressive air stream.

SPECIFIC MANAGEMENT FOR PSYCHOGENIC SPASTIC DYSPHONIA

Patients falling within the psychogenic category respond to the type of therapy in which direct work on voice enables the patient to realize his or her ability to attain control over production (Aronson *et al.* 1966). In this writer's experience, the patient must also face up to personal responsibility to impose this control in order to achieve vocal improvement. A brief summary of two young adult females with sudden onset of severe spastic dysphonia symptomatology is presented to illustrate the above (Stoicheff 1988). Each patient's symptomatology was from five to six months' duration when seen. The diagnosis of spastic dysphonia had been made by at least one other speech pathologist and by two or more medical doctors including otolaryngologists and neurologists.

Patient No. 1 was a 29-year-old female, referred from a psychiatric institution with the diagnosis of an affective disorder. The request was made to 'disabuse her of the idea that she has spastic dysphonia and requires surgery.' Voice had an overall severely squeezed quality with frequent phonatory breaks and strangulation of voice. An associated hand tremor and facial tic were attributed to her medication (lithium). She had been seen by neurologists in the United States and in Canada who found no evidence of a neurological basis. The patient complained of pain on phonation.

Twice-weekly sessions resulted in few gains for the first two months. Progress became evident when the patient was forced to take more responsibility for making changes by making the next appointment contingent on completing assigned work. This resulted in consistent practise and marked reduction in the symptomatology from session to session. Within two months she was speaking normally within therapy sessions, with occasional reminders when she slipped back into squeezed productions. Due to a vacation schedule, therapy was terminated for one month. When therapy resumed, voice had regressed but not to the initial severity level. The patient began to express doubts about her ability to control her voice and seemed to be less able to tolerate practising such control. A contact was made by the clinician to the referring psychiatrist to determine how much might be expected of the patient without upsetting her emotional equilibrium. The patient came to the next session, having been apprised by the psychiatrist of this contact and incensed by the implication that she had not been working as hard as she might on her speech. From that point on she made gains that were retained from one session to the next. Within two months she was speaking normally both inside and outside of therapy sessions. This normal voice was maintained over a six-month period when she was lost to further follow-up.

Patient No. 2 was a 35-year-old housewife who was referred by her speech pathologist and otolaryngologist for some assistance with management. There were a number of stress factors which precipitated an anxiety attack (chest pains and difficulty breathing). This was followed by a flu-like illness and sudden vocal deterioration. The patient complained of pain below the left ear and at the base of the skull on the left side as well as constant shortness of breath. She had received voice therapy over a five-month period and had experienced some return to normal voicing for periods up to a day. However, in the month preceding her referral, she had begun to whisper because she was experiencing so much difficulty with obtaining voice.

In the week prior to being seen, she was seen by a third otolaryngologist who frightened her into 'taking hold' (her assessment) by warning her that she would not get any vocal improvement if she persisted in whispering. This seemed to be the turning point for this patient. Her symptomatology was at a mild-to-moderate stage when seen and over the following three months she gradually reduced the spastic symptomatology and achieved normal voicing. Freedom from vocal symptoms has persisted over 18 months. The associated pains and shortness of breath also disappeared with the vocal symptoms.

These patients required much support, reassurance, and strengthening of their speech-production skills. They differed from other patients with spastic dysphonia in the magnitude of the changes in voice that could be triggered in therapy. These changes seemed to require the right environment/timing/confidence to become permanent.

SUMMARY

This chapter has dealt with adductor spastic dysphonia and our present understanding of its aetiology and management. Although management goals are limited in most instances, there are contributions that speech pathologists can make toward effecting better voice production and better adjustment to remaining vocal difficulties in this population.

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14

The voice of the deaf

Sheila Wirz

INTRODUCTION

The speaker characteristics of hearing-impaired people are different from those of speakers who are able to use their auditory sense to monitor their production of speech. This book is concerned with voice and it is the vocal characteristics of hearing-impaired people that are discussed here. Vocal characteristics are discussed in two ways, first by a review of the literature about 'deaf voice' and secondly with illustration from a study applying the Vocal Profile Analysis (VPA) scheme to the description of 'deaf voice'.

There are of course a whole range of reasons why and how the voice of a hearing-impaired person may be aberrant, reasons such as the degree and type of hearing loss; the age at which the person became deaf; the type and appropriateness of the auditory amplification prescribed; the educational regime that the speaker followed; and the amount of speech therapy the speaker has had, etc.

This however, is a book about voice, not deafness, and the aim of this chapter is to describe the voice of hearing-impaired speakers, not to replicate descriptions of the effects of hearing loss upon spoken language. Comprehensive reviews of these effects are included in Sims *et al.* (1982) and in Hochberg *et al.* (1983).

There is of course an enormous difference between the speech characteristics of a hearing-impaired speaker who has had a period of normal hearing (and normal auditory feedback) and another who has never heard. The hearing-impaired population themselves refer only to the latter, the congenitally deaf, as deaf. This chapter is primarily concerned with the voice of congenitally deaf speakers. A thorough review of the speech and voice characteristics of speakers with acquired hearing loss is given by Parker (1983). She outlines the difficulties of speech production occurring after the onset of hearing impairment, and divides these into changes in speech production affecting the 'naturalness' of speech production and those affecting intelligibility.

She refers specifically to problems that may arise in the breathing patterns of deafened adults, related or unrelated to increased tension, and the effects that this can have upon phonation.

Parker also points out that a loss of the facility to control smooth and appropriate pitch changes is common among deafened speakers, with marked effect upon their intonation patterns. Difficulties in controlling volume and rhythm may also occur. These speech parameters, if disrupted, will affect the speaking characteristics of the deafened speaker but they are unlikely to grossly affect intelligibility.

Deafened adults, Parker notes, may also have disruption at a phonetic level of speech production. Changes of the phonological structure are unlikely among speakers who have learned the rules of speech before the onset of their hearing impairment.

In this chapter, the definition of voice that will be followed is one that includes those parameters at laryngeal, supralaryngeal, and subglottal levels, which interact to affect a speakers voice.

Deaf speakers have abnormal voices. Received wisdom and casual observation support this view, and the invitation to contribute this chapter to a collection such as this seems to lend confirmation to it. Yet the literature is confused and confusing in its descriptions of deaf voices. It is often difficult to establish whether a writer is referring to a disturbance at a laryngeal level, or uses the term 'voice' or 'voice quality' to refer to the overall product of a deaf speakers vocal apparatus.

In this review the relevant literature has been divided for convenience into three sections.

1. A review of that literature refering to the laryngeal performance of hearing-impaired speakers;
2. A review of those studies referring to the velopharyngeal incompetence disturbing the resonance characteristics of deaf speakers, and finally;
3. A consideration of those studies that have looked at other prosodic aspects of deaf speakers.

There is, of course, considerable overlap between the various parameters of deaf speech which can be disturbed, and any division of the literature in an arbitary way like this leads to problems of classification. For example, does one classify loudness as a comment on the laryngeal performance of a deaf speaker or as a reflection of his disturbed prosody? 'Over fortis' is frequently cited (but seldom defined!) in the literature as a feature of deaf speech. Is 'over fortis' synonymous with loudness or is it an articulatory feature?

LARYNGEAL FEATURES OF DEAF SPEECH

The inability of hearing-impaired speakers to control their laryngeal performance results in different voice quality and poorly controlled pitch and intonation. These factors are commonly cited in the literature. Jones (1967) in his study lists the attributes of voice quality which are most commonly cited as: 'tense', 'flat', 'breathy', 'harsh', 'throaty', 'monotone', 'lack of rhythm', 'poor resonance', and 'poor carrying power'. Calvert (1962) also noted that none of the adjectives used by teachers of the deaf to describe the voice of deaf speakers suggested pleasing quality – all were unpleasant.

Poor laryngeal control is often attributed in the early literature to abnormal breathing patterns. Rawlings (1935) found that the speech of deaf people is 'breathy and accompanied by excessive breathing movements.' Hudgins (1937) at a similar time also noted that the deaf expended more breath on each 'unit of speech' (he appears to mean syllable) than did hearing speakers. Peterson (1953) investigated the co-ordination of breathing and articulatory timing by hearing-impaired speakers, and suggested that it was the difference in transitions which led to the perception of their voice quality as being different from that of hearing speakers. Calvert (1962) looked at harsh and breathy voices of deaf speakers and compared these with simulated voices of hearing speakers. He concluded that deaf voice quality was identified not only by fundamental frequency and subsequent harmonies but by information from the articulatory timing of deaf speech.

Stark (1972) studied the vocalizations of young (preverbal) deaf children and one of her observations was that young deaf children did not acquire control over voicing or pitch and intensity variation as did hearing children.

A variety of terms, then, such as hoarse, breathy, weak, harsh, husky or strident have been used to describe the voice quality of the deaf (Fairbanks 1960, Zemlin 1968, Nickerson 1975). While there appears to be some general agreement as to what these terms mean, there have been very few efforts to study how these perceptual features can be related to acoustic aspects or to the actual respiratory and phonatory dynamics responsible for the quality.

In attempts to describe voice quality in deaf speakers many studies have used perceptual ratings but few have gone on to demonstrate that the use of such ratings is replicable and can be used with considerable interjudge reliability. Markides (1983) asked 30 teachers of the deaf and 36 lay people to rate the voice quality of 85 hearing-impaired children. But in this study one does not know if the teachers were similarly using terms such as 'deep', 'throaty', 'hoarse' or 'soft', 'fairly normal', or whether they were using different terms to describe the same phenomenon.

However, there are studies demonstrating that valid reliable judgements of voice quality can be obtained using perceptual rating scales (Yanagihara 1967, Whitehead and Emanuel 1974, Whitehead and Subtelny 1976). Monsen (1978) compared listeners' evaluations of the same word tokens on different occasions.

One of the qualities commonly cited as characteristic of deaf speakers is a tense/harsh voice quality. At the National Technical Institute for the Deaf (NTID) between 10% and 12% of students entering college education have tense/harsh voice quality. This term is used in the voice classification scheme employed by the speech pathologists at NTID, where there is high reliability of perceptual judgements by experienced judges (Subtelny 1975). Wirz *et al.* (1980) attempted to isolate the acoustic features which allowed this high interjudge reliability. An examination of the spectrographic features of deaf speakers' production showed that generally tense phonations of the vowels of hearing-impaired speakers were significantly different from those phonations perceived to be relaxed. The difference was characterized by increased distribution of higher amplitudes of sound energy in the higher frequencies of the spectrum.

It is clear that there continues to be lack of agreement in the published literature about voice quality in hearing-impaired speakers, even when care is taken in the research design to ensure objectivity with perceptual ratings. It is possible to specify reasons for this lack of agreement. Firstly, the speech item in the sample may affect the perceived quality (Rees 1958). Secondly, a variety of spectral features contribute to a perceived quality, and although there are discernible general spectral features among deaf speakers there is also considerable individual voice variation (Wirz and Anthony 1979, Whitehead and Emanuel 1974). Thirdly, if the aberrant quality is associated with laryngeal tension there may be accompanying supralaryngeal tension (Spector *et al.* 1979), which affects other speech parameters.

Commonly the literature refers impressionistically to 'high pitch' among deaf speakers (see, for example, Boone 1966, Miller 1968, Martony 1966, Levitt 1971) without attempting to define more closely the pitch level. Rather than apply impressionistic labels, other writers have described the laryngeal performance of deaf speakers by looking at the pitch and intonation. One of the earliest attempts to look at pitch parameters among hearing-impaired speakers through instrumentation is that of Voelker (1935). He used stroboscopic techniques to describe both mean pitch and pitch range in a group of 28 deaf children and compared them with a group of matched controls. He found that 'the average pitch of the deaf voice was identical with the average normal voice' (Voelker 1935). However, when he investigated pitch range, he found that the deaf used a narrower range than their hearing peers – '80 per cent of the deaf have less average pitch change than the normals.' He goes on to stress that deaf speakers *do* use pitch movement although in a more restricted way and with more 'perseverated pitch patterns' than do hearing speakers.

Gilbert and Campbell (1980) studied the fundamental frequency characteristics of deaf and hearing children and found, in a subject intra-group analysis of variance, there was no significant difference between the deaf and the hearing individuals. Their work suggests that there is a trend for some hearing-impaired speakers to have a higher pitch than their hearing peers, but that this is not always the case. In Gilbert and Campbell's study the fundamental frequency of young adult females who were hearing-impaired was approximately 30 Hz higher than the data reported by Michel *et al.* (1966) for hearing young female speakers. Similarly the fundamental frequency of the young adult deaf male group was approximately 20 Hz higher than that of hearing young men reported by Hollien and Shipp (1972).

Not only is the fundamental frequency of hearing-impaired speakers reported to be different, and usually thought to be higher, but also the frequency range is reported to be narrower. Angelloci (1962) in a spectrographic analysis of deaf speech found that hearing-impaired speakers had a wider range of distribution of the mean fundamental frequencies but that the speech of the hearing-impaired speakers was monotonous. Monsen (1978) noted that there is no correlation between the speech intelligibility of hearing-impaired adolescents and either mean fundamental frequency or mean change of fundamental frequency. Thus, while noting that it is 'commonplace that poor control of fundamental frequency detracts from the speech intelligibility of the hearing impaired, it is not entirely clear how the pitch control of hearing impaired differs from normal in ways that affect voice quality' (Monsen 1978).

VELOPHARYNGEAL FEATURES

Nasal voice quality is frequently cited as one of the characteristics of deaf speakers.

Hudgins (1934) in his classic study was the first to describe 'excessive nasal resonance' as a feature of deaf speech. However, it is always difficult to establish the features that influence the perception of 'nasality'.

Spriesterbach (1955) has demonstrated with cleft-palate speakers that the perceived quality of 'nasality' is affected by features such as misarticulation and pitch variation. We can infer that this is probably the case with the speech of the hearing-impaired, and that many of the references to nasality in deaf speech refer to either misarticulation of nasals, or lack of oral/nasal distinctions, or to pitch variation, or any combination of these parameters! In addition some writers may also be referring to the actual feature of nasal resonance.

Colton and Cooker (1968) in an attempt to minimize the confounding influence of misarticulation, pitch variation, etc. used backwards playback as a technique to investigate whether naive listeners perceived deaf speakers as being 'more nasal'. They found that hearing students consistently rated the deaf subjects as being 'more nasal' than the hearing, even in the group where the hearing subjects read in a 'word by word' manner (attempting to simulate deaf rhythm) (Colton and Cooker 1968). They did not find a statistically significant difference between the profoundly deaf and the less deaf, as both groups were perceived to be more nasal than the control group.

This search for a relationship between degree of hearing loss and degree of perceived nasality is followed by Seaver *et al.* (1980). They investigated the velopharyngeal characteristics of 19 hearing-impaired subjects who exhibited nasality. One of their results was a non-significant relationship between degree of perceived nasality and degree of hearing loss. They also investigated the velopharyngeal positioning of these hearing-impaired speakers by the use of lateral X-rays taken during the production of /i/ and /Θ/. Surprisingly they found that in all but one case the velopharyngeal contact observed on these X-rays was very similar to that which one would see in patient's with normal speech. This finding seems to be in direct contrast to the suggestion by Nickerson (1975) that deaf speakers have difficulty in velopharyngeal control! Seaver *et al.* (1980) conclude that 'in terms of anatomical physiological attributes, the hypernasality observed in the speech of many hearing-impaired speakers is not analogous to the hypernasality observed in the craniofacial cleft population' (p. 246). Thus, although the nasal resonance features of the deaf may be perceived to be similar to those of the velopharyngeal-insufficient population they are of a different origin. Boone (1966) raises the question of how deaf speakers achieve their characteristic quality and suggests that the deaf use 'cul-de-sac' resonance by using pharyngeal tension and lowering the body of the tongue.

OTHER PROSODIC ASPECTS

Other suprasegmental parameters affecting the vocal characteristics of deaf speakers include intensity, intonation, and frequency. Frequency disturbances affecting pitch have been reviewed above in the discussion of laryngeal parameters.

Stoker and Lape (1980) posed the question 'is it possible to determine a [hearing-impaired] child's competence in speech with measures other than articulation?' Among the parameters they examined in their sample of 42 hearing-impaired children were breath duration and suprasegmental competence. 'Pitch', 'loudness modulation', and 'duration modulation' were rated by four speech pathologists. Only items with an interjudge reliability coefficient of 0.05 level of confidence or better were included in their study. In this respect the methodology of this study was much more rigorous than many others using ratings.

Stoker and Lape (1980) found that 'pitch modulation', and 'loudness modulation' correlated with hearing loss and intelligibility at a 0.001 level of significance, and breath control and duration modulation correlated at a 0.05 level of significance. Interestingly none of these four suprasegmental features had a significant correlation with hearing aid use, or age, or sex.

Voelker (1935) examined the pitch and timing characteristics of hearing-impaired speakers. He looked at the rhythmic quality of the speech of his 28 hearing-impaired subjects. He comments on the fact that deaf speakers commonly have an interval of 1.0 to 2.1 seconds between adjacent segments. Such intervals among the hearing control group rarely exceeded 0.5 seconds. Rhythm also was disrupted – 'the deaf group used on average three times as many phonations to say a sentence as the normals' (Voelker 1935).

Martony (1966) suggests that the reduction of vowel transitions and the increased holding of vowel postures disrupts rhythm and contributes to a lack of intelligibility.

Levitt (1971) comments on the excessive effort that deaf children use in speech. This excessive effort he refers to as an 'over fortis' of breathing and phonation, which is manifest as poor pitch control and rhythm.

Penn (1955) conducted a large-scale study of the vocal characteristics of 100 conductive and 100 nerve-deaf speakers in the United States armed services. In her study of suprasegmental features she found that 35% of the nerve-deaf subjects 'manifest a loudness that exceeded a level reasonably appropriate to the distance from the listener and to environmental noise while only 9 per cent of conductives revealed this deviation.'

It can be seen from the above review that there is a wide variation in the aspects of deaf voice which have been studied, and in the methodologies used to examine these different parameters. What all these studies have in common is that they study one, or in some cases a few, parameters of deaf voice, frequently drawing comparisons with hearing speakers. These studies do not attempt to be assessment procedures but very definitely pinpoint areas where assessment of deaf voice would be advisable.

A range of assessment techniques exist but it is tempting to suggest that many of them fall into the category described by Butterworth (1980), who suggests that a common research strategy for investigating speech is for the investigator to formulate a hypothesis, hypothesize factors affecting this process, then collect data that meets the needs of his hypothesis. One feels that the assessment of voice and phonation is rather like this. A researcher or clinician lists parameters that are often disturbed in the vocal characteristics of a given group of speakers. The assessment then consists of fitting the speaker to this list of parameters.

One of the problems of a review of existing assessment procedures, or an evaluation of descriptions used, is that there is a lack of common agreement as to what constitutes voice. As Monsen (1978) says, voice quality is a rather ill-defined term.

> For the phonetician 'voice quality' is a technical term and refers to perceptual attributes pertaining to the way the vocal folds vibrate for example, to laryngeal gestures. In this technical sense it is separate from qualities of speech which derives from articulation. However, while it may be true that the phonetician can listen to a word and separate the poorly executed gestures of the larynx from those of the other speech articulators most listeners probably cannot!

Here Monsen is probably expressing a concern felt by many listeners and going some way to explaining the inefficiency of some of the perceptual assessment procedures reviewed above.

The Vocal Profile Analysis (VPA) scheme

One of the problems leading to these confusions is that phonetic theory has provided us with few tools with which to attempt the task of describing parameters (or groups of parameters) such as voice quality. Laver (1968, 1980, Laver *et al.* 1981) is one of the few phoneticians who has addressed this question. He says:

> . . . if it is the legitimate business of general phonetic theory to take on the task of describing phonetic realizations not only of phonological elements but also of paraphonological attitudinal signals and of the learnable features of voice quality that signal membership of a given community, then a more comprehensive scheme for accounting for phonatory quality has to be available than that at present utilized in linguistic description (Laver 1980).

Laver (1980) provided such a phonetic description of voice quality by specifying laryngeal and supralaryngeal parameters of voice quality.

Laver *et al.* (1981) devised an assessment procedure, the Vocal Profile Analysis (VPA) scheme, which can be applied to both normal and non-normal speakers. The VPA scheme is a system that allows description of those parameters at laryngeal and supralaryngeal levels affecting voice, and which cannot be readily described using traditional phonetics.

The VPA scheme is based on the fact that a speaker's voice quality is derived from those laryngeal and supralaryngeal features idiosyncratic to him. Such idiosyncrasy is the product of both the anatomical make-up of the individual and his learned phonetic settings. The anatomy of a speaker's vocal tract will affect his vocal characteristics. These differences in anatomy may be at a supralaryngeal level – for example, a speaker with a class 3 orthodontic bite will have different oral resonance characteristics from a speaker with a class 1 bite. Or, more obviously, a speaker with an inadequate velopharyngeal sphincter will have a different oral/nasal resonance balance from a speaker who is able to achieve adequate velopharyngeal closure.

At a laryngeal level too, anatomical differences will affect phonation. An extreme difference will be the way the increased length and bulk of the vocal folds of an adult male speaker produces a very different phonation from the shorter, less massive folds of a woman or child. Similarly, the change in mass of slightly inflamed oedematous folds will change the phonation characteristics of a speaker.

As well as these skeletal differences that lead to marked differences in voice, the way in which a speaker habitually uses his vocal tract will also affect his voice quality. A speaker who has learned and habitually uses a forward tongue body posture will have a different oral resonance from a similar speaker who has a habitual back posture of tongue body.

Thus a speaker's voice quality can be said to be affected by learned muscular bias and by his anatomical make-up. The VPA identifies those supralaryngeal and laryngeal features which are affected by either long-term muscular bias or by skeletal idiosyncrasy.

These features are muscular bias or skeletal differences at the lips, the jaw, the tongue tip, the tongue body, the velopharynx, and the larynx. As well as identifying the posture of those articulators, the VPA also notes the range of movements of lips, jaw, and tongue, the efficacy of phonation and the degree of muscular tension.

The degree of habitual supralaryngeal and laryngeal tension will affect the long-term muscular tension at laryngeal and supralaryngeal levels, and thus voice quality.

The phonetic theory developed by Laver (1980) suggests that by specifying a neutral point for each of these supralaryngeal and laryngeal features and tension characteristics it is possible to measure displacement from these specified neutral points. Measurements from neutral can be made acoustically or physiologically and they can, of course, also be perceived.

The VPA scheme, then, provides a perceptual rating scheme based on neutral settings of supralaryngeal and laryngeal parameters and allows measurement and perceptual rating of a speaker's deviations from the neutral points. The resulting profile of these deviations from neutral is a specification of the characteristics of a speaker's voice.

Table 14.1 shows the parameters included in a VPA. A trained user listening to a speaker makes a first judgement as to whether the speaker

Table 14.1 Parameters included in a vocal profile

Supralaryngeal features	Labial features	Rounded or spread
		Labiodentalized
		Extensive or minimized range
	Jaw features	Close or open
		Protruded
		Extensive or minimized range
	Tongue tip	Advanced or retracted
	Tongue body	Fronted or backed
		Raised or lowered
		Extensive or minimized range
	Velopharyngeal	Nasal or denasal
		Audible nasal escape
Tension features	Pharyngeal tension	
	Supralaryngeal tension	Tense or lax
	Laryngeal tension	Tense or lax
	Larynx position	Raised or lowered
Phonation type		Harsh
		Whisper
		Creak
		Falsetto or modal
Prosodic features	Pitch mean	High or low
	Pitch range	Wide or narrow
	Pitch variability	High or low
	Tremor	
	Loudness mean	High or low
	Loudness range	Wide or narrow
	Loudness variability	High or low

deviates from neutral for each of the supralaryngeal, laryngeal, or prosodic parameters. If there is a deviation from neutral the listener judges whether this is a deviation within or outside the normal range. Having made that judgement the listener then identifies the precise nature of the deviation on a six-point rating scale.

The application of the VPA can be illustrated by describing its application to the vocal characteristics of hearing-impaired speakers; 40 profoundly hearing-impaired young adults, aged between 18 and 23 years, in tertiary education, and with an average hearing loss (over the speech frequencies in their better ear of 85 dB) were recorded reading the Rainbow Passage from Fairbanks (1960). Three trained listeners then rated these recordings using the VPA, and had an interjudge reliability of 80% over the 287 scalar degrees of the VPA. They also listened to recordings of 40 hearing speakers. The results of these analyses are presented in Table 14.2.

Table 14.2 Percentages of hearing and hearing-impaired speakers exhibiting non-neutral supralaryngeal, laryngeal, or prosodic features, using the Vocal Profile Analysis scheme

	Control group speakers exhibiting the parameter (%)	*Deaf group speakers exhibiting the parameter (%)*
Lip rounding	45	55
Lip spreading	5	15
Labiodentalized	0	2.5
Extensive lip range	5	25*
Minimum lip range	7.5	55***
Close jaw	37.5	15
Open jaw	10	40
Protruded jaw	5	17.5
Extensive jaw movement	2.5	20*
Minimum jaw movement	12.5	60***
Advanced tongue tip	45	25
Retracted tongue tip	12.5	48
Fronted tongue body	37.5	20
Backed tongue body	52.5	65
Raised tongue body	42.5	40
Lowered tongue body	15	27.5
Extensive tongue range	0	0
Minimum tongue range	5	97.5***
Nasal	100	95

Table 14.2 (Cont'd)

	Control group speakers exhibiting the parameter (%)	*Deaf group speakers exhibiting the parameter (%)*
Audible nasal escape	0	12.5
Denasal	0	5
Pharyngeal constriction	47.5	87.5***
Supralaryngeal tension	57.5	85.0
Supralaryngeal lax	2.5	7.5
Laryngeal tense	72.5	95.0*
Laryngeal lax	0	5.0*
Raised laryngeal	17.5	55.0**
Lowered laryngeal	30.0	27.5
Harsh	25.0	72.5***
Whisper	97.5	92.5
Creak	77.5	67.5
Falsetto	0	20.0***
Modal	100.0	97.5
High pitch mean	30.0	40.0
Low pitch mean	42.5	40.0
Wide pitch range	0	7.5
Narrow pitch range	27.5	90.0***
High pitch variation	0	5.0
Low pitch variation	7.5	87.5***
Tremor	25.0	25.0
High loudness mean	17.5	10.0
Low loudness mean	2.5	47.5
Wide loudness range	2.5	2.5
Narrow loudness range	5.0	90.0***
High loudness variability	0	0
Low loudness variability	5.0	90.0***

*** $P = 0.001$
** $P = 0.01$
* $P = 0.05$

DIFFERENCE BETWEEN VOCAL PROFILES OF DEAF AND HEARING GROUPS

It can be seen from these data that the differences between the vocal profiles of the deaf and hearing groups can be divided broadly into four groups:

1. ratings relating to the range of movements;
2. ratings relating to pitch and loudness;
3. ratings relating to tension;
4. ratings relating to laryngeal factors.

Range of movements

The deaf speakers were markedly different from the hearing speakers in terms of the range of articulatory movements.

97.5% of deaf speakers had *minimized tongue movement* compared with 5% of hearing speakers;
60% of deaf speakers had *minimized jaw movement* compared with 12.5% of hearing speakers;
55% of deaf speakers had *minimized lip movement* compared with 7.5% of hearing speakers.

In direct contrast to this are the significant differences between the occurrence of extensive ranges of lip and jaw movements among the deaf.

25% of the deaf speakers had an *extensive range of lip movements* compared with 5% of hearing speakers;
20% of the deaf speakers had an *extensive range of jaw movements* compared with 2.5% of hearing speakers.

Pitch and loudness

In these parameters too there is a highly significant difference between the pitch and loudness characteristics of deaf and hearing subjects.

90% of deaf speakers showed *narrow pitch range* compared with 27.5% of hearing speakers;
87.5% of deaf speakers showed *low pitch variability* compared with 7.5% of hearing speakers;
47.5% of deaf speakers showed *low loudness mean* compared with 2.5% of hearing speakers;
90% of deaf speakers showed *narrow loudness range* compared with 5% of hearing speakers;
90% of deaf speakers showed *low loudness variability* compared with 5% of hearing speakers.

Surprisingly the pitch means of the deaf and hearing groups were not significantly different even at $P = 0.05$ level.

Tension

Here the following results were noted:

87.5% of the deaf speakers were characterized by *pharyngeal constriction* compared with 47.5% of hearing subjects;
95% of the deaf speakers showed *laryngeal tension* compared with 72% of hearing speakers;
5% of the deaf speakers showed *laryngeal laxness* but no hearing speakers showed this characteristic.

These figures are difficult to interpret. We can see that nearly all deaf speakers show *laryngeal tenseness*, but so do a large number of the hearing speakers. However, the difference between the deaf and hearing groups is significant. No hearing person shows *laryngeal laxness*, but all the deaf speakers who did not show *laryngeal tenseness* show *laxness*. The difference in the incidence of the laxness too is significant.

Finally, a highly significant group of deaf speakers showed a non-neutral degree of pharyngeal constriction.

Laryngeal factors

Of the deaf speakers 72.5% show *harshness* compared with 25% of hearing speakers, this is probably interrelated with the high incidence of *laryngeal tension*. Of the deaf speakers 20% used *falsetto*, while none of the hearing speakers did. Both *harshness* and *falsetto* are highly kinaesthetic laryngeal performances, and it is possible that the high incidence among deaf speakers is related to this fact. Of the deaf speakers 55% had *raised larynx position* compared with 17.5% of normals. The reported results showing the percentage of deaf and hearing speakers who exhibited a non-neutral setting of a parameter goes some way towards indicating whether a feature is common among deaf speakers, when compared with hearing speakers. Where the occurrence is greater for the deaf group than for the hearing there is some justification for calling such parameters 'typifying features' of deaf voice. In the results reported above it can be seen that there are several features in the vocal balance of these 40 deaf speakers that were significantly different from those of the 40 hearing speakers.

OTHER FACTORS AFFECTING THE VOICE OF DEAF SPEAKERS

The discussion above describes the voice characteristics of congenitally deaf speakers. It does not account for the other factors that may affect the vocal characteristics of deaf people. These 'other factors' may be organic voice disorder, secondary voice disorder, or functional voice disorder. Organic voice disorder, where there is an organic problem of the laryngeal assembly, laryngeal tract, or of the velopharynx, may occur in deaf speakers as readily as in hearing speakers.

Non-organic voice disorders arising from emotional stress or from vocal abuse may also occur among deaf speakers. Following Boone (1983) and Aronson (1980) it is useful to consider non-organic vocal pathology as a continuum with the disorders related to vocal abuse resulting in secondary changes to the larynx at one end of the continuum, and disorders where there is no observable laryngeal pathology at the other (Wilson 1987).

Secondary voice disorder arises from misuse of the vocal apparatus. Changes in healthy patterns, posture, and voicing, as well as extraneous irritants combine to cause laryngeal distress and subsequent laryngeal changes. Chronic laryngitis, vocal nodules, Reinke's oedema, and polyps are the four commonest changes in laryngeal structure associated with misuse (Van Den Broek 1987, Damste 1987, Bennett *et al.* 1987, Lancer 1988).

Deaf speakers as a group have increased tension of pharynx and larynx, increased harshness, and raised larynx position (Wirz 1987). It is tempting to suppose that deaf speakers may, as a group, be more vulnerable to secondary voice disorder than hearing speakers. A literature search suggests that such a study has not been published. Clinical experience does, however, suggest that some deaf speakers have frequent periods of chronic laryngitis (is this a manifestation of secondary voice disorder?).

There is increasing evidence that secondary voice disorder is related to certain personality characteristics (Yano *et al.* 1982, Greene 1980, Wilson 1987) Aronson comments that speakers with secondary voice disorders frequently exhibit emotional stress. It was common to find in the literature of the 1950s and 1960s attempts to describe *the* personality traits of *the* deaf population, and factors such as stress and rigidity were frequently cited (Vegely *et al.* 1968, Zivkovic 1971). However, enlightened recent research has moved away from this homogeneous view of personality in deaf people. Work by Goetzinger (1966) and others stresses the diverse nature of studies of personality traits among deaf young people.

It is this diversity that the clinician must remember when dealing with deaf speakers with secondary voice disorders. He or she must be aware that the stress-related features of secondary voice disorder are as likely to appear in deaf as in hearing speakers.

Organic voice disorders and secondary voice disorders will occur among deaf speakers. So too will functional voice disorder, where there is no observable laryngeal pathology, but there is discernible voice change. Such voice disorder is frequently associated with life-stress and ameliorated by counselling and personal goal-setting tasks.

In addition to the characterizing vocal features of deaf speakers, to their vulnerability to secondary voice disorder or functional voice disorder, therapists must also consider the effects which ageing has upon deaf voice. Hollein (1987) reviews the vocal changes that occur with ageing, which he attributes to biochemical, aerodynamic, and laryngeal changes. Ringel (1987) introduces the concept of biological ageing as the important concept in any considerations of ageing voice. He stresses that although there are inevitable changes in larynx and phonation as well as the general anatomical and physiological changes of senescence, this decline varies considerably in rate and extent.

It is important, then, for a clinician to consider the totality of deaf voice, including those features occurring commonly in deaf speakers and which may arise from organic voice disorder, secondary voice disorder, or as a consequence of ageing.

This review has attempted to show that there are features which distinguish the voice quality of hearing-impaired speakers. However, because voice is seldom clearly defined, it is difficult to make cross-comparisons from the literature as to precisely which are these distinguishing features. The Vocal Profile Analysis scheme (Laver *et al.* 1981) provides a comprehensive labelling procedure for the supralaryngeal and laryngeal components of voice, and appears to provide a very useful tool for identifying those features that typify deaf voice.

REMEDIATION: USE OF VISUAL DISPLAY

Remedial intervention to improve the vocal features of hearing-impaired speakers is a concern of teachers and therapists. This intervention may be directed towards improving inadequate laryngeal performance, resonance disturbances, or prosodic difficulties. It was cited earlier in this chapter that common laryngeal difficulties of hearing-impaired speakers are in the maintenance of regular phonation, appropriate pitch range, and pitch variability.

The aim of the teacher/therapist in improving the laryngeal performance of a hearing-impaired speaker, is to develop his self-perceptual skills. This is greatly aided by the use of visual display. There are a range of visual display systems which exhibit different laryngeal features. Maki (1984) reviews some of these. Abberton *et al.* (1984) describe their therapy regime with post-lingually deaf subjects as 'speech production feedback therapy' using the Voiscope display. Their term succinctly describes the twofold nature of vocal therapy using on the one hand visual display to develop the speaker's speech production, and on the other the speaker's self-feedback mechanisms. Teaching/therapy techniques with the hearing-impaired which use visual display only as an aid to production, but pay no attention to the development of self-feedback, will yield poor results.

Spector *et al.* (1979) describes the use of another visual display system, the simultaneous spectrographic display (SSD) in improving the voice quality of congenitally deaf young adults. Specifically Spector *et al.* used the SSD to reduce the laryngeal tension habitually used by a group of profoundly deaf young speakers.

Wirz and Anthony (1979) also describe the use of visual display, in their case the Voiscope, as an agent in improving voice quality with hearing-impaired school children. Parker (1974) described the use of the laryngograph in teaching intonation to profoundly deaf children.

The common feature of all these studies is the emphasis on visual display as a way of improving the self-perceptual skills and subsequently the self-monitory skills of hearing-impaired people. Visual display is seen as a teaching aid to heighten the hearing-impaired speaker's awareness of a speech parameter and, subsequent to this awareness, to help that speaker develop intrinsic self-perceptual skills which he could use when there is no visual display providing an extrinsic aid.

There are of course remedial objectives that can be achieved in voice therapy with hearing-impaired speakers without the use of visual display. A hard glottal attack (the 'over fortis' mentioned above) is common in hearing-impaired speakers. Therapy directed towards a reduction of this hard attack can greatly improve a speaker's voice quality. It is often a revelation to hearing-impaired speakers to recognize how little physical effort is required in order to produce easy phonation. The teacher/therapist can encourage the hearing-impaired speaker to produce different phonations and reinforce those relaxed phonations which occur in his random productions, until the speaker becomes able to produce easy relaxed phonation to request and later as his habitual phonation.

Amplification

Many hearing-impaired speakers also exhibit poor laryngeal control through their habitual use of an inappropriate loudness level. If the teacher/therapist finds it difficult to encourage the hearing-impaired speaker to use a lower loudness level, it may be helpful to use a sound level meter as an aid to help the speaker appreciate how loudly he is speaking. If the speaker uses habitual amplification, it may be helpful to increase the level of amplification within the relatively quiet setting of the therapy session, if there is any probability of the hearing-impaired speaker being able to associate the increased volume which he uses with his proprioception of his voice production. He can then be helped to reduce his volume and learn to monitor this more acceptable intensity level.

Poor pitch control

A further vocal disturbance common among hearing-impaired speakers, and amenable to therapy, is poor pitch control. As cited above, various writers (Parker 1974, Maki 1980) have shown how visual display can help the teacher/therapist to teach the hearing-impaired speaker to control his pitch level or variability. Without visual display, too, the teacher/therapist can help the speaker to appreciate the concept of pitch level by analogous use of hand positions, or by feeling the position of the larynx in the neck, or by relaxation of the musculature of the neck, or by reducing the degree of pharyngeal tension. By using procedures proven and familiar to the teacher/therapist, the hearing-impaired speaker can be helped to appreciate the difference between his habitual pitch level and that of the desired objective.

SUMMARY

The communication of hearing-impaired speakers is impaired. The degree of impairment of language is obviously the primary difficulty for most hearing-impaired children, and not unreasonably becomes the primary teaching objective for teachers and therapists. However, the effects that poor voice quality can have upon the listening 'set' of a naive listener to a hearing-impaired person should not be underestimated. It the teacher/therapist can encourage easy relaxed phonation among young hearing-impaired children, voice problems should not develop (Ling 1976). However, there will be many hearing-impaired speakers who do develop aberrant voice patterns where specific voice therapy will be applicable.

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15

Mutational disorders of voice

Robert Fawcus

INTRODUCTION

The process of phonation is the first complex motor act that heralds the infant's entry to the world and is not uncommonly the last an individual achieves at the end of human life. The nature of the phonation produced changes significantly throughout life. The rapid transient changes conforming to the linguistic and communicative needs of the individual occur against a backcloth of phonatory function that alters slowly throughout our speaking lives. Most of these latter changes occur so gradually that they are hardly noticed by either speaker or listener. A few, however, have a dramatic impact, such as the shift from a boy's voice to the mature male pattern of phonation.

As the mass of the vocal cords increases during childhood there is a steady, often imperceptible, decrease in the fundamental frequency of phonation. In the female this process usually continues by infinitesimal decrements until the menopause when, in a number of individuals, a marked shift can occur, bringing the fundamental frequency well within the male range. The sudden nature of the change in the pubertal male leads to the occasional occurrence of a maintenance of the former fundamental frequency of phonation. This is commonly achieved by a shift, of which the individual is usually unaware, from modal voice to loft register (falsetto).

PHYSICAL AND PHYSIOLOGICAL CAUSES OF PUBERPHONIA

Greene (1980) outlines the range of physical and physiological causes of puberphonia suggested in the literature.

1. Unusually early breaking of the voice, leading to self-consciousness and habitual continuation of a high-pitched voice (West *et al.* 1957).

2. A desire to retain a successful soprano voice that has brought distinction (Seth and Guthrie 1935).
3. Fear of assuming a full share of adult responsibility. (Greene rejects the oft-quoted alleged link with the Oedipus complex, but comments on her frequent observation of a strong bond with the mother and the relative prevalence of puberphonia in boys without siblings.)
4. Hero worship of an elder boy.
5. A natural tenor voice or small larynx.
6. Delayed pubertal development (Luchsinger and Arnold 1965).
7. Severe deafness (Greene 1961).
8. Congenital abnormalities and asymmetries, paralysis of one fold (Arnold 1961) or congenital web (Baker and Savetsky 1966).

Aronson (1980) would add to the list the effect of 'general debilitating illness during puberty, which not only may delay overall growth during puberty but, because of the physical restrictions of being bedfast, may reduce the range of respiratory excursions and consequently, tidal air volumes, preventing the development of adequate infraglottal air.'

He goes on to enumerate laryngeal–respiratory postures and movements that have been noted as bases for high-pitched mutational falsetto voice.

1. The larynx is elevated high in the neck.
2. The body of the larynx is tilted downward, apparently having the effect of maintaining the vocal folds in a lax state.
3. With the vocal folds in a flabby state, they are stretched thin by contraction of the cricothyroid muscles.
4. The vocal folds are thus in a state of reduced mass and offer little resistance to infraglottal air pressure.
5. Respiration for speech production is shallow, and on exhalation infraglottal air pressure is held to a minimum, so that only the medial edges of the vocal folds vibrate and do so at an elevated fundamental frequency.

The first of these characteristics was noted by Makuen in 1899 (cited in Luchsinger and Arnold 1965) and is quoted in almost every work on the subject of puberphonia.

Evidence derived from simple observation of laryngeal excursions during normal phonation and falsetto suggests, however, that the reported high elevation is associated with the typical upward shift in pitch that occurs when a male speaker demonstrates the switch from true cord phonation to falsetto. This usually involves a pitch change of at least an octave. If the transfer is made at the same pitch level the elevation is much reduced.

Despite the wide range of alleged causes of puberphonia there is an alternative explanation that matches our own experience and many of the accounts occurring in the literature. These typically ignore the possibility that a pubescent male may blunder into an alternative mode of phonation during the initial period of vocal mutation and then be unable to escape voluntarily.

The fact that an individual is apparently unable to shift from one mode of phonation to another should not be at all surprising. After the successful transfer from falsetto to true cord phonation it is often just as difficult for the former puberphonic to achieve falsetto voice.

The flexibility which some individuals appear to have in control of their phonatory and articulatory behaviour is not universal. The range of skilled behaviour evident in such activities as mimicry and singing suggests that a significant proportion of those with a normal speech mechanism are unable to achieve even average performance (Fawcus 1980). Luchsinger and Arnold (1965) comment that 'while their peripheral auditory perception is usually normal many of these [puberphonic] patients are not musical.' They also note the influence of auditory factors reflected in the occasional occurrence of falsetto voice in profoundly deaf males.

It is often not appreciated that falsetto phonation is employed by the normal speaker: it is a feature of war cries in many cultures, and can also be heard on British Army parade grounds in the issuing of orders during drill. More peaceful phenomena include giggling, laughing, yodelling, and the singing of the counter-tenor.

At the London Conference of the International Association of Logopaedics and Phoniatrics in 1959, Moses traced the swings in fashion which were associated with the castrato singing voice over the previous 200 years and made the confident prediction that male singing styles were about to enter a new phase in western culture. Many in the audience including the present writer found this prediction difficult to accept. With the possible exception of a single popular male alto, Alfred Deller, the overwhelming majority of male singers rarely strayed into falsetto phonation. On the popular stage as well as the concert hall, male singers exuded as strong a masculine image as possible.

For the past quarter of a century successions of highly successful popular singers have laboured consistently to lend credence to Moses' prediction. The Beatles, the Beachboys, Tiny Tim, the Jacksons, and hosts of others, have spent a major portion of their time producing falsetto phonation to the evident delight and full acceptance of their followers.

Gutzmann (1897) described the role of the crycothyroid in the production of falsetto voice in the normal larynx by means of a 'functional over-contraction'. Arnold (1961) investigated the operation of the laryngeal musculature by means of electromyography and confirmed that the external vocal cord tensor (cricothyroid) is the muscle chiefly involved in falsetto phonation. Hirano *et al.* (1970) studied the regulation of register, pitch, and intensity in the larynges of a small group of singers using hooked wire electrodes.

Traditionally, falsetto voice has been considered as the main component of head register and part of the constituent pattern of the mid-register or mixed register. It is not held to be involved in the highest range, known as the whistle register, or the lowest described as chest register. The Hirano recordings show most differences occurring in the trace derived from the vocalis muscle of one of the authors (Vennard), an accomplished bass as well as a speech scientist.

Fawcus (1986) reported on a group of young men seen at both the Middlesex Hospital and Guy's Hospital, over a period of two decades.

All were reported to have laryngeal structures within normal limits and there was no evidence of endocrine disorders. None of the young men gave cause to either the referring ENT surgeon or the speech therapist to consider the necessity for psychiatric referral. Their complaints centred on the basic acceptability of the high-pitched voice and in no case did this seriously affect social adjustment. The group bears strong resemblance to subjects in studies by Hammarberg (1987) in Stockholm, and Green (1988, personal communication) in Sydney, Australia.

TREATING PUBERPHONIA

Diverse techniques as well as accounts of their success abound in the texts devoted to voice disorders. Greene (1980) suggests a number of activities, principally concerned with postural adjustments and relaxation. Gutzmann's pressure test, for example, cited in Luchsinger and Arnold (1965) is recommended by Aronson (1980) as a successful therapeutic technique. It requires digital pressure on the thyroid cartilage during attempts at phonation.

After one has taken the necessary case history it is obviously important to investigate the patient's pitch range. The first problem encountered is that he is very likely to be able to produce falsetto voice at or near the normal adult male fundamental frequency. This is, however, clearly different from the normal male voice. It usually has a slightly breathy tone, tends to be weak and somewhat flat. Depending on how long the individual has been using falsetto, however, the stage of growth of his vocal cords, and idiosyncratic factors related to phonation patterns, it is possible that he may have achieved a reduction in breathy quality and more power than is usual for a puberphonic voice. This can be seen most clearly in the male alto who can typically achieve considerable intensity with a minimum of breathiness.

The principal test is to listen to conversation or reading aloud to determine whether or not the low pitch is maintained and whether the transition to a higher pitch is a smooth one without voice breaks.

Many individuals find singing scales difficult or embarrassing, and it is just as satisfactory to proceed in simple steps to pairs of notes up to the top of his comfortable range and then down to the lowest point. The therapist who is not a musician may find it simpler to employ a small electronic keyboard which is usually nowadays portable and inexpensive. This has many applications with other types of dysphonic patient as well as offering a broad range of opportunities in work on listening skills with young children.

A laryngograph or Voiscope (Fourcin and Abberton 1971) preferably with hard copy printout can provide the therapist with a visual display of the pattern of phonation. The puberphonic does not produce the typical saw-tooth output of the normal speaker, but a wave-form that closely approximates to a sine wave.

The absence of the characteristic bursts of laryngeal output is responsible for the weaker almost ethereal tone of the falsetto. The tissues of the vocal folds are vibrating with reduced mass and a lower level of tension in the closed phase. They are behaving like a tuning fork or the air in a flute and the resulting voice is reminiscent of these sounds.

It is preferable not to attempt to alter the mode of phonation too quickly in the session. The abrupt change in voice which is relatively easy to achieve is usually very difficult for the patient to adjust to. It is important to determine if he has been aware of any occasional shifts into true phonation. These can occur accidentally, but it is not usually possible for the puberphonic male to reproduce them at will.

The exploration of range of falsetto may have resulted in production of 'creaky voice' particularly in the lower frequencies. It is very useful to assess how easily the patient can achieve creak, or glottal fry as it is known in the American texts on dysphonia. Of all techniques suggested the most effective with the above group of persistent puberphonic cases at the Middlesex Hospital and Guy's was the transfer from falsetto phonation first to glottal fry (creak) and then into true cord phonation.

One should ask the patient to initiate 'creaky voice', and when he is comfortably producing this mode of phonation ask him to raise the pitch gradually. There is a reasonable chance that he may shift dramatically into normal phonation immediately. If this does not occur, then it is necessary to attempt the task two or three times and then divert to a relaxation task; if there is repeated failure (see Greene 1961, 1980) after an interval the technique may be repeated. Many authorities, however, report success within a few minutes of commencing the process.

Such success leads almost without exception to one of the major paradoxes in the field of speech therapy. A young man has come to the clinic, complaining that his voice is too high pitched and that he is often upset by people mistaking him for a woman when speaking on the telephone. Within a matter of minutes it is possible for him to achieve true cord phonation. The pitch drops accordingly and he has achieved exactly what he requested. The most common, initial reaction is to reject the new voice. The reasons given differ from individual to individual, but with very few exceptions this is a typical response.

This behaviour only served to confirm the views held by psychoanalysts, and those therapists who were inclined to their philosophy, that the young man actually preferred his original state and that it was the result of a process of 'symptom-choice'.

ESTABLISHING THE NEW VOICE

Although disconcerting to the therapist, even if the response is anticipated, it would be a serious mistake to interpret the rejection of the new voice as anything but a normal and temporary reaction.

It is very similar to the panic described by some stammerers when they realize for the first time that they can approach speaking situations with a low risk of stuttering (Dalton and Hardcastle 1977). This is usually the result of a rapid response to a specific therapy procedure which can leave him feeling 'naked and vulnerable', as a stammerer once described it.

Another example is the response of the adult patient who requests therapy because he or she habitually uses a lateral /s/ or uvular /r/ and wishes to learn to speak 'normally'. In both such cases it is possible to achieve, sometimes with singular difficulty, the performance which they claimed to desire, only to find that they dislike the result.

Appropriate advice and counselling can usually overcome this very human, quite normal reaction to change. The most effective approach can be to accept the negative response as a normal reaction. It has to be remembered that if the therapist is disconcerted, the individual himself is not unaware of the paradox and is likely to feel just as uncomfortable about his protestations as he does about the quality and 'feel' of his new voice or new articulatory pattern.

In the puberphonic it is helpful to work on developing and establishing the new voice in spite of the initial protests. This entails exploring the vocal range, and encouraging the young man to experiment with the new mode of phonation. He should be encouraged to use his new voice as often as possible with strangers before he encounters his family, friends or colleagues at work. Some gain great benefit from talking on the telephone or having a face-to-face conversation with a sympathetic friend prior to approaching a situation which may be potentially threatening.

It can be emphasized that, contrary to his expectations, people in the patient's environment are not likely to notice the change. Furthermore, it should be pointed out that he himself will be much more aware of any difference as most people will tend to listen to what he says rather than how he speaks. It helps to keep the volume of the voice down at first as this aids the maintenance of stability and tends to limit the attention paid by others.

Strong reassurance can be given but this will be greatly reinforced if some assignments are attempted. These can include telephone calls to strangers, and being interviewed by a colleague of the therapist unfamiliar with the original puberphonic voice.

Sometimes the young man is more anxious about the reaction of parents and siblings than strangers.

Case history 1

KS, a young man whose family were immigrants from Pakistan had been criticized and ridiculed for up to a year by relatives, particularly his uncles. He was very concerned about their reaction to his new voice but found that they did not notice the change until he brought it to their attention.

Case history 2

TJ, a young man in his early twenties, showed a particularly distressed reaction to achieving a very serviceable male voice in the first session of therapy. 'Well as you know, I work for a construction plant hire firm, and have to deliver and demonstrate vehicles on site. I often get a bit of leg pulling about my voice but this will be terrible. Tomorrow I'm getting married and when I get back from my honeymoon, they will all fall about laughing.'

He resigned from work that day and sought a similar post in another district after his honeymoon.

Case history 3

PM was referred in his mid-forties after an ENT examination, following a period of laryngeal discomfort. His father had undergone laryngectomy a few months previously, and he was, understandably, very conscious of his own larynx.

His response to therapy employing a glottal fry initiation was rapid and effective, and he showed less concern about the change than the younger cases mentioned previously. It was agreed that he should return after a few days to make a laryngographic recording, so that we could examine the transition from falsetto to true cord phonation and obtain a visual record. When he returned to the clinic, he was quite unable to achieve falsetto voice, he was now as locked into the normal mode of phonation as he had been trapped into the former phonatory pattern since puberty.

Few if any mutational disorders of phonation share the dramatic nature of persistent puberphonia. Most of the disorders are so rare and so subtle that they have even avoided acquiring a specific label. A very small number of children may be referred to a speech therapist with problems relating to their fundamental frequency well before the anticipated effects of puberty. The few cases in my own experience were associated with growth problems and observation of the children over a number of years showed little significant change in the tendency to use a fundamental frequency markedly higher than their peers. On the single occasion when a six year old was referred because his voice was virtually an octave below normal it was found that he had a major chronic infection pervading his vocal cords. The ENT surgeon had not been able to view the larynx by indirect laryngoscopy and the diagnosis was later confirmed by direct laryngeal examination.

The problems of the female adolescent whose fundamental frequency remains at a pre-pubertal level have received little attention either as a clinical problem or in the literature. Within the range of females in the population at any age there is inevitably a proportion whose voices lie even more than two standard deviations below or above the mean. It is the lack of social stigma attached to the possession of a high pitched voice by a female which reduces the conspicuousness of such individuals and their referral is very rare. This is not to say, however, that the problem is unimportant because for some women a fundamental frequency which deviates from the norm may be a source of considerable embarrassment and concern.

Biever and Bless (1989) investigated the acoustic and aerodynamic characteristics of the phonation of twenty geriatric and twenty young female adults and contrasted these findings with video-stroboscopy. They found that the elderly women showed a greater degree of shimmer and more intersubject variability in fundamental frequency and mean airflow rate. Videostroboscopy revealed a profile including greater aperiodicity, incomplete glottal closure, mucosal wave alterations and a relative reduction in the amplitude of vocal fold vibration. It was perhaps misleading to describe the elderly women as geriatric. Their mean age was 69 (range 60 to 77 years), their hearing was better than average for their age group, they had no known neurological disease and were non-smokers.

Therapy for individuals who exhibit phonatory dysfunction due primarily to mutational factors is inevitably very similar to the basic principles outlined in Chapter 8 of this volume with particular emphasis on the pitch component of the problem.

As men and women pass through their middle years there is a tendency for them to show evidence of a gradual reduction in fundamental frequency of phonation. This is undoubtedly more evident in the singer who is constantly aware of the parameters of the singing voice but it is nevertheless a feature of the vast majority of speakers. Hollien (1987) and other authors have noted a tendency for a rise in fundamental frequency in male speakers during the 1960s and 1970s, and Hirano *et al.* (1983) suggest that elderly females tend to show oedema of the vocal folds which has the effect of maintaining a lower fundamental frequency. Histological changes associated with ageing are reported widely but there is little clear evidence as yet to show whether or not such changes are associated with factors such as smoking, exposure to irritants or patterns of vocal use.

As our understanding of hormonal influences develops we shall be in a better position to monitor and possibly control the changes which occur during development (cf. Abitbol *et al.* 1989). Recent work at Cardiff University has provided techniques for studying laryngeal growth which offer evidence gained non-invasively. MacCurtain's (1990) initial investigations into the possibilities of Magnetic Resonance Imaging also offer prospects of the co-ordination of anatomical studies in vivo with other pertinent acoustic and physiological information.

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16

The voice of the transsexual

Judith Chaloner

INTRODUCTION

It may seem a departure from the traditional view of the speech therapist's role in the treatment of voice disorders to include a chapter on voice work with transsexuals (individuals who feel they have been born into a body of the wrong gender). However, it is important to realize that this type of work is increasingly becoming the responsibility of the speech therapist as part of the medical team working with these clients. Consequently there is a need for these therapists to be aware of the medical programme involved when sexual reassignment is considered, and be conversant with the transsexual condition and the many ramifications that work of this type entails. This is in addition, of course, to any therapy procedures that may need to be undertaken.

The object of this chapter, therefore, is to give speech therapists a background knowledge about transsexualism, guidelines for approaching voice work with these clients, and suggestions about general management.

Most transsexuals want to have a sex-change operation, and with a view to possibly qualifying for this very serious undertaking they must undergo rigorous screening. Part of this preoperative period may include help to make their voices sound as convincingly feminine as possible.

Much of the discussion in this chapter is based on personal experience gained over a period of 12 years. During this time most of the work has been with groups of male-to-female transsexual clients who have been referred from the Gender Identity Clinic at Charing Cross Hospital in London. In addition, there have been an increasing number of clients requesting some individual therapy, often in conjunction with the group programme. Over the years nearly two hundred individuals have been referred.

The group work involved once-weekly two-hour sessions in blocks of eight to twelve weeks. Many clients came back several times. The numbers in a group ranged from six to a maximum of ten. At all times a total approach was aimed at, with a beauty therapist working closely with the speech therapist. Voice work was at all times coupled with general communication skills.

Final results regarding the voice work were, in general, very satisfactory at a subjective level. Approximately a quarter of these clients eventually had a sex-change operation. It is worth mentioning that the majority of sex-change operations are now paid for privately by the individuals, with relatively few being paid for by public money. Many individuals are still waiting for referral for the operation and approximately a quarter dropped out of the programme or were encouraged to leave for various reasons. It is always accepted that many individuals in a situation of this kind are simply not able to satisfy the rigid requirements imposed during this trial period.

Long-term contact has been sustained with many group members whom it was felt achieved satisfactory voice results, and in general their own attitude to their voices is one of ease when speaking, with little attention to the mechanics involved. They feel, for the most part, that their voices are acceptable and no longer cause them personal concern. This is the goal that the therapist hopes to achieve for the patient – a convincing sounding voice and a confident unselfconscious speaker.

The first referral of a transsexual client to a speech therapist may well present a daunting prospect. This is not surprising as it is unlikely that there will have been much reference to work of this type during training; consequently it will probably be a situation far removed from both clinical and personal experience.

In England the majority of work with transsexuals is concentrated in three London hospitals; Charing Cross, Kings College, and the Maudsley. Speech therapists associated with these centres will frequently have these clients referred, and then will possibly refer these individuals on to a therapist near their home. People with gender identity problems travel to London from all over the country, particularly to Charing Cross, where approximately two hundred people are referred each year to the Gender Identity Clinic in the psychiatric department.

Speech therapists exploring this area of voice work will be interested in various research projects involved in measuring fundamental frequency and intensity differences between the male and female voice. This will be discussed later in the chapter. It is hoped that any therapist who feels that he or she has a client who is a suitable subject for self-monitoring work with instrumentation techniques, or if the precise progress needs to be recorded, will realize the possibilities in this area.

This chapter's discussion is largely a basic and practical guide based on empirical observation, to be expanded by individual therapists as their own knowledge and expertise increases, and to suit each particular situation.

THE TRANSSEXUAL CONDITION

The term transsexual was coined by an American psychiatrist, Harry Benjamin (1966), who reported on a number of cases and became one of the first workers to stimulate study of the subject.

In her study on bisexuality, Charlotte Wolff (1977) defines transsexuals as people who believe that their mind is trapped in the wrong-sex body. As she explains, some are satisfied with hormone therapy, but many insist on surgery, when there is a violent clash between their sexual and gender identity. It is the sense of belonging to the opposite sex that disturbs them rather than the qualities of 'masculinity' or 'femininity'.

Benjamin believed that there were a number of causes for the condition (far more common in men than women) and that some were biological and some psychological. There are many other psychiatrists with a variety of theories, but no clear-cut consensus has evolved. It is clear, however, that there is not a chromosomal abnormality in these individuals.

Whatever the aetiology, these people feel overwhelmingly that they are in the wrong-gender body. This conviction has been with them their entire life and has been the dominant feature of their existence. Mentally and emotionally they completely identify with the opposite sex, and feel that their body is a tragic mistake. In their study on gender identity, Money and Erhardt (1972) explain that the transsexual is driven by a compulsion to have the appearance, body, and social status of the opposite sex.

Most transsexual clients referred to a speech therapist would be candidates for a gender reassignment operation. It is not uncommon, however, for a transsexual to decide that he or she wishes to live permanently as the opposite gender, but cannot face the idea of surgery. These are generally older clients who feel that surgery is a great physical risk.

All these individuals would be referred from a psychiatrist, and would be seeing him/her for consultations. They might also be seeing a psychiatric social worker who would be helping with the practical difficulties involved. When a change of lifestyle so enormous as a sex-change is contemplated these problems can be overwhelming. The social worker may also be involved in family counselling of the client's partner, children or parents.

Although, of course, transsexuals can be of either sex this discussion deals exclusively with the male-to-female situation.

The sex-change operation is performed by a urologist. The patient is castrated and the penis is then modified to form an artificial vagina, which requires a considerable period of dilatation after the patient leaves hospital. The patient is usually in hospital a week and requires at least six weeks off work to recuperate. For most patients the elation at finally having 'the operation' seems to transcend the very considerable discomfort following surgery.

Breast implantation surgery is occasionally done at the same time as the main operation, but it is more commonly a secondary procedure. Although hormone therapy is usually part of the preoperative treatment, and is carried on afterward, the resulting breast development is only moderate. Many transsexuals feel that they need this further surgery to satisfy the desire for a totally feminine figure.

There is often confusion about transvestism and transsexualism. Transvestism is the act of cross-dressing, usually in connection with sexual arousal, but the individual involved does not actually wish to assume the identity of the opposite sex. There is also the question as to whether there is a homosexual quality in the transsexual's desire to change sex. Most male transsexuals deny this although some wish for a permanent relationship with a man at some future time, after the operation.

One should be aware that in many cases the question of gender identity has led the individuals to experience a variety of sexual experimentation. However, the true transsexual wants above all to appear and be accepted as the opposite sex; all other sexual considerations are very much secondary to this.

The progress of most of these clients follows a certain pattern. In early adulthood they try to conform to accepted social expectations and fit into their gender role. Many have deliberately taken on a very masculine job in the hope that it might help resolve their conflicting feelings. Quite a number of transsexuals say they have joined a branch of the armed forces for this reason.

A continuation of this pattern is that many transsexuals marry and have children, but in most cases they say that sexual relations were conducted as a duty, and that they had little interest in that aspect of the relationship. The rapport with their wives is often warm and loving; there is frequently a feeling of guilt in later years that their obsessional feeling has destroyed the marriage and caused the partner pain and distress. Many wives remain ignorant of the situation for years, while others are aware of the problem, but try to live with it.

It is surprising that in this sexually enlightened age it is not uncommon for a transsexual to reach middle-age and be unaware that his sexual dilemma is not unique. These people are generally those who read little and have been unwilling or unable to discuss their personal feelings and voice their fears to others. Although nearly all transsexuals have had experiences of cross-dressing (wearing clothes of the opposite sex) from childhood, this may have continued as an entirely secret pastime into adulthood.

Some of the problems that may be encountered by transsexuals are illustrated in the following cases.

Case history 1

John is a 60-year-old civil servant in a provincial city. From earliest childhood he felt that his male body was some sort of terrible mistake and that he was supposed to be a girl. He identified in every way with the female sex.

His entire early life was led against this background of emotional unfulfilment. He often had feelings of terrible anxiety that he was going insane because he had the persistent feeling that he should have been a woman. The fact that he is an extremely masculine-appearing individual with heavy facial hair growth made his predicament seem, to him, compounded.

He had a successful army career as a young man, and his married life was happy in spite of his lack of interest in sex. There were two children and he was outwardly conforming to a routine pattern of life, although cross-dressing whenever he was alone in the house. It was reading an excerpt from the book *Conundrum* by the journalist Jan Morris (1974) that changed John's life. The book, which was serialized in a Sunday newspaper, was an account of Jan's life as James Morris until she was over 40. It gives a vivid account of her unhappiness as a man and her fierce struggle with problems of sexual identity. It then goes on to describe her sex-change operation and her adjustment to a new way of life as a woman. It also tells of the effect this change had on her wife and family.

John realized that his feelings were not unique, and once told the transsexual group of the feeling of joy and relief that this realization made, even if nothing was immediately resolved in his life. Shortly after this he was widowed and for the first time felt he could seek medical help. His family doctor referred him to the Gender Identity Clinic at Charing Cross Hospital in London. From there he was given counselling and was placed in a group with ten other transsexual clients. After living full-time as a woman for eighteen months, he was retired from his job on medical grounds, as his employers were not prepared to tolerate him in this changed status. He was then referred to a surgeon.

His case ended unsatisfactorily for him, however, because the surgeon refused to operate. He did so on the grounds that although his voice was passable and it was felt he had a stable personality, his appearance was too masculine, even if assisted with all possible camouflage techniques, to enable him to pass successfully as a woman.

John continues to live in the female role with great support from his daughter, but he no longer has contact with his son who refuses to accept the situation.

One must remember the great responsibility that falls to the psychiatrist and surgeon when taking a decision to irrevocably alter another human beings's life in this way. The long and often difficult 'trial period' required before any surgical referral is made is necessary for this reason as well as being in the client's long-term interest. It is interesting to note that not all psychiatrists view surgery as the answer. Benjamin (1966), for example viewed it as a last resort – to be considered only if the patient was felt to be suicidal. He felt that more conservative therapy was often the more appropriate course.

The majority of transsexuals seek help earlier than John. However, the age-span of the group members was not particularly young, between 25 and 67 years, the main spread being between 34 and 45.

The average procedure for the client is that the psychiatrist will combine hormone therapy with counselling. The hormones produce some secondary sexual characteristics such as modest breast development, some surface fat, some reduction of beard growth, and skin softening. Some clients are, unfortunately, not suitable for hormone therapy for a variety of medical reasons, as for example a history of thrombosis. The refusal of these drugs often causes a severe reaction in the client. They often show signs of depression or panic. Much reassurance will be needed that this therapy is not absolutely necessary. Many transsexuals, particularly the older ones, manage perfectly adequately with no drug therapy at all.

Before referral to a surgeon the client must live full-time as a woman and be able to support himself in that role for at least a year. This latter stipulation is vital because the question of employment is often very difficult for the transsexual to resolve. Not all clients can continue in their former jobs in their new feminine roles; some feel that the old job is no longer suitable and some employers will not tolerate the idea of employing a transsexual. One can debate the morality of this decision but the situation does exist and must be considered. It is not uncommon for an individual to live and work as a man by day and conduct his domestic and social life as a woman, sometimes for many years. It is difficult to give up a secure job for something new, particularly when there are many other pressures as well. Some clients are lucky enough and have sufficient confidence to make the transition quickly and openly, if it becomes necessary.

It may seem obvious to say so, but of course the organized, perceptive, intelligent man will retain the same personality on becoming a woman. One group member who had a highly successful job in business decided to retrain as a secretary when he changed sex. In a very short time she had gained promotion in her new job and was soon in nearly as responsible a position as the one she had left.

Case history 2

Iris is now in her 50s, a bright, attractive, articulate woman with a warm outgoing personality and a keen sense of humour. She has an excellent voice with a slight regional accent and dresses suitably for her age and build. There really is no sign that this person lived the first 45 years of life as a man. As well as the sex-change operation Iris has had breast implantation and further plastic surgery to her nose and chin. It has been a long struggle.

The story is the same as most, with an early history of feeling he did not fit in with the rest of the boys, and that he hated his male body. There was also the usual secret cross-dressing whenever possible. In spite of severe feelings of depression and emotional discontent, Iris made a success of work, was a popular member of the community, and married young. There were six children and he was a loving and devoted father.

The decision to seek medical help came about twelve years ago. Bill (as he was known then) made many trips abroad for his firm and when in foreign cities took the chance to live quite openly as a woman whenever possible. He described the sense of joy and release of 'at last being able to be me' as truly wonderful. In spite of the pain he knew it would cause his family, he felt he had to go ahead with a sex-change in order to retain his sanity.

The problems were enormous. The family inevitably suffered and there was much grief and disruption. There were also money problems as his firm would not accept the situation and a new line of work had to be found. However, the ending has been interesting, and perhaps a tribute to Iris as a person that her life has reached an even keel. Iris and her former wife live together still. Throughout all this trauma that gallant lady supported Bill, and then Iris, through the years of severe upheavals.

Case history 3

Simon, 42, was luckier than Bill with the question of his job at the time of sex-change. He is a highly paid scientific officer with a large company where his expertise is very much valued. He lived a double life for years until, with the support of his wife, he approached the firm with his problem. The decision was made to allow him a period of leave and then, after all his colleagues were fully briefed about the situation, he returned as Wendy. He has now had the operation and continues to work for the same firm and has moved up the job ladder. His wife did not feel, after an initial trial period, that she could tolerate her husband in the female role, and they have parted.

A further condition for surgery is that the transsexual must have provided for any dependants. He must also satisfy the psychiatrist that he is mentally stable before referral to the surgeon, who has the ultimate decision.

Not all transsexuals, even those considered suitable for surgery, elect to have it. One extremely convincing-looking and -sounding client who satisfied all the criteria and had, in fact, lived many years as a woman never wanted referral for the operation. He explained that counselling had enabled him to come to terms with the situation, and help with voice and grooming had boosted confidence. However, he felt the operation would be an act of mutilation that would not, in his case, change his lifestyle. He continues to live, with apparent success, as a woman.

Physical appearance has not any real bearing on the transsexualism of an individual. Of course the work of the beauty therapist would be much simplier if all transsexuals were of short or medium stature, had small hands and feet, fine delicate features, and minimum beard growth. Sadly this is not the case and often extremely masculine-looking men feel inwardly feminine. Appearance seems to act neither as a deterrent nor an impetus in those people wanting a sex-change.

ACOUSTIC AND LINGUISTIC CONSIDERATIONS IN TRANSSEXUAL TREATMENT BY SPEECH THERAPISTS

It is appropriate at this time to discuss research work done in this area. Oates and Dakakis (1983) give a very full review of the rather scattered and inconclusive literature on communication problems of transsexuals. As these authors emphasize, 'the validity and efficacy of management procedures remains limited, until a more comprehensive data base on sex markers in speech is delineated.' In this connection they discuss the important distinction between male and female 'speech markers' (on which there is little valid published data) and 'speech stereotypes'. The former are those features of speech, both segmental and non-segmental, that constitute the clues by which we consciously or unconsciously assign gender to a speaker when other (for example, visual) clues are lacking or ambiguous.

The 'speech stereotypes' are the subjective expectations of the average person as to what they expect the speech of one or other sex to be. These speech gender indicators are at present still ill-defined. What makes us identify an unknown voice on the radio as male or female? Even those who have carefully studied the subject of such 'markers' produce inconclusive results. For the purist the speech markers are the important attributes about which we need to know more, and on which further research is clearly needed. Of course fundamental frequency is the most obvious of these markers. Oates and Dakakis (1983) summarize the findings of studies of the fundamental frequency of adult speech as follows: adult males from 20 to 29 years have an approximate mean of 138 Hz with a range of 60–260 Hz. Females of the same age span have a mean of 227 Hz with a range of 128–520 Hz. They conclude, 'thus although female voices average 1.7 times higher in fundamental frequency than do those of males, the ranges for males and females overlap considerably.' It is also mentioned that in older age there is a considerable reduction in the difference between the fundamental frequencies of male and female speakers, although no figures are given.

Perhaps 'stereotypes' are more important to the fulfilment of the transsexual's expectations than the fundamental speech markers. As Oates and Dakakis (1983) record, 'the client's goals often arise largely from stereotypical beliefs.' In other words it is perhaps more important that the client thinks he is creating the expected image than that he is actually reproducing the precise idiosyncrasy of the intended voice.

In summary, the help that a speech therapist can give to the transsexual is still based on empirical observations. Until more fundamental research on absolute speech markers has been carried out, the therapist will be guided by subjective criteria.

RESPONSIBILITY OF THE SPEECH THERAPIST

Voice work

The therapist gives help and practical advice on voice modification to help the client sound and project as acceptable and plausible a result as possible to the receiver.

Encouraging general communication skills

There cannot be too much emphasis on the need to develop a confident manner. This must be coupled, of course, with as convincing an appearance as possible. Expectation in the listener of hearing a female-sounding voice, because the speaker appears at ease and looks feminine, is often enough to defy the critical ear.

Referral to other agencies

This entails referral to the appropriate source for additional help if it is indicated. Advice is often sought regarding grooming, clothes, or make-up. Obvious basic suggestions can be made, but referral to a beauty therapist is more satisfactory.

It is sometimes difficult to make the distinction between giving help with voice and communication skills and assisting with other aspects of the client's presentation. Each therapist will feel differently about the ability to advise in these other areas, and should be guided by common-sense rather than a rigid code of rules. The transsexual is usually a very troubled individual who will value the suggestions made by a caring person.

Information about the formalities of changing names by deed poll and queries about legal documents, and other matters of a legal nature, should be referred to the psychiatric social worker, whose responsibility it will be to talk to employers and to do any family counselling.

Nearly all male transsexuals have several years of electrolysis once or twice a week. This is very expensive and time-consuming. Many beauty clinics run evening sessions for men only, as for example the Toa Clinic. A beauty therapist will be able to advise where help can be obtained.

The Albany Trust (24 Chester Square, London SW1) was set up 25 years ago to provide an information and counselling service for members of sexual minorities. This society can give a client the telephone number of a self-help transsexual group, which is often able to supply useful addresses and other support facilities. The people answering the telephone are experienced in this area and the client can be assured of having any queries dealt with efficiently and sympathetically.

The Trust can also put the client in touch with the Beaumont Society. This group was originally founded for transvestites, but transsexuals are also welcome and it provides a social base; wives are also free to attend and many have found it very supportive. Some transsexuals dislike association with the Beaumont Society, but it can be a useful link since it publishes a newsletter. This paper lists sources for wigs, clothes, large-sized women's shoes, and other items sometimes difficult to find or embarrassing to ask for in shops. There are other smaller groups and societies willing to include transsexuals, and the Trust will also advise about these.

Refraining from personal involvement

This should be mentioned because it may be a temptation to try to undertake more in the way of counselling than one is qualified to give.

The client may sometimes request a great deal of your help and advice about his often very troubled existence. Transsexual referrals are unique in speech therapy work. One must be aware that some of these clients may be under more stress than is immediately apparent, and require specialized guidance.

It must also be said that many fears and worries will be voiced to the speech therapist instead of the psychiatrist. This is due to the fact that the client may be fearful of appearing unstable to the psychiatrist, and jeopardizing his surgical referral if he shows any vulnerability.

Voice modification

It is assumed that anyone attempting voice work with these clients will be completely familiar with the mechanics of the normal voice and have had experience working with adult voice patients. The anatomical differences of the voice-producing apparatus of the male and female, such as size of larynx and length and mass of vocal tract will be well known.

The rationale, therefore, behind any techniques suggested will be self-evident, so it is expedient to outline the therapy programme in terms one would use in explanation to a client. All the following procedures have been practised without creating problems of vocal strain.

The only case of hoarseness (not including problems following vocal-cord surgery) among the group members started when a client was about to have the sex-change operation. The condition persisted to such a degree that she was seen postoperatively by an ENT surgeon. It was found to be an entirely functional problem and gradually resolved itself in a few months. This patient had had a period of several years caring for a terminally ill wife. Although her death allowed the husband freedom to have the longed-for sex-change it was still an emotionally traumatic period, and the voice suffered.

As was mentioned earlier this is a guide to the straightforward techniques employed in the ordinary clinical situation. In other words the answer to, 'But what do I *do* with the client?'. That there are more sophisticated methods employing instrumentation are well known, and one American case study of a postoperative client will be referred to at the end of the chapter.

It might be argued that as this is essentially an exercise in acting, it might be more expedient to send transsexuals to a drama coach. After all, the only 'disorder' of the voice is that the client views it as a hindrance to his ability to function successfully as a woman. However, these are not professional actors but troubled individuals who need the help of someone who is used to dealing with people under stress, and where there is medical back-up available.

This reference to acting may seem obvious, but it is not always easy for these clients to accept this idea. It has been my experience that much as a transsexual may wish to produce a convincing female voice naturally, he often dislikes the idea of having to deliberately work to achieve it. To concentrate on how the voice sounds, and thinking about altering its production is sometimes, understandably, felt to inhibit thought and conversation.

It is the dislike of feeling they must 'put on an act' that worries the transsexual. This feeling does not extend to wearing female dress or make-up, because this is the natural taste and inclination. Clothes are simply part of the female image that he wishes to project to the world and himself. To achieve concentrated effort on voice training is often quite difficult. There are, of course, some natural actors who enjoy the process of vocal gymnastics, but these are fairly unusual. For others it may be necessary to discuss the fact that although one may understandably dislike the mechanics involved, good results are possible. My work has been almost entirely with preoperative patients who need a passable voice to qualify for surgical referral. In my experience the voice has generally improved with practice and continual use and is usually quite acceptable.

It is convenient to divide the plan for voice work into the following categories and for these to be interwoven as appropriate:

1. assessment
2. relaxation
3. voice experimentation
4. breathing for speech
5. pitch establishment
6. elimination of chest resonance
7. intonation, peaking, and lilt
8. role-playing and self-expression practice
9. non-verbal communication
10. personality projection and communication skills.

Assessment

As assessment is our tool for drawing up a plan for treatment, the following outline is suggested as a useful guide. This is a subjective assessment based on the first meeting with this client. We assume that the client will present at the initial interview dressed as a woman and using his 'female voice' if he has one.

1. Is the voice convincing enough to pass as feminine?
2. Does it need only minor adjustments?

3. Is it a light-sounding male voice?
4. Is it unmistakably masculine?

This impression will be influenced, of course, by how well the client presents and how at ease he is with his voice and his ability to communicate as a woman. Many clients have been playing this role successfully for years. There can be every permutation of looks and voice with no absolute categories.

The following things should be noted:

1. Quality of voice.
2. Impression of the degree of chest resonance.
3. Pitch.
4. Method of delivery.
5. Manner of articulation.
6. Type of breathing used for speech.
7. Manner of speech. Is it flat and unemotional? Is there a regional accent? Has an attempt been made to make it sound feminine by being overly affected in speech?
8. Physical impression. One needs to record how the client presents as a person, how intelligent he appears to be, his size, age, and appropriateness of his clothes and make-up. One must also note habits that detract from his appearing to be a relaxed speaker, or communicator in general, as for example poor eye contact, rigidity of face, overanxious manner, covering his mouth or Adam's apple, and similar traits. Some of these items may sound very trivial, but they all add up to the general impression presented and to be judged by the viewer and listener.

All these aspects of the speaker and his voice will give a profile, and one can draw up a list of priorities to work through, eliminating certain aspects, and modifying others, or capitalizing on them.

In general, as was mentioned earlier, one can naturally expect the pitch to be lower than in the female speaker, although many females have reasonably low voices. There will also probably be too much chest resonance for a convincing sounding female voice. This is, in fact, the most important single difference in the two voices and the area where most work is needed.

It sounds very simplistic to state the following, but what one is attempting to do is instruct the speaker in ways to modify his own speech production. In realistic terms this means that one should try to bring about as little vocal change as possible, and still carry off the illusion of a female voice. It is the rare client who has the discipline to work endlessly on trying to create a voice of mechanical perfection. The effort involved tends to create such a self-conscious speaker that pleasure in human communication is lost. The plan of voice work as set up earlier is a useful flexible check-list to follow.

At this point it is interesting to mention that one of the most convincing speakers in any of the groups was a small frail-looking South American man with an elegant manner, and at 43 an excellent dress choice appropriate to size and age. His gentle contralto voice, speaking English with a strong Portuguese accent, was totally feminine. I was interested that he refused to speak in his native language during the eight months I knew him. I often asked him to do this so that I could compare the effect of speaking his second language rather slowly and deliberately, with his more fluent native tongue. He never gave any reason for his refusal, but I suspect that as his living in England and speaking the language was the beginning of his living as a woman he did not want to interrupt the total masquerade by speaking Portuguese as a female.

The glaring problem that Carlo had was complete lack of animation. He had a rigidity of face and manner that called attention to him unfavourably, and detracted from his ability to establish rapport with others, no matter how good an image he created.

In this particular case we spent a great deal of time doing role-play exercises and relaxation therapy, as well as talking about the problem, of which he was well aware. He became far more animated during the time he was with the group, and began to relate much more normally with others. However, he still retained a somewhat 'wax dummy' image that drew the eye to him. Too much perfection perhaps is not totally feminine. In any case he went on to have the operation and one might feel that this was a total success story as far as external presentation goes. His profession as a writer continued, and he supported himself very adequately, working as always, from home. I felt far less satisfied, however, with Carlo's ability to cope with a new lifestyle, than I have felt with many others who seemed more 'human' in spite of their imperfections. This is, of course, not the speech therapist's problem, but it is almost impossible to separate the voice from the personality, and one is always aware of the total person. Some things are too deep-seated to try to correct in speech therapy sessions, and it would be inappropriate to try. Carlo's personal isolation was a pyschiatric problem, but if it was dealt with at all during counselling this did not bring about any evident change.

Relaxation

Whatever the feeling about the use of relaxation as part of voice therapy, one cannot deny that it is a useful aid in getting an individual to feel in control of his own body. It is also essential to be physically relaxed in order to breathe correctly. Progressive relaxation is effective and it is important to suggest that the client concentrate on feeling the state of relaxation in order to try to return to it at times of alarm or great tension. In her book on voice disorders, Greene (1975) summarizes many of the various relaxation techniques.

This ability to be in 'control' means that the client is not going to forget all about using the feminine voice whenever a stressful situation occurs. Many of these clients live in a constant state of nervous tension. One can readily understand the reasons for this, and giving them a tool like relaxation therapy to use in time of panic is an investment in ensuring that the overall therapy programme succeeds as well as possible.

Vocal experimentation

Most individuals have no idea of the variety and range of sounds that the voice is capable of producing. It is often reassuring for someone to realize that it is possible to free the voice from rigid vocal habits even if it feels initially embarrassing to try to attempt it. To accomplish this, suggest that imitation is made of sounds that have no direct connection with speech and require no intellectual effort. For example, the copying of musical instruments, birds, sounds of nature, and even animal noises. This type of exercise is very disinhibiting and encourages further voice experimentation, and can also be incorporated when trying to eliminate chest resonance, which will be discussed later.

Breathing for speech

Instruction in diaphragmatic breathing, with exercises to increase the efficiency of breath control is extremely important. The procedure explained to the client is that instead of pushing the surge of air needed to speak into the mouth in a powerful burst from the lungs he employs another method. This other method involves taking gentle 'tucks' of air into the mouth from the reservoir created by efficient diaphragmatic breathing, and then articulating. This is really another way of explaining breath control to the client. This will have the effect, if combined with light articulation, of adding a slightly breathy quality. This breathy sound will need careful monitoring to be sure that it is not overly noticeable. If this is done properly the softening result can be very effective.

Pitch establishment

Something has to be said about pitch, but in fact it is not an area that one should interfere with very much. It has often been thought that for a man to make his voice sound more feminine he should raise the pitch to falsetto. In reality, of course, all this accomplishes is to make the voice sound like a man speaking in a falsetto voice! In addition, even if it were effective, it would be a very difficult type of speech to sustain.

As was mentioned, there is considerable overlap between the pitch ranges of male and female voices. Often in the middle-aged speaker the pitch needs to be raised only very slightly. It is the resonant quality that makes the voice sound more 'male' than the actual pitch. The pitch level finally deemed appropriate to try to adopt will be decided both by what the therapist thinks is suitable to the individual and by a realistic appraisal of the client's abilities.

I agree with Bryan-Smith's (1986) experience with her clients, that ear training and practice gradually bring about a gentle rise of pitch. It is also interesting to note that she had two of her clients xeroradiographed by MacCurtain at the Middlesex Hospital, and in both cases found that there was a change of laryngeal position when they were using a female voice instead of a male one. It was found that both clients achieved an enlarged supraglottic space during female speech due to a tilting back of the larynx not done when they were speaking in the male voice. Apparently both these clients passed very well when speaking as females.

Elimination of chest resonance

This is one of the most vital areas of this work. I think it is useful to have the client think of his body as a series of empty spaces or echo chambers, one on top of the other. He must then learn to move sound up and down through this series of chambers from chest to neck to head and down again until the feeling and sound of each is established in his mind and ear. This exercise may take some time and concentration. The ultimate aim with this is to establish the ability to produce sound from the head region. It is possible to suggest to the client that when he actually feels the vibration coming from the head region he concentrates on prolonging the sounds until he finds it easy to hum or intone various nasal or vowel sounds from this area. From there he should progress to the intoning of words starting with these sounds, as for example, 'my music', 'much money', 'many moons', etc. From there he can be asked to flatten the intoning into speaking the phrases and thus establish the pattern of using head resonance.

As this is an important part of the voice training programme it is necessary to take plenty of time working through this stage of therapy. Let the client hear the difference on the tape recorder and actually feel with his hands the vibrations moving from chamber to chamber.

Articulation techniques

Emphasis should be on 'light' articulation, with suggestions that the client should think deliberately of making delicate contact with lips, tongue, and teeth as he reads a prepared passage. He should focus speech forward in the face as much as possible, thinking always of pushing the sound forward to the lips. It is also useful to suggest that he effect a very slightly rounded lip position if possible. During practice suitable choice of material is helpful particularly if the client can identify with it and feel 'feminine' when reading it.

Peaking, intonation and lilt

Peaking is a term used to explain the method of raising the pitch of the voice at intervals on certain syllables to add variety and keep up the pitch level. This can be practised using a passage with arbitrary markings of syllables where the pitch should be raised.

It should also be noted that in general the female voice tends to end phrases with a rising intonation pattern while the male voice uses a falling pattern. The female voice also has much more rise and fall and variety of pitch levels as opposed to the much flatter male monotone.

Role playing, non-verbal communication and personality projection

These last three items are areas that are combined together and there is considerable overlap. One must always be aware that the client is a communicating individual as well as a 'voice case'.

When working with male-to-female transsexuals one does not want to feel one is running a charm school as this is certainly not our object. However, to try to help the client work on the voice and ignore obviously masculine personality traits, mannerisms, and habits is being shortsighted. These will be self-evident to the therapist during his/her meetings with the client, and one can suggest ways to modify some of these, if it seems appropriate.

Role play was used a great deal in the group situation and proved an excellent means of practising techniques learned. Often when emotive or controversial subjects were discussed, many clients were so caught up with the subject that the 'new' voices were completely lost. One of the reasons that some individuals came for so many months was to have the chance for long-term practice.

The clients who made the greatest success of living in the female role, from the point of view of personality, were those who were warm and outgoing and interested in other people. Transsexuals are often made very insular because of the circumstances of their lives and are totally self-absorbed; they find it difficult to communicate, whether as a man or a woman. This was a subject we discussed a great deal, and awareness of these barriers helped break some of them down.

VOCAL CORD SURGERY

The rationale behind performing surgery on the transsexual's vocal cords was that if the cords were reduced in length (by pulling the cords through the arytenoids and fastening them) the pitch would be raised. In reality most speech therapists dealing with these patients postoperatively find little change in the pitch, but do find there are often resulting voice problems. An operation to reduce the laryngeal prominence can be undertaken without vocal cord surgery.

USING INSTRUMENTATION

Some speech therapists have used Visispeech to help their clients monitor their speech and help them to match their pitch contours with those of a female speaker's as displayed on the screen. Mount and Salmon (1988) give an account of changing the vocal characteristics of a 63-year-old postoperative patient, over an eleven-month period, using this type of instrumentation with a high degree of success. This is an important study of an in-depth analysis of the measurable differences between the male and female voice. Any speech therapist who feels that he/she has a suitable individual client, and the facilities and time to work with him very intensively, should certainly study this literature.

SUMMARY

Most transsexuals can achieve an adequately unisex voice to enable them to be absorbed into the world as females provided they are intelligent enough to understand what is expected of them. Far more important, however, than the vocal mechanics is the building of a confident manner and a feeling of self-worth in the individual.

As was said earlier the reasons these clients want to change their sex are varied and deep-seated, and the therapist is not expected to try to unravel them, and should not attempt to do so. Sufficient to say that in some cases failure to achieve adequate voice is not the failure of the therapist, but lies within the client's psyche. In a few cases, much as the client insists they want to change sex, there seems a reluctance to let go the male voice, even when they have shown the ability to do so.

Not all transsexuals are going to completely blend into society as women, although many do and those are the ones we do not notice. Life for some will eventually have to be a great compromise. But even this compromise can often bring a greater degree of happiness and peace of mind than has ever been experienced before for these individuals.

Research is going on to enable us to measure more accurately the differences between the voices of the sexes. It may be that even when there is fuller theoretical understanding of male/female discriminators this will not materially affect the present empirical pattern of therapy adopted in these cases.

Lastly, one can endlessly debate the moral issue of whether one should, in fact, help these clients at all. They are, in the eyes of many people, acting immorally by going against nature, and should not be assisted in achieving this goal. This is a decision for the individual therapist, and if it is wrong for him or her personally, that decision should be respected.

I feel that one should not be judgemental in these cases, and that the moral issue is not one for the therapist to decide. I also feel that no matter what our personal feelings, one must realize that these clients are going to go ahead and try to pass visually and vocally as women with or without our help. We are simply giving them the benefit of our expertise. The final decision about what they decide to do with their lives lies with the individual.

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17

Post-radiotherapy voice

Margaret Stoicheff

INTRODUCTION

Preservation of the larynx in patients with glottic carcinoma by means of radiotherapy is a relatively recent development. In 1955, at a leading cancer treatment centre, 90% of glottic cancer patients were being treated surgically and only a few by radiation therapy (Hawkins 1975). Since then, the policy at this centre and elsewhere increasingly has become that of conserving the larynx wherever possible while minimizing morbidity. With early glottic cancer, radiation therapy has become the initial treatment choice, with surgery being reserved for radiation failure (Hawkins 1975, Harwood and Tierei 1979, Dicknes *et al.* 1983). Hawkins (1975) reported that complications arising in 673 patients treated by radiation for cure were low; transient dysphagia and an increase in huskiness during and immediately after treatments was usual; laryngeal oedema, the most troublesome feature, usually subsided but occasionally persisted, particularly following the successful treatment of extensive tumours.

It has been implicit in the medical literature that the voices of patients following radiotherapy are superior to those of patients following varying degrees of medical extirpation of the larynx, although objective studies detailing this are not available. In the medical literature the vocal results of patients treated successfully by means of radiation therapy are reported to be normal to near normal. Fletcher and Klein (1964) reported that 80% had essentially normal voice after irradiation. Woodhouse *et al.* (1981) reported that voice results were good to excellent in 63% and fair in 32% of patients following radiotherapy. A few vocal problems have been mentioned, such as huskiness associated with persistent oedema in a few patients (Marks *et al.* 1971), tiring of the voice after excessive use and in the evening in most patients (Morrison 1971, Vermund 1970), and a deeper sounding voice (Vermund 1970).

QUANTIFYING VOICE CHANGES

There are two reports, both single-case studies, which have employed objective measures to quantify changes in voice before, during and following radiotherapy. Werner-Kukuk (1968) collected cinematographic, aerodynamic, and acoustic measures for a 77-year-old male who received 6170 rads over a period of 46 days. They found that changes in the vibratory function of the vocal cords were reflected in the voice measures. One of the measures, Yanagihara's spectrographic classification of hoarseness, demonstrated a change from a type IV hoarseness before radiotherapy to a type I three months after the completion of treatments. Murry *et al.* (1974) examined the changes in phonational range, most comfortable fundamental frequency level, airflow rate, and intraoral pressure for a 49-year-old male who received 5800 rads over 39 days. All measures indicated improved vocal function eight weeks after the end of treatments (the last measurement period), although the patient was still hoarse and the vocal folds were slightly reddened. The measures showed least efficient vocal function late in the treatment period when the patient exhibited second-degree mucositis and complained of difficulty in talking.

Zegger (1983) looked at longitudinal changes in voice in 12 subjects from immediately after treatments to five years following treatments. Judges rated when best and most deviant voices occurred. Ratings of most deviant voice were most frequently given immediately following the completion of treatments. The best voice ratings were distributed over a wider range of time periods with the most concentration in the eight to nine month period.

Patients who have been treated by radiotherapy for cure report satisfaction with their voices. In a questionnaire study of 227 of 235 glottic cancer patients successfully irradiated from 1960 to 1971, Stoicheff (1975) found that 83% reported that their voices were normal to near normal. However, the majority of them (80%) indicated one or more of the following persisting difficulties: fatiguing of voice with much usage, reduced loudness, decreased clarity of voice, and inability to shout. It is of interest that almost one-half of the patients who were employed prior to treatments continued to work *during* the time that they were receiving radiation therapy and that most of the remainder returned to work within a 12-week period. The voice necessitated some minor changes in employment for nine patients and major changes for four patients.

POST-RADIOTHERAPY AND NORMAL VOICES

Few studies are available comparing post-radiotherapy voice with the voice of normal controls. Colton *et al.* (1978), using the technique of long-term spectral analysis, compared the spectral levels of five patients with T_1 laryngeal cancer subjected to radiation therapy with those of normals matched for age. They found that at one year post-treatment, the patients exhibited spectral levels within normal limits. Stoicheff *et al.* (1983) had listeners rate the voices of 46 male patients and control males matched for age. They found that the mean dysphonia ratings of the patients at one year post-treatment were significantly different from those of the control subjects. However, 35.3% of the patients and 84.1% of the controls received ratings of one or two (on a seven-point equal-appearing intervals scale) indicating that some irradiated patients' voices fell well within normal limits. In this study the listeners were also asked to indicate the predominant voice quality using the descriptions 'normal', 'breathy', 'hoarse', 'rough', and 'strained'. The qualitative classifications of the patients' voices before and after radiotherapy indicated that the characteristic quality moved closer to that of the control group following radiotherapy, with 53.5% of the post-treatment voices (and only 18.5% pretreatment) rated as normal or rough compared with 72.5% of the control group voices. Stoicheff *et al.* (1983) concluded that these perceptual judgements tended to provide some limited support for subjective reports in the literature that voice tends to sound normal or near normal following radiotherapy. Stoicheff (1984) compared the mean speaking fundamental frequency of patients in the preceding study with that of the control subjects and found no statistically significant difference.

Surprisingly little attention has been paid to post-radiotherapy voice by researchers. This may be partially due to the fact that these patients do not tend to be concerned about voice nor to seek assistance for it. The lack of research may also be a function of the relatively recent general acceptance of initial radiation therapy rather than surgery for early glottic carcinoma.

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18

Phonosurgery

Marc Bouchayer and Guy Cornut

INTRODUCTION

Phonosurgery is the name given to a branch of laryngeal surgery whose primary aim is the best possible restoration of laryngeal function rather than the simple removal of lesions to restore normal laryngeal appearance. The concept of phonosurgery emerged in the early 1970s with the introduction of suspension microlaryngoscopy and the operating microscope. Considerable advances in surgical technique became possible, because surgeons using these instruments could make finer, more precise hand movements.

Phonosurgery embraces the treatment of a considerable range of benign vocal-fold lesions such as nodules, polyps, Reinke oedema, cysts, and sulcus vocalis. Within this domain we would also include incomplete vocal-fold closure and approximation problems secondary to recurrent laryngeal nerve paralysis, as these may be corrected by intrafold injection. Surgical procedures intended to change vocal pitch and the surgical treatment of spasmodic dysphonia will not be considered in this chapter for two reasons: firstly, the surgical principles are still very much open to debate and we have no personal experience of these procedures, and secondly, the phonosurgical approach is inappropriate in the management of dysplasias or malignancies of the vocal folds.

Genuine phonosurgery is simply not possible without close collaboration between a phoniatrician/speech pathologist and a phonosurgeon. Their respective skills are complementary, the one being responsible for preoperative assessment and voice re-education, while the other is responsible for the surgery. The authors have worked together as a team in this manner for about twenty years.

PROTOCOL

Preoperative assessment

Before any phonosurgical procedure the patient undergoes a complete phoniatric assessment. This consists of:

1. A videolaryngostroboscopy recording. This is made using a rigid endoscope coupled to a videocamera. The vocal folds are first filmed in normal light in order to study laryngeal morphology, and then in stroboscopic light in order to study alterations in the vibratory behaviour of the vocal folds (assessment of the significance of faults of closure, localized rigidity, modification of the mucosal wave, etc.). We prefer to use a rigid endoscope rather than a fibreoptic nasendoscope, as the latter produces a smaller, less well-defined image, which makes precise assessment of detail more difficult. A good quality videorecorder incorporating both a slow-motion mode and a good freeze-frame image is important in order to get the maximum information from the recording. Good quality still photographic prints may also be produced by downloading direct from the videotape to a videoprinter.
2. A full vocal assessment. First, a tape recording of the voice is made whilst the subject is reading, speaking spontaneously and singing. A phonetogram is then performed, and when practicable the examination is completed by a full instrumental study (electrolaryngography, frequency analysis, sonography, etc.) in order to provide data on the various voice parameters for subsequent detailed analysis.

Maintenance of good acoustic and visual records is important in order to make an objective assessment of any modifications produced by phonosurgery.

The operation

This is performed as a suspension microlaryngoscopy and is always carried out under general anaesthesia with endotracheal intubation and full muscle relaxation. Full laryngeal relaxation allows for optimum positioning of the laryngoscope and hence nearly always gives excellent exposure of the whole glottis. Under these conditions the surgeon can operate safely, performing whatever surgical manoeuvres may be necessary in an unhurried manner. Patients usually remain in hospital for 48 hours following operation.

The equipment comprises:

1. a binocular operating microscope with a focal length of 350 or 400 mm;
2. two operating laryngoscopes of different sizes, together with a suspension arm;
3. relatively few instruments, most of which are angled to right or left: curved forceps, microscissors, dissectors, fine microforceps, fenestrated heart-shaped tissue-holding forceps, an arrowhead knife, a needle for injection, and a point monopolar diathermy electrode. All these instruments are approximately 22 cm long;
4. finally, the CO_2 laser. Use of the laser is strongly advocated by some practitioners although we prefer to use microinstruments, which are even more precise in practice and are better suited to the size of lesions to be treated.

Postoperative follow-up

In the immediate postoperative period the patient must maintain complete vocal silence for eight days until reviewed at the first postoperative follow-up appointment.

Medication is routinely prescribed postoperatively. The patient is given an injection of a depot preparation of steroids, a laryngeal steroid spray, and mucolytics. In addition, antibiotic cover may also be supplied in cases where infection is thought to be a significant factor or when fibrin glue has been used during the operation. When the phoniatrician sees the patient for the first postoperative follow-up appointment the full preoperative workup is repeated. A period of intensive speech therapy then begins, and sessions continue throughout a month of convalescence. Subsequently the frequency of sessions is reduced and the patient returns to work between four and six weeks after operation. Going back to work is always a vulnerable time for patients when their work demands extensive voice use, teachers being particularly at risk. The phoniatrician makes a final assessment at the end of the course of speech therapy.

INDICATIONS FOR OPERATION: TECHNIQUES AND RESULTS

ACQUIRED BENIGN LESIONS OF THE VOCAL FOLDS

Nodules

A nodule is a mucosal thickening situated at the junction of the anterior and mid-thirds of the vocal fold, slightly under the free border. The thickening is of variable size and is usually elongated although occasionally it may be rounded. A nodule may be pink or whitish in colour where there is old surface keratinization, and may on occasion also present as a small, pearly-white, pointed heap, this latter appearance being generally seen in singers. The lesion is normally bilateral.

Histological examination shows that the predominant changes are in the stratified squamous layer of the vocal fold cover, which is always thickened and which shows many epithelial pegs penetrating deeply into the superficial layer of the lamina propria (Reinke's space). This latter usually presents as hyaline degeneration.

There are other lesions that may resemble this typical nodule.

The serous pseudo-cyst is a well-circumscribed lesion whose macroscopic appearance is that of a translucent, thin-walled cyst containing serum that runs out as soon as the cyst is incised. Histological examination, however, shows that this lesion is not a true cyst as there is no cyst wall. These anomalies are predominantly situated within the superficial layer of the lamina propria and essentially consist of an area of gross oedema over which the epithelium of the vocal-fold cover is thinned and atrophic.

Fusiform thickening of the mucosa differs from a nodule in both its extent and its elongated shape, and in the degree of associated inflammatory changes. It is like the typical nodule in that the thickening is usually bilateral. Histological sections show that the epithelium of the cover is thickened and hyperplastic, while the superficial layer of lamina propria is diffusely oedematous.

Nodules are most commonly seen in adult females. They are unusual in adult males and children, particularly boys.

Indications for surgery The principal factors in deciding whether surgery is appropriate or not are as follows.

The size and, most importantly, the age of the lesion (whether the surface is keratinized or not).

Alteration of stroboscopic vibration (the 'hour-glass' glottic chink is more clearly visible under stroboscopic light).

The objective and subjective importance of the voice problem to the patient. With singers, for example, one may occasionally suggest operating on a very small nodule that produces significant problems in singing despite the speaking voice remaining virtually unaffected.

Failure of medical treatment or speech therapy.

Preferably one should always begin treatment with speech therapy prior to any surgical procedure.

The operation Avulsion of tissue by tearing it off the fold with cupped or plain forceps is best avoided as it may remove unnecessarily large fragments of mucosa. A much better technique is to remove the lesion as precisely as possible by gripping it with fenestrated heart-shaped tissue-holding forceps, and then using microscissors to divide the mucosa alongside the edge of the forceps in order to conserve as much healthy tissue as possible. This method minimizes the risk of producing a secondary notch when the mucosa heals. Two nodules may be removed at the same time, even in older children over the age of eight, so long as a zone of intact mucous membrane is preserved around the anterior commissure. This prevents the formation of adhesions by subsequent scarring.

In 22% of cases of nodules, a congenital mucosal micro-web may be found at the anterior commissure. This may be divided with an arrow-head knife if the web is of significant size.

Finally, after excision of the nodule, if associated inflammatory changes are present, cortisone is injected into the fold and any remaining dilated capillaries on the upper surfaces of the folds are sealed with diathermy.

Postoperative follow-up and results The immediate postoperative results are generally excellent. At the end of the eight-day period of complete voice rest, the folds have resumed their normal shape with a good, straight, free border. Stroboscopy shows that the mucosa is vibrating well, albeit with slightly diminished amplitude. At this stage it also shows a persistent small longitudinal notch. Initially the voice is usually slightly higher in pitch, with a clearer though still slightly veiled quality. Voicing is still somewhat unstable and weak.

Postoperative speech therapy produces rapid stabilization of the results and normal voicing generally returns within a few weeks. During this period there is marked improvement in the stroboscopic appearance of the vibration and glottal closure. Nonetheless, speech therapy should be continued over several months in order to stabilize modified vocal habits and prevent recurrence.

Long-term results are on the whole excellent, and very much depend on the quality of the speech therapy. Recurrence of a nodule is rare when speech therapy has been regularly attended (3% of revision procedures in our personal series).

Capillary telangiectases

These present as small, dilated vessels situated on the superior aspect of the vocal folds. These vessels normally travel in a direction parallel to the free border but frequently terminate in angiomatous clusters of variable size; this appearance is often referred to as 'vascular corditis'. The term 'varices of the vocal cords' is sometimes used (incorrectly) and should be avoided.

Indications for surgery The most important aspect of the diagnosis at indirect laryngoscopy is the elimination of intrafold lesions of which capillary telangiectases are simply the superficial manifestation. Stroboscopy may make one suspect the presence of cysts or a sulcus vocalis, both of which are associated with these vascular dilatations.

Capillary telangiectases are also frequently associated with nodular lesions. In this instance, vocal problems and indications for surgery are related more to the nodule than to the telangiectasis itself.

There are occasions, however, when a capillary telangiectasis alone may be solely responsible for all the laryngeal symptoms. Generally these lesions do not hamper stroboscopic vibration, nor do they produce much modification of vocal timbre. Patients mostly complain of vocal fatigue. Without doubt this is due to secondary vasomotor phenomena which appear after prolonged voice use. It is therefore the functional disability experienced by the patients (especially singers), rather than any visible change in vibration patterns that suggests a surgical solution.

The operation A series of point coagulations are made along the length of the vessel with a needle-point monopolar diathermy electrode. It is always wise to check that palpation of the fold does not show any localized areas of induration, which would make one suspect the presence of an underlying intrafold lesion. Where there is any uncertainty, one can perform an exploratory cordotomy.

As before, hydrocortisone suspension is injected into the fold at the end of the procedure.

Postoperative follow-up and results Postoperative follow-up is straightforward. It is important to remember that cauterized vessels take many weeks to disappear completely. The final result is usually good both from the anatomical and vocal point of view, as long as the patient has pre- and postoperative speech therapy. Even so, from time to time there are patients who will relapse.

Polyps

The vocal-fold polyp is an inflammatory laryngeal pseudotumour seen almost exclusively in males, and most common in the age group between 25 and 50 years. Vocal strain is a recognized factor in the production of polyps.

Histologically a polyp is composed of fibrinous exudates separated by proliferations of vascular clefts. They are described as being oedematous or haemangiomatous, depending on the predominant component.

Polyps nearly always arise anteriorly near the free border of the vocal fold. They may be sessible or pedunculated, and vary in size. Contralateral keratotic lesions with notching of the mucosal cover of the fold arise when the polyp has been present for a long time.

Indications for surgery All polyps warrant microsurgical removal as spontaneous regression is the exception rather than the rule. In addition, it is worth remembering that 15% of polyps represent a complication of an intrafold lesion: cyst or sulcus, which is often extremely difficult to demonstrate at preoperative assessment.

The operation We are firmly of the opinion that polyps should not be removed at indirect laryngoscopy, regardless of the ability of the surgeon. Operating under direct vision using the microscope diminishes the likelihood of incomplete removal with subsequent recurrence, and more importantly, avoids production of a scarred notch where an over-enthusiastic avulsion has 'bitten' into the vocal ligament.

Resection of a polyp is simple and is performed by excising it at its attachment to the vocal fold. Because polyps are most commonly sessile, the excision will tend to produce a large raw area which may be initially rather haemorrhagic and thus may require the application of swabs of vasoconstrictor. However, when secondary healing of the mucosa has taken place, this area fills out without leaving a depression.

Postoperative follow-up and results After excision of a polyp, the anatomical and vocal recovery is normally extremely rapid. Where the base of the polyp has been particularly broad and deeply implanted within the superficial layer of the lamina propria (Reinke's space), on stroboscopic examination at the first follow-up one may periodically see a minimal depression at the site of excision. This always disappears rapidly and perfect anatomical resolution is the rule. The voice is usually changed in a spectacular manner by this simple surgical manoeuvre. Even so, we insist on pre- and postoperative speech therapy as standard clinical practice, and perhaps because of this we have only ever had a single recurrence.

Reinke oedema

This particular form of chronic laryngitis is principally associated with smoking and vocal abuse. These days females are almost as commonly affected as males. Typically this is a myxoid oedema that develops in the easily distended Reinke's space, usually on the superior surface of the fold spreading over the free border, thus making it extremely bulky. This process can continue to the point where the oedematous mucosa may obstruct the whole glottic orifice.

The gelatinous quality of the vocal folds in Reinke oedema explains the low-pitched guttural vocal characteristics associated with the condition.

Indications for surgery Indications for surgery are governed not so much by the anatomical appearance but more by the patient's vocal requirements. Some moderate pseudomyxomas are well tolerated, particularly by males, and do not necessarily justify surgery.

The operation The greatest possible care should be taken of the mucosa covering the free border of the vocal fold. Overenthusiastic resection of mucosa that has been distended by pseudomyxomatous oedema produces perfect anatomical results which may nonetheless be vocally disastrous.

Beginning with a mucosal incision just medial to the ventricle the pseudomyxoma is dissected off the vocal ligament and aspirated. The mucosa is then laid back on the superior surface of the vocal fold and any excess is removed with microscissors. After an intrafold injection of cortisone the mucosa is kept in place with a biological glue.

Usually both sides are operated on at the same time. An intact zone of mucosa is always left anteriorly. However, if it is difficult to expose the whole glottis properly (which is quite common with this type of lesion) or if the lesion is very bulky, it may be preferable to operate on one fold at a time, leaving four to six months between procedures in order to avoid producing adhesions.

Postoperative outcome and results The postoperative outcome is excellent. As soon as the period of voice rest is finished the folds no longer appear thickened and are supple on stroboscopic examination. The voice is higher in pitch, clearer and distinctly less rough. This type of minimal surgery avoids too radical (and often inappropriate) modification of vocal characteristics and conserves the 'vocal personality' of the patient.

The results should remain stable if the patient has stopped smoking and co-operated fully with the speech therapy programme. If neither of these conditions are met, the Reinke oedema tends to recur.

Mucus retention cyst

These are true cysts found in the submucosa. They are of glandular origin, hence their mucinous contents. The origin of a retention cyst is due to an obstruction of the excretory canal and the resultant accumulation of mucoid secretions within the lumen of the mucus gland. The cyst wall consists of glandular epithelium made up of two layers of cells, an external layer of cuboidal cells, and an internal layer made up of cylindrical ciliated cells lying on a basement membrane. The lumen typically contains mucinous liquid. These cysts may be found in any age group including children. They are as common in adult females as they are in male subjects.

Indications for surgery The prime indication for surgery is the diagnosis of a mucus cyst at indirect laryngoscopy. The diagnosis may be made because of a yellowish and occasionally very voluminous arching of the middle third of the vocal fold, which causes a bulging outwards of both the free border and the superior surface. Usually the fold distended by this cyst will not vibrate on stroboscopy.

More commonly the cyst presents as an elongated bulge slightly below the free border, and may quite easily be confused with a nodule, especially if a contact lesion has developed on the opposite fold, producing an appearance of kissing nodules. Stroboscopy leads one to suspect a cyst when one finds a loss of stroboscopic vibration localized to the area of the bulge. Occasionally the presence of a cyst is only revealed at operation: when ablating a lesion which was thought to be a simple nodule produces a characteristic flow of mucous liquid.

The operation Ablation with microcups or microscissors is not recommended because removal of too much overlying mucosa risks the production of a significant notch postoperatively. Moreover, an incomplete excision is liable to produce recurrence. We recommend another technique: incising the mucosa on the superior aspect of the fold where it overlies the bulge and meticulously dissecting out the cystic pocket with microdissectors. The dissection is extremely delicate because the cyst wall is particularly thin and fragile and one rarely performs a complete exenteration without rupturing the cyst. It is nonetheless possible to progressively separate the cyst wall from the mucosal cover, and even from the vocal ligament, and remove it intact. Cysts are routinely sent for histopathological examination. The nidus from which the cyst was removed is checked and cleaned with a very small cotton-wool ball soaked in vasoconstrictors. The mucosa then collapses down in a normal position onto the fold without any loss of substance. The contralateral contact lesion is always removed.

Postoperative follow-up and results The immediate result is usually good. At the first postoperative visit the vocal fold remains slightly pink, the volume of Reinke's space has returned to normal and it is unusual to find a notch in the mucosa. Stroboscopic vibrations, however, are usually diminished in amplitude with respect to the contralateral vocal fold. The voice is much improved although at this stage it remains a little veiled and unstable. Voice breaks still persist on quiet phonation.

The final result after speech therapy is excellent both anatomically and functionally. There is always a risk of recurrence however, because of the difficulty of dissecting out the entire contents of the cystic pocket clearly.

CONGENITAL LESIONS

Epidermoid cysts

Epidermoid cysts of the vocal fold are more or less rounded or flattened structures, limited by a wall, and are situated in the submucosal space. From time to time they may invaginate into the fibroelastic fibres of the vocal ligament, which are spread apart. The contents are generally liquid, and are white and opalescent due to accumulation of squamous debris in the cavity. Histologically, an epidermoid cyst is composed of a cavity bounded by stratified squamous epithelium of variable degree of keratinization and thickness, which develops in a centripetal manner from a rest on a basement membrane. The cavity contains cornified desquamated material together with crystals of cholesterol. There is sometimes an inflammatory reaction in the tissue of Reinke's space around the cyst.

Some cysts may have an opening, most commonly slightly underneath the free border of the vocal fold, which allows intermittent spontaneous emptying of the cyst.

These cysts may be seen at any age, including childhood.

Indications for surgery Diagnosis of this lesion is sometimes easy at indirect laryngoscopy. Some cysts, however, present as a whitish arching of the mucosa, which bulges out of the superior surface of the mid-third of the fold and which produces stroboscopic absence of vibration over the whole fold.

In general the lesion is not clinically obvious and the indirect signs suggesting the probable diagnosis are given below.

Localized swelling of the mid-third of the fold, where stroboscopic examination shows a reduced amplitude of the mucosal wave where it overruns the swelling.

Dilated capillaries converging on a precise point on the superior surface of the vocal fold in the mid-third. Monocorditis.

In children, a fusiform appearance of the vocal folds with loss of stroboscopic vibration.

When the appearance is not absolutely pathognomonic, other factors suggest that surgery is still the appropriate management.

The characteristic acoustic patterns: lesions that increase rigidity of the vocal fold produce rather irregular, weak laryngeal vibrations.
The clinical history which often suggests a dysphonia beginning in childhood.
Failure of speech therapy.

The operation An incision (cordotomy) a few millimetres in length, slightly longer than the diameter of the cyst and running parallel to the free border, is made in the mucosa of the superior aspect of the vocal fold. A blunt dissector is then used to modify the incision appropriately.

In general, mobilization is fairly easy underneath the cyst next to the vocal ligament and more delicate superficially in the plane between the epithelium of the vocal-fold cover and the cyst. From time to time the inferior pole of the outer surface of the cyst wall may be embedded within a split in the elastic fibres of the vocal ligament. As with aural surgery for cholesteatoma, when the cyst is excised intact there is no risk of future recurrence.

Following the removal of a cyst, the pocket should always be meticulously checked to avoid missing a second, deeper cyst, which sometimes occurs concealed within the vocal ligament.

Commonly there are inflammatory changes associated with the lesion and so cortisone is injected into the body of the fold before replacing the mucosa. The mucosa is not trimmed, the incision edges are simply approximated edge to edge and are held in place with an application of fibrin glue.

Postoperative follow-up and results There is generally a satisfactory appearance of the vocal fold at the first postoperative inspection: although modest inflammatory changes remain, the cordotomy incision is usually no longer visible. Sometimes there is a slight depression in the vocal-fold cover over the area that previously contained the cyst. Stroboscopic vibration is usually weak at the outset but rapidly improves during the first examination. Initially, voice quality is often rather mediocre, being rather veiled and unstable and producing voice breaks on quiet phonation. Postoperative speech therapy is absolutely essential in order to produce a steady and entirely satisfactory improvement in voicing. It must be stressed that improvement is a progressive affair and that it will be necessary for the patient to undergo a protracted course of therapy.

Sulcus–stretch marks

The term sulcus has been used since the turn of the century to define a lesion that at indirect laryngoscopy appears as a 'whitish furrow running parallel to the free border of the vocal cord giving the glottis an oval appearance'. In reality the sulcus thus defined corresponds to two quite different anatomical entities.

The term sulcus glottidis, when correctly used, describes an invagination of the epithelial cover of the fold into Reinke's space. This produces a pocket of variable depth that pushes downwards and inwards, often deeply enough to contact the vocal ligament to which it may be more or less adherent depending on the degree of inflammatory reaction in the surrounding tissue. Histological examination shows that the sulcus is a true blind-ended sac bounded by walls of stratified squamous epithelium of variable thickness, keratinization being most marked around the base of the pocket. We think that these features show that a sulcus is actually an open epidermoid cyst.

A furrow-like appearance may also be produced by an entirely different type of lesion that we have entitled a 'stretch mark' (a reference to an article by Garel published in 1920). This lesion presents as an atrophic furrow of variable extent lying underneath the free border of the vocal fold, giving the border a bowed appearance. The inferior margin of the furrow often contains a tight, stiff, submucosal band whereas the superior margin is rather more supple. The mucosa lining the floor of the stretch mark is thin, atrophic, and intimately bound to the fibres of the vocal ligament. This prevents any sliding between the layers.

Both sulcus and stretch marks may be seen from adolescence onwards, and they appear slightly more common in males than females. It would seem most likely that they are both congenital in origin.

Indications for surgery In some cases the furrow may be obvious, lying at the level of the free border in one or both vocal folds, producing an oval appearance of the glottis highly suggestive of a sulcus or stretch mark. Occasionally the appearance is less obvious and the furrow may only be visible in stroboscopic light. There may only be evidence of an absent closed phase over the entire length of the free borders of the vocal folds, perhaps associated with monocorditis or some capillary telangiectases.

The acoustic voice patterns are highly characteristic and support the diagnosis: the voice is often loud, and particularly in males, dull. It is also rather veiled, with frequent voice breaks. Patients usually present with significant vocal fatigue, paralaryngeal aches, or the need for further treatment when speech therapy has not improved things sufficiently.

The operation For a sulcus glottidis or open epidermoid cyst it is essential not to remove too much mucosa in order to avoid producing a secondary puckered scar. To achieve this the superior and inferior crests circumscribing the epidermal pocket are precisely incised with a very sharp arrowhead knife. The floor of the pocket is then dissected off the vocal ligament with blunt elevators. Following this the sulcus may be removed intact after section of the remaining anterior and posterior attachments with microscissors. The subglottic mucosa is mobilized over a few millimetres in order to achieve approximation of the superior and inferior mucosal margins without loss of tissue thickness.

Surgery is extremely difficult to perform. It requires excellent instruments and considerable competence of the surgeon, but it does give good primary and secondary anatomical and functional results. The phoniatrician in charge of the postoperative care will be well aware of this.

For a stretch mark the aim of the surgery is to elevate the atrophic adherent section of mucosa after distending the fold with an injection of hydrocortisone suspension. An incision is made on the superior surface of the fold and a plane between the mucosa and the ligament is created using a blunt elevator. This is always an extremely difficult dissection because the mucosa is closely adherent to the ligament and cannot always be preserved. It is frequently necessary to detach fibres of connective tissue from the mucosal cover, and when freed these fibres should be laid back in place on the vocal ligament. This is particularly important for the inferior bar where these fibres may act like a bow-string, pulling a flange of mucosa over the inferior margin of the stretch mark.

This operation generally produces a satisfactory sliding plane under the mucosa of both the free border and the subglottic margins. The period of scarring and shrinkage then pulls both parts into the closest possible approximation.

These lesions are generally bilateral and may be operated on at the same time. Nevertheless, when the dissection of the first side has been particularly difficult, or where the larynx is small, as for instance in children, then it is preferable to operate on one side only and to leave an interval of approximately six months before operating on the second side.

Postoperative follow-up and results After removal of a sulcus, the area of resection often appears as a small discrete dent which rapidly fills out and becomes supple with postoperative speech therapy.

Eight days after operating on a stretch mark, the furrowed appearance is still evident and the stroboscopic vibration remains feeble. The voice is usually mediocre, and is sometimes actually rather worse than it was prior to the operation. Frequent voice breaks and very veiled voicing are the norm. It is only with protracted postoperative speech therapy that one begins to clearly see a steady improvement in the suppleness of the vocal folds. In particular, the stroboscopic appearance of the hitherto rigid inferior border demonstrates greatly improved mucosal waves, and one often ends up with a considerably improved closure of the folds, given that it is never possible to achieve a perfect result. The pitch of the voice is generally lower and the timbre improves although retaining a rather veiled quality. The majority of patients are well satisfied even though the objective result is not perfect, because the combination of surgery and speech therapy completely removes both the pronounced laryngeal ache and the vocal fatigue, thus producing a significant improvement in the patients' vocal comfort.

Mucosal bridge

A mucosal bridge presents as a separate mucosal band running parallel to the free border, having anterior and posterior attachments to the fold. Structurally it is composed of everted stratified squamous epithelium and is always associated with one of the three lesions previously described. We think that the bridge arises from a cyst open sac with two (superior and inferior) ostia. Between these openings there remains a characteristic healthy band of mucosa of variable size and it is this that becomes the mucosal bridge.

The operation Usually mucosal bridges are thin, and most of the time the appropriate technique is simply to excise the bridge using microscissors at its anterior and posterior attachments. From time to time, however, a mucosal bridge is large and thick, and simple resection would incur an excessive loss of mucosal bulk, resulting in the secondary production of a notch on the free border of the vocal fold. These thick bridges are fortunately uncommon, their surgical treatment being particularly difficult. An attempt is made to reduce the thickness of the bridge by removing the mucosa from the underside of the bridge whilst leaving the band and the overlying mucosa intact. The epidermoid pocket underneath the bridge is then dissected out and removed, thus allowing the band and remaining overlying mucosa to be replaced against the vocal ligament.

Unilateral recurrent laryngeal nerve paralysis

Indications for surgery Surgical treatment of unilateral recurrent laryngeal nerve paralysis is appropriate where speech therapy rehabilitation alone has produced insufficient improvement, and inspection shows that the vocal fold remains atrophic and inadequately medialized or has remained in the intermediate position. Stroboscopic examination is essential in order to assess the vocal importance of any misalignment of the folds, atrophic change in vocal fold bulk, and the degree of failure of glottal closure, and is thus the single most important examination for assessing suitability for surgery. We normally wait for a year after the onset of the paralysis before injecting a paretic fold.

The operation The aim of intrafold injection, be it with Teflon or with collagen, is to expand the paralysed fold in order to bring the free border back towards the midline without interfering with the vocal-fold cover's capacity to generate waves.

Teflon paste is injected with a needle having a double-angle offset near the tip, and which is fitted to a pistol with a notched plunger. The needle has a wide diameter and should be inserted deeply and lateral to the vocalis muscle, which will then be displaced from within by the Teflon.

It is essential to avoid two things:

superficial or submucosal injection;
injection of too much paste.

Generally, injection into an anterior and a posterior site is adequate, although Teflon paste cannot be spread in the area adjacent to the arytenoid; hence there is always a persistent posterior interarytenoid gap.

Phonagel (GAX collagen), after many initial problems, is now freely available and offers several advantages over Teflon:

it is highly biocompatible;
the suspension is much more fluid than Teflon paste, which allows the use of a much finer needle for injection and can thus be spread much more easily within the fold, usually from a single posterior injection site.

In either case massaging the fold with the end of the sucker or some other suitable instrument produces a much more even spread of the paste throughout the length of the fold, making the free border as straight as possible.

Postoperative follow-up and results Postoperative benefits are immediately apparent. There is no point in the patient's remaining silent for a period and we advise them to start speaking again the day after operation. Following the repositioning of the fold, the voice is stronger and frequently rather lower in pitch. Dyspnoea whilst speaking diminishes and may disappear completely, coughing becomes more forceful, and episodes of overspill/inhalation of liquids cease.

Laryngeal examination shows a somewhat overinflated fold initially, which will retain a rather inflamed appearance for several weeks. There is an obvious improvement in glottal closure.

Speech therapy sessions should be started again so that the patient learns how to use his or her new voice. A few patients may find the initial experience of a new voice quite disorientating.

In the majority of cases anatomical and functional improvement is maintained in the long term. After collagen injection, the fold seems to appear progressively more normal, rather as if the collagen were being evenly distributed throughout the substance of the interior of the fold; the stroboscopic vibration meanwhile reappears in a reasonably satisfactory manner. In a few cases following either Teflon or collagen injection the vocal result is not stable and a further topping-up injection is necessary.

A final note about Teflon. There is a risk of occasional serious secondary complications due to a granulomatous inflammatory reaction in the vocal fold. This may present as a pseudotumour of the fold sometimes years after the original injection (seven years in one of our cases).

SPECIAL PROBLEMS

Iatrogenic scars

Under the general heading 'scars of the vocal folds' we include:

- notches in the vocal folds;
- adhesions:
  - between folds;
  - between a fold and ventricular band;
- fibrous scars;
- stiffening of the fold following use of the laser.

Indications for surgical revision must be carefully assessed. It is not always easy to say whether a poor result from previous surgery is due to scarring or vocal dysfunction.

Laryngeal examination may sometimes show clear evidence of a notch in the fold producing air escape and an explanation of the veiled quality of the voice.

In contrast, sometimes the anatomical appearance shows little abnormality, and only stroboscopy will produce evidence of localized or even very extensive scarring of the fold.

Revision surgery may be suggested when a prolonged trial of speech therapy has been manifestly unhelpful, and if the patient is sufficiently motivated and has been fully forewarned about the hazards and limitations of this type of repeat procedure.

The operative technique that we use most commonly is derived from the technique used to elevate mucosa off a stretch mark. Where there is a notch or area of fold rigidity, one always finds that the mucosal scar and the surface of the vocal ligament are intimately stuck together. Using the technique described above, we try to mobilize the mucosa in order to restore some flexibility to this rigid area: intrafold injection of hydrocortisone suspension, superior cordotomy, meticulous dissection, and elevation of the mucosa in an attempt to find a plane of cleavage between mucosa and vocal ligament.

The results are difficult to schematize because they depend on both the initial lesion and the extent and difficulty of the revision surgery. However, postoperative examinations have shown us that after this 'mucosal freeing', the vocal fold does regain a degree of suppleness, which is demonstrable by improved stroboscopic vibration patterns and better glottic closure. At the same time there is an undeniable improvement in voicing which continues *pari passu* with postoperative speech therapy.

Microsurgery in children

Until very recently, phonosurgery was only undertaken in children with the greatest reluctance. In addition to the usual constraints, there are other relative contraindications to surgery in children: the small size of the immature larynx, the virtual impossibility of insisting on a period of postoperative silence, and above all, the habitual vocally abusive speech patterns of children presenting with lesions amenable to surgery. Nonetheless, several factors are causing us to turn to surgery as a treatment option with increasing frequency. Appropriate surgical and anaesthetic procedure is now well characterized, congenital lesions (cysts) are being discovered with increasing frequency when previous indirect examination had suggested that the lesions were simple vocal nodules, and speech therapy may fail to improve the voices of even the most co-operative children. The final decision to opt for surgery is often made on the basis of the length of the history of dysphonia, which may suggest that the lesion is congenital, and the degree of handicap caused by the dysphonia, for instance in children studying music. Full pre-operative preparation of both the child and the family is absolutely essential.

The operation itself is no different from the adult procedure, and generally one is struck by the ease and quality of the exposure in a childs larynx. The optimum age for surgery is between 9 and 11 years old.

The outcome following surgery is straightforward and depends to a great extent on family support and speech therapy. The final result depends largely on the type of lesion that was removed. It is excellent following nodule excision and rather slower after removal of a cyst. The aim of postoperative speech therapy is to maintain this improvement, and therapy should be continued over several months to prevent the child's returning to vocally abusive patterns. Nodules recur more frequently than in adults and are the direct result of continuing vocal abuse.

Microsurgery for singers

Lesions found on the vocal folds of singers are perfectly amenable to microsurgical treatment, provided that the operator is particularly cautious and meticulous in avoiding leaving a scar, no matter how small, which could be catastrophic for the singing voice. The lesions found in singers on whom we have operated are not solely varieties of nodule, there are also a significant number of epidermoid cysts and sulcus. We thus conclude that small congenital anomalies of the larynx may be entirely compatible with a good quality singing voice, but that the passage of time may lead to a secondary 'decompensation'.

When faced with any singer who presents with chronic vocal difficulties, it is thus obligatory to perform a full laryngeal assessment using optical magnification and stroboscopy, which may suggest the presence of a cyst or a sulcus, before blaming the problem on poor technique. In a few cases where the diagnosis remains uncertain, it may be necessary to inspect or explore the folds at microlaryngoscopy. One should be aware at all times that any laryngeal microsurgery poses particular problems for the professional singer:

The anxiety of the patient that they may lose the tool with which they make their living.

The difficulty of coping with a lengthy interruption in their professional singing career. In our experience, that interruption should not be less than three months.

Delicate postoperative adjustments in vocal technique require the help of a therapist with personal knowledge of singing problems.

CONCLUSION

Within the realm of phonosurgery, we feel that collaboration between phoniatrician and surgeon is absolutely indispensable. Such a collaboration is highly instructive to both parties, who as a result are able to make increasingly accurate diagnoses as well as adapting and refining surgical techniques required to improve vocal function. Improved microsurgical technique has drastically altered the prognosis for a large number of benign laryngeal lesions; nonetheless pre- and postoperative speech therapy remain an essential adjunct to the surgery.

19

An interdisciplinary voice clinic

Tom Harris, Sara Collins and David D. Clarke

INTRODUCTION

In principle there are two sources of therapeutic advancement in medicine and related fields. One is the invention of new elements of treatment such as specific diagnostic procedures, therapeutic techniques, or instruments, and the other is a matter of bringing together existing elements of treatment into new and more effective combinations. It is often the first of these two that attracts more attention, but in some fields, of which the treatment of voice disorders is one, very striking advances can be made by adopting the second method.

The ingredients of a combined approach to the treatment of voice disorders mainly involve the disciplines of laryngology, speech therapy and experimental phonetics. On occasions clinical psychologists and psychiatrists may need to be involved, and the equipment and expertise of physiotherapists is also extremely valuable. In addition to the personnel, the technology that has been developed and adapted from other branches of science also plays an important part. In particular the use of stroboscopy, combined with the advances in laryngoscopy, laryngography, and air-flow measurements now make laryngeal examination more accurate, informative, and easier (Williams *et al.* 1975, Abberton and Fourcin 1972, Berry *et al.* 1982, Laver *et al.* 1982).

Interdisciplinary voice clinics have been established for a considerable time in Scandinavia, on the continent, and in the United States. The concept has also been developing in the United Kingdom for some time, but despite the pioneering work of Simpson (1971) the effectiveness of the multidisciplinary approach has been little researched in this country until recently (Harris *et al.* 1986).

WHAT IS A VOICE CLINIC?

A voice clinic is a multidisciplinary clinic, involving the appropriate professions, to provide an accurate, multifaceted diagnosis and management programme for dysphonic patients.

Dysphonia is usually multicausal in aetiology and involves both physical and psychological habit patterns in its maintenance. Even where the diagnosis looks straightforward, for example with a small carcinoma on a vocal fold, the treatment plan should take account not only of the removal of the tumour, but also of the changes in voice production caused by interference from the tumour, and the psychological effect of such a diagnosis on the patient. Advice on voice use and vocal hygiene along with supportive counselling will increase the patient's chances of a good post-treatment voice.

WHO IS INVOLVED IN RUNNING A VOICE CLINIC?

A voice clinic should always involve the laryngologist and the speech therapist. These two professions are already dealing with dysphonic patients in the hospital setting. Both are funded at present by the National Health Service, but they often work quite separately with only an ENT referral note and speech therapy assessment report for communication. It is usually relatively easy in terms of time and location for these two professions to work together for a clinical session and they usually form the basis of the voice clinic.

The laryngologist

The role of the laryngologist is to provide a thorough examination of the ENT system, and in particular of the structure and function of the vocal folds. Ideally the latter will involve video recording the vocal folds at rest and in action with the aid of stroboscopy. Not only are subtle structural defects then possible to detect, but the patients' habitual patterns of voice use can also be observed.

In addition to the examination of the larynx and ENT system, the laryngologist will also be involved in the history taking and in diagnosing other concomitant medical factors, for example, reflux oesophagitis, thyroid disorders, and neurological conditions. Seeing the patient as a whole in this way allows all the necessary medical management to be initiated immediately, rather than focusing only on the voice and ENT-related disorders. The patient is then much more likely to be able to respond successfully to any speech therapy intervention, reducing clinical time and patient and team frustration.

The speech therapist

The speech therapist will also be actively involved in the history taking and in the clinical diagnosis, concentrating on the areas of voice and speech production. It is extremely important that the speech therapist is present during the examination of the larynx in order to help assess the efficiency of laryngeal function.

The phonetician

The collection of objective data relating to the dysphonic voice is becoming increasingly important, both in terms of monitoring the effectiveness of treatment and in understanding and analysing the nature of the symptoms. Acoustic analysis of tape recordings of the patient's voice provides good objective data for both these purposes. Some university phonetics departments are willing to provide this service, although problems of finding funding, except through research grants, often make this impractical. Fortunately, the advent of home computers has resulted in the development of suitable software at reasonable prices, allowing acoustic analysis to be carried out within the clinic. Where available this is ideal.

Teachers of singing and voice

Voice clinics are the ideal setting in which to assess professional voice users such as singers and actors. This patient group requires specialized knowledge of singing and acting techniques of voice production and it is wise either to include the patient's own teacher or to develop a good working relationship with well-qualified teachers in this field. It is rare for voice clinics to have 'resident' teachers of singing or voice. This is partly because they cannot be paid by the National Health Service, and partly because there are relatively few singers and actors coming through a typical NHS clinic. It is therefore rarely possible to devote a whole clinic to such clients as the nature of their profession usually demands a priority assessment and they cannot afford to wait two to three weeks for a special assessment clinic.

Where voice clinics do deal with singers and actors it is essential that their findings are relayed clearly to the teachers of singing and voice working regularly with them. It may also be necessary to discuss matters directly to make sure that there is consistency in approach between the therapist and the teacher, so that confusion is avoided and treatment can be fast and effective. It is rare for therapists and teachers to disagree fundamentally on good voice use. Usually they tend to see each others work as complementary and reinforcing, although at different levels: the therapist taking the patient through the early work on breath support, vocal co-ordination and articulatory placement, and the teacher extending this to support a specialized use of the voice.

The clinical psychologist

It is generally recognized that voice production is closely linked with the emotional system, and where possible a trained counsellor, psychologist or psychotherapist should be included in the voice clinic team. Many speech therapists have received specialist training in counselling techniques and will be able to provide help where necessary for patients presenting in the clinic whose problems reflect their emotional state. There are times, however, when the team conclude that a patient will need more detailed psychological assessment and treatment, and it is essential for the clinic to develop links with the local psychological services in order to refer patients for the appropriate help.

The physiotherapist

Most voice disorders involve some form of compensatory muscular patterns and/or musculoskeletal hyperfunction. The speech therapist and laryngologist do address these problems in their assessments and in the management programme, but again there are times when more specialized help is necessary. Physiotherapy may have much to offer in this area and it is useful to form links with the local department. There are also some excellent osteopaths who may be interested in these problems, although the difficulties of NHS versus private treatment may need to be overcome.

The volunteer

All hospitals now have thriving volunteer schemes. Volunteers can play a very useful role in the voice clinic by making the tape recordings or other assessments as decided by the clinical team. It is important, however, that volunteers are considered as part of the team, as patients will often talk to them during assessments in an unguarded fashion, providing much relevant information. They also often give them feedback about the clinic, preventing misunderstandings arising and ensuring patients have understood the explanations given to them about their condition and the proposed treatment.

WHY HAVE A VOICE CLINIC?

The lost patient – a single decision-making process

A voice clinic is useful in resolving a number of problems that occur in the usual outpatient management system. In most hospitals today the surgeon sees dysphonic patients as part of his routine outpatient clinic, referred to him by the general practitioner. There is rarely time for a very detailed case history, and stroboscopy may not be available. The surgeon alone will decide whether to offer patients surgery, speech therapy, review, or discharge, and each surgeon's criteria for making these decisions will be different. As a result some patients, who would have responded well to voice therapy techniques, advice, counselling or vocal hygiene are never referred to the speech therapist, but are simply reassured that there is no serious problem and discharged. Sometimes the reassurance will be enough and gradually the voice will return to normal. Frequently, however, the difficulties persist and the patient will re-present to the surgeon at a later date, sometimes with visible pathology. If this requires surgery, the patient still may not be assessed by a speech therapist, but merely operated, reviewed, and discharged again with the original causative factors still present in their voice production.

Other medical problems

Where the patients are referred to speech therapy other problems may arise. Often during an hour-long case history, medical problems emerge that require the speech therapist to refer that patient back to the general practitioner or surgeon for further diagnosis and treatment. Alternatively, these problems may not emerge until much later. As a result the patient may not have been able to respond to the voice therapy provided and much time will have been wasted. There is also a danger that the patient may feel voice therapy has nothing to offer and will not return for follow-up assessments. Failure to change bad vocal habits may prevent full vocal recovery or result in a relapse later on.

Inappropriate referrals Sometimes conditions that are not amenable to conservative treatment are referred for voice therapy, for example hard fibrous vocal nodules, occult cysts or sulcus vocalis, or even advanced cases of Reinke oedema. As the therapist is relying on the description given by the surgeon he or she may waste several sessions of therapy time before querying the referral. This problem may be partially responsible for some surgeons in the past feeling that speech therapy was not an effective form of treatment for their patients. Their lack of faith in speech therapy may have communicated itself to the patients, who then fail appointments. Many surgeons and therapists have reported in the past that they have a high proportion of patients who fail to attend their initial speech therapy appointments.

Patients referred inappropriately are also discouraged by their lack of progress in speech therapy. This is another reason for failed appointments and the refusal of further therapy postoperatively.

Joint voice-clinic assessment resolves the problems described above through mutual discussion and the greater time allowed for assessing dysphonic patients. Patients are given a full explanation of the nature and probable causes of their dysphonia and as a result they understand the rationale behind voice therapy better. Voice clinics appear to have far fewer non-attenders (see research section, and Donnelly and Kellow 1988).

HOW TO RUN A VOICE CLINIC

There is no 'right' way to run a voice clinic but there are two definite approaches. The first is to assess *all* voice patients coming through the ENT department in the voice clinic, and the second is to see only those who present complex problems or who have failed in conventional therapy.

Initial referral

The first approach has the advantage of providing a full assessment at the initial interview, which should ensure that the most effective medical and therapeutic intervention is provided immediately, reducing clinic time and maximizing patient co-operation. The disadvantages are that some patients do not require a multidisciplinary approach and therefore may be considered a waste of clinical time. Hoarse patients need to be given priority in attending an ENT screening in order to discover malignant lesions as early as possible. Voice clinics running only once a month will not be able to provide this quickly enough. Finally, this approach often requires close co-operation between the hospital consultants, and where the voice clinic is staffed by a registrar or senior registrar, this may not always be possible.

Tertiary referral

The second approach has the advantage that screening of hoarse patients is carried out prior to referral to the voice clinic, eliminating those with malignancies or those requiring primary surgery. This allows the selection of appropriate voice-clinic patients, giving time to arrange the relevant team members attendance, perhaps by arranging clinics covering different problems, for example non-urgent singers or those with a psychological base to their voice disorders. Again clinical time is usually saved and the most effective form of treatment provided early.

The disadvantages are that many patients fall into a 'grey' area, where surgery may be avoided with the right therapy. If they are screened in clinic initially the decision for surgery may be made without the benefit of a multidisciplinary approach, resulting in unnecessary operations, possibly with less than ideal vocal results. It may also result in a delay in detecting other medical or psychosocial factors, increasing clinical time for the patient and reducing their response to the therapy.

Number of patients per clinic

Once the referral style has been decided upon it remains to work out the probable case load so that the number of clinics necessary per month can be decided. Usually departments seem to decide to run clinics once a month initially, increasing or decreasing according to the case load. The number of patients per clinic will also vary, but on average our experience suggests seven to be manageable with half-hour appointments for each.

History taking and clinical records

Many clinics send a questionnaire to their clients prior to their attendance; this supplies much of the case history. The advantages of this idea is the saved clinic time, but there are also some disadvantages. Firstly, 'mental set' often misleads clinicians, preventing them from making use of their powers of observation. Reading the patients' presentation of their own history may act in this way. Also patients often omit important information or fail to understand items on the questionnaire. The most common example of this is 'indigestion' or 'heartburn'. Frequently patients respond in the negative to this question, but when asked about discomfort in the chest area, burning pain, a 'lump in the throat', second swallowing, bad breath, waking in the night with choking and coughing, etc. they respond positively and express surprise that their symptoms might be caused by reflux. Provided these points are borne in mind, however, the use of a questionnaire can be helpful. Check-lists for case history points and for assessment criteria are also useful and can be used at later dates if research is undertaken. Video- and tape recordings are usually kept in clinic order and it is therefore imperative that the dates of the patients' attendance are clearly recorded in the notes so that the previous tapes are easily available for comparison. This saves much wasted tape and can still be efficient if well documented. Occasionally, long-standing patients may well warrant their own tapes, particularly if surgery and long-term follow-up is necessary.

Where time is limited and the case load high, it may be useful for the speech therapist to have an initial interview with the patient prior to the clinic. The case history and objective clinical data can be collected at this interview and discussed with the rest of the team before the patient is seen in the clinic. This saves time, but may be open to the problems of mental set and relying on only one person's judgement that have been mentioned before.

Explanations

It is important to allow time for a full explanation to the patient. This ensures maximum co-operation with the treatment plan and allows the patient to take responsibility for his or her voice problem and its management. Patients given this opportunity usually report much greater satisfaction with the clinical management.

Administration

Some ENT departments may choose to run voice clinics staffed by different teams at different times in the month. For example, where two consultants have an interest in voice, they may choose to run clinics on alternating weeks. It is important, however, that they continue to provide consistency of care for their patients to prevent confusion in diagnoses and management.

Finally it is important to address the administrative side of things. A clear appointment system needs to be created, as frequently several different people may be booking cases, and also statistics will need to be kept, both for the hospital records and for the clinicians own needs. It is well worth documenting not only how many patients were seen and the referral sources, but also the patient's diagnosis, occupation, age, sex, and treatment so that the relevant information is at hand for research purposes or for the unexpected clinical statistics that hospitals often request.

WHAT EQUIPMENT IS NEEDED?

Indirect laryngoscopy and stroboscopy

The most important aim of a voice clinic is to obtain a good examination of the larynx in order to ensure there is no serious disease present. This may be carried out with a laryngeal mirror, which will be quite sufficient to diagnose laryngeal pathology. All ENT surgeons will be skilful in this form of examination. It is also important, however, to make accurate functional diagnoses of the larynx, and to see the action of the mucous membrane cover that overlies the vocalis muscle. This mucous membrane movement over the muscle is an extremely sensitive indicator of early pathology and examination is essential where hoarseness is present in a structurally normal larynx. In order to examine this a stroboscope is necessary, along with either a fibreoptic nasendoscope or a rigid 70° laryngoscope.

If financial resources are limited, and only one piece of equipment is to be obtained, then the stroboscope and a suitable laryngoscope should head the list for its clinical value.

Videorecording

A video camera suitable for the low light filming of the stroboscopic examinations, and a monitor to relay the images to the patient and other staff during the clinic, is also extremely valuable clinically. Not only can the team freeze-frame or run the tape in slow motion to examine points of interest, but the patient can see his or her own problem, understand the diagnosis, and even try some therapeutic manoeuvres on camera and have clear visual feedback of their effects. This facility reduces patient anxiety and increases the co-operation in therapy. Finally, videotape acts as an excellent record of the patient's progress in therapy.

Tape recording

A good audiotape recorder is also extremely valuable, especially where the clinic has access to computer acoustic analysis, most of which can be taken from good recordings nowadays. These recordings also monitor the patient's response to therapy objectively. If new equipment is to be bought, it is worth discussing the type of recorder with a phonetics department carrying out the analysis. It is important to have recorders that are compatible with their laboratory equipment, and they also usually know the best machines for the best prices. We believe that the laboratory standard is likely to become DAT (digital audiotape) recording.

Electroglottography

An electroglottograph (laryngograph) is useful both for assessment of the vocal fold contact during phonation and for monitoring the changes in this during treatment. It is also a very valuable form of biofeedback for the patient during the early stages of therapy. Computer analysis of the EGG waveform will also provide data about irregularity in the fundamental frequency of the patient's vocal signal. Stroboscopy, however, also provides accurate descriptions of vocal fold contact, so if money is short, the laryngograph is not essential in diagnosis, provided stroboscopy is available. It remains a very useful adjunct to therapy.

Visispeech

Visispeech also provides some useful information about the patients' fundamental frequency and vocal variability. It is also useful in early stages of therapy for some patients as it provides visual feedback of fundamental frequency and frequency perturbation, voiced/voiceless distinctions, and vocal intensity. The latter two programmes are not always sensitive enough to really be of help to many dysphonics and were designed predominantly for other categories of speech-impaired patients.

Phonetograms

A phonetometer provides a visual record of the entire range of a patient's pitch and intensity on phonation and is thus an extremely useful record of a patient's increasing vocal abilities. It is simple for a patient to understand that increasing vocal flexibility is represented by an increasing area enclosed by the ellipse measured on the phonetogram.

Air-flow measures

Air-flow measures are very valuable and can often be accessed by liaison with the physiotherapy or lung function departments. These can provide static measures of vital capacity, resting respiration and respiration on continuous phonation. For the dynamic aspects of air-flow measurement, there is an important distinction to be made between laboratory investigation of voice and the clinical situation. The former requires instrumentation capable of measuring changes in pressure over a single vocal cycle, the latter requires accurate assessment of air flow throughout a passage of continuous speech or song. Even so, it is still difficult to find instrumentation that will provide inexpensive analysis of dynamic air-flow measurement during speech.

It is important to remember that equipment in therapy, while ideal if available, is not essential to carry out good work in the remediation of vocal pathology. At some point in all therapy the time comes to wean patients from visual and auditory feedback and teach them to rely on their own auditory and kinaesthetic feedback, and treatment may be more effective long-term if this is carried out early.

Conclusion

There is no single 'right' way to run a voice clinic. There is only what is practical in terms of resources, patient case load, and hospital administration. While all the equipment discussed above is ideal, much can be done through the combining of the different approaches and discussion between the members of the team, whoever that may include. The experiences of voice clinics now springing up in this country all point to the enormous advantages this approach allows in clinical management and it is clearly here to stay.

THE OXFORD VOICE CLINIC

The Oxford voice clinic was set up in 1982 in order to:

1. Provide re-evaluation of voice patients who were not progressing with treatment as well as expected – the so-called problem cases.
2. Provide additional diagnostic information in cases where there is no visible abnormality of the vocal folds but where the voice quality is abnormal.
3. Identify other contributing medical factors among voice patients and to provide the appropriate treatment.

Since the voice clinic was set up, however, other important aims were developed as the necessary equipment and knowledge were acquired. These included:

1. Earlier diagnosis of carcinoma or residual disease in patients previously irradiated for carcinoma of the larynx. This has become possible through the acquisition of a stroboscopic light source for laryngeal work and, as a result, more accurate guidelines are available for assessing which patients must be biopsied, and which are safe to review.
2. A dramatic reduction in the number of patients requiring direct laryngoscopy simply because they were not possible to examine in an outpatient clinic.
3. The opportunity to investigate the nature of voice disorders, their course of recovery, and the efficacy of the treatment provided.

The role of the voice clinic as a tertiary referral clinic for 'problem' cases meant that dysphonic patients attending outpatient ENT clinics were not automatically seen in the voice clinic. As a result it was possible to compare the performance of the group of patients referred to the voice clinic with those seen in a 'regular' ENT clinic. We wanted to evaluate the effectiveness of the multidisciplinary approach, determine the different characteristics of the two groups, and monitor patients' satisfaction with their treatment.

METHOD

Samples

Fifty patients from the voice clinic and 50 who had been assessed in the outpatient ENT clinic and referred to speech therapy were randomly selected and asked to complete a questionnaire. All the patients were seen between August 1982 and December 1984, and had completed therapy. Patients with psychiatric disorders were not included, nor were laryngectomees. From the outpatient group, 36 patients returned their questionnaire, and from the voice clinic group, 37.

Questionnaire

The questionnaire contains three sections.

The first relates to the characteristics of each group, and includes the following information: the patient's age, sex, smoking habits, concomitant disorders, the nature of their work and voice use, the length of time before seeking help and seeing a specialist, and whether or not the voice returned to normal; it also investigates the time this took, and the length of time off work or prevented from participating in various activities because of the voice disorder.

The second section deals with the course of the voice disorder. A nine-point rating scale ranging from very dissatisfied (9), dissatisfied (8), fairly dissatisfied (7), slightly dissatisfied (6), neutral (5), slightly satisfied (4), fairly satisfied (3), satisfied (2), and very satisfied (1), was used to assess the following voice qualities:

1. voice quality
2. pitch range
3. volume
4. comfort
5. overall pitch
6. vocal stamina
7. the comments of others.

The patients completed these scales to rate their voice before the disorder, when at its worst, and following treatment.

The final section included questions to determine how many people were involved in the assessment and management of the voice disorder, and the patients' rating of how satisfied they were with this on the same nine-point scale described earlier. The following group of people was rated:

1. the general practitioner
2. the local speech therapist
3. the hospital doctor
4. the hospital speech therapist
5. the voice clinic.

Screening of case notes

In addition to the questionnaire, the case notes for all the patients were reviewed and the main items of information transferred to a summary sheet. Diagnosis was recorded by assigning each case to one of 26 coding categories, or else category 27, 'NAD' (nil abnormal discovered) in the cases where no specific pathology had been found. The category scheme for diagnosis is summarized in Figure 19.1.

RESULTS

The characteristics of the samples

As a separate matter from the criteria by which the two samples were originally selected, they were found in the course of analysing the results to have a number of other similarities and differences which are summarized in Table 19.1. This, of course, means that this was not a fully controlled trial on perfectly matched samples, but nevertheless gives a good preliminary indication of the kinds of people receiving the two sets of treatment and how they fared. Given the smallness of the samples collected, a number of the differences were not statistically significant, but nevertheless they provide an interesting summary of the information collected so far, and a guide to further research.

In order to assess the severity of the disorder of the two groups, the mean of ratings were calculated as given by the patients to the sound, range, power, comfort, pitch, stamina, and other's opinions of their voice before having a voice disorder, and when their voice was at its worst. These results are shown in Table 19.2.

The voice clinic samples report rather worse disorder of the qualities of sound, comfort, and stamina in particular.

The course of events was worked out for the voice clinic samples

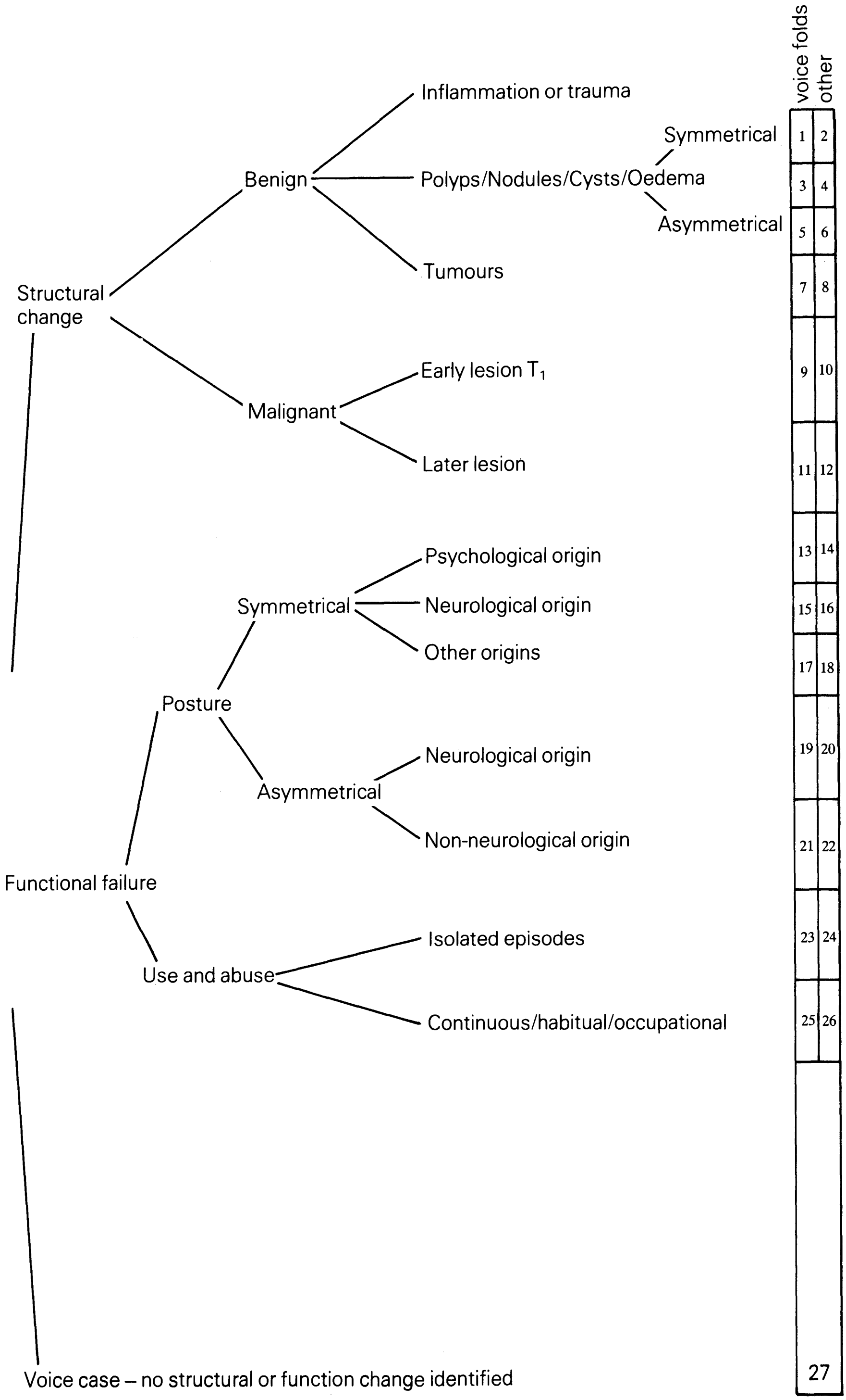

Figure 19.1 Category scheme for diagnosis.

Table 19.1 The characteristics of the two samples

	Outpatient	*Voice clinic*
Age (mean)	52.7	50.9
Males (%)	35.5	44.4
Smokers (%)	32.3	2.2
Reporting neck problems (%)	33.3	25.0
Reporting reflux (%)	22.6	25.7
Reporting persistent sore throats (%)	38.7	28.6
Reporting tremor/rigidity (%)	6.7	6.1

Table 19.2 Voice properties before disorder and at worst rated (1–9)

	Outpatient	*Voice clinic*
Before disorder		
sound quality	7.69	7.97
pitch range	7.50	7.73
power	7.58	7.87
comfort	7.52	7.53
pitch	7.58	7.90
stamina	7.28	7.56
opinion of others	7.38	7.59
When at worst		
sound quality	3.68	3.34
pitch range	3.38	3.48
power	3.32	3.37
comfort	3.29	2.88
pitch	3.74	3.83
stamina	3.24	2.48
opinion of others	3.43	4.36

showing how each of the seven voice quality variables changed from before the disorder, to its height, and then to the time following treatment. This is shown in Table 19.3.

Generally all the variables show a positive trend and recover well, but there are differences. Pitch range, comfort, and power are the properties that remain problematic even after treatment. Comfort and stamina fall

Table 19.3 Time-course of treatment for voice clinic sample – means on a rating scale of 1–9

	Before disorder	*At worst*	*After treatment*
Sound quality	7.97	3.34	7.41
Pitch range	7.73	3.48	6.40
Power	7.87	3.36	6.81
Comfort	7.53	2.88	6.21
Pitch	7.90	3.83	7.00
Stamina	7.56	2.48	5.88
Opinion of others	7.59	4.36	7.30

Table 19.4 Effectiveness of diagnosis and treatment

	Outpatient	*Voice clinic*
Months before seeking help	11.0	6.6
Months before seeking ENT specialist	10.1	4.5
Per cent viewable at IDL	82.1	94.4
Months off work or other activities because of voice	8.7	5.6
Rated constancy of clinical personnel (1–5 scale)	3.71	4.37
Rated helpfulness of professional groups (1–9 scale):		
general practitioners	7.68	6.50
district speech therapists	8.39	7.89
hospital doctors	8.19	7.97
hospital speech therapists	8.54	8.44
joint voice clinic	–	8.61
Per cent NAD	46	6*

* $P<0.01$ (test for the significance of the difference of two proportions, $2=3.71$).

to the lowest levels during the disorder and the opinions of others shows the least marked depression during the disorder.

A number of other methods reflect on the effectiveness of diagnosis and treatment in the two groups, and these are shown in Table 19.4.

These results suggest that patients in the voice clinic group are seen by a specialist sooner, are more likely to be viewable at indirect laryngoscopy, have less time away from work or hobbies because of their voice problem, and also feel that there is greater consistency in the people by whom they are seen in the clinic. Furthermore the joint voice clinic is rated the most helpful agency seen by either group of patients, and most significantly (statistically significant at $P > 0.01$) many more voice clinic patients than outpatients have a specific pathology identified and recorded in their case notes.

DISCUSSION

The main factors highlighted by this evaluation are that the patients seen in the voice clinic are generally worse at the height of their voice disorder than the outpatient group and yet achieve a comparable level of recovery. Also, significantly more voice clinic patients can be given a specific diagnosis, rather than fall in the NAD category. Looking in detail at the recovery of specific vocal attributes it is found that both comfort and stamina recover less well than such things as voice quality or volume. Since these are both attributes that cannot be objectively measured by doctors or therapists, they do not receive as much attention in treatment as the more easily measured attributes to which treatment is usually addressed. It is perhaps important to aim therapy more towards these problems, as it is likely these are some of the most distressing for the patients.

Secondary findings of the evaluation are that the voice clinic patient group were viewable at indirect laryngoscopy in the clinic more often, thus saving unnecessary hospital admission for direct laryngoscopy under anaesthetic. They were off work or inconvenienced by their voice disorder for less time than the outpatient group. Finally they received greater continuity of management in the voice clinic, which they seemed to prefer, as they gave it the highest rating. Their rating of the voice clinic was also higher than any of the forms of management received by the outpatient group, who of course had not been to the voice clinic and gave their highest rating to the hospital speech therapist.

Looking at working voices and trying to equate what we see with the sound we hear has always been somewhat 'hit and miss'. We hope that by evaluating our own performance as well as that of the patient, we may in the future be able to help improve the 'state of the art' into the 'state of the science' to the benefit of both the artists and the scientists concerned.

Since this chapter was first written multidisciplinary voice clinics have been increasing in this country and more are planned. Their experiences appear to support the research described above (Donnelly and Kellow 1989, Williams *et al.* 1990). There has also been an increase in the numbers of conferences dealing with a multidisciplinary approach to voice disorders and research is now beginning to be carried out in the clinics in this country.

Research currently in progress in our own clinic relates to the importance of musculoskeletal tension and habitual posture as a factor in dysphonia, and the effectiveness of osteopathic techniques in resolving these problems. Patients attending the clinic who would normally have been offered speech therapy are now being offered six sessions of osteopathy, either before or after their six-week course of speech therapy. Patients judged to be aphonic for predominantly emotional reasons and those needing surgery prior to their therapy will be excluded from the trial. Those accepting a place on the project will be randomly allocated to receive either speech therapy first or osteopathy first. After the initial course of treatment patients will be fully reassessed before receiving the second part of their treatment. In this way it is hoped that the effectiveness of osteopathic techniques in reducing neck, shoulder girdle, and laryngeal tension will be demonstrated and the effects of this alone on the dysphonia can be monitored. It is also hoped that light can be thrown on the criteria for choosing patients for this type of treatment.

The following assessments will be carried out to monitor changes in the patients voice, posture, and muscle tension.

1. Full videostroboscopy will be recorded pre-therapy, at the six-week-therapy changeover, and at the end of treatment. This will monitor structural changes in the patient's vocal folds, internal vocal posture and symmetry, together with mucosal wave activity and vocal fold contact during phonation. The accuracy of the examining surgeon's observations will be checked by another independent surgeon experienced in the technique of stroboscopy.
2. A digital tape-recording will be made of the patient's voice at the three assessment times for pitch extraction analysis.
3. These tapes will also be used by an independent speech therapist experienced in the technique of vocal profile analysis (VPA) (10% of the vocal profiles will be re-rated by another experienced therapist to ensure the accuracy of observations).
4. A phonetogram will be carried out on each patient at the appropriate assessment times to check changes in the range of vocal pitch and intensity.
5. Each patient will complete five-point rating scales assessing their vocal pitch, volume, comfort, stamina, and voice quality prior to the onset of their voice disorder, before speech therapy, before osteopathy, and when all treatment is complete. These will be statistically analysed by an independent statistician.
6. The project speech therapists will complete the same rating scales for both pre-therapy conditions and for the post-treatment condition. The results will be analysed by the same independent statistician,

allowing a check on the practitioner agreement between the therapists, and on the agreement between patients and therapist.

7. Three-point rating scales will be independently completed by the surgeon, osteopath, and speech therapists for the following: the level of the thyroid and hyoid cartilages at rest and in speech, laryngeal tension, thyroid visor opening, anterior neck muscle tension, posterior neck muscle tension, and thyrohyoid membrane tension.
8. In addition the laryngeal movement in swallowing will be assessed, laryngeal rotation noted, and the relationship between the cervical and dorsal spine observed.
9. Each patient will have a series of photographs taken against a grid at the assessment times to monitor changes in posture.

One of the most important side-issues of this research is the development of assessment techniques for laryngeal position and tension and the relevance of these to dysphonia. We will also be working on correlating the observations of internal laryngeal posture and symmetry with the observations of the external position and tension. Clinical experience suggests it is helpful to use the external assessment to predict the internal postural findings. We will be most interested in comparing the findings of this work with the relationships between specific neck and laryngeal structures described by MacCurtain *et al.* using xeroradiography (Julian *et al.* 1981).

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20

The voice clinic in a general hospital

Eryl Evans

INTRODUCTION

This chapter will describe the running of a voice clinic within the speech therapy department of a general hospital. The hospital itself is relatively small (400 beds) and deals mainly with acute problems, with the inpatient population being largely transient. The ENT department on the other hand, serves a large, rural catchment area, and therefore the proportion of ENT referrals among the speech therapy caseload is high. Over a period of twelve months 90% of referrals to the department had some form of voice disorder, and this obviously influences the running of the department.

Apart from ENT referrals, the general caseload is made up of acquired language disorders following cerebrovascular problems. The management of these two main client groups is necessarily different, as most of the ENT referrals are outpatients as opposed to inpatients, although there is a certain amount of involvement with the ENT ward. Most are seen following a consultation at the consultant clinics, which involves close liason with outpatients' staff as well as medical personnel. The close proximity of the ENT and speech therapy departments can be both a blessing and a hindrance to the general smooth running of our department!

The following information is based on individual experience in a specific situation, and the points discussed will not apply universally. The proportion of ENT to general referrals will vary from setting to setting, as well as with therapists' interests. However, some common points of reference can be made, and some of these will be discussed.

WHAT SORT OF PERSON IS REFERRED FOR VOICE THERAPY?

During an eight-year period from April 1980, 657 ENT referrals were received. Wherever possible they were classified according to guidelines suggested by Simpson (1971) based on Luchsinger and Arnold (1965). The referrals can be broken down as follows.

Dysplastic dysphonia

Four cases of congenital disorders of the larynx were referred. This small number is probably due to the paediatric department's being situated at another local hospital. All four children had a history of congenital laryngeal stenosis. One had a severe stenosis, which was ultimately treated by inserting a rib graft. The resulting voice disorder was only minimally improved by therapy, but the child benefited from closure of the tracheostoma present preoperatively.

Traumatic dysphonia

Thirteen cases were referred with dysphonia resulting from laryngeal injury. Of these ten were as a result of direct blows to the larynx, the others following laryngeal damage during surgery. The laryngeal blows had in each case caused immobilization and swelling of the vocal cords, and swallowing and breathing were affected. There was no permanent nervous damage, and all recovered without formal therapy, except advice regarding voice care. In one case the vocal cords had been damaged during excision of a thyroid tumour, necessitating laryngeal reconstruction. The resulting voice disorder was exacerbated by the patient's anxiety regarding his general health and ability to return to work. This functional aspect of the dysphonia persisted after physical recovery was complete.

Mechanical dysphonia

This group of referrals was the largest, with a total of 225 clients referred with dysphonia due to faulty voice production. They presented as either hyper- or hypofunctional problems, which were often long-standing and recurrent. Although the vocal problems were caused by laryngeal strain, the number of additional psychological problems described by some was sufficient for an additional 68 cases to be categorized under 'mechanical dysphonia with strong functional overlay'. The distinction between these and cases of functional dysphonia is often difficult. The presenting symptoms of mechanical dysphonia included:

1. Reinke's oedema. Forty cases were referred, with the severity of oedema varying from localized swelling to generalized laryngeal oedema. The majority made progress following therapy, but in 14 cases vocal abuse persisted and surgical stripping of the cords was necessary.

2. Vocal nodules. Ninety-three cases were referred where persistent vocal abuse had resulted in the formation of non-malignant nodes on the vocal cords. A proportion of these were seen post-surgery for the removal of the larger of two nodules, and others were referred so that voice therapy could attempt to reverse the disorder. Each group had its successes and failures, but generally the early diagnosis of nodules resulted in good therapeutic results. Lancer (1988) emphasizes the 'importance of teamwork, especially between the laryngologist and the speech therapist, which is the key to the successful management of the vocal nodule patient.' Four cases involving vocal nodules in children were referred, and in these therapy was especially important, aiming at establishing good patterns of vocal care as suggested by Wilson (1972) and others.
3. Contact ulcer. Only two cases were referred with a diagnosis of contact ulcer. The two gentlemen presented with well-established ulcers following prolonged, excessive voice use, and surgery was necessary. Following a period of complete voice rest, a programme of voice therapy was successfully carried out.
4. Tensor weakness. Fifty-two cases were referred with 'bowing of the cords', 'incomplete approximation' or similar diagnoses, where habitual vocal abuse had resulted in vocal-cord weakness. There were no cases of permanent myopathy and all achieved a functional voice, although still weak under stress. There were often strong psychological factors that maintained the dysphonia beyond the point where the laryngeal condition had improved.
5. False cord phonation (ventricular dysphonia). Twenty-three cases were referred where, on laryngoscopy, the ventricular folds are seen to approximate above the vocal cords during phonation. All but three achieved true vocal-cord phonation following therapy, which was usually prolonged due to the resistance to changing vocal habits. One lady totally failed to improve, but had complained of dysphonia for 20 years!
6. Precancerous lesions (hyperkeratosis, leukoplakia). Fifteen cases were included in this category. Although reported as being of 'obscure pathology' (Simpson 1971) they are associated with chronic irritation or excessive vocal use, and regress under voice therapy. Five cases ultimately required stripping of the cords, but there had been some reduction in the severity of the hyperkeratosis.

Inflammatory dysphonia

A diagnosis of 'chronic laryngitis' was made for 64 cases, where the irritation of the cords had been caused by factors other than mechanical ones. Twenty had non-specific bacterial infections, secondary to respiratory infections, others were due to irritation from dust, fumes or other environmental irritants. Despite therapy, 14 failed to improve due to persisting irritant levels.

Vasomotor dysphonia

Four cases were referred with dysphonia due to unilateral monochorditis. The autonomic nerve supply to the larynx had been disturbed following allergic reactions, resulting in episodes of transient dysphonia. Three were teachers with additional pressures of occupational voice use, and continued to have a predisposition to this condition when the dysphonia itself had improved.

Endocrine dysphonia

A number of endocrine disorders may have dysphonia as a side-effect. Among those referred for speech therapy have been puberphonia, dysphonia due to thyroid imbalance, and dysphonia as a side-effect of steroid therapy. Three young men were referred following a failure of vocal mutation at puberty. They were all able to achieve a voice more appropriate to their age and sex, and had no difficulty in maintaining their 'new' voices. Two women reported frequent hoarseness following thyroid imbalance, and on laryngoscopy showed incomplete glottal closure. One failed to improve her voice due to permanent vocalis muscle atrophy and resulting bowing of the cords. Three women were referred with voice changes as a result of steroid therapy, and there was limited vocal improvement whilst steroid therapy persisted, which mirrored the results noted by Williams *et al.* (1983), with the voice returning to normal once steroid therapy was discontinued.

Functional dysphonia

In this category 147 cases were referred where the disorder was psychogenic in origin. There is an overlap in this category with that of mechanical dysphonia with functional overlay. The severity of the problems varied from long-standing aphonia to occasional weakness, and the majority of problems seemed to be triggered by anxiety. The variety of symptoms was surpassed only by the complicated and often tragic case history details. Only three patients refused any attempt at vocal rehabilitation, and recovery for the remainder varied from dramatic voice restoration to slow, gradual recovery, requiring prolonged therapy and much counselling, a factor expressed by Greene (1984). Frequent follow-up appointments were necessary to ensure maintenance of the voice. Eighteen cases were men and all had occupational pressures, although one developed a functional dysphonia following treatment for laryngeal malignancy.

Paralytic laryngeal dysphonia

There were 53 referrals with unilateral or bilateral vocal cord paralysis. The interruption of the nerve supply was caused by a variety of disorders including a cerebral haemorrhage, pressure from a secondary tumour, and surgical damage during thyroidectomy. It is essential for the speech therapist to have a clear indication of the cause of the palsy as 'a left recurrent nerve palsy is considered as being due to malignant pulmonary lymph nodes until proved to be otherwise' (Cohen 1986). Where a unilateral cord palsy was unresolved after six months of therapy, the ENT surgeons considered a Teflon injection into the affected cord. This was most effective where a weak voice was possible but tired easily.

Dysarthric dysphonia

There were nine referrals where the dysphonia originated from disorders of the central nervous system, with laryngeal, resonance, and articulatory symptoms. Seven had been diagnosed as having multiple sclerosis, and had difficulty with phonation timing and voice quality. During remission periods, all found voice exercises helpful in controlling the voice. Two patients complained of volume problems associated with Parkinson's disease, and benefited from work on breathing and the provision of an amplifier. However, long-term benefits were minimal in all these cases due to the progressive nature of the diseases.

Myopathic dysphonia

There were seven referrals of dysphonia caused by a block at the neuromuscular junction, e.g. myasthenia gravis, and as for other progressive disorders the aim of therapy was maintenance of voice quality for as long as possible.

Arthritic dysphonia

Four patients with a history of polyarthritis were referred with fixation of the vocal cords and acute inflammation of the larynx. They reported difficult and painful phonation, and one improved as the arthritis subsided. One woman suffered adverse reactions to the prescribed drugs, which further complicated her vocal distress.

Neoplastic dysphonia

There were 23 referrals following surgical removal of vocal cord polyps. Not all cases of polyps require voice therapy, and the voice usually recovers spontaneously. Where the hoarseness persisted after surgery, voice therapy was arranged, and in many cases it became apparent that there was vocal abuse in addition to the presence of a polyp.

Alaryngeal aphonia

In this category 96 cases were referred following a diagnosis of laryngeal malignancy, which resulted in laryngectomy. Of these, 12 were assessed and considered suitable for surgical speech rehabilitation (Singer and Blom 1980, Perry 1988). Due to the specialized management of this group they are not included in the general information that follows.

INVOLVEMENT WITH THE ENT DEPARTMENT

An essential condition for the acceptance of a client for voice therapy is a recent ENT report. Although 'the majority of voice disorders are the result of abuse and misuse of vocal mechanisms' (Boone 1983), the possibility of laryngeal pathology must be investigated before therapy is considered. When referrals are received from sources other than the ENT department, a request is made for the appropriate examination to be arranged, either by the referral agent or the speech therapist.

In an ideal situation, the ENT surgeon and speech therapist would interview dysphonic clients together, providing information required by both disciplines (Gordon 1986), and emphasizing for the patient the interrelationship of the 'specialist' and the speech therapist. However, most speech therapists are pressurized by large caseloads and waiting lists and are unable to allocate the time to attend every ENT clinic, where not all patients are dysphonic.

At present we have a working relationship, which although not ideal, encompasses some of the requirements for our specific situation. For example, due to clinical commitments, it is impossible for us to attend all ENT ward rounds, but we can arrange to be present for specified patients. A discrete telephone call from the ward staff is usually possible, reducing time-wasting for the therapist and ENT staff.

A speech therapist also attends a monthly voice clinic run jointly with an ENT consultant, where only dysphonic cases are seen. Where necessary, arrangements are also made for a speech therapist to be present at the laryngoscopy examination during routine ENT clinics. The opportunity to visualize the larynx is invaluable, providing feedback regarding the laryngeal condition (Fawcus 1986).

It is also useful to meet the junior medical staff as they are appointed to the ENT firm, so that the speech therapist can introduce some concepts of their joint management of dysphonics. This generally results in improved communication and referrals with appropriate medical information, details of presenting symptoms, and any laryngeal abnormality, although it is still not unknown to receive a referral stating 'hoarse – please see' – fortunately not too often!

GENERAL MANAGEMENT OF VOICE CASES

The management of dysphonic patients depends a great deal on individual circumstances and facilities, but it cannot be too strongly emphasized that in all cases it must begin with an up-to-date ENT report. No one is accepted for therapy, however mild the dysphonia, unless there has been a recent ENT examination. This not only excludes the possibility of malignant disease but provides the therapist with valuable information regarding the larynx, vocal cords, and related structures.

Following the referral, the initial interview is arranged within two weeks of the ENT examination wherever possible. This may or may not be the first time that the client has met the therapist and the latter often has to explain why the referral was made. (This situation is made much easier when the need for therapy is emphasized by the laryngologist.) Once the rationale for therapy has been explained, the case history and voice assessment are carried out. The case history details will vary from client to client, but enough time should be allocated for this first interview, and time allowed for treatment to commence at the end of the session.

From the information in the ENT report, the speech therapist should be able to plan a rough outline to likely treatment goals, but finer details can only be added following the case history. When the case history has been taken the voice problem is discussed fully with the client, and immediate guidance given as to ways of alleviating any obvious problem areas. Advice may be given regarding voice conservation and specific situations in the client's own lifestyle, always relating the information at a level which is intelligible and appropriate to each individual. Exercises are practised in clinic, and then written down for reference, so that the likelihood of forgetting or misunderstanding is diminished. Greene (1980) advocates intensive daily therapy and this is obviously beneficial when attempting to instil new vocal habits. However, in practice it is often impossible to offer intensive therapy, due to time, travelling, or employment constraints. It is not unknown however, for a general practitioner to arrange sick leave for a period of intensive voice therapy, especially where the client is a professional voice user.

The laryngologist is kept informed of the outcome of the initial interview and the proposed plan of treatment. A progress report is sent prior to the next ENT appointment, requesting information regarding any change in the laryngeal condition. As treatment progresses, review speech therapy appointments are arranged to coincide with ENT appointments, and discharge does not take place until all parties are satisfied that vocal rehabilitation is complete, and that this can be maintained without further supervision.

FACILITIES AND EQUIPMENT REQUIRED

As for most therapists, the facilities and equipment that one would like to use in dealing with dysphonia and related problems are not those generally available. The advance in instrumentation being developed for visual feedback and measurement in voice therapy is encouraging and exciting, but should be seen only as a complement and not a replacement for conventional therapy. It is important to realize that they are 'almost superfluous . . . in the delicate psychological work so often needed with voice problems' (Cook *et al.* 1986). It is possible to run a successful voice clinic with basic equipment. Greene (1980) suggests the following essentials.

A detailed case history

This can be taken using a commercial form, e.g. Boone Voice Program or detailed headings as suggested by Luchsinger and Arnold (1965) and Gordon (1986) among others, or from the therapist's own guidelines. Our present format includes the categories:

1. present problem;
2. general health;
3. occupation and voice use;
4. family and social history;
5. personality.

Each category contains subsections with relevant headings, e.g. details of onset of the problem or precipitating factors. Sataloff (1987) outlines a very comprehensive case history format, which is useful in dealing with the professional voice user.

An auditory assessment of dysphonia

Whilst obtaining the history details, the therapist will be listening and watching, not merely to the information being given, but the way in which it is given, allowing insight into the person as a whole and not merely the presenting symptoms. A tape-recording of the dysphonic voice is essential, and although the quality of recording available is not always high, this is a useful tool, along with observation of general and localized tension, breathing, articulation, and a description of the voice itself. Where the therapist is trained in using the Vocal Profile Analysis Protocol (Laver *et al.* 1981) a more objective description of the voice is possible.

Observation of breathing

In addition to noting the method of breathing, whether clavicular, abdominal, etc., the control of breathing for speech is noted, along with specific testing of phonation time and breath control.

Observation of oral and laryngeal movements

The way in which the client uses his articulators for speech is another source of information for the therapist. Tension in this area can obviously relate to generalized tension of the laryngeal area, and therefore contribute to the dysphonia in addition to any physiological changes in the larynx itself (MacCurtain 1981). Laryngeal movements are observed by the laryngologist using either mirror laryngoscopy or more recently fibreoptic laryngoscopy. In both cases the speech therapist can also view the larynx, either by means of a teaching attachment to the mirror or an additional eyepiece on the fibreoscope.

An ENT report

This gives information regarding the appearance and health of the respiratory tract and the condition and function of the laryngeal components.

EQUIPMENT USED IN THERAPY

This includes the following:

1. A high-quality tape recorder for assessment and recording progress as well as developing awareness and self-monitoring skills.
2. An amplifier to provide feedback for disorders where excess volume is used, or amplification where vocal volume is reduced.
3. A pitch pipe, which sometimes helps achieve a more appropriate pitch for the voice.
4. Videotaping facilities, where available, are invaluable, providing a visual as well as auditory record of the client's behaviour.
5. Printed exercise sheets. Although a voice programme needs to be

tailored to an individual's needs, a supply of printed exercise sheets can be useful for commonly used procedures. Relaxation and breathing exercises can be dealt with in this way, as can advice regarding vocal care and avoiding abuse. However, they cannot replace face-to-face contact, and are always used in conjunction with a full explanation and discussion of the problem.

SOME OF THE PROBLEMS

Therapists working with voice disorders could no doubt compile an extensive list of problems that voice cases bring with them. Lack of co-operation from a laryngologist can result in vague and sparse referrals, when the client has no idea why he/she is being referred for speech therapy, leading to poor motivation to attend (although this can also happen with a well-informed person). Feedback to and from the therapist may thus become restricted. The motivation to attend for therapy may be poor once the absence of laryngeal malignancy has been confirmed. Clients may be reluctant to be absent from work 'just for my voice'. When a professional voice user has voice problems, employment pressures add to the tension already present.

Few therapists can boast ideal facilities and equipment; recent technical advances are still outside many therapists' budgets; they struggle instead in noisy, poorly equipped rooms, where ingenuity is stretched in dealing with limited resources.

However, there continue to be many attractions to running a voice clinic, and the experience of working through a programme of rehabilitation provides a great deal of satisfaction for the therapist and client.

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Index