VOCAL CHARACTERISTICS OF HEARING IMPAIRED PEOPLE

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The speech characteristics of hearing impaired people have been described for several hundred years. Only recently have there been attempts to provide objective descriptions of these characteristics. One of the great difficulties in describing aberrant speech patterns is the lack of a commonly used precise terminology for non segmental aspects of speech.

In this study the literature about deaf speech is reviewed and possible assessment/descriptive schemes are examined. The Vocal Profile Analysis Scheme (Laver et al 1981) is described and the reasons for choosing this particular analysis procedure are discussed.

50 hearing impaired young people were recorded. These comprised a large group of profoundly hearing impaired young people and a smaller group of moderately hearing impaired young people. Vocal profiles were compiled by 4 independent judges for these subjects and for a control group of 40 hearing speakers.

The vocal profiles of the profoundly hearing impaired speakers were different from those of the moderately hearing impaired and also different from the profiles of the hearing subjects.

The characteristics of the hearing impaired speakers were identified and described, and correlations between selected vocal characteristics and intelligibility ratings and between selected vocal characteristics and audiological features were explored.

The study concludes with a discussion of the remedial implications which arise from the findings of these investigations.

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INTRODUCTION

For centuries teachers have tried to describe the speech characteristics of hearing impaired speakers and to suggest appropriate remedial strategies. They have consistently found it very difficult to do so. This study shows how a procedure developed at Edinburgh University, the Vocal Profiles Analysis Scheme, can succeed in this area of difficulty.

This study describes the speaker characteristics of hearing impaired people. Speaker characteristics refer to those parameters of an individual's speech production which are characteristic of him; characteristic because of the speaker's physical makeup, and because of how he has learned to speak. The term speaker characteristics is described fully below.

This introduction will first describe why a speech pathology project should be submitted in a Department of Linguistics; second it will outline the value of this project and the motivation behind its inception and third will review the framework of this thesis.

The nature of the work dictates that the writer will take concepts and information from a range of disciplines, notably from speech pathology, special education and phonetics. The dual aim of description AND remedial planning puts this piece of work firmly within the discipline of speech pathology with the adjacent subjects of phonetics and special education providing a necessary context.

Speech pathology as an area of study has developed over the past fifty years although it has existed as a practice for much longer. The practice of helping people with communication difficulties has a long history. Such help has been given for centuries by teachers, clerics, doctors and elocutionists. The skills which these early practitioners brought to their clients were those of their professions coupled with the imagination to use their skills ingeniously. The roots of speech pathology are set in the disciplines of neuropsychology, phonetics, linguistics, otolaryngology and education. Historically it is interesting to see how speech pathology has developed different emphases in different countries. Thus speech pathology in contemporary Russia is closer to neuropsychology than to the other disciplines, whereas in the rest of mainland Europe speech pathology is closely allied both in training and practice to special education. In the United States of America there is a division of speech pathology into two branches. First, there are practitioners who are trained as speech correctionists to work primarily with children who have deviant speech and language, and second, those who have been differently trained so as to enable them to include neurologically impaired speakers among their client groups. The training of speech correctionists is based largely on developmental linguistics and education, whereas the second group, in addition to neurology, relies heavily on speech science as the area which best serves their diagnostic needs. Neither group of American practitioners undergoes the amount of phonetic training which both historically and currently characterizes British speech pathology education and practice.

In the United Kingdom speech therapy has remained a single profession, historically developing either from those pioneers who tried to apply phonetic principles to describe deviant speech among children and adults and to improve their intelligibility; or those equally important pioneers who worked with neurologists (especially during and after the Great War) to try to understand the neurological breakdown of language and how best to remedy it.

There are very few speech pathologists in the UK who have completed PhD degrees. Speech pathology necessarily interacts with a range of disciplines and the post-graduate research which has been completed has been conducted in various departments, notably psychology, linguistics, or medicine. Each post-graduate speech pathologist has chosen a department where the supervisory need could be met and where there was general departmental sympathy to the application of the core discipline to the needs of speech pathology.

This particular piece of research has been conducted within the field of Phonetics but it remains within the domain of speech pathology. This study forms part of a larger study conducted in the Department of Linguistics between 1979 and 1982 funded by the Medical Research Council (Grant No. G7811925N). This larger research project was designed by John Laver and the author with the aim of developing a scheme to be used for the description of speaker characterizing voice quality. The purposes of the larger project were threefold:

1. To develop a scheme which would describe long-term speaker characteristics - the Vocal Profile Analysis (VPA) Scheme.
2. To develop teaching materials which would enable speech therapists, phoneticians and others to learn the VPA.
3. To apply the VPA to the description of various speech disorders.

The absence, hitherto, of a systematic description for deaf speech suggested that this application of the VPA constituted an appropriate field of study for a doctoral thesis. It was therefore decided that the author would take responsibility for collecting the recordings of hearing impaired speakers and processing these results. In addition she had of course involvement with other aspects of the project.

The work submitted here describes the application of the VPA to the description of deaf speech and the remedial implications of such a description.

Speech characteristics of hearing impaired people have been described for several hundred years, but for the practitioner who seeks a descriptive system which aids remedial planning many existing descriptions are inadequate. Descriptions from the education literature often use vague impressionistic labels without any attempt at descriptive rigour. Descriptions of deaf speech by phoneticians describe one, or a few, speech parameters in some detail but with little regard for how these parameters have been influenced by factors such as audiological status, language competence or proprioceptive feedback. Such descriptions may help phoneticians in their understanding of speech, but are not in their present form especially useful for practitioners who want to understand remedial possibilities.

The reasons for starting this project were various. The author as a practising speech therapist had become increasingly frustrated by the lack of phonetic tools available to describe <u>long term</u> speaker characteristics. Various phoneticians, such as Grunwell (1985), have suggested ways in which phonetic description can be modified to meet the needs of speech pathologists who wish to describe the phonology or phonetic realizations of a disordered speaker. Others, such as King et al (1984), have developed assessment tools to look specifically at the phonology of deaf speakers.

It is necessary at this point to offer some explanation for two terms which will occur commonly in this work, namely 'voice quality' and 'long term speaker characteristics'.

A term which is often used in this study is 'long term speaker characteristics'. This concept moves away from traditional segmental phonetic description to the concept of articulatory tendency or 'articulatory setting' (Honikman 1964: 73). This is a particularly helpful concept when describing deaf speech where the hearing impaired people frequently have multiple and often inconsistent segmental variation. A segmental description of their speech shows when their speech differs from that of a hearing speaker but because of the multiplicity of their 'errors' such deficit description offers no unified explanation about what the hearing impaired speaker is actually doing with his vocal apparatus. In contrast an attempt to describe a hearing impaired articulatory setting attempts to provide a unified explanation of this sort.

This piece of work concentrates on aspects of the prosody and voice quality of deaf speakers. The author however was more interested in the <u>long term</u> speaker characteristics than in individual phonological systems or in the phonetic productions of individual hearing impaired speakers. For such an interest no satisfactory descriptive tool exists. The long term settings used by a speaker have an impact on the segmental realizations of his speech. This interaction between settings and segmental aspects of speech has important remedial implications. If improvements of settings lead to improvements in segmental aspects of speech, a more effective remedial regime can be developed. The motivation for the study was then to see if the VPA could be applied to the description of deaf speech and whether such a description would reveal useful remedial guidelines.

A discussion of the relationship between articulatory settings and segments is given by Laver:

> 'Because phonetic description finally has a linguistic motivation it is the differences between the segments that tend to be emphasized rather than the similarities. There is an alternative approach to the task of articulatory description, however, that concerns itself with both differences and similarities in vocal performance in speech. In such an approach individual segments are seen as being articulatorily related to other segments in that a particular articulatory feature could be abstracted from the chain of segments as a shared property of all or most of the segments' (Laver 1980: 3)

In this interaction between chains of segments it is the setting which is the 'shared property' or the 'long term speaker characteristic'. The reader is referred to Laver (1980) for a detailed and extended explanation of how phonetic, physiological and acoustic aspects of speech interact. It is the shared properties of this sort which are referred to as long term speaker characteristics and this study aims to identify the long term speaker characteristics of profoundly hearing impaired speakers by using VPA procedures to describe their speech.

Sometimes the term voice quality is used to refer to idiosyncrasies of resonance in a speaker. Normal speakers of English use a balance of oral to nasal resonances where there is a predominance of oral resonance except for the nasal consonants /m/ /n/ /ŋ/, and some adjacent vowels. There is considerable tolerance among English speakers as to how much nasal resonance they will accept within the bounds of 'normality'. However, if, as for example with a cleft palate speaker, the velopharyngeal insufficiency is so great as to interfere with this predominantly oral to nasal balance, the speaker is often described as having a 'nasal' voice quality.

Thus for example a speaker who habitually uses a close rounded lip setting may still make a distinction between the vowels which he makes in the words 'sheep' and 'shoot' but the 'shared property' (Laver 1980) of the realizations of these words will be lip rounding. Similarly a speaker who habitually uses a fronted tongue tip position will hold the tongue at rest against the inner surface of the upper teeth (or perhaps protrude slightly). However, despite this 'habitual property' of fronted tongue tip the speaker will still make a segmental distinction between words such as 'die' and 'thy.' Voice quality is used often in an ill-defined way to mean phonatory changes which derive from laryngeal performance. Thus a speaker who develops polyps may be described by an ENT surgeon in his referral note to the speech therapist as having 'harsh' or 'rough' or 'hoarse' voice quality. The adjective used to describe the voice quality will have perhaps some local intra-departmental validity, but no more than that.

In this project voice quality is taken to include both laryngeal and supralaryngeal adjustments which, in addition to affecting segmental aspects of speech, contribute to the individuality of the sound of a speaker. Such a definition follows Abercrombie (1967) who defines voice quality as 'those characteristics which are present more or less all the time that a person is talking; it is a quasi-permanent quality running through all the sound that issues from his mouth' (Abercrombie 1967: 91) or Laver, who defines voice quality 'as the characteristic auditory colouring of an individual speaker's voice' (Laver 1980: 1).

Thus the study is a description of all the long term aspects of the vocal performance of deaf speakers, rather than a narrow description of the laryngeal aspects of vocal quality.

In this study the first task was to identify descriptions of deaf speech which occur in the literature and to examine published speech analysis procedures which might be used to describe long term speaker characteristics among hearing impaired people. This examination convinced the author that the VPA scheme was the most useful for this study. The review of the literature confirmed the author's impression that most descriptions of deaf speech were derived from single case studies or from ill-matched groups of speakers. An attempt to find a homogeneous group of hearing impaired speakers was considered important in this study. Homogeneity is important in order that descriptive trends can be attributed to degree of hearing loss and not to age, to intellectual status, or to factors such as educational attainment. Hearing impairment and deafness are used synonymously by many people. Hearing impairment is the term preferred by most professionals and deaf the term used by them specifically to describe severely and profoundly hearing impaired people. In this study it was decided to choose a homogeneous group all of whom had profound hearing loss. Profound hearing loss is taken to mean those people whose hearing impairment is so profound that they cannot easily benefit from portable hearing aids. These definitions of degree of hearing loss are amplified below in Chapter 4.

In order to find such a homogeneous group, it was necessary to go to the USA where there is a national college with a population of around 900 hearing impaired young people. From this unique setting it was possible to select a very homogeneous group of 40. Such a task would not have been possible in the UK. In addition, 10 further British hearing impaired speakers were analysed, 5 with severe hearing loss and 5 with only partial hearing loss.

The VPA characteristics of these 3 groups of speakers were then compared with the VPA characteristics of 40 control speakers with normal hearing. These comparisons allowed group characteristics to emerge. One of the questions posed by this study was whether there were any typifying features in the long term speaker characteristics of profoundly hearing impaired speakers. The smaller groups were then examined to see if such characterizing features were found only among profoundly hearing impaired people, or whether other degrees of hearing loss precipitated similar speech patterns.

The final part of the study was to examine the remedial implications of the descriptions which had been made.

CHAPTER 1

LITERATURE REVIEW OF DEAF SPEECH

1.1 Introduction to the literature

1.2 Overview of deaf education

1.3 Review of literature relating to the laryngeal performance of deaf speakers

1.4 Review of studies referring to velopharyngeal incompetence in deaf speech

1.5 Review of some supralaryngeal characteristics of deaf speech

1.6 Review of literature referring to timing and other prosodic aspects of deaf speech

1.1 INTRODUCTION TO THE LITERATURE

The greatest problem for severely and profoundly deaf children is their poorly developed language. Because of their inability to hear, they do not acquire language with the ease of hearing children and for most severely and profoundly hearing impaired people these language deficits remain evident in spoken language, written language and in their understanding of language throughout their lives. It is argued that those hearing impaired children who are exposed to sign language early in childhood will suffer less marked language deficits than most of their peers. This certainly seems to be true of deaf children brought up by signing deaf parents (Vernon and Koh 1970). Similarly children whose deafness is recognized early, who are given good amplification and whose parents are helped to cope with the problem of deafness, will often acquire competent or even good language skills (Ling 1976). The major problem for most deaf people is then one of language acquisition.

This study is concerned with the speech characteristics of young hearing impaired adults, where one can assume that most of their language learning will be complete. However, because the literature in the field of deaf speech is very diverse, the review includes studies which refer to the speech characteristics of hearing impaired children as well as those of hearing impaired adults.

The literature about deaf speech varies in form depending often on the discipline from which the writer comes. Description or descriptive research by educators has almost always been designed to emphasize remedial implications or to investigate the educational efficacy of a given course of action. Work reported by speech pathologists tends to be descriptive and primarily concerned with the potential therapeutic application of the work. In contrast work conducted and reported by psychologists or speech scientists often involves quantitative studies of specific parameters and may be part of a broader model building exercise about some aspect of communication.

This current work is primarily a descriptive study and its goal is to indicate remedial implications. To achieve this goal the study looks at certain speech parameters in some detail. Thus it was considered important to include in the literature review those references which give scant, ill-defined accounts of deaf voice as well as those which provide detail. It should be noted that the number of detailed accounts is small.

It is interesting to note that most papers and studies about deaf speech attempt to compare the characteristics of deaf speech with those characteristics of normal speakers. Such studies can be called comparative studies. In sharp contrast a few studies, notably West and Weber (1973), Fisher et al (1983), warn that when the target speech behaviour is unclear or unknown and/or when the deaf speech is unintelligible, such comparative descriptions are quite inappropriate. A few writers, notably Brown et al (1983), have in contrast to most other investigators also eschewed comparisons between deaf and hearing speakers and have isolated those features which contribute to intelligibility in deaf speech and then examined these features in some detail.

The hypothesis of this study, which is more fully explained below, is that it is inadequate to look only at the segmental articulatory features of deaf speech. It is hypothesized that to describe the speech of a deaf speaker adequately it is important to look at speech characteristics from a broader base than that often suggested by traditional methods. Any attempt to characterize deaf speech must consider laryngeal factors, velopharyngeal factors, factors affecting articulation and those affecting prosodic aspects of speech.

It was decided to use this four part organizational arrangement as a way of categorizing the literature review. The review will consider, first, work which has examined laryngeal components of deaf speech, features of pitch and intonation and phonatory quality. Secondly, the review will look at the reported velopharyngeal characteristics of the speech of the deaf. Traditionally the hearing impaired speaker is thought to have a very 'nasal' voice; the reality of this as reported in the literature will be explored. Thirdly, the review will look at studies which have attempted to describe supralaryngeal characteristics of deaf speakers. Finally, the review will look at some of the temporal organizational and prosodic aspects of deaf speech.

Before examining these specific areas in the literature, there follows a brief explanation of how contemporary thought about education of the deaf has affected attitudes to spoken language.

1.2 OVERVIEW OF DEAF EDUCATION

This work is a descriptive study of the long term speaker characteristics of young hearing impaired adults. In this chapter, the literature relating to the speech performance of hearing impaired speakers is reviewed.

It is necessary to preface this literature review with a brief historical account of deaf education, because of the great influence which contemporary pedagogic thought has had on writings about deaf speech. As educational opinion has swung from advocating instruction through communication to finger spelling, and from oral methods of communication to total communication, these shifts of emphasis have been reflected in the interest (or lack of interest) in deaf speech.

Green (1783) gives one of the earliest accounts written in English about deaf speech entitled 'The most curious and important art of imparting speech and the knowledge of language to the naturally deaf and (consequently) dumb' (his brackets). He suggests that

> 'They at first use cries only or uncouth irregular exertions of voice with signs, until art, in other words precept and example regulate these sounds:- the first advance is made by an ingenious method of sounding the vowels ...
>
> It hath been already promised that vowels are the fundamentals and expressed with little or no action of the loquelary organs ... that when these are learned by the method just hinted at articulation of the most easy syllables is next to be inculcated ...

Green then pays particular attention to the need to teach vowel articulation as the first step in teaching deaf speakers to talk. In the intervening 200 years there have been many studies and descriptions of deaf speech but only recently have acoustic studies begun to appreciate how important it is to look systematically at vowel articulation.

It is worth sketching the historical background of the interest in deaf speech. Some of the earliest recorded work with deaf speakers was by monks in Spain. In early Hispanic law it was impossible for someone who could not speak (was dumb) to inherit property. In an attempt to overcome the potential problems of divisions of estates, loss of family property etc., monks tried in their abbey schools to teach speech (and other educational attainments) to the deaf sons of Spanish noblemen. It was a curious twist of fate that congenital deafness seems to have been especially common among the Spanish nobility. Pedro Ponce de Leon, a Benedictine monk, recorded his considerable success in teaching deaf mutes at the monastery of Ona in the 16th century. He taught through a combination of Benedictine signs, finger spelling, reading and speech.

In the middle of the 18th century the publication of two papers, by L'Abbé de L'Epée in Paris in 1776 and Heinike in Germany in 1778, brought into focus the divided opinion on how to communicate with deaf children, by oral/aural means or by manual sign techniques. At about this time the Braidwood family ran a highly successful school in Edinburgh where children were taught by the oral method. It was to this school that Francis Green (quoted above) sent his son from Boston, Mass., and the work of this school inspired Green to write 'Vox Oculis Subjecta'. In the 1790s a young teacher of the blind, Clerc, was sent by American philanthropists to Europe to learn about the education of the deaf. He went first to the Braidwoods' school, encouraged by their world wide reputation. Unfortunately they were very guarded in their explanations of their educational techniques and, discouraged, Clerc went on to Paris where he learned from Abbé de L'Epée's followers about their (manual) techniques. This inhospitality of the Braidwoods appears to account for the close historical relationship between French Sign Language and American Sign Language (ASL) and for the fact that education of the deaf in the USA has always accepted the place of signing in the education of the deaf.

The divergence of educational opinion in the mid 18th century resulted in the development of two parallel educational regimes for the deaf in most western countries. One regime following an 'oral' philosophy stressed that deaf individuals live in hearing, speaking society and therefore should be taught to speak and speech-read. The contrasting regime, 'manual method', subscribed to the view that deaf people found sign a much easier and more natural medium of communication and should be taught in this way. Britain and most of northern Europe followed a broadly 'oral' tradition, while the southern part of Europe accepted that signing had a place in the education of deaf children.

It was not until 1893 that the education of deaf children became compulsory in the UK and after that date there was a growth in the volume of written work about deaf speech. Because teachers of the deaf were the only professional group interested in deaf speech it follows that the separation of educational literature from linguistic literature at this early stage is extremely difficult and indeed somewhat useless. It is not until the 1930s that there are any serious attempts to describe deaf speech by speech scientists, who cooperated with teachers of the deaf.

Writers such as Charles Voelker (1938), a speech scientist during the 1930s at Dartmouth College, New Hampshire, worked in collaboration with staff at the Ohio School for the Deaf and staff at the Phonetics Laboratory of Ohio State University. He conducted experiments using early recording techniques and early stroboscopic procedures. His work is described more fully below. Charles Rawlings, a teacher at the New Jersey School for the Deaf, worked with Charles Hudgins, a research speech scientist at the Clarke School for the Deaf in the early 1930s, examined the breathing pattern of deaf speakers. His work too is described below (Rawlings 1935; Hudgins 1934).

One is struck by these early investigations; firstly by their ingenuity in measurement techniques, taking procedures from the Speech Laboratory and adapting such procedures for use with young children in schools, and secondly by the fact that all these people were professional members of school staff with real experience of hearing impaired people. How seldom is there a contemporary appointment such as that of Hudgins as director of a 'Research Department' at a school for the deaf?

It is worth continuing this thumbnail sketch of the development of education of the deaf through the 20th century because it goes some way to explaining the changes of interest which are evident in those linguistic/phonetic descriptions which do exist. In 1893 the Royal Commission on the Education of the Deaf, Blind and Dumb advocated a 'purely oral' method of instructing deaf pupils. Melville Bell (1872) and Alexander G. Bell (1906), writing in the late 19th and early 20th centuries respectively, reflect this interest in the speech of the deaf.

It should be remembered that audiometric testing procedures were rudimentary, and at schools for the deaf in the early part of the 20th century partially hearing and profoundly deaf people were educated together. A further confusion arose in pre-antibiotic days in that there were many more children who became deaf after encephalitic/meningitis infections. This meant that among the pupils in a school for the deaf there would be children who had been profoundly deaf from birth (the pre-lingually deaf); children who had had a period of normal hearing (and consequently normal language acquisition) before their acquired deafness (the post-lingually deaf); and those children who either pre- or post-lingually had developed slight hearing loss. The consequence of this mixed bag of pupils in schools for the deaf meant of course that there were some pupils (notably the partially hearing and those who had acquired hearing loss in mid or late childhood) for whom the 'oral' method of instruction was highly successful. The success of these children fuelled the view that the 'oral method' was the best educational regime for hearing impaired children. A few educators began to recognize the need to separate these 3 main groups of hearing impaired children. In Glasgow, for example, Sir James Kerr Love opened a school for partially hearing pupils (for those who had post-lingual deafness <u>and</u> those with more hearing) as early as 1902. He was the first to recognize the importance of separating deaf from less deaf children and to provide differently for them.

Alexander G. Bell (1906) pinpoints the fact that the speech of the deaf was not only disturbed in articulatory placement, but also sometimes in prosodic features, thus emphasizing the fact that it is not only segmental aspects of speech which affect intelligibility.

> 'Ordinary people who know nothing of phonetics or education have difficulty in understanding slow speech, composed of perfect elemental sounds, while they have no difficulty in understanding an imperfect gabble, if only accent and rhythm are natural.'

With this observation Bell was probably unknowingly describing differences in the speech characteristics of those with less and those with more hearing. During the war years and the 1920s in the UK, the oral method was the official education policy of a school, but behind closed classroom doors, signing was used but never really taught. This was in direct contrast to the educational policy in the USA where many state schools for the deaf taught language through sign.

This difference between the acceptance of sign language as the medium for classroom instruction in the USA, as opposed to its non-acceptance in the UK, led to important differences in both educational practice and in the literature from the USA and the UK. In the USA there has always been a dual system for the education of the deaf; on the one hand the oral method, on the other signed language. The existence of such a dual system confirms that hearing impaired children are a diverse group with diverse educational needs. The dual system accepted that some children would always benefit from sign as the medium to ensure that they achieved good language skills and good educational standard, and that these children may or may not also achieve good spoken language skills. It also meant that in schools using sign there were often deaf teachers (providing role models), and that there was a more coherent national system of signed English. There are of course native deaf languages, British Sign Language (BSL) and American Sign Language (ASL) in the UK and USA respectively, but the question of how to sign English is a question which has vexed educators. In the USA, Signed English became nationally more homogeneous partly as a result of teachers moving from one school to another, and partly because pupils were encouraged to develop grammatical form in their signed as well as their written and spoken language.

In the UK, however, during the middle part of the 20th century, the official Department of Education and Science's policy was to provide an oral education for all deaf children and, except in a few Roman Catholic boarding schools, sign language was not used officially. This meant that those hearing impaired children with greater hearing losses who failed to develop the oral skills of their partially hearing or post-lingually deaf peers were severely disadvantaged. They and some of their (more sympathetic) teachers developed signs which were used, but they were very local and lacked clear grammatical structure. Thus the 'non oral' deaf children were severely disadvantaged. They were unable to learn through the oral method and were not given a real alternative.

The implications, for this study, of this difference in practice between the USA and the UK are important. In the USA spoken language skills and speech intelligibility were seen and described as phenomena separate from 'language skills'. In the UK, with its oral policy, spoken language skills and speech intelligibility were incontrovertibly dependent upon the efficacy of the teaching programme. This led to claims of high intelligibility ratings and good spoken language skills being made as a defence of oral teaching, regardless of the reality. This is particularly evident when one reads many British accounts of speech of the deaf from the earlier part of the century up until the 1970s.

It should be remembered that until after the Second World War not only were there poor audiometric facilities to determine the degree of hearing loss of children but also hearing aids were very basic amplifiers. They were large, cumbersome, and often rejected by the children. It was not until 1930, with improvements in amplification, and later in the 1950s with transistorization of hearing aids that it became possible to train the residual aural skills of severely and profoundly deaf individuals. Similarly with the emerging National Health Service the provision of appropriate aids for all hearing impaired children became possible. Whetnall and Fry (1963: 31) described deaf speech:

> 'The (deaf) infant can make use of sounds which to the adult with fixed habits of listening are almost impossible. This auditory control is available for a brief few years.... The least vestige of auditory control is of value for the infant because of his great facility for using it.'

However, in the later 1960s and early 1970s in the UK, when the results of improvements in pre-school guidance, aural rehabilitation and provision of amplification became apparent among the younger school children, there was a movement to take children with more residual hearing or with the capacity to develop better spoken language than their peers, away from schools for the deaf into units for hearing impaired children within the normal school system. This of course meant that the residual population in schools for the deaf were deafer and had a greater proportion of additional handicaps than did earlier populations of deaf schools. A consequence has been a resurgence of interest, in recent years, in the place of sign language in communication with young deaf children.

In the past five to eight years there has been a growth of interest in the UK among linguists, psychologists and educators in using sign language, along with use of residual hearing, speech reading and spoken language, as the media for educational communication. Reviews such as those by Kyle and Woll (1983) and Woll, Kyle and Deuchar (1981) cover the arguments for the use of total communication. The simultaneous use of sign language, residual hearing, speech reading and spoken language, together with facial expression and written language, is referred to as total communication. This use of total communication as the most satisfactory educational paradigm for severely and profoundly deaf children is now widely accepted. It has been shown both in the USA and in the United Kingdom (Meadows 1980; Stokoe 1972; Stuckless and Birch 1960; Montgomery 1968) that the use of total communication not only assists severely and profoundly deaf children's developing language and cognitive skills, but also that the use of total communication does not detract from spoken language skills.

Meadows (1980) argues in support of the use of total communication by saying (1980: 173):

'My reading of the literature on deafness and child development leads me to the conclusion that almost all the

> deficits related to deafness are created by deficiencies related to language and communication'

and (1980: 176):

> 'If sign language is viewed as a support to parent-child interaction, and as an additional means to the acquisition of inner language, it will be introduced to any child with a hearing impairment that requires remediation, and as early as possible.'

It might seem paradoxical at a time when there is an increasing interest and understanding of sign language systems that the author is interested in conducting a piece of work concerned with the speech of hearing impaired speakers. However, with improved communicative potential among hearing impaired children it is important to examine the vocal characteristics carefully and point, if possible, to areas of possible remediation and improvement.

This thesis looks at the long-term speaker characteristics of hearing impaired speakers, so it is important to consider the existing literature about voice quality of the deaf. It is frequently stated that the voice quality of hearing impaired speakers is abnormal. Often the supporting citations are ill-defined and it is difficult to establish whether the writer is referring specifically to an aberrance at a laryngeal level or is using the term 'voice quality' to refer to the overall product of the vocal apparatus. As stated earlier this literature review has been divided for convenience into five sections.

1. A review of that literature which refers to the laryngeal performance of hearing impaired speakers

2. A review of those studies referring to the velopharyngeal incompetence in deaf children
3. A brief review of some of the supra laryngeal features of hearing impaired speech. It has been considered outwith the scope of this study to complete a full review of the consonant and vowel articulation of hearing impaired speakers, but if one is to look at voice quality in the context of both laryngeal and supralaryngeal qualities, then it is important to take cognisance of some of these articulation studies.
4. A review of the literature referring to timing and rhythm and other prosodic aspects of deaf speech.

Any division of the literature has to be somewhat arbitrary and because of the considerable overlap between various parameters of deaf speech there are problems of classification. 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 does it refer to an articulatory feature? Such confusions in the classification of the literature are frequent, and the reviewer has drawn attention to this problem, but it is felt that the clarity which a classification brings to a literature review of this type outweighs the occasional confusions which it may engender.

1.3 REVIEW OF THE LITERATURE RELATING TO THE LARYNGEAL PERFORMANCE OF DEAF SPEAKERS

The inability of hearing impaired speakers to control their laryngeal production results in their use of a variety of voice qualities with poor control of pitch and intonation. These factors are commonly cited in the literature. Jones (1967: 508) in her study, 'Deaf Voice - a classification derived from a survey of the literature', 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 (1962a: 401) 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'. This finding by Calvert is of interest to the present study in the way it highlights the notion of 'correctness'. He suggests implicitly that most people working with the deaf describe deaf voices in comparison with the voices of hearing people, and do not describe them objectively. This leads to confusion in the speech pathology literature and specifically literature relating to deaf speech. It is evident that speakers with disordered speech speak differently from those who have not such a handicap. For writers merely to describe the degree of this difference rather than to examine the parameters within which lie the principal contribution to the differences seems to be an exercise of little value.

In a more recent study by Markides (1983) 30 teachers of the deaf and 36 lay people were asked to rate the voice quality of 85 hearing impaired children. They were given a list of terms (Markides

1983: 76) and asked to rate the voice quality of the speaker as 'deep', 'breathy', 'throaty', 'harsh', 'hoarse', 'strident', 'soft', 'nasal', 'fairly normal', 'normal', 'other'. Markides reports that there was considerable disagreement among both experienced and naive listeners. This seems hardly surprising when there were no guidelines as to what the terms meant nor any perceptual training. This study is illustrative of many others, where impressionistic labels are used without definition rendering the 'results' virtually meaningless and the value of the study questionable.

Poor laryngeal control is often attributed in the early literature to abnormal breathing patterns.

Rawlings (1935: 136) indicated that the 'speech of deaf people is breathy and accompanied by excessive breathing movements'. Hudgins (1937: 338) at a similar time also noted that the deaf expended more breath on each 'unit of speech' (he appears to mean syllable) than did the hearing. Peterson (1953) was the first to look at how breathing and articulatory timing were co-ordinated by hearing impaired speakers, and suggested that it was the difference in transitions which led to the perception of voice quality as being different from that of hearing speakers. Calvert (1962b) 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 harmonics but also by information about the articulatory timing of deaf speech.

Calvert is commenting upon the phenomenon, which is now better understood than in 1962, that there are usually many factors which contribute to a single perceptually discernible parameter. It was a failure to realize the complexity of the underlying contributions to perceptual parameters which led to many early investigators (and some ill-informed modern ones) to try to establish simple relationships between perceptual parameters and aspects of speech production. Thus the ingenious early efforts of Rawlings, Peterson and Hudgins cited above to describe how deaf speakers breathe for speech failed to take account of factors such as the lack of fluency of most deaf speakers, their increased vocal intensity, the heightened articulatory effort and the effects which these and other factors would have upon any measurements of breathing for speech. In their quest for simple relationships between perception and production early investigators often failed to design appropriate investigations.

Stark (1972) looked in detail at the speech production of 9 bilaterally severely/profoundly deaf children aged 16m - 24m. She compared their VOT in steady state vowel productions with the VOT of young hearing children who were not yet using speech. One of her observations was that young deaf children do not acquire control over voicing nor pitch and intensity variation as readily as hearing children. In addition she found that there were some articulatory items which were found only among the deaf, and suggests that these 'relate to attempts on the part of the deaf child to increase the amount of tactile and kinaesthetic feedback from his own vocalization output'.

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 by those writers cited above and by others such as Fairbanks 1960; Zemlin 1968; Nickerson 1975. While there appears to be some general agreement as to what terms such as these mean, there have been very few efforts to study how these perceptual features can be related to acoustic features, 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 whether they can be used with interjudge reliability. Thus, for example, in Markides' (1983: 78) study one does not know if the teachers were using terms such as 'deep', 'throaty', 'hoarse', or 'soft', 'fairly normal', in similar ways, or whether they were using different terms to describe the same phenomenon.

However, there are studies which demonstrate 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 (1979) all compared listeners' evaluations of the same words on different occasions. The average correlation coefficient was less than .75, showing that unless listeners are trained, perceptual evaluation is not highly reliable.

One of the qualities common in deaf speakers is a tense/harsh quality. Wirz et al (1979) investigated this feature of voice quality. Between 10% and 12% of students entering the NTID have tense/harsh quality, using the voice classification system used at NTID (Subtelny 1975). In this study there was a high reliability of perceptual judgements by experienced judges. It was an attempt to isolate those acoustic features which allowed this interjudge reliability, which partly instigated the study. Spectrograms of single vowels and of intervocalic vowels were made and examined. The results reported in the study support the general view that tense phonations of the vowels of hearing impaired speakers differ significantly from the relaxed phonations by increased distribution of higher amplitudes of sound energy in the higher frequencies of the spectrum. This increased distribution of energy was evident in the grouped data deriving from the spectrograms. Analysis of individualized data confirmed that this increased distribution of energy in higher frequencies is probably a feature which contributes to the ability of experienced judges to identify and rate vocal tension. Spectrographic analysis of the individual speakers showed that tension was not similarly produced by all subjects and was produced by a variety of different laryngeal and supra laryngeal adjustments. Similar acoustic correlates for tense voice quality in deaf speakers are reported by Whitehead et al (1974). Rees (1958) suggests that the degree of tense/harshness is perceived in an inverse relationship to the height of the tongue during the vowel articulation.

These reported data go some way to explaining why 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 in the perceptual rating. These explanations are first that the speech item in the sample may affect the perceived quality (Rees 1958). Second, that a variety of spectral features contribute to a perceived quality and that although there are discernible general spectral features there is some individual voice variation (Wirz et al 1979, Whitehead et al 1974). Third, if the aberrant quality is associated with laryngeal tension there may be accompanying supralaryngeal tension (Spector et al 1979) which affects other speech parameters.

It is precisely because of these confusions in the literature that the present study was initiated. Chapter 2 will review various assessment procedures and suggest how the Vocal Profile Scheme (Laver et al 1981) is a more satisfactory method of describing aberrant voice quality than other techniques using impressionistic labels.

Some writers have avoided the application of impressionistic labels describing the laryngeal performance of deaf speakers in terms of the pitch and intonation. Commonly the literature refers impressionistically to 'high pitch' among deaf speakers (e.g. Miller 1968, Boone 1966, Martony 1968, Levitt 1971) without attempting to define more closely the pitch level or to measure fundamental frequency. This review has concentrated on accounts of measurement of pitch among the hearing impaired.

One of the earliest attempts to look at pitch parameters among hearing impaired speakers through instrumentation is that of Voelker (1935).

Voelker used stroboscopic techniques to describe both pitch mean 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: 247). However, when he investigated pitch range, he found that the deaf used a narrower range than their hearing peers. '80% 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.

Green (1956) carried out a study of the mean pitch of 49 severely/profoundly deaf school children reading. He used the 'Purdue Fundamental Frequency Recorder' which involved a tape recorder, an attenuator, a pitch meter, a period timer, an oscilloscope and a motion picture camera. He found that the mean fundamental frequency of his older pupils (16 - 20 years) was 76.6 quarter tones for boys or 100.84 quarter tones for girls. This compares with cited references by Fairbanks and Wiley (1959a) and Fairbanks and Herbert (1959b), of 100.4 quarter tones or 297 Hz for 8yr boys or 99.2 quarter tones (288 Hz) for 8yr girls.

Subsequent studies vary in their conclusions about how pitch characteristics of deaf children differ from those of hearing children. Meckfessel and Thornton cited in Gilbert and Campbell (1980) reported that the fundamental frequency values of 7-8 year old hearing impaired children were higher than the values obtained for hearing children. Ermovuk and Grunewald also cited in Gilbert and Campbell (1980) reported the values for the hearing impaired to be lower or the same. Gilbert (1980), whom one can assume from the addresses had been the supervisor of the four theses mentioned immediately above, investigated the fundamental frequency of hearing impaired speakers in three age bands. Twenty young children 4 - 6 years, twenty school children 8 - 10 years and twenty-two young adults 16 - 25 years.

The youngest children had a mean fundamental frequency (in oral reading) that was approximately 55 Hz higher than that obtained for normally hearing children of the same age. For the school children the mean speaking fundamental frequency was approximately 41 Hz higher than for normal speakers. This trend in the group was, however, not borne out by a subject-within-group analysis of variance where there was found to be no significant difference between the deaf and the hearing individuals. This seems to suggest 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.

For the young adult group the fundamental frequency of the young adult females who were hearing impaired was approximately 30hz higher than the data reported by Michel et al (1966) for hearing young female adults. Similarly the fundamental frequency of the young deaf adult group was approximately 20 Hz higher than that of hearing young men as reported by Hollien and Shipp (1972).

Not only is the fundamental frequency of hearing impaired speakers reported to be different, 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 the 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 (1979) noted that there was 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 the hearing impaired differs from normal in ways that affect voice quality' (Monsen 1979: 200).

While confirming that it is difficult to establish clear correlations between speech intelligibility and mean fundamental frequency, Monsen's spectrographic study shows that the fundamental frequency contours of hearing impaired speakers do correspond well to judgements of voice quality.

1.4 REVIEW OF STUDIES REFERRING TO VELOPHARYNGEAL INCOMPETENCE IN DEAF SPEECH

Nasal voice quality is frequently cited as one of the characteristics of deaf speech.

Earlier in this review (page 35) it was suggested that the naive search for simple correlations between perceptive phenomena and acoustic parameters was a fruitless one. Nowhere is this more evident than in the area of nasal resonance. Also earlier in this review (page 34) it was suggested that writers frequently make comparative descriptions, comparing the speech characteristics of non-normal speakers with those of normal speakers. In the area of velopharyngeal incompetence this approach is not useful as the tolerance for nasal resonance in English is very wide.

Native speakers of English do not learn to use their velopharyngeal sphincter specifically. At no point are most speakers aware that for the articulation of nasal consonants the velopharyngeal sphincter must be open. All native speakers of English have some nasal resonance with allophonic variation. The degree of nasal resonance is dependent primarily on how close the segment of speech under scrutiny is to the nasal consonant. Thus, when a writer cites deaf speakers as having 'nasal voice quality' he is making an implicit qualitative statement, namely that deaf speakers have more nasal resonance than 'hearing people'. The questions which then have to be asked are 'how much more?' or 'how effectively can one judge this additional nasality?'.

Hudgins (1934) in his classic study was the first to describe 'excessive nasal resonance' as a feature of deaf speech. It is always difficult to establish the features which influence the perception of 'nasality'. Spriesterbach (1955) has demonstrated that with cleft palate speakers 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 misarticulation of nasals or lack of oral/nasal distinctions, or to pitch variation or any combination of these parameters as well as referring to actual nasal resonance. Bradford, Brooks and Shelton (1964) demonstrated that there was very poor reliability in the judgements of experienced listeners when they were asked to rate the nasality in cleft palate speakers.

In contrast Razzell (1984) tried to identify which features speech therapists identified when they rated 'nasality'. She found that they rated nasal resonance and levels of nasal escape with high levels of agreement. Furthermore it appeared that therapists with a heavy cleft palate involvement and those without such an involvement could do this equally well.

Colton and Cooker (1968) examined ratings of nasality in the speech of the deaf. In an attempt to minimize the confounding influence of misarticulation, pitch variation etc., they used backwards playback as a technique to investigate whether naive listeners perceived deaf speakers as being '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: 556). They did not find a statistically significant difference between the profoundly and the less deaf; both groups were perceived to be more nasal than the control group.

The literature supports the view of the man in the street that hearing impaired people have 'nasal speech' but often goes no further than the man in the street might in defining what is meant by this. Seaver et al (1980) investigated the velopharyngeal movements of 19 hearing impaired speakers who were judged to have hypernasality. Manometric ratio measurements of oral and nasal pressure were measured with an oral manometer and compared with perceptual ratings of nasality. Seaver et al found a non-significant relationship between the degree of perceived nasality and the ratio of oral nasal air flow. They also found a non-significant relationship between the degree of perceived nasality and degree of hearing loss. With these findings Seaver et al confirmed the view expressed by the author above that it is nigh impossible to relate perceptual ratings to aspects of nasality when we are still unclear about the multiple facets which contribute to the phenomenon that we label nasality.

This search for a relationship between degree of hearing loss and degree of perceived nasality was followed by Seaver, Andrews and Granata (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.

Seaver et al also investigated the velopharyngeal positioning of their hearing impaired subjects by the use of lateral x-rays taken of the production of /i/ and /u/. Surprisingly they found that in all but one case the velopharyngeal contact observed on these x-rays was very similar to that one would see in patients with non-nasal speech. Seaver et al 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.'
> (Seaver et al 1980: 246)

Stevens, Nickerson and Rollins (1983) also investigated the nasal resonance of hearing impaired children. They suggest that the perceived increase of nasal resonance in the speech of hearing impaired people may result not from nasopharyngeal insufficiency but rather from the inappropriate timing of the opening and closing movements of the nasopharyngeal sphincter.

1.5 REVIEW OF SOME SUPRALARYNGEAL CHARACTERISTICS OF DEAF SPEECH

Traditionally a division has been made between voice quality and articulation. This division is either not defined or at best ill defined. The present study is concerned with the long term speaker characteristics of 40 hearing impaired speakers and as such is concerned not only with long term laryngeal features but also with long term supralaryngeal characteristics. Laver (1980) in his phonetic description of voice quality clearly specifies those laryngeal and supralaryngeal parameters which reflect individual speaker bias. His work is reviewed in Chapter 2 where the various voice quality assessment procedures are considered, and indeed it is his model of assessment which underpins the whole of this study. With this in mind it has been considered necessary in this literature review briefly to notice some studies which have investigated the consonant and vowel articulation of the hearing impaired thus gaining some insight into the supralaryngeal features of hearing impaired speakers.

Martony (1965) conducted one of the first studies which attempted an objective description of the speech of deaf speakers. He investigated by spectrographic techniques the acoustic correlates of segmental features in a continuous reading passage. Martony (1965: 24) comments on the 'super stationary form of vowels', that the vowels of deaf speakers (readers) tended to be held far too long and that the transitions were often missing or if present were too short. These features were perceived as abrupt articulatory movements. Calvert (1964) in a similar study used sonagraphic measurements to investigate the articulation of unstressed vowels. He found that in the measurements of his data from five profoundly deaf speakers saying two syllable nonsense words, that the deaf speakers lengthened the unstressed vowels, typically 4/5 times as long as the hearing speakers. He also found that the distinction which hearing speakers made, by holding an unstressed vowel for longer before a voiced consonant than before a voiceless one, was not upheld by the deaf speakers.

Angelocci, Kopp and Holbrook (1964) examined ten vowels spoken by each of eighteen deaf and eighteen hearing boys. Spectrographic measurements of the frequency and amplitude of the fundamental frequency and first three formants were taken. Angelocci et al found that the deaf had higher fundamental frequencies for all ten vowels and that the mean range of the fundamental frequency was greater for the deaf. Perhaps more important is the perceptual part of this study. Listeners were able correctly to identify 81% of the vowels spoken by hearing subjects but only 32% of those spoken by the hearing impaired. When Angelocci et al plotted the first and second formant frequencies of the hearing impaired, it was clear from the mean F_1F_2 measurements for each of the two 'vowel triangles' that the deaf speakers tended to centralize the vowel articulations. These suggested differences between vowel articulations of deaf and hearing speakers include: lengthening of vowels by deaf speakers (Martony 1965), lack of length differences in the vowels produced by deaf speakers before voiced as opposed to voiceless consonants (Calvert 1961), and differences of mean fundamental frequency range of fundamental frequency between deaf and hearing speakers' production of vowels (Angelocci 1964). In addition several investigators comment upon the fact that deaf speakers tend to centralize their vowel articulations towards schwa.

This feature of the common use of schwa has interested many investigators. Lach, Ling, Ling and Ship (1970) analysed recordings of seven young deaf children aged from 11 to 32 months. They found that before training the commonest vowel used by these young children was schwa accounting for 39% of all vowels produced, and they saw it as an indicator of the success of their programme that schwa was used decreasingly as the programme proceeded. Similarly, Monsen and Shaughnessy (1978) were able to demonstrate that it was possible to improve the intelligibility of deaf speakers by enlarging their useable vowel space. They found very similar results to Angelocci. They plotted F_1F_2 and showed that most deaf speakers' vowels moved towards a central schwa position. However, a programme of training demonstrated that such centralization can be changed and after training their subjects were using a much larger vowel space. Rothman (1976) too conducted a spectrographic study of vowel transitions in the speech of deaf adults. He comments on the fact that the co-articulation effect of adjacent consonants on vowel articulation was minimized in the speech of the deaf speakers. He also notes that because the deaf speech is discontinuous the 'deaf group treat the schwa as a separate entity rather than as a part of a series of inter-related articulatory events' (Rothman 1976: 135).

These comments on the relatively static centralized vowel articulation of deaf speakers are very relevant to the results of this present study. Rothman goes on to conclude that his results show 'that deaf speakers treat phonological segments, syllables, and words as isolated events rather than integral parts of longer inter-related articulations'.

Geffner (1980) examined the feature characteristics of the spontaneous speech of young deaf children. Her analysis of vowels revealed that on the whole they were produced more accurately than consonants and, within the vowel groups, vowels with a low tongue position were articulated more accurately than vowels with mid or high tongue positions.

Deaf speakers are less intelligible than hearing speakers. The single feature which correlates with intelligibility in grouped data studies of hearing impaired speakers is the feature of increased hearing loss. Hudgins and Numbers (1942), Quigley and Frisina (1961) and Brannon (1966) showed that the greater the hearing loss the more likely is there to be a reduction in intelligibility. Further, many investigators have shown that the degree of familiarity of the listener with deaf speech will also affect the intelligibility of a deaf speaker (Thomas 1963). The parameter which most markedly determines the intelligibility of a deaf speaker is consonant articulation.

Several investigators have studied the consonant articulations of hearing impaired speakers. Calvert (1962b) found that hearing impaired speakers maintained closure of plosives markedly longer than did hearing speakers. In addition he found that deaf speakers did not maintain the usual differential closure times of voiceless and voiced plosives. Among hearing speakers voiceless plosives are held for longer than voiced plosives; Calvert found that this difference was not maintained by deaf speakers. He also found that the fricatives produced by hearing impaired speakers were held for 4/5 times longer than those of hearing speakers.

Brannon (1966) found that consonants in word initial positions were more accurately articulated than consonants in medial or word final positions by deaf speakers.

Irvin and Wilson (1973) examined the difference between hearing and hearing impaired speakers in terms of measurements of closure time, aspiration time and vowel duration time. They found that, whereas there were no differences in the absolute values of measurements of closure time and vowel duration time between deaf and hearing subjects, there was a difference in the 'aspiration duration'. By 'aspiration duration' it appears that Irvin and Wilson are referring to VOT, which is the slight delay before the burst of voicing in a stop consonant begins. Abramson and Lisker, to whom Irvin and Wilson refer in their introduction, do use the term VOT rather than 'aspiration time'. Irvin and Wilson suggest that it is the atypical ratios of VOT and vowel duration used by deaf speakers which go some way to explaining the unclear distinction between voiced and voiceless segments in the speech of the deaf. This lack of a clear distinction between voiced and voiceless consonants has sometimes been interpreted as continuous voicing. Millin (1971) and Stark (1972) also refer to the fact that deaf children do not have good control of voicing. They appear to be 'not so capable of turning voicing on or off once an utterance is initiated' (Stark 1972: 440). Normal hearing children, she notes, learn this important control at around nine months.

Other investigators have also investigated the differences in voice onset times (VOT) for plosive articulation between hearing impaired and hearing speakers. Stark (1972) refers to the finding that deaf children use a long pre-voicing in the production of stop consonants; Monsen (1978) measured VOT in twenty-four words read by thirty-seven hearing impaired speakers. In a multidimensional set of correlations with intelligibility he found that VOT was one of only two variables (the second concerned F_2 shifts in the intelligibility of vowels) which correlated positively with intelligibility. Frequently the V.O.T. of hearing impaired speakers was distorted. This distortion included a reduction of VOT which led to a loss of distinction between voiced and voiceless plosives. Brown, Goldberg and Rothman (1983) too found that, despite great differences in mean values of VOT, it was those hearing impaired speakers who reduced their VOT (below 50 msecs) who were perceived as intelligible.

Difficulties with voicing control including differences of VOT are comments on the inability of hearing impaired speakers to coordinate the timing of their articulation.

Whitehead and Jones (1977) show that a further contributing factor to the difficulty which hearing impaired speakers have with the voiced/voiceless distinction concerns air flow. Whitehead's study demonstrates that normal hearing and intelligible hearing impaired speakers have significantly greater air flow for voiceless than voiced plosives. The less intelligible hearing impaired speakers did not show this difference in air flow. He speculates that this might be due to the fact that there will be less glottal resistance in a well articulated voiceless plosive and, therefore, greater air flow. If an unintelligible hearing impaired speaker is not making appropriate glottal adjustments for voiced and voiceless consonants this glottal resistance will not be brought into play, resulting in similar air flows for voiced or voiceless. Alternatively, Whitehead speculates from his previous work that less intelligible deaf speakers may not be utilizing their lung volume capacity.

A further finding in the literature which can be broadly interpreted as an indicator of the lack of phonatory control for consonant articulation by hearing impaired speakers is the appearance of interjected sounds. Smith (1975: 126, 127) studied these intrusive sounds (usually schwa) and found that 51% of them occurred in the formation of consonants and 49% at release. She suggests that there are three types of interjected sounds. Firstly when the articulatory timing was so slow as to allow the perception of an (intrusive) segment, e.g. in 'himself' the intrusion of schwa results in a realization of /hɪməsɛlf/ . 37% of errors fell into this category. In 32% of cases the interjection was due to articulatory 'overshoot', e.g. the articulatory constriction required for the articulation of an intervocalic fricative may be too constricted resulting in the intrusion of a plosive. Thus for the target 'bathroom' the realization was /baθdɹʊm/. In addition to these interjected sounds she found that 25% of consonant articulation errors were the result of mistimed laryngeal action and 6% poor velar action.

Two studies have attempted to investigate through EMG techniques some of the difference in consonant articulations by deaf and hearing speakers. Huntington, Harris and Scholes (1968) used surface reaction electrodes on the tongue and lips and facial muscles of deaf and hearing speakers. They found that the muscular activities of the facial muscles were generally correct, although they comment that they were sometimes exaggerated. However, the information from the tongue showed that the tongue muscle patterns were stereotyped and 'frequently wrong, though there is no consistent pattern to the direction of the errors' (Huntington et al 1968: 147).

Rothman (1977) in another EMG study comments on the greater inter-speaker variability among the deaf. He also comments on the lack of co-articulation effects being reflected (caused?) by the longer closure durations and closure release times for stop consonants.

In this discussion of segmental aspects of deaf speech most studies have concentrated upon either a description of the features of deaf (usually children's) speech or have tried to isolate the differences between deaf and hearing children's speech skills. A further way in which the segmental production aspect of deaf speech can be examined is to look at the development of articulatory skills and at the phonological development of deaf children. Deaf children have less integrative learning of phonological and phonetic aspects of speech development than do hearing children. If one examines hearing children's mastery of the phonological rules of English using a tool such as the Edinburgh Articulation Test (Anthony, 1968), it can be seen that hearing children have an understanding of the need for phonological differences before they have achieved the phonetic skills with which to signal these phonological differences in adult form. Thus a hearing 3 year old may show that (s)he knows the phonological difference between /p/ and /t/ in the clusters /sp/ and /st/ when (s)he says /səbon/ spoon and /sədɑ/ star, despite the fact that (s)he has not achieved the adult form. With an intact hearing mechanism (and normal cognitive and cortical processing skills), (s)he will be exposed to the adult form of /sp/ and /st/ over the next few months and learn to produce this adult realization with imperceptible difficulties. The ease with which a hearing child's articulatory accuracy follows his phonological development arises from the indirect learning from 10/12 hours of sound and speaking exposure every day. Hearing impaired children deprived of this 10/12 hours of sound exposure are less able to develop their phonology and articulatory accuracy at near equal rates.

Quigley and Paul (1984) examined the oral development of young deaf children between birth and 5 years at the Lexington School for the Deaf in New York (a school with a strongly oral tradition). They found that, whereas the deaf children babbled at around 6 months, which is only very slightly delayed, they were not using words until around 2 years (some 12 months behind hearing children) and were not combining words until around 3 years (some 18 months later than hearing children).

Quigley and Paul also report a study designed to determine the phonology of 11 year old hearing impaired children. They report that in a cohort of 10 eleven year-old hearing impaired children all had acquired at least half of the phones used in English and that they had developed a phonological system. The phonological system of hearing impaired children is rule governed even though they may not easily acquire all the phonological rules of English. This acquisition of rules has important implications for prognosis. A child who has acquired a mastery of some of the phonological rules of his language is more able to be helped to acquire others than either a child whose articulatory production is somewhat random or a child who has articulatory production deficits.

A further way in which the speech skills of hearing impaired children can be examined is to examine the effects of developing reading skills upon phonology and vice versa. Whereas most hearing children have acquired a mastery of the phonology of their language before they are introduced to written symbols, this is not true of all hearing impaired children. Some hearing impaired children's acquisition of oral skills is enhanced by the introduction of written symbols.

Kretschmer (1978) introduces the concept of reading being a parasitic skill for hearing people (in that it builds upon the skills learned orally) but he suggests that reading is a more separate development with hearing impaired children who depend less heavily upon their previously learned oral skills. This issue of the relationship between the development of reading and the development of oral skills in deaf children depends on whether the child uses a so-called 'top-down' or 'bottom-up' approach to reading. A 'top-down' expanation of reading suggests that the development of reading is dependent upon general learning experiences, upon cognitive development and involves the development of schema. Such a view suggests that some children develop reading as part of generalized language acquisition. Conversely a 'bottom-up' explanation of reading suggests that some children learn to read by being text specific, recogizing letter shapes and word shapes, etc. There is strong evidence that deaf children with their comparative poverty of language fall into the second group. If this is the case the introduction of and familiarization with written symbols will assist the child's oral skills more than a 'top-down' approach.

This relationship between the development of oral skills and developing reading skills raises the issue of feedback for the hearing impaired child. Because of their impaired auditory self monitoring system deaf children are helped by the feedback which they can be given through written symbols. Feedback of success is enormously important and vital if the deaf child is to use his oral skills. Such feedback is important for two principal reasons, both as a confidence builder and as a learning strategy. Confidence in the use of developing oral skills is clearly very important to deaf children if they are to persist with their use of developing skills.

Feedback is also an important component of learning. If the deaf child is to develop adequate oral skills he must be aware of his success, both as immediate feedback and less immediately in terms of knowledge of results. If he finds that his newly acquired speech skills are effective he is encouraged and continues with their use (Lach et al, 1970). In addition he also needs specific feedback both from others (Kretschmer, 1978) or in terms of his own developing feedback mechanism (King et al, 1982). Mogford (in Woll, 1981) stresses the difficult patterns of feedback given to deaf and hearing children. She demonstrates that mothers of young hearing impaired children interact differently with them when compared with the mothers of similarly aged hearing children. Mogford suggests that mothers of hearing impaired children are more formal in their interaction with their deaf children and that they and their children turn take less effectively in the preverbal stage than do mothers of hearing children. This has considerable implications for the development of feedback and knowledge of results by the deaf child. If the deaf child's preverbal attempts are given less effective feedback by the other he is less likely to develop near normal patterns.

This discussion has focussed on those areas of the literature which have examined the development of segmental skills among hearing impaired children and suggests ways in which this development differs from that of hearing children. The implications are clear: if the development is different the resulting skills evident in later childhood or adulthood will be different from those hearing children whose oral skills followed a normal process of development.

The literature reviewed thus far has concentrated upon descriptions of

(a) laryngeal control by hearing impaired speakers;

(b) velopharyngeal control by hearing impaired speakers; and

(c) vowel and consonant articulations by hearing impaired speakers.

It is important now in this review to examine the prosodic aspects of deaf speech. The parameter of 'timing' is frequently cited as an aspect of speech production which is different among hearing impaired speakers. For this reason it has been decided to review the literature relating to timing first and then the literature relating to other prosodic aspects of speech.

1.6 REVIEW OF LITERATURE REFERRING TO TIMING AND OTHER PROSODIC ASPECTS IN DEAF SPEECH

Among those early investigators who described deaf speech, 'timing' was often an area of comment and/or measurement. Unfortunately these early writers were not rigorous in giving definitions of their terms and 'timing' appears to include aspects of 'tempo' and 'continuity' (Abercrombie 1967) as well as components of speech rhythm. A discussion of these contributory factors to timing disturbance is given below.

Voelker (1938) attempted to quantify rate of utterance among deaf children reading simple phrases and to compare this with normal rate of utterance as measured from radio recordings. He found that the average rate of utterance for deaf speakers was 67 words per minute and that the average rate for normal speakers was 168 words per minute. From this study of 62 deaf subjects he found that the 'deaf speak substantially slower than normal hearing people' (Voelker 1938: 282) and on the basis of his data calculated that this was 149% slower.

Rawlings (1935) refers to the fact 'that the speech of the deaf person is very slow and laboured; ... peculiar monotony of tone and the lack of accent and rhythm in the speech' (Rawlings 1935: 147).

Hudgins (1934), who used kymographic recordings to study airflow in deaf speakers, also comments on the 'excessively slow rate' (Hudgins 1934; 16) and the inefficient breathing for speech which requires the deaf speaker to take frequent breaths as he speaks. More recent studies of 'timing' in deaf speech (Hood and Dixon 1969, Johns and Howarth 1965 and Asp, Wood and Keller 1971) include in their definition of 'timing' considerations of syllable duration, use of pause, utterance durations and use of intrusive sounds. Hood and Dixon (1969) refer in their article, 'Physical characteristics of speech rhythm of deaf and normal hearing speakers', to the difficulty of defining speech rhythm. In their instructions to the listeners in their study they give a definition of speech rhythm as

'being composed of the following characteristics

1. Intonation - the change of pitch within syllables and from syllable to syllable

2. Loudness - the change of loudness within syllables and from syllable to syllable

3. Temporal factors - (a) relative duration of syllables witin a sentence and (b) the rate of utterance and general timing of a sentence.'

(Hood et al 1969: 22)

In their study these researchers played recordings of deaf and hearing male young adults to trained judges. The recordings were played through a 500 hz low pass speech filter so as to minimise the effects of other cues on the listeners' judgements of rhythm. They found among their results that the differences between deaf and hearing subjects were most pronounced in the areas of both syllable duration and utterance duration.

Johns and Howarth (1965) found an increase in intelligibility of 65% in recordings of deaf children's utterances before and after specific training in the timing of these utterances. They divide the 'errors of timing' which they found in the deaf speakers into 4 groups: 'lengthengin of vowels and consonants, lengthening of silences between words and abnormal stress pattern', and 'the occurrence of intrusive sounds' (Johns et al 1965: 128). In the 'specific training' they describe how they encourage children to 'improve their rate of utterance and to achieve normal duration of phonemes words and phrases ... reducing hesitations as these distort the rhythm and speed of the speech' (Johns et al 1965: 129). These two researchers appear to understand by 'timing' a notion of tempo at both segmental level and over longer units; but they also include in their term 'timing' considerations of rhythm and continuity.

Asp, Wood and Keller (1971) studied the rate of vocalization of deaf and hearing children, by recording random 5 minute periods of social interaction where the children were unaware that they were being recorded. The researchers then compared the mean vocalizations per minute and found that for the hearing group the grand mean was 23 vocalizations per minute, whereas for the deaf group the grand mean was only six vocalizations per minute. The contribution of this piece of work is to remind the reader that not only do deaf speakers speak more slowly than hearing people but that they also speak less.

This article also shows the importance of dividing rate of utterance from incidence of pause. Abercrombie (1967) draws the distinction between tempo 'which is best measured by rate of syllable succession' and continuity 'which refers to the incidence of pauses in the stream of speech'. All too often in the literature of deaf speech these two terms are collapsed into one comment such as 'rate', 'speed', etc.

The studies mentioned above have described disturbance of timing in deaf speech, over comparatively long utterances - usually of read material.

There have also been studies which examine consonant and vowel articulation time in deaf speech and attempt to explain how a disturbance of articulatory timing is a principal factor in contributing to the characteristically disturbed rhythm of deaf speakers. These more recent studies cast some doubt on the popularly held belief (and description in early studies) that deaf speech is slow. It may only be perceived as being slow because of greater pausing (disturbances of continuity) or greater interference by intrusive syllables. Boothroyd, Nickerson and Stevens (1974) looked at features which disturbed the timing of deaf speech and suggest that the dimensions where the speech of eight profoundly deaf pupils differed most from that of 25 hearing pupils were in the areas of longer speaking time, having longer unstressed syllables and longer pauses. Martony (1965) also suggests that increased holding of vowel postures, coupled with a reduction in vowel transitions, are factors which disrupt the rhythm of deaf speech and contribute to lack of intelligibility. Lindner (1962) in an analysis of 3 deaf boys' reading found that, despite the considerably slower speed rate of the deaf children, it was only the voiced sounds which were lengthened. Voiceless sounds were of approximately normal lengths. Monsen (1974) studied vowel length in different phonetic contexts using spectrographic analysis. He found that deaf speakers tended to use duration in an absolute way to separate /i/ from /ɪ/ , regardless of the phonetic contexts of these vowels. The durational overlap of these vowels when spoken by deaf speakers was considerably less than the overlap which could be expected in normal speech. He suggests that his work on vowel length

> 'contradicts the common assumption that the speech of the deaf is slow. It is of course possible that perceived slowness of speech is a phenomenon more immediately related to the rate of utterance than to relative phoneme duration, or even that the perceived slowness is due to nondurational acoustic features.'
>
> (Monsen 1974: 394)

Calvert (1961) also used spectrographic techniques to study voice/voiceless difference in deaf speech. He found:

(a) that deaf speakers held unstressed vowels typically 4/5 times longer than hearing speakers

(b) that the deaf did not hold vowels longer before voiced than voiceless consonants (as do hearing speakers)

(c) that they held fricatives typically 4/5 times longer than hearing speakers

(d) that with plosive articulations they held the closure for longer than do hearing speakers.

Boothroyd et al (1974) using spectrographic measurements studied durational differences between 3 types of syllable and two types of pause. they found that the unstressed syllables and secondary syllables were produced significantly slower by the deaf speakers (noting that unstressed syllables were over twice as long in the deaf group, whereas there was not a significant difference in the length of word initial syllables). Boothroyd et al do not specify whether this non-significant difference in length of word initial syllable refers to stressed or unstressed syllables. By inference, they appear to be referring to stressed syllables. Looking at pause they found that both 'end of phrase' and 'within phrase' pauses (or gaps as they call them) were significantly longer in deaf speakers. The mean within-phrase gaps were 8 times as long among deaf speakers. This bears out Asp, Wood and Keller's point, described above, that deaf speakers speak less over comparable periods of time.

It is interesting to speculate whether these inter-phrase pauses are a function of the language poverty of deaf speakers and indicative of a groping/planning function. In a previous study (Wirz 1976) the author studied tempo and continuity in deaf children's speech and found that pausing in conversational speech was 4 times more frequent than in hearing children of the same age.

Early studies (Voelker 1938, Rawlings 1935 and Hudgins 1934) attempted to describe and to make comparative measurements of rate of utterance between deaf and hearing speakers. More recent studies (Hood and Dixon 1969, Johns and Howarth 1965 and Boothroyd, Nickerson and Stevens 1974) have attempted to look at the way in which changes in syllable duration and use of pause affects the rate/timing of deaf speech. Studies such as these are making a differentiation which Abercrombie (1967) makes between 'tempo ... rate of syllable succession' and 'continuity ... the incidence of pauses in the stream of speech'.

The most recent studies of timing of deaf speech have compared the syllable duration of deaf and hearing speakers. Boothroyd, Nickerson and Stevens (1974) and Calvert (1961) comment on the increased length of unstressed syllables among deaf speakers. Martony (1965) found that deaf speakers held vowel postures longer than hearing speakers whereas Monsen (1974) found that this was complicated by the way in which deaf speakers' vowel length was less affected by phonetic context than was that of hearing speakers. Boothroyd (1974) and Calvert (1961) provide the most comprehensive data about syllable duration and there is convincing evidence from their work that deaf speakers hold unstressed syllables markedly longer than do hearing speakers and that this, coupled with greater pausing (or disturbed continuity), accounts for much of the durational difference between deaf and hearing speech.

Other prosodic parameters than timing are disturbed in deaf speech. Parameters such as intensity, intonation and of course pitch which has been already reviewed as a laryngeal parameter.

There are always some difficulties in deciding on the separation of the parameters of pitch and intonation. In this review 'pitch' has been taken to refer to long-term fundamental frequency (pitch mean) and the habitual range of fundamental frequency used by a speaker (pitch range). Intonation refers to the linguistic use which a speaker makes of frequency changes to signal differences in meaning. Most severely and profoundly hearing impaired speakers have great difficulty with both the control of pitch and the ability to select the appropriate place for pitch changes in intonation. This means that intonation is commonly disturbed in deaf speech.

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?' (Stoker et al 1980: 137). Among the parameters which they examined in their sample of 42 hearing impaired children were breath duration and suprasegmental competence. The ability to sustain a vowel was recorded as the variable identified as breath control. 'Pitch', 'loudness modulation' and 'duration modulation' were rated by 4 speech pathologists. Only items with an interjudge reliability coefficient of .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, e.g. Markides (1983) whose study was discussed above. Stoker then examined the correlations between these suprasegmental aspects of speech with intelligibility, hearing loss and aid use. He found that 'pitch modulation' and 'loudness modulation' correlated with hearing loss and intelligibility at a .001 level of significance. Breath control and duration modulation correlated at .05 level of significance with intelligibility and hearing loss. Interestingly none of these 4 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. The results of his later study are discussed above (page 58). In addition he looked at the rhythmic quality of the speech of 28 hearing impaired subjects. He comments on the fact that, commonly, deaf speakers have an interval of 1.0 to 2.1 seconds between adjacent segments. Such intervals among the hearing control group rarely exceeded .5 seconds. Rhythm was also disrupted by the way 'the deaf group used an average 2 times as many phonations to say a sentence as the normals' (Voelker 1935: 259).

Martony (1965) whose work on vowel articulation among deaf speakers is reported above suggests thatin his analyses the reductions of vowel transitions and the increased holding of vowel postures disrupts rhythm and contributes to a lack of intelligibility.

Levitt et al (1971) comment on the excessive effort which deaf children use in speech. This excessive effort they refer to as an 'over fortis' of breathing and phonation. This excessive effort, they assert , greatly affects the degree of pitch control of which a hearing impaired speaker is capable and further disrupts the rhythm of speech.

Penn (1955) conducted a large-scale study of the speech characteristics of 100 conductive deaf and 100 nerve deaf speakers in the US 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% of conductives revealed this deviation' (Penn 1955: 20)

The level of probability is highly significant at .01 level that nerve deafness correlates with increased volume.

Hixon et al (1973) measured changes in anterioposterior diameter of the chest wall during speech. Using these measurements they showed that hearing impaired adults have greater air expenditure between word production than do hearing subjects. This inefficient respiration among hearing impaired speakers disrupted the rhythm of their speech.

Whitehead and Maki (1978) investigated the respiratory patterning of hearing speakers. They found that, whereas hearing subjects only seldom involved their respiratory musculature at levels below functional residual capacity, hearing impaired subjects frequently extend their expiratory muscles well into the reserve volume levels.

Not only did the deaf use their respiratory muscles differently from hearing subjects but they also used them less efficiently. They also found that less intelligible speakers used substantially higher volumes of air than did more intelligible speakers.

This review has summarized the reported literature about deaf speech. It can be seen that the literature varies widely in its form, from the carefully controlled studies of writers such as Monsen (1979), Whitehead (1978) or Martony (1965) to the almost anecdotal reports of writers such as Jones (1967) and Markides (1983). There is also wide variation in the aspects of deaf speech which have been studied and the methodologies used to examine these different aspects.

What all these studies have in common is that they study one or in some cases a few parameters of deaf speech, frequently drawing comparisons with hearing speakers. These studies do not attempt to provide assessment procedures but very definitely pinpoint areas where assessment of deaf speech would be advisable.

In the next chapter assessment procedures will be reviewed.

CHAPTER 2

VOICE ASSESSMENT

2.1 Reasons for the clinical assessment of voice

2.2 Selection criteria of voice assessments

(a) The type of vocal sample

(b) Which component of the vocal apparatus should be examined

(c) Some instrumental procedures which have clinical currency in voice pathology

2.3 Physiologically based assessments

2.4 Procedures which assess the acoustic consequences of physiological postures

2.5 Perceptual assessments of voice

2.6 Description of VPA and reasons for choosing it

The literature review in Chapter 1 reveals that there is disagreement among writers as to the vocal characteristics typifying deaf speakers. It has been shown that this disagreement is in part attributable to the different objectives of their descriptions, but is also attributable to the disappointing lack of objectivity in description of deaf voice.

One of the purposes of this investigation is to show that the use of an objective assessment tool can provide useful information about deaf voice. Such information provides valuable background for remedial planning programmes. Some assessment procedures are reviewed next.

The assessment of voice has become the Cinderella in the developing field of investigative therapy in speech pathology. Speech pathology now has objective, standardized tests and procedures for the assessment of syntactic development or breakdown, for the assessment of phonological development or disintegration, and for the assessment of segmental phonetic variation either in acquisition or breakdown. Models of semantic processing and cognitive function are also beginning to provide tools for the objective assessment of semantic aspects of language. This objectivity is still sadly lacking in the assessment of voice.

Traditionally investigators of vocal dysfunction have looked at the parameters of breathing, posture, muscle tension and laryngeal production. The early writers in this field were concerned with singers' and actors' voices. Writers and practitioners, such as Aitken (1927) were primarily interested in singers and sought how best they could develop the laryngeal potential of trained singers. Similarly those early phoneticians who concentrated their interests in the description of voice (as opposed to their contemporaries who were interested in articulatory phonetics) were often drawn to a study of actors' voices. Early investigators such as Bell, M. (1872), Bell, A. (1906) and Paget (1930) were greatly influenced by anatomists and tried to provide in their descriptions an anatomical explanation for voice. Their assessments tended to be restricted to attempts to describe the extra and intra laryngeal musculature, rather than phonatory or articulatory process.

More recently assessments of voice have included physiological, acoustic and perceptual parameters.

It is not the purpose of this thesis to describe voice assessments for all types of voice pathology. Nevertheless, as background to a discussion of voice assessment of hearing impaired speakers, it is necessary to introduce some ideas about the clinical assessment of voice.

In this chapter the following topics will be discussed: first the reasons for clinical assessment of voice, secondly the selection criteria influencing the choice of voice assessment, thirdly a description of some physiologically based assessments, followed by a description of some acoustic based assessments which have clinical currency, and a description of some perceptual assessments, and finally a description of the Vocal Profiles Analysis Scheme and reasons for selecting this assessment for the present study.

2.1 REASONS FOR THE CLINICAL ASSESSMENT OF VOICE

As stated above, voice assessments tend to fall into three main categories.

A Those assessments which are physiological, e.g. direct laryngoscopy where the ENT consultant examines the larynx and observes vocal fold action;

B Those assessments which are acoustically based, e.g. using instrumentation to measure the acoustic consequences of phonatory and articulatory supralaryngeal performance;

C Perceptual assessments which exploit the perceptual skills of listeners who have a clinical knowledge of voice pathology.

The professionals who undertake clinical voice assessments are primarily ENT surgeons and speech pathologists. Both want to describe voices so that they will be able to plan appropriate remedial strategies. They are less interested in simple descriptive assessment than in prescriptive assessment which prescribes the remedial action appropriate to an individual speaker's needs. For example, an ENT surgeon needs to examine not only the physical state of the larynx but also take account of how the state of that larynx affects phonation. A speech pathologist not only wants acoustic measurements of the vocal output of her patients as a yardstick against which to measure the efficacy of her treatment, but she also needs to find a relationship between these acoustic measurements and the underlying physiological causes.

The clinical assessment of voice helps ENT surgeons, speech therapists and others to see how best to help an individual speaker. They must select the type of voice assessment which will best suit the needs of an individual patient.

2.2 SELECTION CRITERIA OF VOICE ASSESSMENTS

In selecting an appropriate method of voice assessment the clinician has to decide:

(a) What type of vocal sample should be analysed, in order to most effectively highlight the aberrant voice features;

(b) Which components of a speaker's vocal apparatus should be examined in order that his vocal performance be assessed;

(c) Which instrumental procedures (if any) are appropriate in the assessment.

(a) The type of vocal sample

The clinician must ask whether an assessment of the vocal apparatus in a static position is sufficient or whether a dynamic assessment is required. To take a rather simplified example; in an assessment of the resonance disturbances of a cleft palate speaker, x-ray pictures (static) of the velopharyngeal sphincter during the phonation of a high close vowel /i/ may give necessary and useful information about the adequacy or inadequacy of the velopharyngeal closure. If other factors, such as neuromuscular control, hearing etc. are unimpaired such static information will help the clinician to decide if palatal levation is possible, and whether for example biofeedback training of the soft palate is a viable remedial strategy.

Such a static physiological assessment would, however, give little information as to why a mentally handicapped child with no craniofacial abnormalities and no history of nasal regurgitation uses hypernasal resonance. A dynamic physiological assessment such as cinefluorography (Donnelly 1985) would be more useful for such an assessment.

In the selection of an appropriate voice assessment the clinician must ask not only whether a dynamic or a static assessment is advisable, but also if a dynamic assessment has been deemed advisable what length of vocal sample is required. Would steady state vowels give sufficient information or is a longer, more representative vocal sample required? Thus a laryngographic display of vocal fold vibration during the production of steady state vowels may be sufficient to confirm the presence/absence of a mechanical disturbance to vocal fold vibration such as unilateral vocal fold paresis or the presence of a polyp. Skilled users of a laryngographic display claim to be able to interpret different waveform patterns for polyps or vocal fold paresis. However, such a display will not help even the most skilled user to discriminate a polyp from a nodule.

In summary, the type of vocal sample to be assessed will vary on a continuum from

(a) steady breathing with no vocalization;

(b) through steady state vowels;

(c) to continuous spoken samples.

The clinician must decide which vocal sample would be most appropriate for the assessment requirements of the speaker. The election of an assessment procedure will reflect this decision.

(b) Which component of the vocal apparatus should be examined

Just as different vocal samples are advisable for the assessment of different laryngeal pathologies, so too the level of the vocal tract at which a speaker's vocal performance should be assessed varies, depending on the needs of the assessment. Thus, for some pathologies, assessment of laryngeal performance will be required, e.g. in examining polyps/nodules. In others, supralaryngeal examination is required, e.g. looking at resonance disturbances of hearing impaired speakers. In yet others it will be important for the clinician to examine both the laryngeal and supralaryngeal performance of the speaker under scrutiny.

Thus some routine physiological assessments, e.g. fiber-optic examination of the larynx, give full and useful information about the state of the vocal folds and, in the hands of a skilled user, information about the vibration of those folds. However, because of the invasive nature of the nasal fiber-optic tube and the position in which the person being examined must sit, it is self evident that the speaker's supralaryngeal assembly is grossly disturbed by this assessment. Such an assessment gives then only partial information about the voice, although it gives very full information about the vocal folds.

Similarly, laryngographic traces (Fourcin and Abberton 1971) give information about the function of the vocal folds by displaying laryngeal waveform but give no information about the supralaryngeal assembly. Visipitch (Kay Electronics) gives an analysis of fundamental frequency and intensity characteristics of a sepaker, but little information about the contributory factors of laryngeal and supralaryngeal states relative to these characteristics.

The clinician in her assessment has then to decide whether information about laryngeal or supralaryngeal areas of the vocal tract (or both) is necessary for the assessment in hand.

(c) Some instrumental procedures which have clinical currency in voice pathology

There is a wide battery of instrumental procedures available to examine laryngeal and supralaryngeal states. Why then should a clinician have to make some of the choices suggested above? Why should she not have a battery of possibilities and do a full voice assessment on each patient? The answer is twofold: cost and invasiveness.

It is outwith the limits of medical ethics to submit all dysphonic speakers to x-rays. Therefore procedures such as cinefluorography (Donnelly 1985), XEL (Xeroradiolaryngography)

(MacCurtain 1983), and X-ray examination are only possible where information cannot be determined by other procedures. This usually means that x-ray assessment procedures are brought into play as a second stage assessment, when earlier less invasive assessments have been inconclusive.

At a different level, fiber-optic examination of the larynx may be too invasive for a very anxious patient or may be impossible in a small child.

Cost, too, is an important factor. Most voice assessment clinics are poorly equipped. Even among those which have been well equipped, decisions have had to be made as to which instrumentation to buy. There will always be situations where, no matter how carefully these purchasing decisions have been made, patients will occasionally come for assessment for whom the instrumentation is inappropriate. For example, for most patients the laryngograph gives very clear information about waveform. For a few patients with thick adipose tissue on their necks or with a very short cervical length, laryngograph traces are very difficult to obtain.

Finally, there is some local variation between health boards as to what constitutes an invasive procedure. A widely used piece of equipment such as the laryngograph, because it involves strapping electrodes to a patient's neck, is considered invasive by some health boards. In such a case permission will be given to use the equipment for assessment but not for regular therapy. In an earlier study (Wirz & Anthony, 1987) of the effectiveness of the laryngograph in speech therapy with hearing impaired children in a large residential school for the deaf, permission to use the laryngograph had to be sought from the medical ethics committee of each child's health board and from his parents before the study could commence. Permission was not always given.

2.3 PHYSIOLOGICALLY BASED ASSESSMENTS

Assessments which are predominantly physiological in nature aim to explain phonatory performance by assessing the physiological (and anatomical) adjustments of the vocal tract; for example, the interaction between larynx and pharyngeal state or between nasopharyngeal sphincter action and tongue root position and other similar relationships. Much of the work on the assessment of cleft palate speech and velopharyngeal dysfunction (e.g. Subtelny 1970, Spriesterbach 1955, Edwards et al 1980) has looked at the relationship between anatomical evidence from lateral x-rays and perceptual judgements of the resonant features of the voices. More recently the work of MacCurtain et al (1981) has demonstrated that an assessment procedure based on soft tissue x-rays (xeroradiography) is applicable to a wide range of voice disorders. MacCurtain et al have amassed a large body of normative data of men and women of different ages and sizes and are able to compare the anatomical static 'postures' of non-normal voices with these normative data.

They provide for the first time normative data about the vocal tract and laryngeal assembly. Through their procedures for measuring soft tissue x-rays they measure parameters such as the position of the larynx in the neck, the degree of opening of the glottis, the state of the laryngeal vestibule. Similarly, at a supralaryngeal level, they are able to show the position of the components of the velopharyngeal sphincter, the constriction or opening of the pharyngeal cavity, the size of the oral cavity, tongue position at rest, etc.

These data provide, probably for the first time, the facility for measuring the changes in relative size and position of parts of the vocal apparatus which occur among speakers with different build and among speakers with different habitual patterns of laryngeal and supralaryngeal postures. To date MacCurtain et al have little data about deaf speakers.

Such physiologically based techniques have aided our understanding of the phonatory mechanism considerably and the work of MacCurtain et al should be especially singled out as it provides measured data against which an aberrant voice user can be compared. Her work provides measurements of both laryngeal and supralaryngeal parameters. The disadvantages, however, of all these assessment procedures based on x-ray techniques are twofold. First, they are based on static information, whereas speech and phonation are dynamic processes. Thus the assessment findings may (and often do) point to anatomical sites of inefficiency, insufficiency etc. but they cannot, by the nature of the procedure, begin to assess the integrative effects of the different parameters one on another.

A second objection to techniques such as these is that they are both costly, because they involve highly specialized equipment, and are invasive. These techniques, then, while giving useful information about phonation, will never become routine assessment procedures, especially for speakers such as the hearing impaired, where there is no rationale for expecting them to submit to x-ray.

Other physiological assessment procedures which are sometimes used involve electromyography where muscle activity is monitored and measured. Two such studies (Huntingdon et al 1968 and Rothman 1977) were reviewed in the previous chapter. Again, while such techniques may provide useful research data, it is unlikely that such sophisticated and expensive instrumentation will be used in the routine clinical assessment of voice.

2.4 PROCEDURES WHICH ASSESS THE ACOUSTIC CONSEQUENCES OF PHYSIOLOGICAL POSTURES

There are various procedures which examine the acoustic characteristics of voice. Some concentrate on waveform analysis and can be considered analogous with those physiological procedures which assess laryngeal function only. Others are concerned with the total voice signal of a speaker's output and can be considered analogous to those physiological procedures which examine both laryngeal and supralaryngeal features. Several of the acoustic analysis procedures referred to above in the literature review have a place in the experimental phonetics or speech science laboratory but as yet do not have clinical currency. It is the purpose of this chapter to describe only those assessments which are clinically available.

The procedure which is most widely used in voice clinics in the UK to examine the laryngeal waveform is electroglottography. This procedure was first reported by Fabre (1957) and has been developed in the UK as the 'Laryngograph' (Fourcin et al 1971). This procedure measures the change in impedance across the larynx at the glottal level, a closed and open vocal fold position and from these changes displays a waveform analogue. The periodicity, frequency, amplitude and slope of the closing and opening phases of that waveform are the assessment points which have clinical value. Various investigators have used the 'Laryngograph' to measure dysphonic voices (Wechsler 1978, MacCurtain 1981) and some have looked at the waveform features of hearing impaired speakers (Abberton et al 1983, Parker 1978). It is possible, with an adaptation to the laryngograph, to abstract and display fundamental frequency information with the 'Voiscope' (Fourcin 1974). Frequency display using the 'Voiscope' as a biofeedback technique and as an assessment procedure has been used in the treatment and investigation of hearing impaired speakers (Wirz & Anthony 1987, Parker et al 1978).

Other procedures which examine waveform vibration include:

(a) ultra high speed photography;

(b) stroboscopy;

(c) glottography.

Ultra high speed photography as an assessment procedure for voice pathology has been developed primarily in Japan (Hirano 1981). It has not been used with hearing impaired speakers and is not widely used in the UK.

Stroboscopy is based on the principle of a light source flashing in near synchrony with the vocal fold vibration. By means of this technique clear illumination of the folds is possible (Yoshida et al 1977). Although still popular in German voice clinics its use has been overtaken in the UK by the use of fiber-optic examination and perceptual assessments with intense light sources built into the fiber-optic tool. The high level of illumination which is now possible with cold light sources to which fiber-optic examination tools can be attached has made stroboscopy somewhat redundant. Professional differences exist between the UK, where speech therapists (with their highly trained perceptual skills) work with ENT consultants, and Germany, where phoniatrists (medical doctors with an interest in speech) tend not to have such highly developed perceptual skills.

Glottography of various types, auditory photoelectric (Coleman & Wendahl 1968) and ultrasound (Hamlet 1973) have been tried as ways of examining the capabilities of the vocal fold movement. They are widely used in mainland Europe but not in British clinics, mainly because of the different patterns of practice outlined above.

Procedures which analyse the voice signal fall broadly into three groups:

(a) those which examine parameters related to fundamental frequency;

(b) those which examine parameters related to vocal intensity;

(c) those which examine spectral features.

Kay Visipitch (Kay Electronics) is used in some voice clinics in the UK both as a biofeedback therapy tool and for assessment purposes. It examines the fundamental frequency and intensity characteristics of a voice. The Madsen Vocal 2 (Madsen Corp) gives a similar frequency and intensity display and is used in some schools for the deaf. Its value as a biofeedback procedure with hearing impaired children has been reported (Bouchier Hayes 1985), but it has been less used as an assessment procedure.

The Simultaneous Spectrographic Display (Stewart 1976) is, as its name suggests, a dynamic spectrographic display which shows spectral features of a voice (either over 8K or 4K). This technique has been used with hearing impaired speakers (Maki 1980) primarily as a remedial biofeedback procedure, although it has obvious assessment value. One of the reasons why these procedures have been used more as biofeedback displays in remedial therapy rather than as assessment tools is the lack of normative information against which aberrant voices can be matched. Further difficulties arise if the signal to noise ratio is too great. In most clinical settings ambient noise in recordings is a great difficulty and accounts in part for the popularity of the 'Laryngograph' as a clinical tool, where ambient noise is not intrusive. In addition, with the exception of the 'Laryngograph', the other four procedures described above are single function tools and do not have the flexibility which the new generation of clinical investigative tools based on microcomputers have.

More recently a procedure has been developed at the Royal National Institute for the Deaf (RNID) (King et al 1982) based on a microcomputer: the 'Visispeech'. This provides a display of pitch and intensity features which can be used in biofeedback therapy but which also includes analysis procedures. 'Visispeech' has been developed specifically for use with hearing impaired people (although it has applications to other dysphonias) and it was this procedure which was selected for use in this study.

2.5 PERCEPTUAL ASSESSMENTS OF VOICE

Some assessments have followed perceptual techniques. As we have seen in Chapter 1, the great danger with perceptual assessments of voice is that they are haphazard, ill defined, and use impressionistic labels which are open to misinterpretation.

Most voice pathology clinics use a perceptual rating scale in order to describe the voices of their patients. Many such scales will be 'in house' scales and the parameters of the scale will include judgements about:

(a) vocal fold vibration;

(b) intensity and fundamental frequency;

(c) spectral features;

(d) breathing and posture.

Such scales usually list these parameters using terms such as:

(a) rough/harsh; weak; breathy; whispery;

(b) high pitch/low pitch; loud/soft;

(c) high/low oral resonance; high/low nasal resonance;

(d) adequate/inadequate breathing for short phrases; adequate/inadequate breathing for reading, etc.

These parameters will usually be scaled 1 - 3 or 1 - 5. One of the difficulties in using 'scaled' assessments is that the assessment seldom specifies whether the scale being used is an equal interval appearing scale, or a cumulative scale. An equal interval appearing scale is one where the divisions between the points of the scale are closely defined; e.g. a scale of vocal intensity may define that:

40 db be scaled 1

50 db be scaled 2

60 db be scaled 3

70 db be scaled 4, etc. etc.

The user of such a scale knows that a measured 10 db increase in intensity is marked by an increase in the scale, thus the difference between points 1 and 2 of the scale is the same as the difference between points 4 and 5 on the same scale.

In a cumulative scale, however, the steps are <u>not</u> closely defined but are merely described. For example, to allude back to the scale of vocal intensity, the scale may be:

quiet

moderately loud

loud

extremely loud.

The difficulty here is that listener A may rate a speaker 'quiet' while listener B may rate the same speaker 'moderately loud'. There is also a tendency for users of cumulative scales to use the bottom of the scale more readily than the top. In this hypothetical example more listeners will use the scalar categories 'quiet', 'moderately loud' and 'loud' than they will use the scalar category 'extremely loud'. The disadvantages, then, of cumulative scales are twofold: first the categories are ambiguous, and second there is a tendency to use the bottom end of the scale more readily than the top.

To return to the use of 'in house' assessments; it is true that such assessments may have some parochial value in that the people working with them tend to centre their perceptions until they reach some degree of agreement; however, such assessments can only be of limited value.

There are five principal published perceptual assessments of voice in wide clinical use. They are:

The Buffalo Profile of Voice Disorder (Wilson 1979)

The Missouri Profile of Voice Disorder (Wilson 1979)

The G.R.B.A.S. (Hirano 1981)

The NTID Speech Assessment (Subtelny 1980)

The Vocal Profile Analysis Scheme (Laver et al 1982)

A comparison of these five schemes must take into account criteria such as:

the replicability of the assessment;

the interjudge reliability;

the ease of administration.

The 'Buffalo Profile of Voice Disorder' (Wilson 1979) and the 'Missouri Profile of Voice Disorder' (Wilson 1979) have formalized the style of 'in house' assessments as described above. They suffer similarly from the great disadvantage of not having tape-recorded examples of the parameters which they specify, nor close definitions of the scalar points of their scales. This means that, despite the ease with which these assessments can be administered, the replicability and interjudge reliability is poor.

Isshiki (1966) attempted, using the Osgood Semantic Differential Technique to explore the psychoacoustic phenomenon of hoarseness. He selected 17 polar opposite pairs of adjectives, made a tape of 16 'hoarse' voices and asked experienced listeners to rate the voices, using the prescribed adjectives. He found that four factors emerged as signficant in the rating of hoarseness:

R = rough

B = breathiness

A = aesthenic

D = degree

He suggested rating pathological voices using a 4 point scale (0 = normal; 1 = slight presence; 2 = moderate presence; 3 = extreme presence) for these 4 factors. Thus, R3 B3 Ao D_1 (means extremely rough, extremely breathy, not aesthenic.

His work was further developed by the Committee for Phonatory Function Tests of the Japan Society of Logopedics and Phoniatrics as the GRBAS scale for describing voice abnormality. Thus:

G (grade) 'degree of abnormality';

R (rough) 'irregularity of fold vibration';

B (breathy) 'air leakage in the glottis';

A (aesthenic) 'lack of power';

S (strained) 'hyper functional state'.

(Hirano 1981, p. 83)

The Japan Society of Logopedics suggests that these 5 factors can each be rated on a 4-point scale 0 - 3 and give tape-recorded examples of the five factors with different scales of severity. This ensures that the GRBAS scale, unlike the Buffalo or Missouri, has some degree of reliability of use. Comments upon a speaker's voice using the GRBAS are primarily comments on laryngeal function with little attention being paid to supralaryngeal parameters. Set against this disadvantage must be the fact that, once a listener has learned the GRBAS scheme, it is very quick and easy to administer.

Subtelny (1975) devised an assessment procedure specifically for hearing impaired speakers which accounted for laryngeal and supralarygeal parameters. She specified clearly in both written form and through taped examples the terms used in her 'speech assessment', and the scalar degrees for each parameter. Her assessment includes a training tape to train the perceptual reliability of the user. The interjudge and intra-judge reliability of perceptual ratings by staff at NTID using this scheme is high.

It would appear then that those perceptual assessments which use specified terms are an improvement on those which use impressionistic labels and those which have accompanying illustrative tapes of these perceptions are an improvement upon those which do not. However, one must ask the question: how easily can these taped examples be learned? A study by Wynter & Martin (1981) showed that it was enormously difficult to train speech therapy students consistently to recognize 16 different voices. A longer study at the Linguistics Department of Edinburgh University, of which this study is part, has shown it is possible to train speech therapists to perceive various vocal characteristics. The method employed used taped material supplemented by face-to-face teaching. (Details of the accuracy with which listeners can learn the VPA scheme are given below in Chapter 4.)

There exists quite a wide range of assessment techniques, some published, and others 'in house'. It is tempting to suggest that many of them fall into the category described by Butterworth (1980). He suggests that a common research strategy for investigating speech is for the investigator to formulate a hypothesis, hypothesize factors affecting this process, and then collect data which meet the needs of his hypothesis, rather then objectively describe all the speech processes. The assessment of voice and phonation somewhat resembles this. A researcher or clinician lists parameters which 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.

It is interesting to note, however, that certain characteristics do occur time and again in assessments. This may be in part attributable to the fact that the salient features of different disorders are similar or that listeners listen for certain prominent features. This is the view of Calvert (1962). There is also the suggestion of Fowler et al (1980) that we listen to co-ordinated structures of information.

In order to study the listening skills of experienced speech therapists and to investigate what labels they would use to describe voices, a small investigation was devised. Ten experienced speech therapists were played tape recordings of disordered speakers, two of whom were hearing impaired. The listeners were not told the pathology of the speakers. They were asked to describe the voices of the speakers as fully as they could. Tables 1 and 2 show the terms used by these experienced therapists to describe the voices of the two hearing impaired speakers. What is interesting in these tables is that, despite their ignorance of the pathology of these two speakers, all ten listeners commented on nasal resonance for both voices. Seven of the ten commented upon pitch mean for both voices and four of the ten, for voice A, and three of the ten, for voice B, commented on narrow pitch range. The other comments, referring variously to phonation, to tension or to resonance features, seem to vary widely and fall into the category of impressionistic labels.

So, although there was some congruence of opinion as to which parameters should be commented upon, there was still a lack of homogeneity in the terms used to describe these voices.

TABLE 1

TERMS USED BY TEN EXPERIENCED SPEECH THERAPISTS TO DESCRIBE A MALE DEAF SPEAKER

Voice 1 - Male Hearing Impaired n = 10 raters

	Term used	No. raters using term	Other comments
A	Nasal	3	10/10 comment on nasal question; 8/10 note increased nasal resonance
	Hypernasal	2	
	Nasalized	1	
	Excessive nasalization	1	
	Hyponasal	1	
	Hyporhynophonic	1	
B	Low pitch	4	7/10 comment on pitch; 6/10 comment on 'low pitch'
	Narrow pitch	1	
	Flattened pitch	1	
	Reasonable male pitch level	1	
C	Reduced intonation	1	4/10 comment on narrowness of pitch range
	Limited intonation	1	
	Monotonous	1	
	Few pitch variations	1	
D	Over voicing	1	3/10 comment on increased loudness
	Loud	1	
	Loud attack	1	
E	Poor oral projection	2	3/10 comment on resonance disturb.
	Poor resonance	1	
F	Suprapharyngeal tension	1	
G	Labialized	1	other isolated comments given by single raters only
H	Fronted	1	
I	Jerky	1	
J	Gravelly voice	1	

TABLE 2

TERMS USED BY TEN EXPERIENCED SPEECH THERAPISTS
TO DESCRIBE A FEMALE DEAF SPEAKER

Voice 2 - Female Hearing Impaired n = 10 raters

	Term used	No. raters using term	Other comments
A	Nasal	5	8/10 comment on increased nasal resonance
	Nasalized	2	
	Some nasality	1	2/10 comment ambiguously
	Slight nasality	1	
	Inappropriate nasalization	1	
B	High pitch	1	7/10 comment on pitch;
	Med high pitch	1	5/10 comment on raised pitch;
	Slight high pitch	1	2/10 comment ambiguously
	Raised pitch	1	
	Sharp pitch	1	
	Pitch female	1	
	Inappropriate pitch level	1	
C	Poor intonation	1	3/10 comment on reduced pitch range
	Flat intonation	1	
	Unnatural pitch range	1	
D	Breathy	4	4/10 comment on breathy quality
E	Vocal tension	1	other isolated comments given by single raters only
	Tense		
F	Poor resonance	1	
G	Phonation breaks	1	

One of the difficulties of reviewing the existing assessment procedures or of evaluating descriptions used (as in the small investigation above) is that there is a lack of common agreement as to what constitutes voice. This study has tried to use 'voice quality', 'voice characteristics' and 'vocal characteristics' synonymously. This is not always the case. As Monsen (1979: 286) 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, the laryngeal gestures. In this technical sense it is separate from qualities of speech which derive from articulation. However, while it may be true that a phonetician can listen to a word and separate the poorly executed gestures of the larynx from those of other speech articulators, most listeners probably cannot.

Here Monsen is probably expressing a concern felt by many listeners and goes some way towards explaining the inefficiency of some of the perceptual assessment procedures reviewed above.

2.6 DESCRIPTION OF VPA AND REASONS FOR CHOOSING IT

One of the reasons why there are these confusions of terminology in the literature 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, 1981, etc.) is one of the few phoneticians who have addressed this question. He says:

> In this broader approach, the view that is taken of the linguistic accountability of phonetic theory is that phonetic theory should be responsible for describing all recurrent, patterned, phonetic activity that characterizes the spoken language of the speech community concerned.
> (Laver 1980: 5)

Laver (1980), following earlier phoneticians from Sweet (1908) to Abercrombie (1967), provides the first really comprehensive phonetic description of voice quality by specifying laryngeal and supralaryngeal parameters of voice quality. It was from the starting point of Laver's phonetic description of voice quality that the present study arose.

The author and Laver worked on MRC Grant No. G7811925N, together with Mackenzie, Hiller and Fisher, to develop the Vocal Profile Analysis (VPA) Scheme. This scheme, developed primarily from Laver's earlier work on the description of voice quality (Laver 1980, 1979, 1968), with some input from the author's earlier work on deaf voice quality (Wirz 1976, 1978). It was in this context that the present study was undertaken. Laver, Wirz, Mackenzie and Hiller developed the Vocal Profile Analysis Scheme, and the training materials accompanying the scheme (Laver, Wirz, Mackenzie & Hiller 1981). Mackenzie (1983) was primarily responsible for the statistical exploration of the interjudge and intrajudge reliability statistics which are reported in this study. The current author was responsible for the data collection, data analysis and reporting of the application of the VPA to deaf speech. The author acted as first judge and Laver and Mackenzie acted as second and third judges in the ratings of the recordings of the deaf speakers in Experimental Group I and the control group, but it was the responsibility of the current author to analyse these ratings. Experimental Groups II and III were rated by two other experienced VPA users and the author.

The Vocal Profile Analysis Scheme is a system which allows the description of those parameters at laryngeal and supralaryngeal levels which need to be accounted for in deaf speech and which cannot readily be described using traditional methods.

The scheme moves away from the traditional phonetic approach of describing articulatory events as if they were isolated events and makes possible the description of speech in the context of a speaker's long-term articulatory bias. This approach is especially applicable to the analysis of deaf speech.

Early attempts to apply articulatory phonetic principles to teaching speech to deaf children were fraught with problems. Haycock (1933) suggested teaching articulatory segments in a crude non-linguistic manner, e.g.:

teaching nasals before fricatives,

teaching front plosives before back plosives,

with no account of either

(a) the articulatory competence and emerging phonological rules which the deaf child may have developed; nor

(b) the fact that, unless hearing impaired children saw the communicative value of speech, they would be unlikely to use it.

Haycock's approach was questioned by his contemporaries (e.g. Groht 1932) but despite this his techniques were used for twenty or so years. It would appear that the popularity of his 'phonetic teaching for deaf children' lay in its apparent simplicity. Without demanding any individual assessment, a teacher could merely follow a series of prescribed speech routines. Such an approach, of course, worked with those children who, because they had more hearing or because they had especially good intrinsic lip reading skills, etc. etc., had developed a phonology which was comparable to English. But for the deaf, phonetically retarded, child such parrot teaching was useless.

Ling (1976), Connor (1971), Parker (1983) and others have re-emphasized Groht's early objections to an articulatory phonetic approach to the assessment and teaching of speech to deaf children. Most current clinical phonological assessments (e.g. Fisher Logeman 1971, Anthony et al 1971, Parker 1983 and Grunwell 1985) have sections which deal with non-segmental aspects of speaker performance; this movement to long-term articulatory performance in assessment and remediation is summed up by Rothman (1976) who states that

> a primary emphasis on teaching deaf speakers the correct articulation for individual sounds without accounting for the effects of context on phonemes, syllables, and words, results in faulty speech production.
>
> (1976; 136)

Indeed, any assessment of the characteristics of deaf speech which does not take into account the long-term characteristics of the speaker will be inadequate.

There is a variety of ways in which one can examine long-term speaker characteristics.

Fowler et al (1980) stress the need to move away from the discrete unit theory of speech and look for a 'coordinate structure' approach to explain speech. They point out that attempts to discover segmental units across the boundaries of articulatory movements, vocal tract area function, or acoustic signals have not been wholly successful. They imply that this is because most writers have attempted to place the articulatory segment centrally and then look for associative movements of articulation, breathing, vocal apparatus, etc. They suggest the reverse: that we should look at the functional groupings of muscles as they are organized into articulatory groups. Such a holistic view appears to the author to be more readily applicable to the description of deaf speech than either segmental phonetic description or clinical phonology assessments.

The VPA (outlined below) does not describe speaker performance with reference to an English model, as do the clinical phonology assessments listed above. Rather it looks at the range of vocal tract and laryngeal settings which the speaker uses. By taking this stance it is far less language-specific than any of the other assessments/procedures listed, and is particularly useful with hearing impaired speakers, many of whom have non-English performance. Because the VPA is not language-specific it does not force that performance of deaf speakers which is non-English into inappropriate categories.

The Vocal Profile Analysis (VPA) Scheme is based on the fact that a speaker's voice quality is derived from those laryngeal and supralaryngeal features which are idiosyncratic to him. It is this idiosyncrasy which determines the individual quality of each speaker's voice, the characterizing quality which allows him to be recognized by those who have heard him before.

Such idiosyncrasy is the product of both the anatomical makeup 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, e.g. a speaker with a Class 3 orthodontic bite will have different oral resonance characteristics from a speaker with a Class 1 bite. 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 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 the vibrating surfaces of slightly inflamed oedematous folds will often change the phonation characteristics of a speaker.

As well as these skeletal differences, which lead to marked differences in his characterizing quality, the way in which a speaker habitually uses his vocal tract also affects his long-term vocal characteristics. A speaker who has learned and habitually uses a forward tongue body posture will have a different oral resonance from a speaker with similar skeletal makeup who has a habitual back posture of the tongue body.

Thus a speaker's voice quality can be said to be affected by learned muscular bias and by his anatomical makeup. The VPA identifies those supralaryngeal and laryngeal features which are affected by either long-term muscular bias or by skeletal idiosyncrasy.

The phonetic model developed by Laver (1980) suggests that by specifying a neutral setting for each of these supralaryngeal features, laryngeal features and tension characteristics it is possible to measure displacement from these specified neutral settings. Trained listeners are then able to perceive deviations from these neutral points. Some of these deviations from neutral can be measured physiologically and acoustically.

The VPA scheme, then, provides a perceptual rating scheme based on neutral settings of supralaryngeal and laryngeal parameters and allows the measurements and rating of a speaker's deviations from these neutral points. The resulting profile of these deviations from neutral specifies the characteristics of a speaker's voice.

A neutral setting of the vocal tract is one where the tract has most nearly an equal cross section throughout its length. In an adult male such a tract setting will produce formant frequencies in the ratio 1:3:5.... Thus if one takes an average male vocal tract of 17.5 cms the formant frequencies will be F_1 500 Hz, F_2 1500 Hz, F_3 2500 Hz etc. (Stevens & House 1961). Laver (1981) uses this neutral baseline as a setting from which changes can be assessed. Changes can be made from this neutral setting by

(a) changing the longitudinal dimension of the vocal tract;

(b) changing the latitudinal dimension of the vocal tract; or

(c) altering the tension features.

Non-neutral settings will be achieved in these three areas by movements of lips, jaw, tongue blade, tongue body, faucal pillars or the laryngeal assembly.

Changes in the longitudinal dimension of the vocal tract will involve either lengthening or shortening the vocal tract. The vocal tract can be lengthened by

(a) LOWERING the LARYNX; or

(b) PROTRUDING the LIPS;

or it can be shortened by

(c) RAISING the LARYNX or retracting the lower lip to

(d) a LABIODENTALIZED position.

Changes in the latitudinal dimension of the vocal tract will be brought about by movements of the LIPS, the JAW, the TONGUE BODY or TONGUE TIP which achieve constriction or opening of the vocal tract. Thus

(a) the LIPS may be ROUNDED or SPREAD;

(b) the JAW may be OPEN or CLOSED;

(c) the TONGUE TIP may be ADVANCED or RETRACTED;

(d) the TONGUE BODY may be RAISED or LOWERED; BACKED or FRONTED.

The convention that will be used in this thesis is that specific VPA settings are written in capital letters. Descriptive terms used in other assessments are not capitalized in this way.

The range of movements of lips, jaw and tongue body are also noted.

In addition to changes in the longitudinal and latitudinal dimensions of the vocal tract there are many changes at the velopharyngeal sphincter. In Laver's phonetic description of voice quality, a neutral setting of the velopharyngeal sphincter is one where the sphincter is closed except for the production of nasal segments. Such a setting occurs extremely rarely among British speakers of English. We commonly have a degree of nasal resonance on vowels which are adjacent to nasal consonants, or conversely have a reduction of nasal resonance in some accents of English. In the VPA Scheme a speaker may have a NEUTRAL velopharyngeal setting or may have INCREASED or DECREASED NASAL RESONANCE and/or may have AUDIBLE NASAL ESCAPE.

In addition to changes in the longitudinal and latitudinal dimensions of the vocal tract and to changes in the velopharyngeal sphincter, the resonant properties of the supralaryngeal tract will be affected by the <u>tension of the musculature</u> of the vocal tract. Changes in muscle tension will affect the properties of the walls of the vocal tract; thus a speaker with a very tense setting of his supralaryngeal musculature will sound very different from one with a very lax supralaryngeal setting.

To summarize the supralaryngeal settings included in the VPA, they can be listed thus:

Labial settings	-	NEUTRAL
	or	LIP ROUNDING or SPREADING
		LABIODENTALIZATION
		EXTENSIVE or MINIMIZED LIP MOVEMENT
Jaw setting	-	NEUTRAL
	or	OPEN or CLOSED JAW
		PROTRUDED JAW
		EXTENSIVE or MINIMIZED JAW MOVEMENT

Tongue tip setting	-	NEUTRAL
	or	ADVANCED or RETRACTED tongue tip
		FRONTED or BACKED tongue body
	and/or	EXTENSIVE or MINIMIZED TONGUE MOVEMENT
Velopharyngeal setting	-	NEUTRAL
	or	NASAL resonance or DENASAL resonance
		AUDIBLE NASAL ESCAPE
Pharyngeal tension	-	NEUTRAL
	or	CONSTRICTED
Supralaryngeal tension	-	NEUTRAL
	or	TENSE or LAX

The concept of NEUTRAL defined in the VPA Scheme in no way equates with normality. Nearly all speakers (normal and non-normal) have some deviations from neutral in their vocal tract settings. Some of these deviations are the result of structural differences between people and some the results of how they have learned to use their vocal apparatus. All combinations of non-neutral settings are possible although some combinations are more likely than others. Thus a speaker with no pathology with slightly ROUNDED LIPS is far more likely to use a CLOSE JAW setting and MINIMIZED MOVEMENT of LIP and JAW than to use OPEN JAW setting with EXTENSIVE LIP and JAW MOVEMENTS. However, if this is a dysarthric speaker such an 'unlikely' combination of ROUNDED LIPS OPEN JAW and EXTENSIVE LIP and JAW MOVEMENTS is quite possible. Thus, although combinations of non-neutral supralaryngeal settings for normal speakers can be somewhat predictable, they are not for non-normal speakers. It should also be emphasized that some supralaryngeal non-neutral settings are uncombinable. Thus one cannot combine SPREAD and ROUNDED LIPS nor ADVANCED and RETRACTED TONGUE TIP. The patterns of combinations of possible settings by speakers with normal vocal apparatus is of course sometimes violated by those speakers whose vocal apparatus is abnormally formed.

A supralaryngeal neutral baseline can be specified, and changes from this can be defined. For example, neutral setting for TONGUE TIP is one where the active articulator articulates against the lowest point of the alveolar ridge for alveolar plosives; ADVANCED 3 is where the active articulator articulates at the boundary of the alveolus and the inner surface of the incisors; RETRACTED 3 is where the active articulator articulates at the border between alveolus and hard palate. ADVANCED 1, 2, 4, 5, 6 and RETRACTED 1, 2, 4, 5, 6 can be equally precisely defined. In the VPA NEUTRAL laryngeal setting can also be specified with rigour A NEUTRAL laryngeal setting is one where:

The true folds vibrate;

The whole length of the folds is involved in phonation;

The vibration of the true folds is regular and periodic;

There is only moderate adductive tension;

There is only moderate longitudinal tension of the vocal folds;

There is only moderate tension of the extralaryngeal musculature.

Phonation of this type would be neutral or, to use the term employed in the VPA, MODAL. Changes from this neutral laryngeal setting can then be perceived.

As described above, neutral, or MODAL, phonation comprises regular vibration of the full length of the vocal folds. If the vibration is less regular so that there is some dysperiodicity in the phonation, the VPA uses the term HARSH phonation. If there is audible friction, because the full length of the folds is not being used, the VPA uses the term WHISPER. Thirdly, if there is a change in the mass of the vocal folds so that the more massive folds vibrate rather slowly, this is called CREAK.

Various phonations are then specifiable. These are:

(1) regular periodic vibration of the folds - MODAL VOICE;

(2) use of a different mode of vibration - FALSETTO;

(3) aperiodicity of the vocal fold vibration, HARSH VOICE;

(4) lack of involvement of the full length of the folds resulting in audible friction, WHISPER or WHISPERY VOICE;

(5) a change in the configuration of the mass of the vocal folds resulting in CREAK or CREAKY VOICE.

It can be seen that, just as supralaryngeal features were combinable, so too the VPA allows description of a cumulation of laryngeal features. Thus a speaker may use voice, but have dysperiodicity of vocal fold vibration, i.e. HARSH VOICE, or he may use CREAK with audible friction, i.e. CREAKY WHISPER, or may use voice with audible friction, dysperiodicity and CREAK, i.e. WHISPERY HARSH CREAKY VOICE.

Increased or reduced LARYNGEAL TENSION may characterize a speaker. Raised or lowered LARYNX POSITION will also greatly affect the speaker's vocal resonance. Similarly, non-neutral phonation may characterize a speaker.

In the VPA protocol, illustrated in Appendix I, the features listed on the left hand side are supralaryngeal, laryngeal and tension features. The first judgement made is whether there is a deviation from neutral for a given parameter. If there is judged to be a deviation from neutral, the next judgement to be made is: what is this particular deviation from neutral, and is it in the normal or non-normal range? Finally the scalar degree of deviation from neutral is noted. Examples of the protocol are shown in Appendix I.

In addition, the VPA makes judgements about prosodic features; these appear on the right hand side of the protocol sheet. The judgements which are made are whether there is a deviation in fundamental frequency features

from neutral PITCH MEAN;

from neutral PITCH RANGE; and

whether there is a non-neutral VARIABILITY within this range; and whether there is a TREMOR (a mismatch between breathing and phonation) or a deviation in intensity features. NEUTRAL PITCH MEAN is one which is appropriate to the speaker's age, sex and size. It is not synonomous with average pitch for a given population of speakers. Similarly, NEUTRAL LOUDNESS features indicate appropriacy to the speaker. Judgements of LOUDNESS MEAN, LOUDNESS RANGE or LOUDNESS VARIABILITY are judged from NEUTRAL. Finally, for the sake of completeness, comments on RATE, CONTINUITY, BREATHING and RHYTHM are made.

In making a scale such as this, where there are many parameters (51 in the VPA), the question of interjudge reliability is important. It was reported above that this study was associated with a much larger study concerned with the development and application of the VPA. Mackenzie (1983) has studied the interjudge reliability by trained users. She found that most experienced speech therapists, given 15/18 hours of perceptual training and teaching about the VPA, were able to achieve a 70% to 75% reliability on a test tape. Reliability was defined as the ability to identify specific neutral or non-neutral settings and, in the case of non-neutral settings, to rate the scalar degree to within one scalar degree of the agreed 'right' answer. For example, in the 4 ratings of harshness given below, the 'right' answer is Harsh 2. Attempts (a) and (b) are within one scalar degree of this 'right' answer, and thus judged correct, whereas attempt (c) is not within one scalar degree and judge to be incorrect. Chart 1 displays this.

<u>Chart 1: A representation of how 'agreement' between raters was derived from three separate ratings</u>

		N	1	2	3		4	5	6	
HARSHNESS	'right' answer			x						
	attempt (a)			x						
	attempt (b)				x					
	attempt (c)	x								

The 'right' answers in this study were derived from composite agreed protocols by Laver, Wirz and Mackenzie, and by Wirz and Dobbs. In Experimental Group I and the control group Laver, Wirz and Mackenzie were the raters. The reliability of Laver with Wirz was 74%, Laver with Mackenzie was 76%, and Wirz with Mackenzie was 79%. In Experimental Groups II and III the raters were Wirz and Dobbs. The reliability between Wirz and Dobbs was 74%.

In other words, Wirz and Laver were within one scalar degree of each other 74% times, Laver and Mackenzie 76%, Wirz and Mackenzie 79% and Wirz and Dobbs 76%. It should be remembered that the total number of judgements made individually by Laver, Wirz and Mackenzie was 960 for Experimental Group I and 960 for the Control Group. The total number of judgements made by Wirz and by Dobbs for Experimental Group II was 120 and for Experimental Group III was 240.

CHAPTER 3

METHODOLOGY

3.1 Subject selection and recording procedures

3.2 Audiological characteristics of the subjects

3.3 VPA rating procedures

3.4 Frequency measurements

3.5 Statistical treatment of VPA ratings

3.1 SUBJECT SELECTION AND RECORDING PROCEDURES

Experimental Group I

The recordings for this study were made at the National Technical Institute for the Deaf (NTID) in Rochester, N.Y.

NTID is a college for hearing impaired students situated on the campus of Rochester Institute of Technology. There are approximately 900 hearing impaired students among a total student body of approximately 12,000. The hearing impaired students follow a variety of higher education courses ranging from 2-year certificate courses to 5-year master degrees. The author had the opportunity to visit this institute in 1975 (Wirz, 1978), returned to work there for 8 months in 1977 and 1978 (Wirz, Subtelny et al 1979) and returned later to collect the data for the present study.

NTID provides a unique opportunity to collect a reasonably homogeneous sample of hearing impaired speakers. All students are over 18 years on entry, all must be of above average intelligence to enter the institute and, because of the large numbers, it was possible to select students with similar hearing loss.

Recordings were made of each speaker individually using an Ampex tape recorder and EMI standard play tape; recordings were made at 7.5 ins./sec.

First the recording tasks were explained to each subject, using total communication to ensure that all subjects fully understood the tasks. They were asked to produce single steady state vowels /ɑ/, /u/ and /i/ and were given practice until it was felt by the investigator that they could make no better attempt. They were also asked to read the first two paragraphs of the Rainbow Passage silently and to ask for clarification of any words they did not know. The Rainbow Passage (Fairbanks 1960) is one of the standard reading passages widely used in speech research. Thirdly they were asked to select a picture and to be prepared to talk about this for two minutes. This proved to be the most daunting task for those speakers who were, and knew they were, completely unintelligible.

When the subject understood the task he was seated in a small soundproof booth, with a mouth to microphone distance of 10" and recordings of the various speech samples, i.e. vowels, reading and conversation, were made.

Mouth to microphone distance was kept constant and similarly the intensity signal of the recording was kept standard by visual inspection of the intensity meter. If, for a very loud or very quiet voice, the intensity meter indicated that it was necessary to adjust the record level of the Ampex tape recorder, a note was made of these adjustments. A note was also made of each subject's age, use of hearing aid and ethnic group.

Experimental Group II

In order to investigate whether the long-term speaker characteristics of the experimental group were typical of all hearing impaired speakers or only typical of American hearing imparied speakers, five further recordings of young British hearing impaired people were analysed. They:

(1) were all aged 19 - 24 years;

(2) had no other disabilities;

(3) had had some period of college or employer based training after leaving school; and

(4) had an average hearing loss of greater than 85 db in their better ear.

In other words they closely resembled the American group. They were all patients of the speech therapy clinic of the Royal Ear Hospital, London, and the recordings were all made on a Revox tape recorder with controlled mouth to microphone distance of 9 inches. They all read either the Rainbow Passage, or 'The North Wind and the Sun' (a second commonly used passage in speech research) or 'The Dog and Duck' (RNID reading passage).

Experimental Group III

Analysis of the results of profoundly deaf speakers (below in Chapter 4) raised some questions about the speaker characteristics of less deaf subjects and also about the changes in long-term speaker characteristics which are affected by remedial intervention. Recordings from a third group of speakers were therefore analysed. This group comprised five speakers who had contact with the speech therapy department of the Royal Ear Hospital. These speakers:

(1) were aged 19-29 years;

(2) had no additional handicaps;

(3) had some college education or employer based training;

(4) had a hearing loss in their better ear of less than 75db, i.e. they had more hearing than the main group or Group II.

Recordings, again made on a Revox tape recorder, were available for this group pre- and post- 20 hours of therapy. The recording conditions were the same as for Experimental Group II. Similarly to Experimental Group II they were all patients of the Royal Ear Hospital, London.

Control group

40 control subjects were recorded on a Revox tape recorder. They were all students and staff of Edinburgh University. Their ages ranged from 18 to 46. The group was composed of 20 male and 20 female speakers. They were recorded in a sound-proof room with the same control of mouth to microphone distance and recorder settings.

There are of course some disadvantages in having one experimental group of deaf American speakers when the control group is of British speakers; accent differences between the 2 groups may contaminate the results. However, it was felt after due consideration that the great advantage of having such a large homogeneous group of hearing impaired speakers in Experimental Group I outweighed the disadvantages. Profoundly deaf speakers have no or at best a very weak auditory model in their language acquisition and it is unlikely that they would acquire accent variations. An experiment was designed to determine whether skilled listeners could distinguish between profoundly deaf Americans and profoundly deaf British speakers. This experiment, which is described below, confirmed the view of the author that with this degree of hearing loss accent variation is not apparent.

It should be remembered that the 40 hearing impaired speakers in Experimental Group I had been selected because they had a <u>profound</u> hearing loss. Such a group was ipso facto going to have different speech characteristics from a group of hearing controls and it was felt that it was these differences which were of interest in this study, not differences between American and British English. If one tried to compare the American hearing impaired speakers with American controls one would have to control for sociolinguistic variation within the American populations in a way which would have been methodologically very difficult.

In speech pathology, there are precedents for using disordered speakers of one nationality as illustrative examples of that disorder in other languages and accents. This procedure is possible when the prime motivation is the characterization of the disorder and not an investigation of any sociolinguistic variation which may also be present.

Darley (1982) in his mammoth study of acquired dysarthria identified speech characteristics of 7 types of acquired dysarthria. He isolated those speech characteristics which occurred in different dysarthrias. His work was completed from a study of American subjects, and the illustrative tape accompanying his classification is of some of these American speakers. His classification, despite its American origin, is widely used throughout the world with great effect, and adds weight to the clinical observation that in extreme cases the characterising features of a speech disorder override accent variation.

The GRBAS scheme, described above, was developed in Japan to facilitate description of pathological laryngeal performance. GRBAS was developed with Japanese subjects, the training tapes are in Japanese, but that does not detract from its use as an objective description of laryngeal function in any language. GRBAS is in fact widely used in the non Japanese speaking parts of the world.

The purpose of this study is to apply the VPA to hearing impaired speakers and, similarly to Darley's study, to identify those features which characterize deaf speech.

In order to establish whether accent variation was evident among profoundly deaf speakers a tape was compiled of 5 profoundly deaf speakers from Experimental Group I and 5 from Experimental Group II. The voices were copied in a random sequence of male, female, American and British. Ten voices were used because this constituted a 15-minute tape which it was felt would not be a fatiguing listening task. Two groups of experienced listeners were then asked to listen to the tape and to note whether the speaker was male, female, American or British. Details of the explanation given to the listeners are given in Appendix 4. The experienced listeners were ten students in their fourth year of an honours speech science degree. They had completed courses in phonetics, linguistics, audiology and some speech pathology. It was felt that they were more used to listening to disordered speakers than were most of the population and for the purposes of this experiment are the semi-experienced group of listeners. A second group of listeners were all qualified speech therapists who worked with hearing impaired people full time and who had completed a VPA training course. They were a group who were highly skilled listeners and probably for the purposes of this experiment the most experienced group of listeners one could use.

The results of this experiment, which are described in detail below, support the view that at this degree of hearing loss, accent is not apparent, and that it is possible to characterize the long-term speaker characteristics of profoundly deaf speakers by looking at both American and British deaf comparing them with a British control group.

To support the listening exercise described above, it is worth noting at an anecdotal level that most hearing people who attend international meetings with deaf and hearing participants are familiar through experience with those aberrant features which tend to be associated with profound hearing loss, with moderate hearing loss, and with less hearing loss. This recognition of features is possible without knowing the country of origin of the deaf participant, or even knowing the language they are speaking.

3.2 AUDIOLOGICAL CHARACTERISTICS OF THE SUBJECTS

Experimental Group I

Full audiological investigations were made on each of the 40 subjects. The battery of audiological testing included pure tone audiometry, speech audiometry, a phoneme identification test, tests of speech reading with and without auditory amplification and an assessment of how much each speaker was using his personal hearing aid. From these data it might have been possible to select subjects on the basis of the way in which they used their residual hearing, i.e. following a functional definition of hearing. It was decided, however, that a group selected with such an approach would be contaminated by factors such as age of detection of hearing loss, type of school programme they had attended, type of aid, maintenance of aid during childhood, and not all this information was available for all 40 subjects.

It was therefore decided to select speakers on the basis of closely matched pure tone audiograms. The pure tone audiograms of all 40 subjects were therefore examined and the mean hearing loss over the speech frequencies was measured for each ear. The following pure tone thresholds were noted for each speaker:

125 Hz

250 Hz

500 Hz

1000 Hz

2000 Hz

4000 Hz

8000 Hz

Only those subjects who had an average loss greater than 85 db in their better ear were included in the group. In other words, only profoundly deaf speakers were included in the group for analysis. Table 3 lists the pure tone thresholds for the 40 subjects in Experimental Group I. When calculating the mean loss no response (NR) was counted as 120 db. Figure A graphs this information.

It will be noted that the 40 hearing impaired speakers included 27 males and 13 females. Most epidemiological studies suggest that the incidence of hearing loss is greater among men than women (Myklebust 1964, Lutman & Haggard 1983).

It is also true that there are more men in higher education than women. In a population of profoundly hearing impaired students one would expect more men than women.

TABLE 3

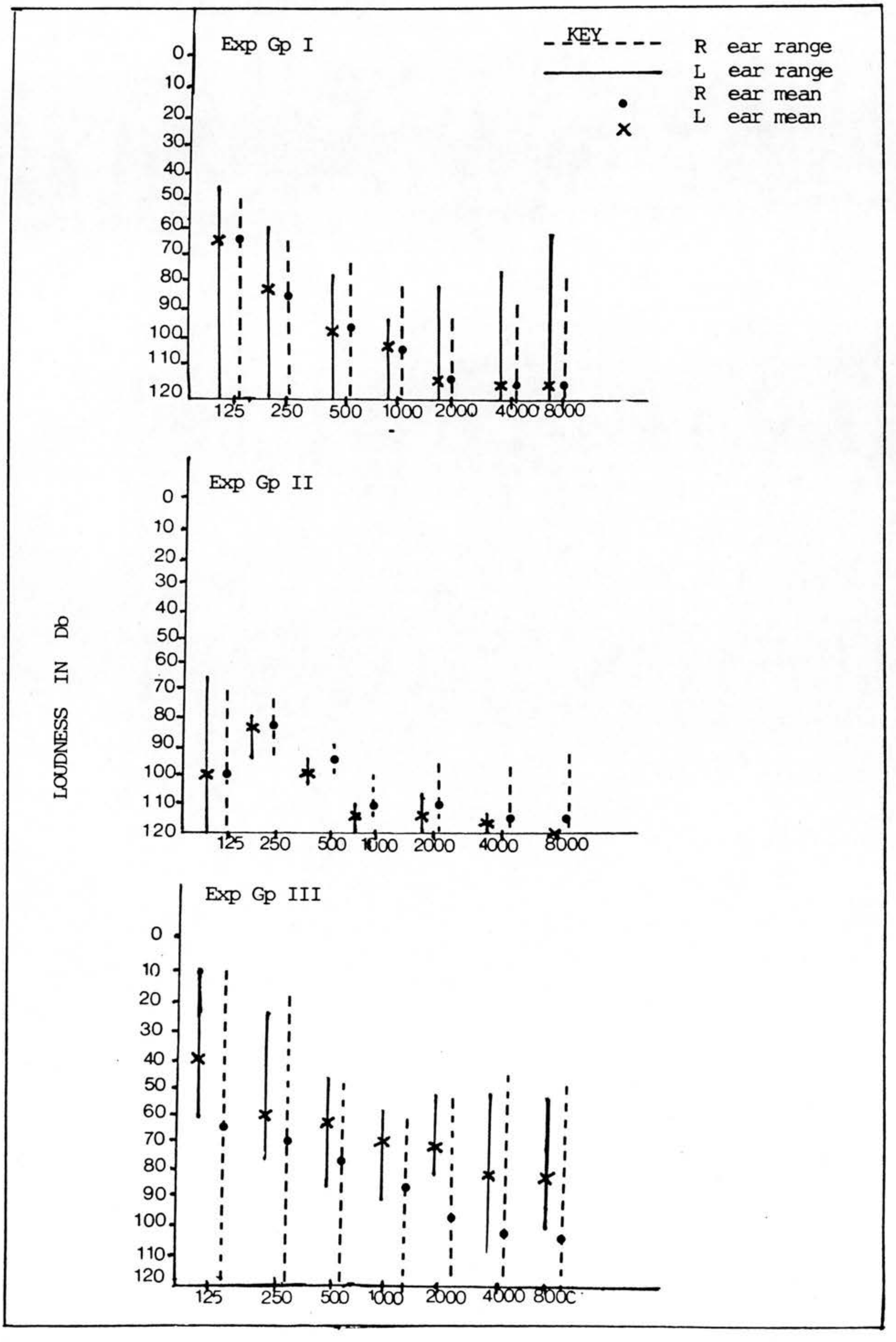
PURE TONE THRESHOLDS IN dB OF 40 HEARING IMPAIRED SUBJECTS IN EXPERIMENTAL GROUP I

Speaker	125 Hz		250 Hz		500 Hz		1K Hz		2K Hz		4K Hz		8K Hz		Mean	
No.	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
1	65	70	70	75	80	80	95	90	110	115	NR		NR		94	96
2	NR	60	85	75	90	95	100	105	110	115	NR		NR		106	99
3	NR	NR	80	NR	90	NR	105	NR	NR		NR		NR		108	120
4	NR	70	90	75	100	75	110	100	NR	115	NR		NR		111	96
5	90	95	95	95	100	90	110	110	NR		NR		NR		108	107
6	65	NR	90	90	100	105	115	115	115	115	NR		NR		104	112
7	NR		NR		110	110	110	105	110	105	NR		NR		116	114
8	75	75	85	70	100	95	110	110	115	NR	NR		NR		104	101
9	NR	70	80	80	85	85	100	100	115	115	NR		NR		106	99
15	NR		NR		NR		115	NR	NR		NR		NR		119	120
16	70	75	90	95	95	100	100	105	110	110	NR		NR		101	103
19	75	NR	85	90	95	80	110	115	115	100	NR		NR		103	106
22	75	75	85	90	95	95	110	105	NR		NR		NR		104	114
23	NR		NR		NR		NR		115	NR	NR		NR		119	120
24	70	50	95	90	NR	90	NR	105	NR	110	NR		NR		109	98
26	NR		90	90	95	90	95	100	105	110	NR		NR		106	107
31	NR		NR	95	90	85	105	105	NR		NR		NR		114	109
33	70	70	85	70	80	80	105	115	105	NR	NR		NR		103	99
34	NR		90	NR	95	105	105	115	NR		NR		NR		110	117
35	65	60	95	80	110	105	NR		NR		NR		NR		102	104
36	70	120	100	NR	NR		NR		NR		NR		NR		110	120
39	50	70	75	80	80	85	95	90	105	115	NR	115	NR		92	96
40	120	60	65	65	80	80	95	95	90	100	85	110	75	120	87	90
41	70	120	80	85	90	95	105	100	120	100	120	90	120	80	101	96
42	70	60	70	75	85	95	100	120	110	120	NR		NR		96	101
44	120	75	90	85	90	90	100	100	95	95	95	95	120	95	101	91
46	NR		80	95	95	NR	115	115	115	115	NR		NR		109	114
47	65	50	70	70	95	90	100	100	115	120	NR		NR		98	96
48	45	60	65	70	80	86	95	95	110	115	NR		NR		91	95
49	70	120	85	95	95	105	115	110	105	NR	NR		NR		101	113
51*					100	100	100	100							100	100
52	60	55	80	70	95	95	95	95	95	110	110	NR	NR		94	91
54	NR		95	90	110	105	NR	120	NR	115	NR		NR		115	113
57	65	60	70	65	80	75	95	95	95	95	100	100	90	85	85	82
59	NR		70	75	80	85	100	100	NR	115	NR		NR		104	105
60	NR	75	NR	85	NR	105	NR		NR		NR		NR		120	106
62	65	50	85	70	110	100	110	105	NR		NR		NR		104	98
64	NR	NR	NR	NR	95	110	105	NR	85	100	75	NR	65	NR	98	115
67*					100	105	NR		NR	100	NR		NR		105	105
71	50	NR	60	95	80	NR	110	NR	NR		NR		NR		94	116
X	64	64	85	88	95	96	104	105	112	111	116	118	116	117		

* incomplete data

FIGURE A

PURE TONE HEARING THRESHOLDS OF 3 GROUPS
OF HEARING IMPAIRED SPEAKERS



In addition to pure tone audiological information, intelligibility ratings were available for the 40 subjects. These intelligibility ratings were completed by speech pathologists of NTID who had been trained to a point of high interjudge reliability (Subtelny 1975). A 5-point, equally appearing interval scale is used by the staff at this institute where 5 means completely intelligible, 4 means 75% of the message is understood, 3 means about half the message is understood, 2 means less than half and *1* means only odd words but no connected message is understood.

Among these 40 deaf speakers there were none rated 5 (intelligible), only 5 rated 4 (75% intelligible), 15 were rated 3 (about 50% intelligible), 15 were rated 2 and a further 5 were rated 1 (completely unintelligible).

Metz et al (1980) in their critique of the use of intelligibility rating scales with hearing impaired people warn that 'It is crucial to recognize that any measure of speech intelligibility is a measure of interaction between a speaker and a listener' (Subtelny 1980: 74). Metz also warns that there are dangers in using an interval appearing scale, such as that used by Subtelny, but concedes that until we can isolate those specific features which contribute to intelligibility, an equal interval appearing rating scale, such as the one used in this study, has some pragmatic value.

The experience which the listener has of deaf speech and his knowledge of the material being spoken may also influence the resulting ratings. Monsen (1978) showed that, after only 4 listening trials, naive listeners were as competent as experienced listeners in their understanding of deaf speech.

However, despite these considerations the author feels sympathetic to Subtelny's (1977) view when she says: 'Intelligibility is considered the most practical single index to apply in assessing competence in oral communication' (quoted in Subtelny 1980: 74).

Experimental Group II

Pure tone audiograms for each of the 5 subjects were noted over the speech frequencies of 125 - 800 Hz. All 5 subjects had an average loss of greater than 85 db in their better ear (see Table 4). The intelligibility ratings of this group are given in Table 5.

Experimental Group III

Pure tone audiograms for each of the 5 subjects were again noted over the speech frequencies and are displayed in Table 6. Intelligibility ratings for these 5 speakers were made pre- and post- therapy. They are given in Table 7.

3.3 VPA RATING PROCEDURES

In Chapter 1 it was shown that the literature describing deaf speakers uses an ill-defined and often confusing terminology in its accounts of the characteristics of deaf speakers. Chapter 2 above outlined the Vocal Profile Analysis Scheme and suggested how this

TABLE 4

PURE TONE THRESHOLDS IN dB OF 5 HEARING IMPAIRED SUBJECTS IN EXPERIMENTAL GROUP II

Speaker	125 Hz		250 Hz		500 Hz		1K Hz		2K Hz		4K Hz		8K Hz		Mean	
No.	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
A	-	-	95	95	100	100	120	115	NR	NR	NR	NR	NR	NR	112	112
B	85	80	90	75	105	100	115	115	120	120	120	120	120	120	107	106
C	65	70	80	90	100	100	110	110	105	105	NR	NR	NR	NR	113	115
D	NR	NR	80	85	100	85	110	100	110	95	110	95	NR	90	105	92
E	NR	NR	85	90	95	95	115	115	115	NR	115	NR	NR	NR	109	114

TABLE 5

INTELLIGIBILITY RATINGS OF EXPERIMENTAL GROUP II

Speaker	Intelligibility rating
A	2
B	2
C	3
D	4
E	3

TABLE 6

PURE TONE THRESHOLDS IN dB OF 5 HEARING IMPAIRED SUBJECTS IN EXPERIMENTAL GROUP III

Speaker	125 Hz		250 Hz		500 Hz		1K Hz		2K Hz		4K Hz		8K Hz		Mean	
No.	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
V	60	85	80	85	85	85	90	105	75	110	65	110	70	NR	74	102
W	-	-	75	75	55	65	55	60	50	50	50	45	50	45	56	57
X	45	NR	65	NR	70	NR	65	NR	70	100	95	NR	95	NR	75	117
Y	10	10	20	15	45	50	55	60	80	100	110	100	110	95	61	63
Z	40	40	55	50	60	65	85	90	80	105	75	110	60	NR	62	83

TABLE 7

INTELLIGIBILITY RATINGS OF EXPERIMENTAL GROUP III

Speaker	Intelligibility rating pre-therapy	Intelligibility rating post-therapy
V	4	4
W	3	4
X	3	3
Y	4	4
Z	5	5

tool can be applied to speech pathology and more specifically how it can be applied to the description of deaf speech.

Experimental Group I

Using the Vocal Profile Analysis Scheme, 3 trained listeners listened to recordings of 40 profoundly deaf speakers and to 40 hearing speakers. The 3 listeners were Laver, the author and Mackenzie, another speech pathologist trained in the scheme who was working closely with Laver and the author. The interjudge reliability of the 3 listeners was close and is defined more clearly at the end of Chapter 2 above.

All 3 listeners listened independently to recordings of the reading passages read by 40 deaf speakers and by the 40 hearing subjects and completed vocal profiles on the 80 speakers. For each speaker a composite vocal profile was then constructed from 2 (and sometimes 3) independent profiles. Agreement was strictly defined in the following ways:

(a) if 2 (or 3) of the listeners agreed on a specific neutral or non neutral rating;

(b) if 2 ratings were within one scalar degree of each other for a given parameter. In other words adjacent ratings were said to 'agree'. This agreement was not upheld if the adjacent ratings were 3 and 4. In other words if one rater rated a parameter 3 and the other 4 they were said <u>not</u> to agree. The criteria for agreement are summarised in Table 8.

In cases where ratings did not fall within these strict perceptual criteria, one of two courses was followed.

TABLE 8

CRITERIA FOR "AGREEMENT BETWEEN RATERS"

Parameter	Neutral	Non-neutral						Agreement outcome
		1	2	3	4	5	6	
Example (a)		xxx						agreed
	xxx							agreed
Example (b)		xx	x					agreed
	xx	x						agreed
					xx	x		agreed
				xx	x			not agreed
				x	xx			not agreed
	x	x	x					not agreed
			x	x	x			not agreed

x = an individual rating by one rater

If the composite profile was being drawn up from only 2 independent profiles, and there was disagreement, then the third judge listened to the recording, made his own independent profile and this was used as in (b) above. If there was still disagreement between 3 independent profiles, 2 or 3 listeners listened again to those parameters of a recording where there was disagreement until they reached agreement.

This involved considerable listening time by the 4 raters. It takes about 15 minutes time to complete a VPA for one speaker reading the "Rainbow Passage". Thus, 10 hours of cumulative listening was required by each rater for Experimental Group I, 10 hours for the control group, 1.25 hours by each rater for Experimental Group II, and 2.5 hours by each rater for Experimental Group III. A total of:

Experimental Group I	10 hours x 3 raters	30.00 hours
Control Group	10 hours x 3 raters	30.00 hours
Experimental Group II	1.25 hours x 2 raters	2.50 hours
Experimental Group III	2.5 hours x 2 raters	5.00 hours

- over 65 hours cumulative listening. In addition time was needed when raters were available to discuss non-agreed judgements.

Using these procedures, composite vocal profiles were drawn up for 4 groups of speakers.

These composite profiles were then analysed. The commonest features of the deaf speakers were isolated and descriptions of these deaf speakers were made. The audiological status of the deaf speakers were then correlated with their composite profiles. Finally, the intelligibility ratings of the speakers were correlated with their composite profiles.

Experimental Groups II and III

The recordings of the 5 speakers in Experimental Group II and the 10 recordings of Experimental Group III were made into 2 randomly presented tapes and rated by 2 raters both of whom were experienced both in the clinical use of the VPA and were trained as VPA tutors (i.e. they were able enough to train other therapists and phoneticians in the use of VPA). The random presentation ensured that no listener knew which recordings were of profoundly deaf and which of moderately deaf speakers. Additionally they did not know which were pre-therapy recordings and which were post-therapy. The same agreement criteria outlined above were used.

For these listening tasks rater 1 was the author and rater 2 was another VPA tutor, based in London. Where a third rater was needed, to arbitrate about occasional disagreement between these 2 raters a further VPA tutor (also London based) listened to some of the recordings and acted as arbitrator in the way described above.

3.4 FREQUENCY MEASUREMENTS

The majority of work in this study involved perceptual rating and the analysis of these ratings. However, there was also the opportunity for some measurement studies.

One of the greatest differences between deaf and hearing speakers is in the area of pitch. In the VPA ratings in this study the PITCH RANGE and PITCH VARIABILITY ratings of the hearing impaired speakers were significantly different from these ratings for the hearing subjects. This would be anticipated from the literature, and was borne out by the preliminary examination of the results of this study.

In order to explore these pitch characteristics more objectively it was decided to take measurements of some of the fundamental frequency characteristics of the 40 hearing impaired speakers. The RNID speech display computer was used for this purpose. The reasons for using the RNID system were twofold:

(a) because the analysis programme has been designed specifically to analyse and display the frequency characteristics of hearing impaired speakers; and

(b) because the equipment was readily available and easily used, with a user friendly programme.

The RNID Speech Display Computer (King et al 1982) has several functions. The functions used in this study were: its frequency analysis display and frequency analysis statistical program.

The speech display computer can use a signal extracted directly from a microphone input or from tape recorded material. In this study recordings of the 40 hearing impaired speakers reading the Rainbow Passage were played into the computer.

The speech display computer comprises:

(1) input from microphone or tape recorder (in this case the input was from T.R.);

(2) pitch detector;

(3) microcomputer, in this case an Apple;

(4) a display mode on a TV screen;

(5) a statistical analysis package;

(6) a printer.

Figure B shows a block diagram of the RNID Speech Display Computer (King et al 1982).

In the RNID speech display computer, the speech signal passes first through an amplifier then through 2 filters. A high pass filter extracts all those parts of the signal over 3k Hz and a low pass filter extracts those parts of the signal which are below 1k Hz. The filtered samples then pass through 2 energy detectors which measure the proportion of the signal which falls above 3k Hz or below 1k Hz. Energy above 3k Hz is judged to be voiceless and that below 1k Hz to be voiced. A second analysis takes place by passing the signal first through a band pass of 100 - 900 Hz. It then passes through an automatic gain control and so to a peak detector. The peak detector then converts these peaks to pitch pulses which pass to the microcomputer. Figure C shows a block diagram of the pitch detector.

These pitch pulses are sampled by the computer every 10 milliseconds and converted into an appropriate log frequency which is displayed on the TV screen. The data displayed at this point are

FIGURE B

A BLOCK DIAGRAM OF THE RNID
SPEECH DISPLAY COMPUTER

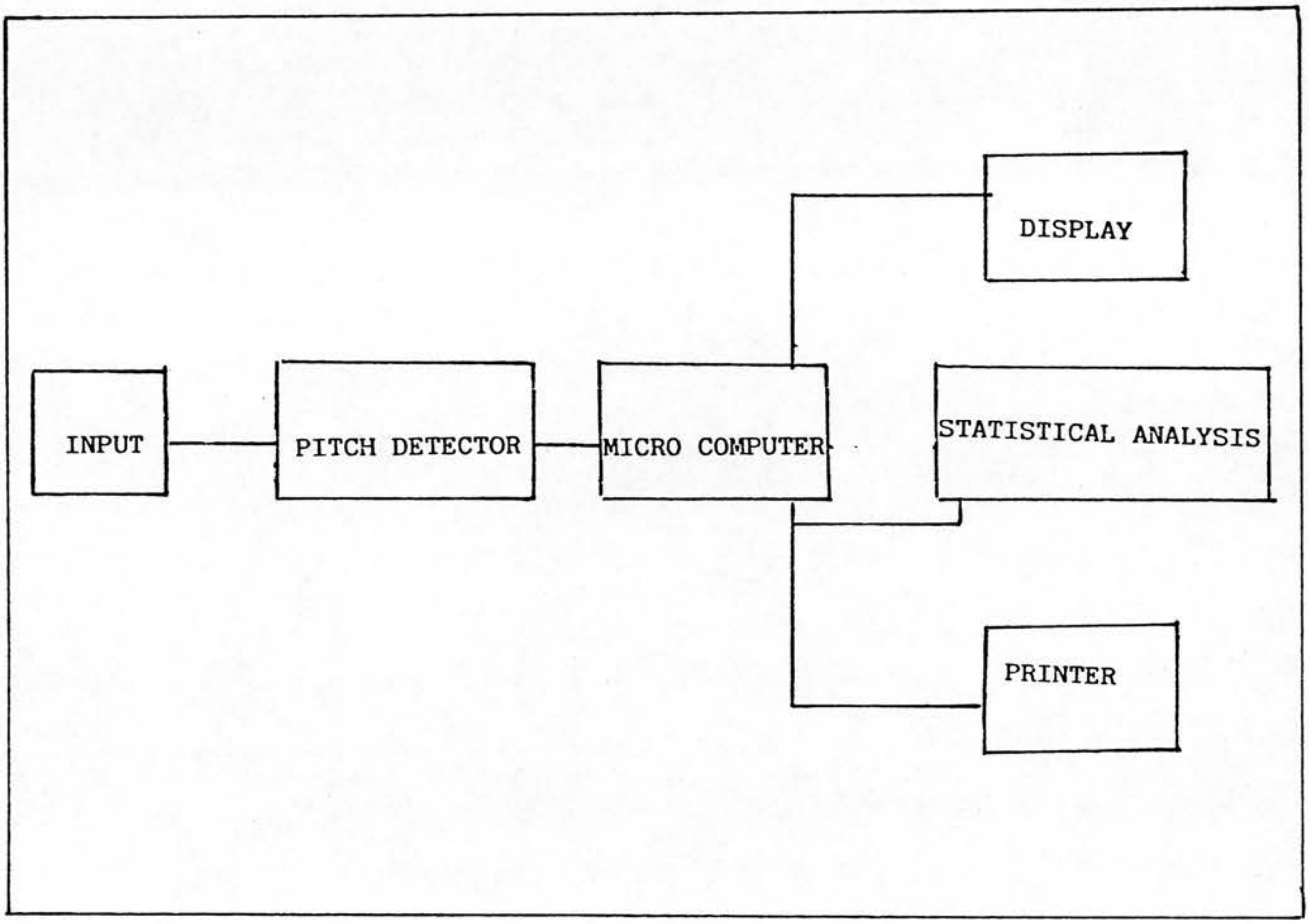
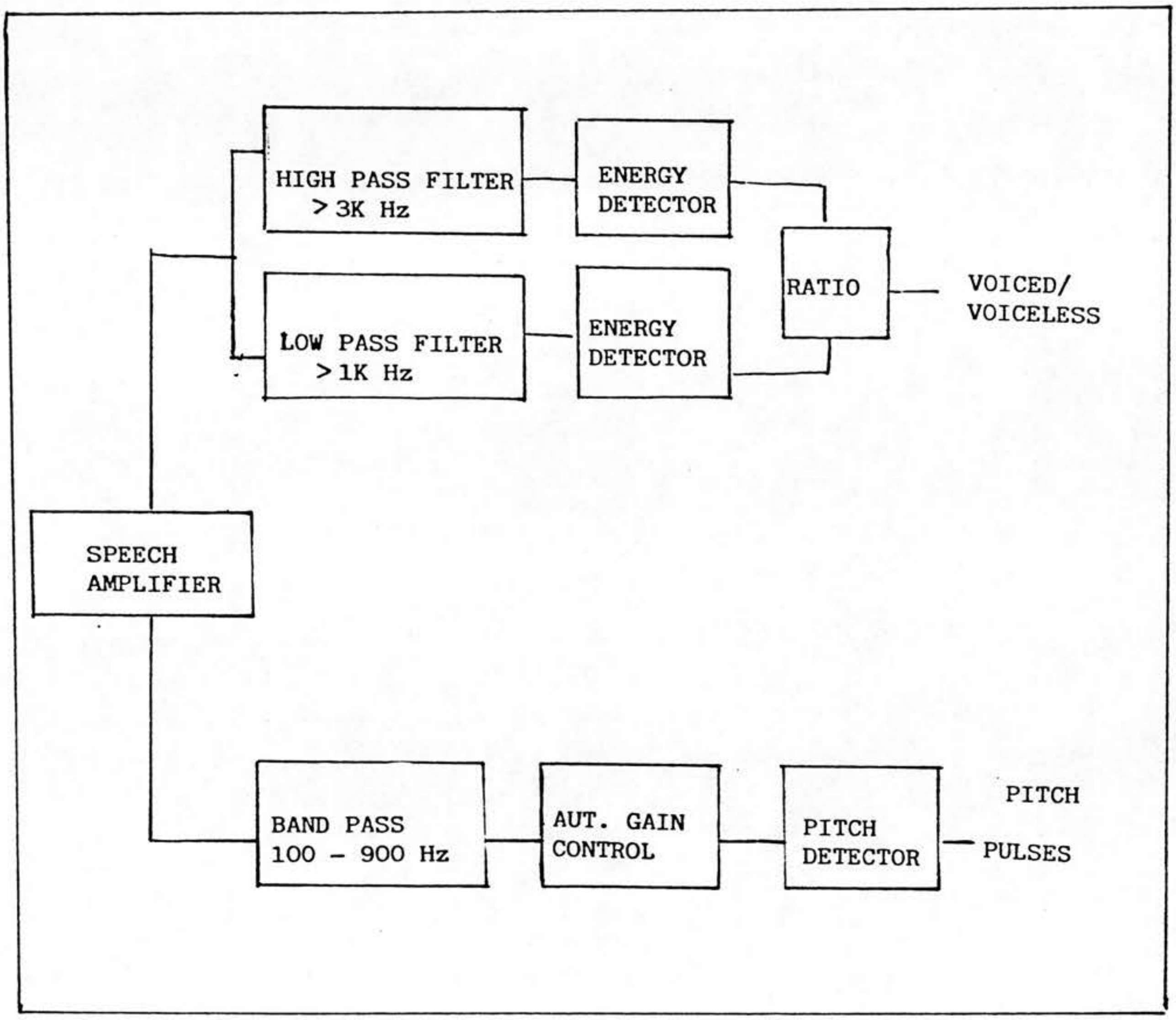


FIGURE C

A BLOCK DIAGRAM OF THE PITCH DETECTOR



the incidence of occurrence of a given frequency plotted against sound frequency. From the display curve the viewer can see which sound frequencies were most common in the speech sample. The great advantage of this simultaneous, real time, display is that the viewer can check by examining the display that there is no tape noise, background noise, etc. interfering with the pitch tracker. If there is interference the viewer can adjust the amplitude gain to reduce the distorting effects of noise on the resulting histogram.

The histogram display built up during the analysis is displayed as the coordinates of frequency (0 - 500 Hz), plotted against the logarithmic expression of the incidence of occurrence of each frequency. An example of such a plot is displayed in Figure D.

This frequency plot is then statistically analysed. The information collected as having relevance to this study was:

(1) Information about the central tendencies of frequency

  (a) average frequency

  (b) median frequency

  (c) modal frequency

(2) The range characteristics of the speakers

  (a) frequency range between the 10th and 90th percentiles; in other words the central 80% of the speakers' frequencies

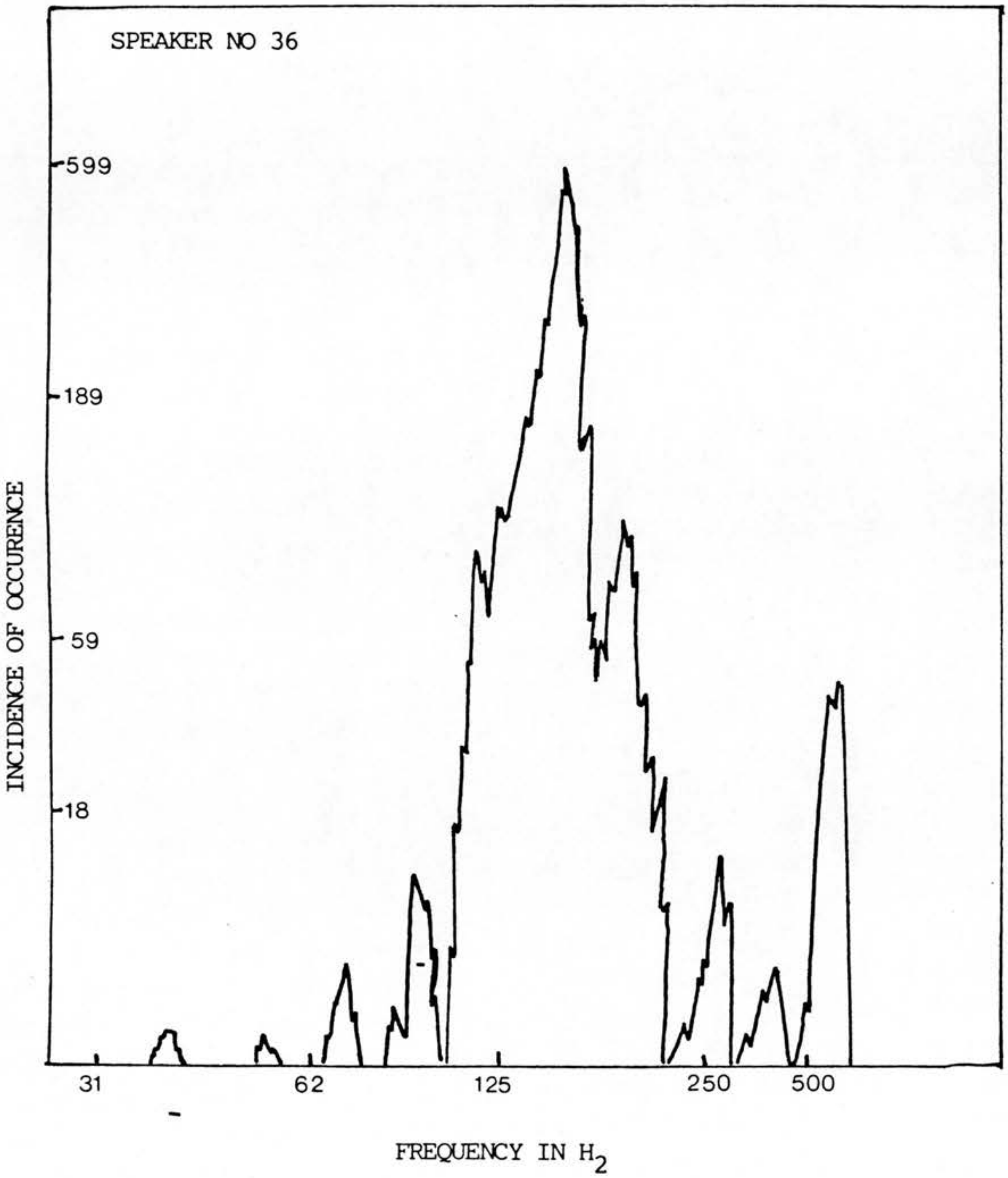
  (b) frequency range between the 25th and 75th percentiles; in other words the central 50% of the speakers' frequencies

  (c) the standard deviation of these frequencies.

(3) Time features

  (a) time taken for the reading

FIGURE D1 AN EXAMPLE OF A HISTOGRAM PLOT OF MODAL PITCH AS DISPLAYED BY THE RNID SPEECH COMPUTER



(b) total voiced and unvoiced time in the sample.

It was important to be able to compare the fundamental frequency characteristics of these 40 hearing impaired speakers with characteristics of hearing speakers. This was done in two ways. First, the results of this study were compared with the reported literature; Gilbert et al (1980) have a very useful review article of fundamental frequency characteristics of speakers of different sexes and ages. Secondly, recordings were made of 3 hearing men and 3 hearing women reading the Rainbow Passage and these were analysed using the RNID Speech Display Computer, for comparative purposes.

In order to test the reliability of the frequency measurements of the RNID computer it was decided to see if there was any difference between the results of measurements made from a microphone signal and measurements made from a laryngographic signal.

4 hearing young adult men and 4 hearing young adult women were recorded reading the Rainbow Passage. In addition the speakers made laryngographic recordings (Fourcin & Abberton 1971). The fundamental frequency as measured by the laryngograph was an additional confirmatory factor in determining the reliability of the frequency analysis capacity of the RNID Speech Display Computer. Laryngographic (Lx)and audio signals were recorded onto a 4 track tape recorder. The audio and Lx signals were then fed separately into the RNID speech computer. The results displayed in Table 9 show that the measurements of mean and modal fundamental frequency and of the range characteristics are broadly similar. The difference in mean measurements is a little disturbing and might merit different measurement. This similarity adds weight to the evidence that the measurements

TABLE 9

COMPARISONS OF MEAN MEDIAN MODAL FUNDAMENTAL FREQUENCY MEASUREMENTS AND RANGE CHARACTERISTICS OF A YOUNG ADULT MALE SPEAKER AS MEASURED BY THE RNID SPEECH COMPUTER USING AN AUDIO SIGNAL AND AN Lx SIGNAL

RNID Sp Computer measurements	Microphone audio signal	Lx signal
Mean Fo	126 Hz	111 Hz
Median Fo	111 Hz	111 Hz
Modal Fo	111 Hz	104 Hz
Range between 25th and 75th percentile	23 Hz	21 Hz

made by the RNID Speech Computer are reliable. (These similarities are graphically displayed in Figure Dii.)

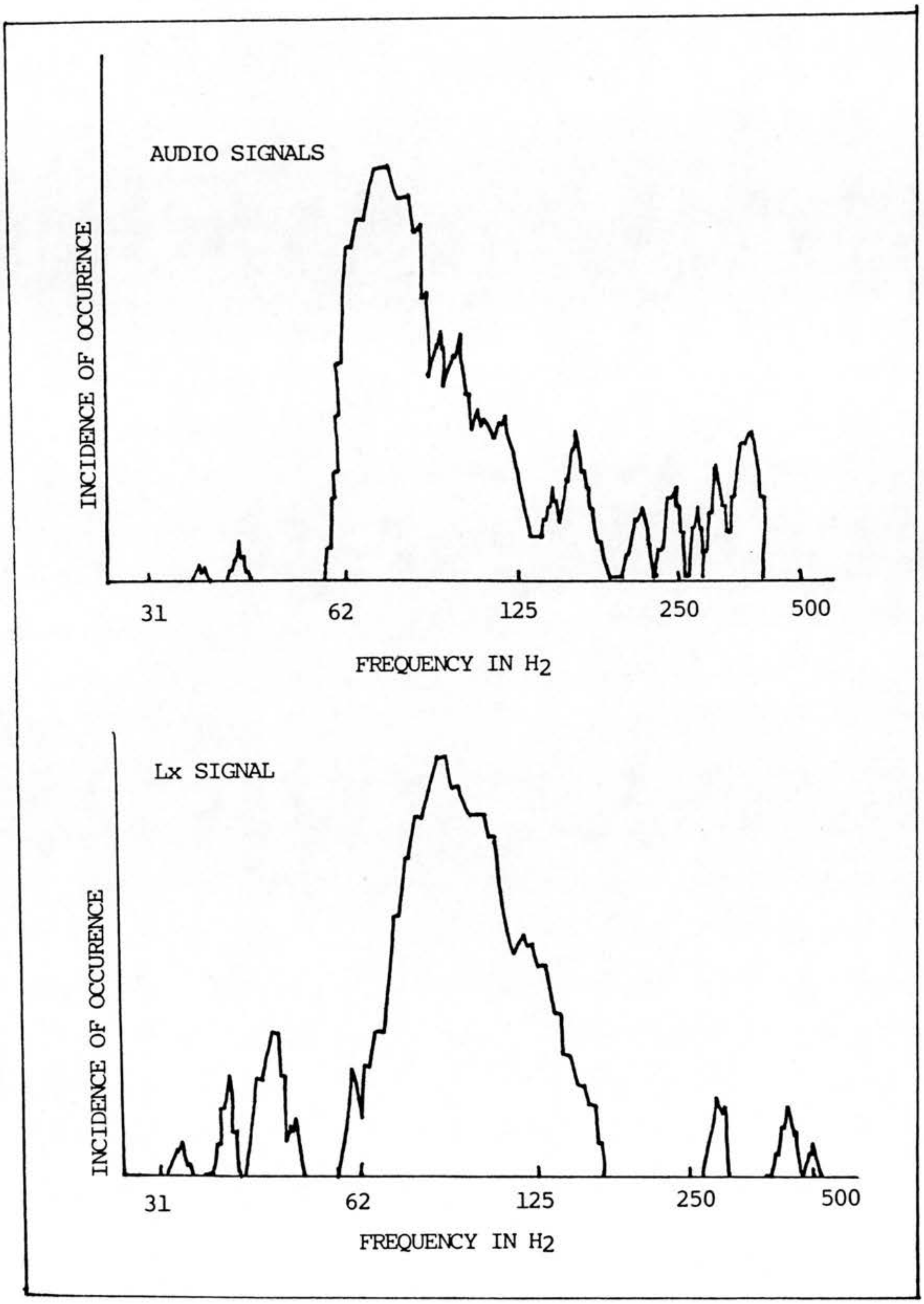
In addition, a study at Cambridge University has confirmed the reliability of the RNID speech Computer measurements (Fenn, 1984 personal communication.

3.5 STATISTICAL TREATMENT OF THE VPA RATINGS

This is a descriptive study of a wide-ranging nature. It involves perceptual ratings, frequency measurements, audiological considerations and the interrelations between these areas in a sample of 40 hearing impaired speakers. It is an integral part of this study that these cross references are both possible and achieved. The methodology has not been designed as a series of controlled experiments where careful statistical exploration of the results might have been possible. Rather, this study collected a large corpus of information about the vocal characteristics and audiological features of 40 hearing impaired speakers. The trends in these results were subjected to statistical scrutiny to determine their statistical significance.

This distinction between the use of statistics in the examination of experimental results and the use of statistics to establish the significance of trends in descriptive studies is important (Robson 1981), especially in social science types of studies such as these.

FIGURE DII EXAMPLE OF A HISTOGRAM OF MODAL PITCH DISPLAYED BY THE RNID SPEECH COMPUTER FROM Lx AND AUDIO SIGNALS



The VPA ratings of the 40 deaf and 40 hearing speakers were examined to determine the mean incidence of each VPA parameter for deaf and hearing subjects.

Chi square tests of significance were calculated for each parameter to determine the significant differences in the frequency of occurrence of the results for each parameter in the deaf and hearing groups. The null hypothesis would be, of course, that the same proportions of hearing and deaf speakers would exhibit specific non-neutral settings in their VPA ratings.

Median ratings of VPA analyses were determined for each parameter for the deaf and hearing groups. It was decided that, because ratings tend to cluster, with scalar degrees 4, 5 and 6 being used relatively infrequently, median scalar degrees would be more representative of group trends than mean scalar degrees which would be skewed by a small number of extreme ratings.

In Chapter 4 the results of this exploration of the use of VPA description for profoundly deaf speakers are given. The commonly occurring speech characteristics of deaf speakers are identified. Possible relationships between the speech characteristics of these deaf speakers and their audiological status are also examined.

Chapter 5 presents a discussion of the results and offers possible explanations for some of the findings.

CHAPTER 4

RESULTS

4.1 RESULTS OF THE LISTENING EXPERIMENT

There is anecdotal and experimental evidence to support the view that the speech characteristics of profoundly deaf Americans closely resemble the speech characteristics of profoundly deaf British speakers. In order to provide further evidence for this view a listening experiment was conducted. This experiment is described above in Chapter 3.

The experiment involved 2 groups of listeners, each with 10 members, listening to a tape, comparing recordings of 5 profoundly deaf young adult Americans and 5 profoundly deaf young adult Britons. The task required of the 20 listeners was to say whether the speaker was British or American. The tape randomly presented the men and women and British and American speakers. A copy of the form which the listeners completed is attached in Appendix IV.

Listener group 1 was a group of 10 speech therapists who all worked with hearing impaired people and who had been trained to use the VPA scheme; a group of experienced listeners.

Listener group 2 consisted of a group of fourth year undergraduate students who had completed 3 years of phonetics and linguistic courses but had only slight experience of deaf people; a semi-experienced group of listeners. The results of the listening task are presented in Table 10.

It can be seen that the experienced group were slightly better than the semi-experienced group at identifying American and British speakers, but that both groups found this task very difficult.

To explore further the ability of experienced and semi-experienced listeners to make this identification the results of the listening exercise were statistically examined.

TABLE 10

RESULTS OF A LISTENING TASK WHERE "EXPERIENCED" AND "SEMI-EXPERIENCED" LISTENERS ATTEMPTED TO IDENTIFY RECORDED SAMPLES OF PROFOUNDLY DEAF AMERICAN SPEAKERS FROM THOSE OF PROFOUNDLY DEAF BRITISH SPEAKERS

Experienced listener No.	No. correctly identified from 10 voices	Semi-experienced listener No.	No. correctly identified from 10 voices
1	5	1	3
2	6	2	5
3	5	3	4
4	6	4	2
5	5	5	6
6	4	6	5
7	7	7	4
8	5	8	3
9	6	9	4
10	5	10	5
	Gp x 5.4 T = 0.11 = 1.26 n.s.		Gp x 4.1 T = 0.19 = 3.66 n.s.

n.s. = not significant x = mean

A 2 by 2 contingency table to demonstrate association was performed for all 20 listeners. The null hypothesis was that there would be no association between the listeners' perception of speakers' nationality and the actual nationality of the speaker.

By grouping the data of the 10 experienced listeners we found that:

On 16 occasions they identified Americans when they were American

On 34 occasions they identified Americans when they were British

On 39 occasions they identified Britons when they were British

On 11 occasions they identified Britons when they were Americans.

Using a 2 by 2 probability table the strength of association for these data is T = 0.11, i.e. a very weak positive. A test of significance was then administered to this association result. The appropriate test is $\chi^2 u$ which is more appropriate than the standard $1\chi^2$ because the marginal totals are fixed (i.e. 5 were American and 5 were British, Upton 1982).

The test of significance of these data is $\chi^2 u = 1.26$ which is not significant.

In conclusion then statistical examination of these data shows that, although there is a weak association between the actual nationality of the speaker and that identified by the listener, this association is not statistically significant. This seems a very important finding from this group of 10 listeners who both worked with the deaf and had VPA training. One can say that for this particular listening task they were the most experienced group one could use. If they cannot identify profoundly deaf Americans from profoundly deaf Britons, it is unlikely that any other group would be able to do so.

In order to complete the examination of these data the result of the listening task by the 10 semi-experienced listeners was also examined.

On 21 occasions they identified Americans when they were American
On 38 occasions they identified Americans when they were British
On 29 occasions they identified Britons when they were British
On 21 occasions they identified Britons when they were Americans.

Using the same 2 by 2 probability table the strength of association for these data is T = -.19 (i.e. a weak negative). The test of significance applied to these data shows no significance ($\chi^2 u$ = 3.66).

In other words, neither the experienced nor semi-experienced listeners were able to say with statistical reliability whether a recording by a profoundly deaf speaker had been made by an American or a Briton.

This experiment supports the experiential view that the speech characteristics of profoundly deaf speakers are common and apparently outweigh sociolinguistic markers.

In the presentation of results of the perceptual ratings the VPA ratings of both Experimental Group 1 (the profoundly deaf Americans) and Experimental Group II (the profoundly deaf Britons) are presented and compared with the perceptual ratings of the control (hearing) group.

4.2 RESULTS OF THE PERCEPTUAL RATINGS OF DEAF AND HEARING SPEAKERS

Vocal profiles were completed for the 40 hearing impaired speakers in Experimental Group 1 and the 40 hearing subjects in the control group. Chapter 3 above described the way in which these profiles were completed and the derivation of the composite profile. Three experienced judges independently rated each voice. The composite profile was derived from these independent profiles in the way explained above in Chapter 3.

In this section the results of an examination of these profiles will be presented and later discussed. Typifying features of the speech of these hearing impaired people are abstracted from these profiles and discussed.

(a) Descriptive account of VPA ratings

An examination of the data contained in these 80 profiles reveals that there are considerable differences in the ratings of the hearing impaired speakers and those of the hearing speakers. The simplest way of presenting comparative information between the VPA profiles of deaf and hearing impaired subjects is to list the percentage incidence of a non-neutral setting of a parameter from Experimental Group I, and from the control group. These data are presented in Table 11.

Percentage incidence goes some way to suggesting where differences in parameters at laryngeal, supralaryngeal or prosodic settings occur between deaf and hearing speakers. In order to test the validity of these trends chi square tests were performed on paired parameters from

TABLE 11

PERCENTAGE OF HEARING AND HEARING IMPAIRED SPEAKERS IN EXPERIMENTAL GROUP I EXHIBITING NON-NEUTRAL SUPRALARYNGEAL, LARYNGEAL OR PROSODIC FEATURES AND SCALAR DEGREES OF THESE RATINGS

	CONTROL GROUP		EXPERIMENTAL GROUP I	
	Percentage of speakers exhibiting parameter	Median scalar degree	Percentage of speakers exhibiting parameter	Median scalar degree
LIP ROUNDING	45	NEUTRAL	55	R 1
LIP SPREADING	5		15	
LABIODENTALIZED	0		2.5	
EX LIP RANGE	5	NEUTRAL	25	MIN 1.5
MIN LIP RANGE	7.5		55	
CLOSE JAW	37.5	NEUTRAL	15	NEUTRAL
OPEN JAW	10		40	
PROTRUDED JAW	5	NEUTRAL	17.5	NEUTRAL
EX JAW MOVEMENT	2.5	NEUTRAL	20	MIN 2
MIN JAW MOVEMENT	12.5		60	
ADV TONGUE TIP	45	NEUTRAL	25	NEUTRAL
RETRACT TONGUE TIP	12.5		48	
FRONTED TONGUE BODY	37.5	B 1	20	B 2
BACKED TONGUE BODY	52.5		65	
RAISED TONGUE BODY	42.5	NEUTRAL	40	NEUTRAL
LOWERED TONGUE BODY	15		27.5	
EX TONGUE RANGE	0	NEUTRAL	0	MIN 4
MIN TONGUE RANGE	5		97.5	
NASAL	100	3	95	4
AUD NASAL ESCAPE	0		12.5	NEUTRAL
DENASAL	0	-	5	NEUTRAL
PHARYNG CONSTRICT	47.5	NEUTRAL	87.5	2
SUPRALAR TENSION	57.5	TENSE 1	85	TENSE 2
SUPRALAR LAX	2.5		7.5	
LARYNGEAL TENSE	72.5	TENSE 1	95	TENSE 3
LARYNGEAL LAX	0		5	
RAISED LARYNX	17.5	NEUTRAL	55	R 1
LOWERED LARYNX	30		27.5	
HARSH	25	NEUTRAL	72.5	2
WHISPER	97.5	2	92.5	3
CREAK	77.5	2	67.5	2
FALSETTO	0	NEUTRAL	20	NEUTRAL
MODAL	100	-	97.5	-
HIGH PITCH MEAN	30	NEUTRAL	40	NEUTRAL
LOW PITCH MEAN	42.5		40	
WIDE PITCH RANGE	0	NEUTRAL	7.5	N 3
NARROW PITCH RANGE	27.5		90	
HIGH PITCH VARIABILITY	0	NEUTRAL	5	LOW 3
LOW PITCH VARIABILITY	7.5		87.5	
TREMOR	25	NEUTRAL	25	NEUTRAL
HIGH LOUDNESS MEAN	17.5	NEUTRAL	10	NEUTRAL
LOW LOUDNESS MEAN	2.5		47.5	
WIDE LOUDNESS RANGE	2.5	NEUTRAL	2.5	N 2
NARROW LOUDNESS RANGE	5		90	
HIGH LOUDNESS VARIABILITY	0	NEUTRAL	0	LOW 2
LOW LOUDNESS VARIABILITY	5		90	

Experimental Group I and the control group. The chi square tests whether the difference between paired parameters is greater than chance. The null hypothesis of the chi square test in this context was that equal numbers of deaf and hearing subjects would exhibit the same ratings. Table 12 shows these results and shows that there were significant differences between deaf and hearing speakers' VPA ratings.

It can be seen from these data that the main differences between the profiles of the deaf speakers in Experimental Group I and hearing groups can be divided broadly into four groups.

1. Differences relating to the range of movements
2. Differences relating to pitch and loudness
3. Differences relating to tension
4. Differences relating to phonation type.

The VPA ratings of Experimental Group I have been described. The ratings of Experimental Group II (the British profoundly deaf group) and Experimental Group III (the British speakers with more hearing) are also presented.

With only 5 speakers in each of groups II and III percentage incidence is not a valid method of presenting results so median ratings for all 27 parameters are given for the 5 speakers in Experimental Groups II and III. These data are presented in Table 13.

It will be recalled that Experimental Group II is smaller than Experimental Group I. Comparison between the speech characteristics of profoundly deaf and hearing subjects is therefore primarily presented as a comparison between Experimental Group I and the control group.

TABLE 12

RESULTS OF A CHI SQUARE TEST OF SIGNIFICANT DIFFERENCE BETWEEN THE OCCURRENCE OF NON-NEUTRAL SETTINGS OF EACH PARAMETER BETWEEN EXPERIMENTAL GROUP I AND THE CONTROL GROUP

Parameter	Chi Square	Probability
LIP ROUNDING	.45	.50
LIP SPREADING	1.25	.26
LABIODENTALIZED	0.0	1.0
EXTENSIVE LIP RANGE	4.8	.028*
MIN LIP RANGE	18.85	.000***
CLOSE JAW	4.13	.04*
OPEN JAW	8.07	.004**
PROTRUDED JAW	2.0	.157
EXTENSIVE JAW RANGE	4.51	.033*
MIN JAW RANGE	17.53	.000***
ADVANCED TONGUE TIP	2.69	.146
RETRACTED TONGUE TIP	10.06	.001**
FRONTED TONGUE BODY	2.2	.138
BACKED TONGUE BODY	1.29	.306
RAISED TONGUE BODY	0.0	1.0
LOWERED TONGUE BODY	1.20	.274
EXTENSIVE TONGUE RANGE	.26	.608
MIN TONGUE RANGE	64.84	.000***
NASAL	.51	.474
AUDIBLE NASAL ESCAPE	3.41	.065
DENASAL	.51	.474
PHARYNGEAL CONSTRICTION	12.82	.000***
SUPRALARYNGEAL TENSION	6.10	.014*
SUPRALARYNGEAL LAXNESS	.26	.608
LARYNGEAL TENSION	5.88	.015*
LARYNGEAL LAXNESS	.51	.001**
RAISED LARYNX	10.6	.001**
LOWERED LARYNX	0.0	1.0
HARSHNESS	16.21	.0001***
WHISPER	.26	.608
CREAK	.56	.453
FALSETTO	6.81	.099**
HIGH PITCH MEAN	.49	.482
LOW PITCH MEAN	0.0	1.0
WIDE PITCH RANGE	1.39	.239
NARROW PITCH RANGE	29.71	.0000***
HIGH PITCH VARIABILITY	.51	.474
LOW PITCH VARIABILITY	42.05	.0000***
HIGH LOUDNESS MEAN	.42	.516
LOW LOUDNESS MEAN	16.53	.000***
NARROW LOUDNESS RANGE	54.59	.000***
HIGH LOUDNESS VARIABILITY	.56	.453
LOW LOUDNESS VARIABILITY	54.59	.000***

Key: *** = p < .0001 ** = p < .01 * = p < .05

TABLE 13

MEDIAN SETTINGS EXHIBITED BY SPEAKERS IN
EXPERIMENTAL GROUP II AND EXPERIMENTAL GROUP III (POST-THERAPY)

Parameter	Median scalar degree Exp Grp II	Median scalar degree Exp Grp III
LIP ROUNDING/SPREADING	R 2	R 1
LABIODENTALIZED	N	2
EX/MIN LIP RANGE	EX 1	N
CLOSE/OPEN JAW	OP 1	N
PROTRUDED JAW	N	N
EX/MIN JAW RANGE	EX 2	N
ADVANCED/RETRACT T TIP	N	N
FRONTED/BACKED T BODY	B 3	B 2
RAISED/LOWERED T BODY	N	N
EX/MIN T RANGE	MIN 2	MIN 1
NASAL/DENASAL	NASAL 4	NASAL 2
AUD NASAL ESCAPE	N	N
PHAR CONSTRICTION	3	2
SUPRALARYN TENSE/LAX	TENSE 3	TENSE 2
LARYN TENSE/LAX	TENSE 2	TENSE 1
LARYN POSITION RAISED/ LOWERED	RAISED 2	N
HARSH	2	2
WHISPER	3	2
CREAK	N	N
FALSETTO	N	N
PITCH MEAN	LOW 2	LOW 1
PITCH RANGE	NARROW 4	NARROW 1
PITCH VARIABILITY	LOW 4	LOW 1
TREMOR	N	N
LOUDNESS MEAN	N	N
LOUDNESS RANGE	N	N
LOUDNESS VARIABILITY	N	N

(b) Percentage occurrence of those parameters of the VPA where the deaf and hearing speakers differ

Comments on differences between VPA ratings of the deaf and hearing subjects have been grouped for convenience into 5 sections. Comments relating to (i) range parameters, (ii) parameters of pitch and loudness, (iii) tension parameters, (iv) laryngeal parameters, and (v) other parameters.

(i) Range parameters. The deaf speakers in Experimental Group I were markedly different from the hearing speakers in terms of the range of articulatory movement which they used:

97.5% of deaf speakers had MINIMIZED TONGUE MOVEMENT
compared with 5% hearing

60% of deaf speakers had MINIMIZED JAW MOVEMENT
compared with 12.5% hearing

55% of deaf speakers had MINIMIZED LIP MOVEMENT
compared with 7.5% hearing

In all these comparisons the chi square probability is < .001.

In 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 showed EXTENSIVE RANGE OF LIP MOVEMENTS compared with only 5% of hearing speakers.

Similarly 20% of the deaf speakers exhibited an EXTENSIVE RANGE OF JAW MOVEMENTS compared with only 2.5% of the hearing speakers.

In both these cases the chi square probability of this occurrence is also significant at < .05 level of confidence. These data suggest that the deaf speakers tended to fall into one of two groups. Either the range of movements was MINIMIZED or less commonly was EXTENSIVE. It is clear from these data that deaf speakers are highly unlikely to have a NEUTRAL setting of LIP, JAW or TONGUE MOVEMENTS. In contrast most hearing speakers have NEUTRAL settings for range of LIP, JAW or TONGUE MOVEMENTS.

It seems likely that those speakers who had a lot of emphasis in their school curriculum on speech training, i.e., the 'oral deaf', are those who have an EXTENSIVE RANGE OF LIP AND JAW MOVEMENTS and that those speakers who depend less on speech and may be embarrassed by it, i.e. non oral deaf speakers, are those whose tendency is towards MINIMIZED movement.

(ii) Parameters relating to 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% hearing speakers

47.5% of deaf speakers showed LOW LOUDNESS MEAN
compared with 2.5% hearing speakers

90% of deaf speakers showed NARROW LOUDNESS RANGE
compared with 5% hearing speakers

90% of deaf speakers showed LOW LOUDNESS VARIABILITY
compared with 5% hearing speakers

In all these comparisons the chi square probability is $< .001$.

Surprisingly the PITCH MEANS of the deaf and hearing groups were not significantly different even at $p < 0.05$ level. In the discussion following the presentation of these results a comparison will be made between these results from the perceptual study and acoustic measurements of fundamental frequency.

(iii) Parameters relating to tension. The degree of PHARYNGEAL CONSTRICTION is significantly different between the deaf and hearing speakers.

87.5% of the deaf subjects had non-neutral settings of PHARYNGEAL CONSTRICTION compared with 47.5% of the hearing speakers. The chi square probability for this is $p < .001$.

95% of the deaf had non-neutral settings of LARYNGEAL TENSION showing settings of LARYNGEAL TENSENESS. This compares with 72% of the hearing speakers who exhibited LARYNGEAL TENSENESS. The probability of this is $p < .05$.

5% of the deaf speakers showed LARYNGEAL LAXNESS but no hearing speaker was rated as having LARYNGEAL LAXNESS. The probability of this is $p < .05$.

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 speakers and the hearing speakers 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 SUPRALARYNGEAL TENSION. The difference in the occurrence of supralaryngeal tension among the deaf and hearing is significant at $< .05$ level.

(iv) Laryngeal factors. 72.5% of the deaf speakers show HARSHNESS compared with 25% of hearing speakers ($p < .001$).

This is probably interrelated with the high incidence of LARYNGEAL TENSENESS.

20% of the deaf speakers used FALSETTO while none of the hearing speakers did ($p < .001$). Both HARSHNESS and FALSETTO are highly kinesthetic laryngeal performances and it is possible that the high incidence among deaf speakers relates to this. It seems clear from the literature (e.g. Monsen 1978, Calvert 1962) that hearing impaired speakers in the absence of auditory feedback come to rely on the proprioceptive feedback which they can derive from an awareness of their oral muscle kinaesthesia. Ling (1978) feels that this over-dependence on kinaesthesia as a form of self-monitoring is responsible for the hypertense, dysphonic quality of many hearing impaired speakers.

55% of the deaf speakers had RAISED LARYNX POSITION compared with 17.5% of normals ($p < .01$). This is probably related to the high incidence of a non-neutral degree of PHARYNGEAL CONSTRICTION among the deaf.

(v) Other factors. In addition to these four categories of parameters there are two other 'isolated' parameters which have significantly different values in deaf and hearing speakers. 48% of the deaf have RETRACTED TONGUE TIP compared with only 12.5% of the hearing ($p < .001$).

The deaf too have different jaw positions from the hearing. 40% of the deaf have an OPEN JAW setting compared with only 10% of the hearing ($p < .01$). A similar trend suggesting that the deaf have a 'slacker' jaw position is demonstrated by the fact that a higher proportion of hearing speakers (37.5%) exhibited a CLOSE JAW SETTING than did the deaf (15%) ($p < .05$).

(c) Median ratings among the speakers

The percentage of deaf and hearing subjects who showed non-neutral settings for a given parameter goes some way towards indicating whether a feature is common among deaf speakers, compared with hearing speakers. Where the incidence of non-neutral settings is greater for the deaf group than for the hearing there is some justification for calling such parameters 'typifying features' of deaf speech. In the results reported above it can be seen that there are several parameters where the non-neutral settings among 40 deaf speakers was significantly different from the frequency of non-neutral settings among 40 hearing speakers.

Simple reporting of incidence of non-neutral settings does however only give information about presence or absence of a feature. It does not give any indication of how severely a feature was present; such reporting gives no indication of the scalar degree.

As described above in Chapter 3, median points for the scalar degrees shown by the 40 deaf and 40 hearing speakers were noted for each parameter. These median ratings reflect the severity of a feature rating in the group data.

The median ratings for each of the parameters were presented in Table 11 for Experimental Group I and the hearing speakers, and in Table 13 for Experimental Groups II and III. The ratings for the four groups have been extracted and are shown in Table 14.

It can be seen that the occurrence of non-neutral settings of deaf Americans and deaf British speakers is very close. This evidence. together with the results of the listening exercise reported above, add weight to the view that the speech characteristics attributable to profound deafness are more marked than (and perhaps mask) those characteristics attributable to sociolinguistic considerations.

The differences which do occur between Experimental Groups I and II are in the features concerning range of movement. In Experimental Group I most speakers exhibited minimization of lip and jaw movements. In Experimental Group II most exhibited extensive lip and jaw movements. This may be a reflection of the type of oral instruction given in schools for the deaf in the UK and USA and is a difference which will be discussed below in Chapter 5.

A further difference is in the phonation type of speakers in Experimental Group I and Experimental Group II. Speakers in Experimental Group I commonly (67%) exhibited creak as a feature of their phonation type. None of the speakers in Experimental Group II did so.

TABLE 14

MEDIAN SCALAR DEGREES OF VPA RATINGS EXHIBITED BY SPEAKERS IN CONTROL GROUP, EXPERIMENTAL GROUP I, EXPERIMENTAL GROUP II AND EXPERIMENTAL GROUP III

Parameter	Control Group	Experimental Group I	Experimental Group II	Experimental Group III (post-therapy)
LIP ROUNDING/SPREADING	N	R1	R2	R1
LABIODENTALIZED	N	N	N	2
EX/MIN LIP RANGE	N	MIN 1.5	N	N
CLOSE/OPEN JAW	N	N	OP 1	N
PROTRUDED JAW	N	N	N	N
EX/MIN JAW RANGE	N	MIN 2	EX 2	N
ADVANCED/RETRACT T. TIP	N	N	N	N
FRONTED/BACKED T. BODY	B1	B2	B3	B2
RAISED/LOWERED T. BODY	N	N	N	N
EX/MIN TONGUE RANGE	N	MIN 4	MIN 2	MIN 1
NASAL/DENASAL	NAS 3	NAS 4	NAS 4	NAS 2
AUD NASAL ESCAPE	N	N	N	N
PHAR CONSTRICTION	N	2	3	2
SUPRALARYNX TENSE/LAX	T1	T2	T3	T2
LARYNX TENSE/LAX	T1	T3	T2	T1
LARYNX POS RAISED/LOW	N	R1	R2	N
HARSH	N	2	2	2
WHISPER	2	3	3	2
CREAK	2	2	N	N
FALSETTO	N	N	N	N
PITCH MEAN LOW/HIGH	N	N	L2	L1
PITCH MEAN WIDE/NARROW	N	NAR 3	NAR 4	NAR 1
PITCH VARIAB HIGH/LOW	N	L2	L4	L1
TREMOR	N	N	N	N
LOUDNESS MEAN LOW/HIGH	N	N	N	N
LOUDNESS RANGE WIDE/NAR	N	NAR 2	N	N
LOUDNESS VARIAB HIGH/LOW	N	L2	N	N

A more graphic way of presenting these data is to display these median ratings on a VPA protocol. These protocols, for the deaf and hearing groups, are included as Figures E, F and G. Figures E_1 and E_2 can then be said to be the typifying profile of the profoundly deaf speakers in Experimental Group I and Experimental Group II and Figure F the typifying profile of the less deaf speakers in Experimental Group II. Figure G can be said to be the typifying profile of the hearing control group.

(d) Characterizing features of the VPAs of 40 deaf speakers in Experimental Group I

The data already presented are the results of the completed VPAs of 40 deaf speakers compared with 40 hearing speakers. There are several characterizing features in these data.

1. MINIMIZED MOVEMENTS of TONGUE, LIPS and JAW are markedly more common among these deaf speakers. The clear remedial implication of this is that hearing impaired speakers should be encouraged to increase their RANGES of articulatory movements. This could be most easily achieved by encouraging an increase in the number of vowel phonemes used by hearing impaired speakers.

This could involve developing a greater awareness of lip and tongue movements by the hearing impaired speaker. Thus developing an awareness of the contrastive necessity for rounded and spread vowels in English or for the front/back, high/low contrasts, a deaf speaker could be encouraged to produce and use a wider range of vowel phonemes. It

FIGURE E

VOCAL PROFILES OF PROFOUNDLY HEARING IMPAIRED SPEAKERS IN EXPERIMENTAL GROUPS I AND II, GIVING MEDIAN RATINGS FOR EACH PARAMETER.

Experimental Group I

Category	Neutral	Normal	Abnormal	Setting	Scalar Degrees
1. Labial				Lip Rounding/Protrusion	
		✓		Lip Spreading	
				Labiodentalization	
		✓		Extensive Range	
				Minimised Range	
2. Mandibular				Close Jaw	
	✓			Open Jaw	
				Protruded Jaw	
				Extensive Range	
		✓		Minimised Range	
3. Lingual Tip Blade	✓			Advanced	
				Retracted	
4. Lingual Body				Fronted Body	
		✓		Backed Body	
				Raised Body	
				Lowered Body	
			✓	Extensive Range	
				Minimised Range	
5. Velopharyngeal				Nasal	
			✓	Audible Nasal Escape	
				Denasal	
6. Pharyngeal		✓		Pharyngeal Constriction	
7. Supralaryngeal Tension		✓		Tense	
				Lax	
B. Laryngeal Features					
8. Laryngeal Tension		✓		Tense	
				Lax	
9. Larynx Position		✓		Raised	
				Lowered	
10. Phonation Type		✓		Harshness	
		✓		Whisper(y)	
		✓		Creak(y)	
				Falsetto	
			✓	Modal Voice	✓

Category	Neutral	Normal	Abnormal	Setting
1. Pitch	✓			High Mean
				Low Mean
		✓		Wide Range
				Narrow Range
		✓		High Variability
				Low Variability
2. Consistency	✓			Tremor
3. Loudness	✓			High Mean
				Low Mean
		✓		Wide Range
				Narrow Range
		✓		High Variability
				Low Variability

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1 2 3	
1. Continuity	✓			Interrupted
2. Rate	✓			Fast
				Slow

IV COMMENTS

	Adequate	Inadequate	1 2 3
Breath Support	✓		
Rhythmicality	✓		

	Present
Diplophonia	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Experimental Group II

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1 2 3 Abnormal 4 5 6
A. Supralaryngeal Features					
1. Labial				Lip Rounding/Protrusion	
		✓		Lip Spreading	
				Labiodentalization	
	✓			Extensive Range	
				Minimised Range	
2. Mandibular				Close Jaw	
		✓		Open Jaw	
				Protruded Jaw	
		✓		Extensive Range	
				Minimised Range	
3. Lingual Tip Blade	✓			Advanced	
				Retracted	
4. Lingual Body		✓		Fronted Body	
				Backed Body	
				Raised Body	
				Lowered Body	
		✓		Extensive Range	
				Minimised Range	
5. Velopharyngeal			✓	Nasal	
				Audible Nasal Escape	
				Denasal	
6. Pharyngeal		✓		Pharyngeal Constriction	
7. Supralaryngeal Tension		✓		Tense	
				Lax	
B. Laryngeal Features					
8. Laryngeal Tension		✓		Tense	
				Lax	
9. Larynx Position		✓		Raised	
				Lowered	
10. Phonation Type		✓		Harshness	
		✓		Whisper(y)	
				Creak(y)	
				Falsetto	
				Modal Voice	✓

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1 2 3
1. Pitch		✓		High Mean	
				Low Mean	
			✓	Wide Range	
				Narrow Range	
			✓	High Variability	
				Low Variability	
2. Consistency	✓			Tremor	
3. Loudness	✓			High Mean	
				Low Mean	
	✓			Wide Range	
				Narrow Range	
	✓			High Variability	
				Low Variability	

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1 2 3	
1. Continuity	✓			Interrupted
2. Rate	✓			Fast
				Slow

IV COMMENTS

	Adequate	Inadequate	1 2 3
Breath Support	✓		
Rhythmicality	✓		

	Present
Diplophonia	

Other Comments:

FIGURE F

VOCAL PROFILE OF A GROUP OF MODERATELY HEARING IMPAIRED SPEAKERS IN EXPERIMENTAL GROUP III, GIVING MEDIAN RATINGS FOR EACH PARAMETER.

Vocal Profile Analysis Protocol

Speaker: .... Sex: .... Age: .... Date of Analysis: .... Tape: .... Judge: ....

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	B	A.		Lip Rounding/Protrusion	A					
				Lip Spreading						
				Labiodentalization		A				
	AB			Extensive Range						
				Minimised Range						
2. Mandibular	AB			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	A	B.		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	A.	B.		Advanced						
				Retracted						
4. Lingual Body		A.B.		Fronted Body						
				Backed Body						
		B		Raised Body						
				Lowered Body						
		A.B.		Extensive Range						
				Minimised Range						
5. Velopharyngeal		A.B.		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		A.B.		Pharyngeal Constriction						
7. Supralaryngeal Tension		A.B.		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension				Tense						
				Lax						
9. Larynx Position	A.			Raised						
				Lowered						
10. Phonation Type		A B.		Harshness						
		A.B.		Whisper(y)						
				Breathiness						
				Creak(y)						
				Falsetto						
				Modal Voice	AB					

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Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
1. Pitch		A B		High Mean						
				Low Mean	A					
		A.B		Wide Range						
				Narrow Range						
		A.B		High Variability						
				Low Variability						
2. Consistency	AB.			Tremor						
3. Loudness	AB.			High Mean						
				Low Mean						
	A.B.			Wide Range						
				Narrow Range						
	A.B.			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees: Inadequate 1	2	3	
1. Continuity	A.B.					Interrupted
2. Rate	A.B.					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	A.B.				
Rhythmicality	A.B				

	Present	Absent
Diplophonia		A.B.

Other Comments:

KEY A = After Therapy

B = Before Therapy

FIGURE G

VOCAL PROFILE OF A GROUP OF HEARING SPEAKERS, GIVING MEDIAN RATINGS FOR EACH PARAMETER

Vocal Profile Analysis Protocol

Speaker: .... Sex: .... Age: .... Date of Analysis: .... Tape: .... Judge: ....

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS			SECOND PASS						
	Neutral	Non-neutral		SETTING	Scalar Degrees					
		Normal	Abnormal		Normal			Abnormal		
					1	2	3	4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
	✓			Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal	✓			Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
				Whisper(y)						
		✓		Creak(y)						
				Falsetto						
			✓	Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS			SECOND PASS						
	Neutral	Non-neutral		SETTING	Scalar Degrees					
		Normal	Abnormal		Normal			Abnormal		
					1	2	3	4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS		SECOND PASS			
	Adequate	Inadequate	Scalar Degrees			
			Inadequate			
			1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

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Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

appears from the data reported here that many deaf speakers will have reduced vowel systems concurrent with their reduced range of tongue, lip and law movements. This confirms the reportedly poor vowel articulation of deaf speakers in the literature (see Chapter 1 above).

2. Hearing impaired speakers show more TENSENESS at the PHARYNGEAL, SUPRALARYNGEAL and LARYNGEAL levels of the vocal tract than do hearing speakers. This increased tension appears to be related to an inability among deaf speakers to accept how little muscular effort is required for speech. Because of the hearing impaired speaker's great reliance upon kinaesthetic feedback there is a tendency to boost this kinaesthetic sensation by increasing tension. This increased tension not only affects the resonant qualities of the speaker but also interferes with ease and speed of articulatory performance and phonation. It is probable that the increased LARYNGEAL TENSION is related to the similar increased incidence of HARSHNESS, although as discussed below the ratings of tension are not as marked as one might expect if there was a simple correlation between tension and the severity of CREAK or HARSHNESS.

The remedial implications of this are clear; hearing impaired speakers must be taught to reduce thir degree of muscular tension. One way to achieve this would be to teach deaf speakers to rely on fewer kinaesthenic monitoring cues. The use of visual display techniques would be an important part of such biofeedback procedures in therapy. This will be discussed below in Chapter 5.

3. At a laryngeal level too the phonatory characteristics of the hearing impaired speakers were different from those of the hearing. The incidence and severity of HARSHNESS and CREAK are greater among the deaf group but the incidence of modal voice and the incidence and severity of WHISPER are similar for the deaf and hearing speakers. This suggests that therapy directed towards phonatory control should concentrate on reducing the degree of HARSHNESS and CREAK, by reducing LARYNGEAL TENSION by kinaesthetic training as outlined above and discussed more fully below in Chapter 5.

4. The overall larynx position was commonly in a non-neutral setting among the deaf speakers, 83% showing non-neutral position compared with 48% of the hearing speakers.

RAISED LARYNX occurred more commonly among those deaf speakers who exhibited a non-neutral setting; 55% of the deaf group compared with only 18% of the hearing. A constellation of features comprising RAISED LARYNX, non-neutral PHARYNGEAL CONSTRICTION and BACKED TONGUE BODY appears to be common among deaf speakers. This is probably attributable to increased tension of the stylohyoid and palatoglossus muscles. In this group 22 speakers showed RAISED larynx position, 35 speakers showed a non-neutral degree of PHARYNGEAL CONSTRICTION and 26 speakers showed BACKED TONGUE BODY. These data confirm the view that RAISED LARYNX settings commonly occur wth BACKED TONGUE BODY settings or non-neutral PHARYNGEAL CONSTRICTIONS or in many cases with both.

It is possible too that the perceptual reality of these 3 parameters is closely related; that a listener perceiving tension in the oral pharyngeal area tends to associate this with RAISED LARYNX. There are however some speakers, e.g. speakers 3, 7 and 35, who have BACKED

TONGUE BODY and non-neutral PHARYNGEAL CONSTRICTION but have NEUTRAL or LOWERED LARYNX POSITION. This confirms the theory of the VPA that, although these are closely related muscular settings, they are anatomically and perceptually separable.

Table 15 summarizes the distribution of these settings which appear to be closely related in determining the perceptual phenomenon of RAISED LARYNX.

5. 90% of the deaf group showed NARROW PITCH RANGE and NARROW LOUDNESS RANGE with median scalar degrees of 3 and 2 respectively. Surprisingly the incidence of non-neutral PITCH MEAN of the deaf and the controls was very similar (49% of the deaf had HIGH PITCH MEAN compared with 30% of controls). 40% of the deaf showed LOW PITCH MEAN as did 42.5% of the controls.

One might have anticipated that deaf speakers would have had dissimilar PITCH MEAN but this was not the case. The dissimil arity was in the very NARROW PITCH RANGE and LOW PITCH VARIABILITY of the deaf speakers. For the loudness parameters there was a very high incidence (90%)of NARROW LOUDNESS RANGE among the deaf speakers and marked incidence of LOW LOUDNESS MEAN (47.5% of the deaf speakers compared with only 2.5% of the controls).

4.3 RESULTS OF FUNDAMENTAL FREQUENCY MEASUREMENTS AND RATINGS

In Section 4.2 the long-term articulatory setting of profoundly hearing impaired speakers were compared with the settings of hearing speakers and the effects which these different settings have upon voice

TABLE 15

DISTRIBUTION OF VPA SETTINGS WHICH APPEAR TO BE CLOSELY RELATED IN DETERMINING THE PERCEPTUAL PHENOMENON OF 'RAISED LARYNX'

Parameter	Scalar degree							Group median
	N	1	2	3	4	5	6	
Raised larynx	7	7	13	2	0	0	0	Raised 1
Lowered larynx		5	2	3	1	0	0	
Pharyngeal constriction	5	6	10	10	7	2	0	2
Backed tongue body		2	11	8	4	0	1	Backed 2
Fronted tongue body		0	6	2	0	0	0	

quality was outlined. In addition to examining the setting and consequent voice quality characteristics of hearing impaired speakers, their pitch characteristics were also examined. The procedure used to examine these pitch characteristics was described above and the results are described here.

The results of the fundamental frequency measurements are presented in two sections. The first concerns those measurements which relate to the central tendencies of the speaker's speech. The central tendencies which were measured were the mean fundamental frequency, the median fundamental frequency, and the modal fundamental frequency. The second group of results presents data relating to the range features, specifically the range of fundamental frequency between the tenth and ninetieth percentiles, between the twenty-fifth and seventy-fifth percentiles and the standard deviation of the range used by each speaker.

It was of course necessary to separate these results of both central tendencies of fundamental frequency and the fundamental frequency range features into the male and female results. There were among the 40 speakers in Experimental Group I 13 hearing impaired female speakers and 27 hearing impaired male speakers. As was discussed in Chapter 3 above there is a higher incidence of hearing loss among males and a higher number attending higher education.

(a) Results of measured central tendencies of fundamental frequency (Fo)

The Fo means of the 13 hearing impaired female speakers ranged from 193 Hz to 359 Hz.

The median frequency ranged from 223 Hz to 389 Hz.

The modal frequency ranged from 230 Hz to 411 Hz.

The Fo characteristics of these 13 speakers are presented in Table 16. These measurements of means, median and modal frequencies were then compared with the perceptual ratings of PITCH MEAN.

An examination of the 13 female speakers reveals that those frequencies which are measurably higher are also rated as being higher. This is especially clear when comparing perceptual ratings of PITCH MEAN to measurements of median or mean frequencies.

To summarise the data presented in Table 16, it can be seen that the medial frequencies ranged from

223 - 264 Hz	rated LOW	n = 3
236 - 257 Hz	rated NEUTRAL	n = 2
279 - 389 Hz	rated HIGH	n = 8

and mean frequencies

216 - 256 Hz	rated LOW	n = 3
193 - 212 Hz	rated NEUTRAL	n = 2
269 - 359 Hz	rated HIGH	n = 8

These data are graphed in Figure H.

The measurements of modal frequency correlated less clearly with perceptual ratings of PITCH MEAN than did median or mean frequency measures.

It is interesting that 8/13 of the female speakers were rated as having HIGH PITCH and only 3/13 were rated LOW PITCH. This is reversed in the ratings of the male speakers, where 13/27 were rated LOW and only

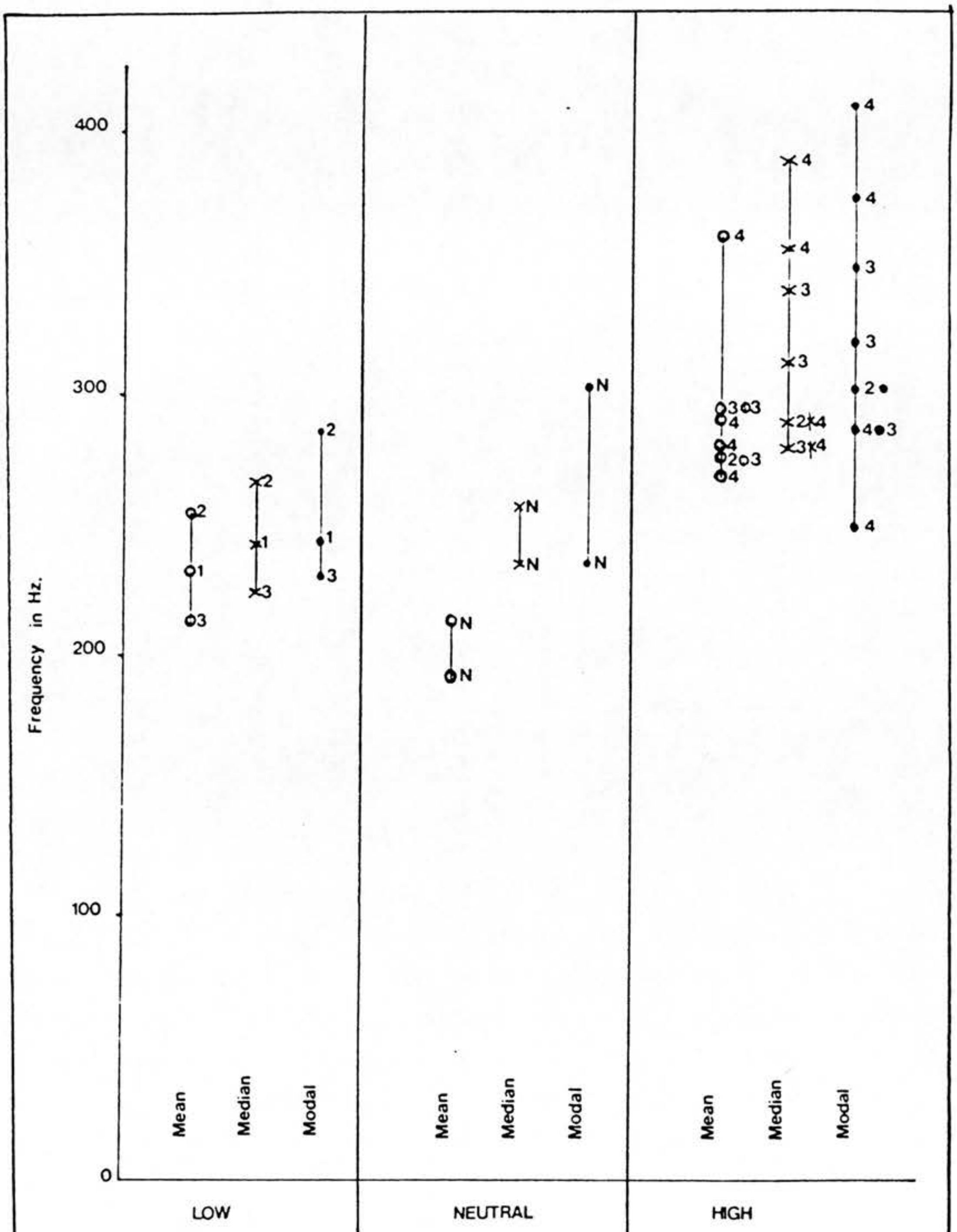
TABLE 16

RELATIONSHIP BETWEEN THE MEASUREMENTS OF FUNDAMENTAL FREQUENCY AND RATINGS OF PITCH MEAN - 13 FEMALE HEARING IMPAIRED SPEAKERS

Speaker No.	Mean frequency	Median frequency	Modal frequency	Perceived pitch Low	N	High
42	193	236	236		N	
71	212	257	303		N	
23	216	223	230	3		
40	236	243	243	1		
35	256	264	287	2		
67	269	279	287			4
1	275	279	287			3
4	275	287	303			2
16	278	287	250			4
34	291	354	375			4
48	293	339	348			3
26	294	312	320			3
2	359	389	411			4

FIGURE H

RELATIONSHIP BETWEEN THE MEASURED CENTRAL TENDENCIES OF Fo AND VPA RATINGS OF PITCH MEAN - 13 HEARING IMPAIRED FEMALE SPEAKERS



KEY:- mean Fo measurement
median Fo measurement
modal Fo measurement
4,3, etc refer to VPA rating of PITCH MEAN

8/27 were rated HIGH PITCH. This suggests that expectancy may play a part in the rating of PITCH MEAN; this point will be discussed in Chapter 5.

The Fo means, medians and modes for the female speakers did then show a general tendency to correlate with ratings of PITCH MEAN. But despite this general trend there was no relationship between measurements of Fo and scalar degrees of pitch ratings on the VPA, e.g. Speaker No. 2 was rated HIGH MEAN 4 and had a mean frequency of 359 Hz whereas Speaker No. 16 was also rated HIGH MEAN at scalar degree 4 and had a considerably lower mean frequency of 269 Hz.

When these measurements of fundamental frequency for the 13 hearing impaired female speakers are compared with the measurements of young hearing adult females the results show that the female speakers in this study had higher fundamental frequency measurements.

To calculate group mean fundamental frequency measurements for a group of only 13 speakers seems rather artificial; however, in order to compare the fundamental frequency measurements of these female speakers with the measurements of hearing females in the literature such a mean is necessary.

The group mean fundamental frequency for this group of 13 hearing impaired speakers was 265 Hz. This compares with measurements of young adult hearing females by Hollien and Paul (1969) of 212 Hz.

Among the speakers rated LOW this poor relationship between measurement and pitch ratings also prevailed, e.g. Speaker No. 35 was rated as having a LOW MEAN PITCH at scalar degree 2, and had a measured mean frequency of 256 Hz, whereas Speaker No. 40, who was also rated to have a LOW MEAN PITCH but rated less low at scalar degree 1, had a lower measured mean frequency of 236 Hz.

A similar examination of the 27 male speakers shows that there is a trend for higher frequencies to be perceived HIGH and lower frequencies to be perceived LOW among male speakers. Table 17 presents the measured central tendencies of frequencies for the 27 speakers and relates these tendencies to perceived levels. This trend for lower frequencies to be rated LOW and vice versa was not true of all the speakers. For some it was difficult to see what distinguished HIGH PITCH ratings from LOW PITCH ratings, e.g. Speaker No. 54 had a mean frequency of 246 Hz and yet was perceived to have a LOW MEAN PITCH at scalar degree 2, whereas Speaker No. 6 had a mean frequency of 240 Hz and was perceived to have HIGH MEAN PITCH at scalar degree 5.

The mean frequencies for these 27 male hearing impaired speakers can be summarized thus:

Mean frequencies ranged from

125 to 246 Hz for those speakers rated LOW	n = 13
147 to 298 Hz for those speakers rated NEUTRAL	n = 5
171 to 253 Hz for those speakers rated HIGH	n = 8

Median frequencies ranged from

121 to 243 Hz for those speakers rated LOW	n = 13
143 to 302 Hz for those speakers rated NEUTRAL	n = 5
160 to 257 Hz for those speakers rated HIGH	n = 8

TABLE 17

RELATIONSHIP BETWEEN THE MEASUREMENTS OF FUNDAMENTAL FREQUENCY AND RATINGS OF PITCH MEAN - 27 MALE HEARING IMPAIRED SPEAKERS

Speaker No.	Mean frequency	Median frequency	Modal frequency	Perceived pitch Low	N	High
22	125	121	121	3		
9	133	125	125	1		
15	147	143	125		N	
7	149	143	139	2		
39	155	147	143	1		
62	160	164	174		N	
49	164	156	143		N	
59	166	160	164		N	
44	171	160	128			1
36	172	169	169	2		
19	174	151	125	2		
3	175	160	156	1		
64	178	169	147	2		
8	178	174	174	1		
5	180	169	160	2		
57	186	205	211			1
24	192	200	211			2
60	195	257	264			4
47	200	236	243			4
31	201	211	211			4
52	205	194	189	2		
33	210	223	118	3		
41	219	230	236			2
6	240	243	250			5
54	246	243	236	2		
46	253	257	271			4
51	298	302	498		N	

As with the female speakers there is a trend for those speakers who have higher pitch measurements to be rated higher by the judges completing the VPA. This trend is graphed in Figure I.

The Fo measurements for both male and female speakers indicate a lack of consistency between the scalar degrees of the ratings of pitch mean and the measurements of Fo. For example, Speaker No. 33 was rated LOW scalar degree 3 yet he has one of the highest mean and median pitch measurements at 210 Hz and 223 Hz respectively.

This lack of correlation between ratings of pitch on the VPA and measurements of pitch leads to the suggestion that our perception of pitch is far wider and more complex than the perception of a single parameter such as pitch mean or median or modal pitch. A discussion of the contributory factors to this lack of correlation will be given in Chapter 5 below.

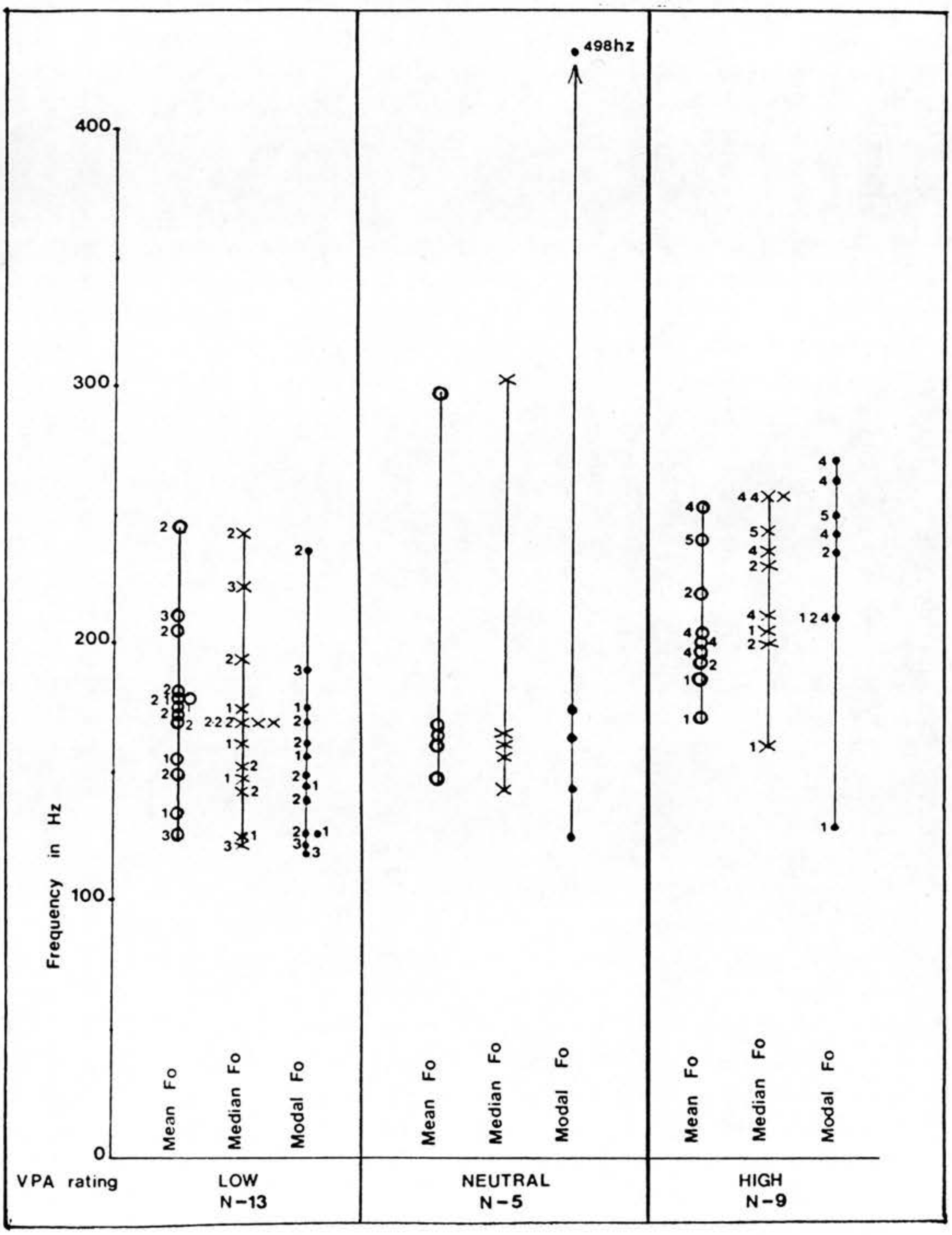
Before leaving these results of the fundamental frequency characteristics of those 40 hearing impaired speakers, several general points can be made.

Firstly there is a clear distinction in these data between the fundamental frequency characteristics of the male and female hearing impaired speakers. The female speakers have higher measurements (of mean median and mode) of fundamental frequency than do the males.

The median fundamental frequency measurement of these 13 female speakers is 275 Hz compared with 178 Hz for the males. (Median points are considered more useful than mean values for these relatively small groups.) In other words the expected sex difference in perceived pitch between profoundly deaf male speakers and profoundly deaf female speakers is the same as that between hearing people.

FIGURE I

RELATIONSHIP BETWEEN THE MEASURED CENTRAL TENDENCIES OF Fo AND RATINGS OF PITCH MEAN - 27 HEARING IMPAIRED MALE SPEAKERS



KEY: Mean Fo measurement
Median Fo measurement
Modal Fo measurement
3,4 etc refer to VPA rating of PITCH MEAN

When the fundamental frequency characteristics of this group are compared with those of hearing speakers it can be seen that they differ. The mean Fo for this group of 13 hearing impaired female speakers was 265 Hz and for this group of 27 hearing impaired male speakers 188 Hz. These mean Fo measurements are slightly higher than those reported by Gilbert and Campbell (1980). Their study was discussed in Chapter 1 above. Their mean speaking fundamental frequencies for female hearing impaired speakers aged 16-25 years was 242 Hz, i.e. 23 Hz lower than the mean of the young women in this study. The measurements of mean Fo for the male speakers are considerably higher than those reported by Gilbert and Campbell: 188 Hz compared with Gilbert and Campbell's 142 Hz. The present study, like Gilbert and Campbell's, finds the mean fundamental frequency measurements to be higher than that which one would expect of hearing young people. Hollien and Paul (1969), reported above, found the mean speaking fundamental frequency for 17 year-old females to be 212 Hz and Hollien and Shipp (1972) the mean speaking fundamental frequency for 20-29 year-old men to be 120 Hz.

These figures in the literature of mean speaking fundamental frequency can be summarized. This summary is presented in Summary Chart 2. The differences between the results of the present study and those of Gilbert and Campbell will be discussed in Chapter 5.

Summary Chart 2: Fo measurements from the literature

Study	Age (years)		Sex	Mean Speaking Fo
Hollien and Shipp (1969)	17	hearing	F	212 Hz
Hollien and Shipp (1972)	20-29	hearing	M	120 Hz
Gilbert and Campbell (1980)	16-25	hearing impaired	F	242 Hz
Gilbert and Campbell (1980)	16-25	hearing impaired	M	142 Hz
Present study	18-23	hearing impaired	F	265 Hz
Present study	18-23	hearing impaired	M	188 Hz

(b) Results of frequency range measurements and ratings

In addition to examining the perceived and measured mean scores, the relationship between measurements of Fo range and perception of pitch range was examined.

The great majority (11 out of 13) of the deaf female speakers were perceived to have a NARROW PITCH RANGE with LOW VARIABILITY OF PITCH. Only 2 were perceived as having a WIDE RANGE with HIGH VARIABILITY or NARROW RANGE and HIGH VARIABILITY. An examination of ratings, by VPA users, of pitch range and pitch variability suggests that there may be 'perceptual set' whereby having made the judgement of NARROW RANGE the listener anticipates LOW VARIABILITY and vice versa, that a judgement of WIDE RANGE is associated with HIGH VARIABILITY.

The way in which range scores were measured was to determine the range of frequencies lying between the 10th and 25th percentiles of an individual's frequency range. Thus, one individual, Speaker No. 34, has a range of 272 Hz between the 10th and 90th percentiles. In comparison, Speaker No. 40 has only a range of 41 Hz between the same percentiles. A table of these range scores is displayed in Table 18 and Figure J.

Two measures of frequency ranges were made: measurements of the range of frequencies between the 10th and 90th percentiles and secondly measurements of the range of frequencies between the 25th and 75th percentiles.

There are only 2 female speakers who were rated as having HIGH VARIABILITY; this makes comparisons between measurements of range and ratings of range difficult, because of a lack of data.

What is clear is that there is little relationship between measured range scores (between either the 90th and 10th percentiles or the 25th and 75th percentiles) and ratings of the degree of NARROW RANGE. Nor is there a clear relationship between measured range scores and ratings of LOW VARIABILITY.

Comparisons of the measurements of fundamental frequency range and ratings of PITCH RANGE were also made for 27 male hearing impaired speakers.

The two measurements of fundamental frequency range did not seem to relate to perceived RANGE or VARIABILITY. Speakers with very wide ranges of pitch between the 10th and 90th percentiles, e.g. Speaker No. 3 with a range of 289 Hz or Speaker No. 64 with a range of 278 Hz between the 10th and 90th percentiles, were rated as having NARROW PITCH RANGE and LOW VARIABILITY. Table 19 presents the data relating measurements of Fo range to rating of PITCH RANGE for the 27 male speakers. These data are graphed in Figure K.

TABLE 18

RELATIONSHIPS BETWEEN MEASUREMENTS OF FUNDAMENTAL FREQUENCY RANGE AND RATINGS OF PITCH RANGE AND VARIABILITY FOR 13 HEARING IMPAIRED FEMALE SPEAKERS

Speaker No.	Range between 10th and 90th percentiles	Range between 25th and 75th percentiles	SD	Perceived range			Perceived variability		
				Wide	N	Narrow	High	N	Low
40	41 Hz	20 Hz	7.2			2			1
23	54 Hz	25 Hz	10.2			3			3
1	77 Hz	38 Hz	7.5			3			2
16	86 Hz	46 Hz	9.1	3			3		
4	96 Hz	63 Hz	8.9			2			1
35	115 Hz	65 Hz	10.7			4			3
26	128 Hz	69 Hz	9.9			2			1
16	161 Hz	98 Hz	12.0	4			3		
2	171 Hz	63 Hz	8.2			2			2
42	221 Hz	90 Hz	18.8			3		N	
48	222 Hz	63 Hz	17.2			4			4
71	242 Hz	109 Hz	19.5			1		N	
34	272 Hz	145 Hz	16.2			2			2

FIGURE J

RELATIONSHIP BETWEEN MEASUREMENTS OF FUNDAMENTAL FREQUENCY RANGE AND RATINGS OF PITCH RANGE FOR 13 HEARING IMPAIRED FEMALE SPEAKERS

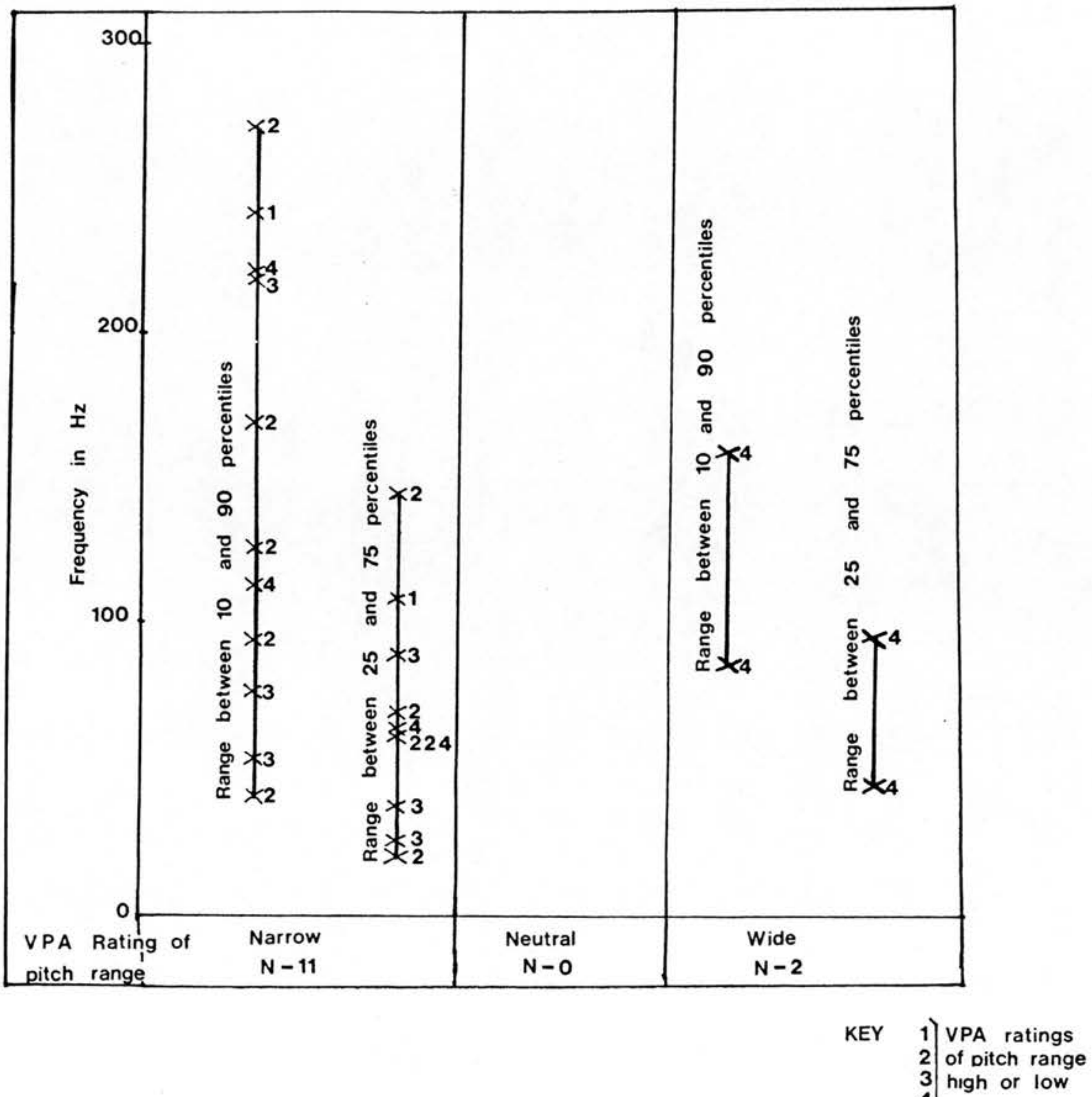


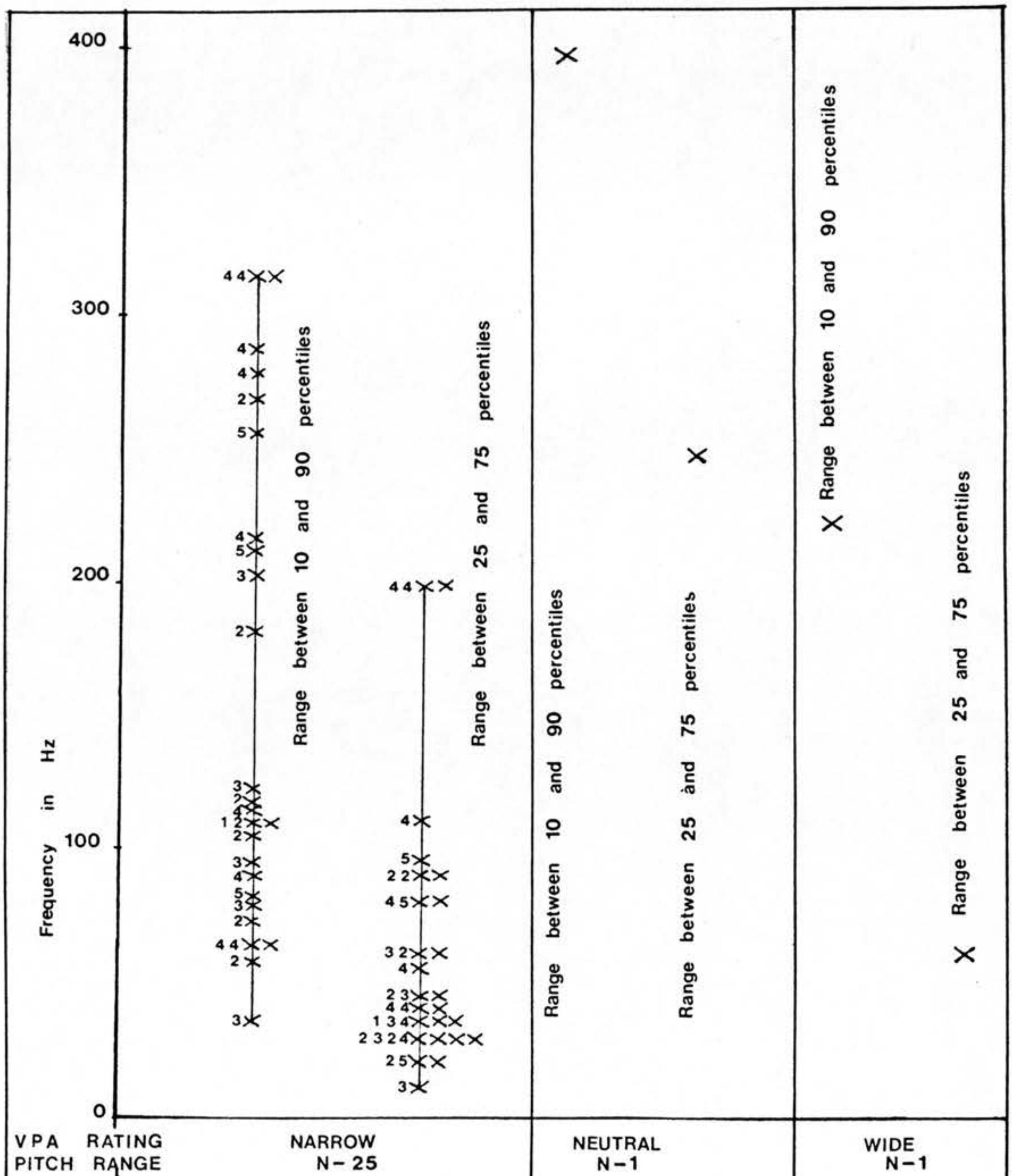
TABLE 19

RELATIONSHIPS BETWEEN MEASUREMENTS OF FUNDAMENTAL FREQUENCY RANGE
AND RATINGS OF PITCH RANGE AND VARIABILITY
FOR 27 HEARING IMPAIRED MALE SPEAKERS

Speaker No.	Range between 10th and 90th percentiles	Range between 25th and 75th percentiles	SD	Perceived range			Perceived variability		
				Wide	N	Narrow	High	N	Low
22	36 Hz	10 Hz	7.6			3			3
9	58 Hz	21 Hz	8.8			2			1
46	64 Hz	36 Hz	5.9			4			4
8	66 Hz	30 Hz	6.7			4			4
41	73 Hz	32 Hz	9.2			2			2
15	79 Hz	36 Hz	9.5			3			2
36	82 Hz	23 Hz	9.6			5			4
6	90 Hz	41 Hz	7.9			4			3
7	96 Hz	32 Hz	11.4			3			1
57	105 Hz	33 Hz	10.9			2			2
59	111 Hz	45 Hz	11.3			2			2
39	112 Hz	37 Hz	12.3			1			1
54	115 Hz	41 Hz	8.0			4			4
44	118 Hz	61 Hz	11.6			2			1
24	122 Hz	61 Hz	13.2			3			1
19	182 Hz	91 Hz	13.2			2			2
52	202 Hz	44 Hz	13.6			3			3
62	213 Hz	80 Hz	17.7			5			5
47	216 Hz	56 Hz	17.8			4			4
31	224 Hz	62 Hz	14.8	5			3		
5	257 Hz	96 Hz	17.9			5			5
49	269 Hz	91 Hz	18.5			2			4
64	278 Hz	80 Hz	17.1			4			4
3	287 Hz	111 Hz	18.4			4			3
33	315 Hz	199 Hz	19.5			4			4
60	316 Hz	199 Hz	23.9			4			4
51	399 Hz	247 Hz	17.8		N			N	

FIGURE K

RELATIONSHIP BETWEEN MEASUREMENTS OF FUNDAMENTAL FREQUENCY RANGE SCORES AND RATINGS OF PITCH RANGE FOR 27 MALE HEARING IMPAIRED SPEAKERS



KEY: 5) 4) 3) 2) 1) VPA Rating of PITCH RANGE

It is interesting that the majority of hearing impaired speakers were perceived to have a NARROW PITCH RANGE and LOW VARIABILITY regardless of the measured reality. This suggests that, despite the attempts at objectivity in perception of PITCH MEAN through the VPA, this was not fully achieved for male speakers either in the perception of PITCH MEAN or PITCH RANGE.

4.4 RESULTS OF INTELLIGIBILITY RATINGS

The results of the intelligibility ratings of the three groups of hearing impaired speakers are presented in four ways.

(a) Relationships between frequency measurements and intelligibility ratings

(b) Relationship between phonation type and intelligibility ratings

(c) Relationships between tension features and intelligibility ratings

(d) Relationship between supralaryngeal features and intelligibility ratings

All hearing impaired speakers were given intelligibility ratings. Three judges independently rated a speaker's reading passage using the following scale:

5 = 100% of words understood (despite some articulatory difficulty)

4 = about 75% of words understood

3 = about 50% of words understood

2 = about 25% of words understood

1 = nothing was fully understood, maybe occasional words

A mean of the 3 independent judgements was then found and used. As described in Chapter 2, this procedure had been found to have high agreement among trained judges (Whitehead and Subtelny 1976). The judges used in this study were trained judges, from NTID, with inter-judge reliability of greater than 92%. The intelligibility ratings of the speakers were as follows:

Rating	Exp. Group I (n = 40)	Exp. Group II (n = 5)	Exp. Group III n ?
5 (wholly intelligible)	0	0	0
4	5	1	3
3	15	2	1
2	15	2	0
1 (wholly unintelligible)	5	0	0

This distribution of intelligibility ratings is as one would predict for speakers with these degrees of hearing loss. The profoundly deaf (Groups I and II) would have the majority of their number with poor intelligibility and those with more hearing (Group III) would have better intelligibility. Stuckless and Birch (1966), Martony (1968), among others, have shown that the degree of hearing loss is the most important factor in determining the intelligibility of hearing impaired speakers.

An examination of the results was made to see if there was a relationship between intelligibility and:

pitch characteristics, or

phonation type characteristics, or

supralaryngeal factors, or

temporal characteristics.

The results of this search for relationships are described below.

(a) Intelligibility ratings related to frequency measurements

The hypothesis preceding this examination was that there might be a trend for those speakers who were rated as having more intelligible speech (those rated intelligibility 4 or 3) to have more 'normal' fundamental frequency characteristics. Both male and female hearing impaired speakers of Experimental Group I in the current study had higher Fo measurements than the speakers with normal hearing reported by Hollien (above pages 172-73).

Comparisons between measurements of fundamental frequency (mean frequency and median frequency) and ratings of intelligibility are presented in Table 20 for female hearing impaired speakers and Table 21 for male hearing impaired speakers. They are graphed in Figure L.

There are several points which were apparent in this comparison of fundamental frequency measurements and intelligibility ratings. Among the male speakers there is a clear relationship between higher mean fundamental frequency and low intelligibility scores. All 3 male speakers with intelligibility ratings of 4 are among the 9 speakers with the lowest mean Fo and conversely the 5 male speakers with

TABLE 20

RELATIONSHIP BETWEEN INTELLIGIBILITY RATINGS AND FUNDAMENTAL FREQUENCY MEASUREMENTS FOR 13 HEARING IMPAIRED FEMALE SPEAKERS

Speaker No.	Mean frequency	Intelligibility rating
42	193	3
71	212	4
23	216	2
40	236	3
35	256	2
67	269	4
1	275	3
4	275	3
16	278	3
34	291	2
48	293	3
26	294	3
2	359	2

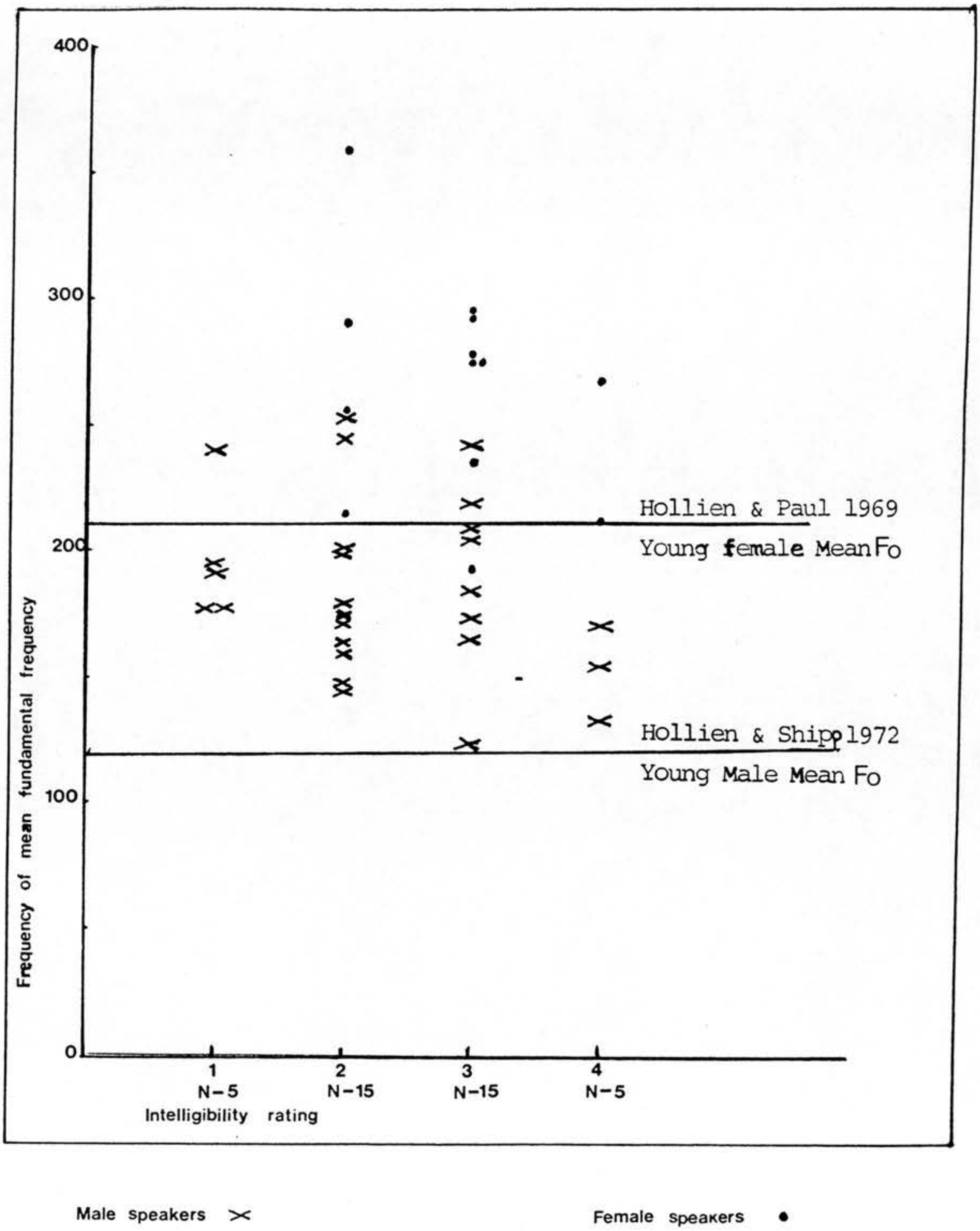
TABLE 21

RELATIONSHIP BETWEEN INTELLIGIBILITY RATINGS AND FUNDAMENTAL FREQUENCY MEASUREMENTS FOR 27 HEARING IMPAIRED MALE SPEAKERS

Speaker No.	Mean frequency	Intelligibility rating
22	125	3
9	133	4
15	147	2
7	149	2
39	155	4
62	160	2
49	164	2
59	166	3
44	171	4
36	172	2
19	174	3
3	175	2
64	178	1
8	178	1
5	180	2
57	186	3
24	192	1
60	195	1
47	200	2
31	201	2
52	205	3
33	210	3
41	219	3
6	240	1
54	246	2
46	253	2
51	298	3

FIGURE L

RELATIONSHIP BETWEEN INTELLIGIBILITY RATINGS AND Fo MEASUREMENTS FOR 40 HEARING IMPAIRED SPEAKERS



intelligibility ratings of only 1, are among the 15 speakers with higher Fo mean measurements. These 5 speakers all had mean Fo of at least 55 Hz higher than the mean Fo reported by Hollien (1972) for hearing speakers.

Although this relationship between intelligibility rating and mean Fo is clear for the most and the least intelligible speakers, it is less clear-cut among those speakers with intelligibility ratings of 2 and 3. There are speakers with intelligibility ratings of 2 and 3 with low Fo scores and others with high Fo scores. This suggests that high Fo may contribute to poor intelligibility but that other parameters have a greater effect on intelligibility than Fo alone.

This result is confirmed by Fo mean measurements of Experimental Group III. All three male hearing impaired speakers in Experimental Group III had low mean Fo and high intelligibility ratings.

The comparison between fundamental frequency measurements and intelligibility ratings for female hearing impaired speakers is less clear-cut. This is partly attributable to the fact that there are fewer female speakers and therefore fewer speakers with a range of intelligibility ratings. For example <u>no</u> hearing impaired female speaker was rated as having an intelligibility rating of 1. The second reason why there cannot be a clear relationship between mean Fo and intelligibility ratings for the female speakers is that there is less spread of the mean Fo among the female speakers than among the male speakers.

(b) Intelligibility ratings related to phonation type

The results were further investigated to determine any relationships between intelligibility ratings and phonation type. In order to do this the speakers in Experimental Group I were grouped on the basis of their intelligibility ratings and characterizing trends were sought in the phonation types they used. These data are presented in Tables 22 and 23a.

An examination of the relationships between intelligibility ratings and phonation type indicates that there is a trend for less intelligible speakers to have ratings further from neutral than do more intelligible speakers. Table 22 reports the raw data and Table 23a the distribution of degrees of phonation type between the less and the more intelligible speakers. Among those speakers who were less intelligible (rated 1 or 2) non-neutral ratings of phonation features tend to be more marked than the ratings for speakers who were more intelligible (ratings of 3 or 4).

The incidence of HARSHNESS, WHISPER and CREAK is similar for the two groups, but the less intelligible speakers have higher VPA ratings for these parameters. It will also be noted that the 7 speakers who used FALSETTO voice were all in the less intelligible group.

An examination of phonation type used by Experimental Group III confirms this finding that more intelligible speakers will have less marked non-neutral phonation settings than speakers who are less intelligible. These data are presented in Table 23b. A further way of examining this finding is to look at the pre- and post-therapy ratings of Experimental Group III.

TABLE 22

RELATIONSHIP BETWEEN INTELLIGIBILITY RATINGS AND VPA RATINGS OF PHONATION TYPE

	Speaker	Harshness	Creak	Whisper	Falsetto
Intelligibility 1	6	3	2	2	/
	8	3	2	3	x
	24	4	0	4	x
	64	0	0	3	x
	60	4	3	0	/
Intelligibility 2	36	1	0	1	x
	15	0	1	3	x
	7	0	1	3	x
	34	2	3	1	/
	31	4	4	3	/
	5	4	3	2	x
	2	2	0	3	/
	3	0	3	2	x
	54	5	5	3	x
	35	0	0	4	x
	23	3	3	3	x
	47	3	3	3	/
	46	3	0	3	/
	62	3	3	4	x
	49	3	3	4	x
	A	2	2	3	x
	B	0	0	3	x
Intelligibility 3	40	0	2	0	x
	1	2	1	2	x
	26	2	2	0	x
	4	0	2	0	x
	19	2	2	1	x
	22	0	2	2	x
	16	3	0	2	x
	33	0	3	4	x
	42	2	3	2	x
	52	3	3	3	x
	57	2	3	2	x
	41	2	2	2	x
	48	3	3	0	x
	59	0	3	3	x
	51	2	3	0	x
	C	2	0	2	x
	E	2	0	3	x
	X	0	3	2	x
Intelligibility 4	39	1	0	2	x
	67	3	4	2	x
	9	2	2	1	x
	44	0	2	0	x
	71	1	3	0	x
	V	0	0	2	x
	W	0	0	3	x
	Y	2	0	2	x
	D	2	0	2	x
	Z	0	0	2	x

x = no falsetto
/ = falsetto

TABLE 23a

RELATIONSHIP BETWEEN VPA RATINGS OF PHONATION TYPE AND INTELLIGIBILITY IN EXPERIMENTAL GROUP I

20 speakers rated 1 or 2 re intelligibility

	Phonation type				
VPA rating	HARSH	CREAK	WHISPER	TOTAL	FALSETTO
5	1	1	-	2	-
4	4	1	4	9	-
3	7	8	10	25	-
2	2	2	3	7	-
1	1	2	2	5	7
NEUTRAL	5	6	1	12	13

20 speakers rated 3 or 4 re intelligibility

	Phonation type				
VPA rating	HARSH	CREAK	WHISPER	TOTAL	FALSETTO
5	-	-	-	-	-
4	-	1	1	2	-
3	4	8	2	14	-
2	8	8	8	24	-
1	2	1	2	5	-
NEUTRAL	6	2	7	15	20

TABLE 23b

RELATIONSHIP BETWEEN VPA RATINGS OF PHONATION TYPE AND INTELLIGIBILITY IN EXPERIMENTAL GROUP III

VPA rating	HARSH	CREAK	WHISPER	FALSETTO
5				
4				
3	√		√√x√	
2	√√√√	x	xxxx√√	
1	x	√		
NEUTRAL	xxxx	√√√√ xxxx		√√√√√ xxxxx

n = 5 speakers
Intelligibility ratings: √ pre-therapy - 3 3 3 4 5
x post-therapy - 3 4 4 4 5

It can be seen that in all cases except one post-therapy ratings were the same or less for harshness and whisper. The exception, that speaker whose post-therapy rating of creak was greater after therapy, was also the speaker with the lowest intelligibility rating. These data are also presented in Table 23b.

(c) Intelligibility ratings related to tension features

The relationship between intelligibility ratings and tension features was also examined. These raw data are presented in Table 24 and the distribution of tension features related to intelligibility in Table 25a. There does not appear to be any difference in the distribution of tension features between the more and less intelligible speakers.

It was anticipated that less intelligible speakers, who as was reported above have more severe VPA ratings of HARSHNESS and CREAK, might also have higher tension scores. The results show that the distribution of PHARYNGEAL and SUPRALARYNGEAL TENSION was very similar between the less and more intelligible speakers in Experimental Group I. There was a slight trend for less intelligible speakers to have greater LARYNGEAL TENSION but this trend was not marked. When the tension ratings of speakers in Experimental Group III are examined it can be seen that there is only one rating (pre-therapy pharyngeal constriction) in the non-normal range. Ratings of laryngeal tension are consistently low (pre- and post-therapy) adding confirmation to the suggestion made above that more intelligible speakers have lower laryngeal tension. Compared with the less intelligible speakers in Table 25a, these

TABLE 24

RELATIONSHIP BETWEEN INTELLIGIBILITY RATINGS AND VPA RATINGS OF TENSION FEATURES FOR HEARING IMPAIRED SPEAKERS

	Speaker No.	Laryngeal tension	Supralaryngeal tension	Pharyngeal tension
Intelligibility 1	6	3	1	1
	8	Lax 2	Lax 3	2
	24	4	4	N
	64	1	N	3
	60	3	5	3
Intelligibility 2	36	2	2	1
	15	3	2	3
	7	2	N	2
	34	3	2	1
	31	2	1	2
	5	5	2	0
	2	3	3	2
	3	4	3	3
	54	5	2	4
	35	Lax 2	2	3
	23	3	3	3
	47	4	3	4
	46	4	3	4
	62	4	5	4
	49	4	5	3
	A	3	3	3
	B	3	3	4
Intelligibility 3	40	2	2	1
	1	2	3	0
	26	2	1	0
	4	1	2	1
	19	1	2	2
	22	1	Lax 1	1
	16	4	0	0
	33	4	4	4
	42	2	3	3
	52	2	3	3
	57	2	Lax 1	3
	41	4	4	4
	48	3	3	3
	59	3	3	5
	51	2	2	2
	C	2	3	4
	E	2	2	2
	X	1	2	2
Intelligibility 4	39	3	3	2
	67	3	2	2
	9	1	1	2
	44	4	4	2
	71	2	3	4
	V	1	1	2
	W	2	1	4
	Y	1	2	2
	D	2	1	3
	Z	0	2	1

TABLE 25a

RELATIONSHIP BETWEEN VPA RATINGS OF TENSION FEATURES AND INTELLIGIBILITY IN EXPERIMENTAL GROUP I

20 speakers rated 1 or 2 re intelligibility
("The Less Intelligible" Group)

VPA rating	PHARYNGEAL TENSION	SUPRALARYNG. TENSION	LARYNGEAL TENSION	Total
5	1	3	2	6
4	4	1	6	11
3	6	5	6	17
2	4	6	3	13
1	2	2	1	5
NEUTRAL		2	0	5
		Lax 3 x 1	Lax 2 x 2	

20 speakers rated 3 or 4 re intelligibility
("The More Intelligible" Group)

VPA rating	PHARYNGEAL TENSION	SUPRALARYNG. TENSION	LARYNGEAL TENSION	Total
5	1	-	-	1
4	3	4	4	11
3	4	6	4	15
2	6	5	8	19
1	3	2	4	9
NEUTRAL	3	1	0	4
		Lax 2 x 2		

speakers also had lower levels of both pharyngeal and supralaryngeal tension. It is interesting to note that 2 speakers increased their pharyngeal tension from a rating of 1 pre-therapy to a rating of 2 post-therapy and increased their supralaryngeal tension from neutral to 1 in one case and a rating of 1 to 2 in the second. In both cases their intelligibility rating improved. This relationship between tension and intelligibility will be discussed in Chapter 5.

(d) Intelligibility ratings related to supralaryngeal features

It has been reported earlier that the RANGE of LIP, JAW and TONGUE MOVEMENTS are commonly minimized among the groups of hearing impaired speakers. In examining the data for a relationship between intelligibility ratings and supralaryngeal features it was hypothesized that there would be more evidence of MINIMIZED RANGE of MOVEMENTS of LIPS, JAW and TONGUE among the less intelligible speakers. In addition it was hypothesized that there may be a greater degree of TONGUE BACKING among the less INTELLIGIBLE SPEAKERS.

To evaluate these hypotheses the LIP, JAW and TONGUE RANGE factors plus the TONGUE BODY position ratings were examined. The mean VPA ratings were calculated for LIP, JAW and TONGUE RANGE factors, for the less, and for the more intelligible groups of speakers in Experimental Group I and for the speakers in Experimental Group III.

Similarly the mean TONGUE BODY POSITION factors were calculated for these 3 groups of speakers. Their mean ratings are presented in Table 26.

TABLE 25b

RELATIONSHIP BETWEEN VPA RATINGS OF TENSION FEATURES AND INTELLIGIBILITY IN EXPERIENTAL GROUP III

Speaker	VPA rating		Pharyngeal tension		Supralaryngeal tension		Laryngeal tension	
	pre-therapy	post-therapy	pre-therapy	post-therapy	pre-therapy	post-therapy	pre-therapy	post-therapy
V	4	4	2	3	1	1	2	1
W	3	4	4	3	1	N	2	N
X	3	3	1	2	2	2	2	1
Y	4	4	2	2	3	2	2	1
Z	5	5	1	1	1	2	N	N

TABLE 26

RELATIONSHIP BETWEEN SUPRALARYNGEAL FEATURES AND INTELLIGIBILITY FOR HEARING IMPAIRED SPEAKERS

	Group 1 "Less intelligible" speakers n = 20	Group 2 "More intelligible" speakers n = 20	Group 3 "Intelligible" speakers post-therapy n = 5
Mean VPA rating for the group			
MINIMIZED RANGE OF TONGUE MOVEMENTS	MIN 4.3	MIN 3.1 *	MIN 1 **
MINIMIZED RANGE OF JAW MOVEMENTS	MIN 1.9	MIN .8 *	EX .2
MINIMIZED RANGE OF LIP MOVEMENTS	MIN 1.6	MIN .5	EX .4
TONGUE BODY POSITION BACK/FRONT	BACKED .4	BACKED 1.6 *	BACKED 2.6
TONGUE BODY POSITION RAISED/LOWERED	RAISED .7	RAISED .3	RAISED .2

* significant difference at .05 level between groups 1 and 2

** significant difference at .05 level between groups 2 and 3

It can be seen from Table 26 that, although the MINIMIZED RANGE of LIP, JAW and TONGUE MOVEMENTS occurs with most speakers, there is a difference between the degree of minimization between the less and more intelligible groups of speakers. The less intelligible speakers had greater minimization of range of TONGUE, JAW and LIP MOVEMENTS than more intelligible speakers. The difference in the range of jaw movements between Group I and Group II as shown in Table 26 is marked (with a chi square test of significant difference) showing a significant difference: (chi square = 7.0) but both were minimized. When the mean rating of Group III is examined it can be seen that this smaller but more intelligible group of deaf speakers shows a mean extensive range of jaw movements.

Similarly there is a less marked trend to minimize lip movements in Group II than there is in Group I, again shown in Table 26. This difference was also examined using a chi square test but did not show a significant difference (chi square = 1.9). Again when the mean rating of lip movements in Group III is examined the mean is found not to be minimized but slightly extensive.

Minimized tongue movement is found in all three groups of speakers, although the degree of minimized tongue movement is greatest in Group I and least in Group III. These differences are both significantly different on a chi square test at .05 level of significance.

To summarize the findings regarding the relationship between supralaryngeal features and intelligibility in hearing impaired speakers, it can be stated that all hearing impaired speakers show minimized range of tongue movements and that the degree of minimization is related to intelligibility. More intelligible deaf speakers will have less minimization of tongue movements. This point will be discussed in Chapter 5. It should be noted that the control group showed a median scalar degree of NEUTRAL for this parameter.

Minimized range of lip and jaw movements also characterize less intelligible hearing impaired speakers. More intelligible speakers will often exhibit an extensive range of lip and jaw movement. This finding and its probable reflection of the effects of teaching will be discussed in Chapter 5. The hearing speakers in the control group showed a median scalar degree of NEUTRAL for both lip and jaw movement.

The further supralaryngeal parameter which was examined and is reported again in Table 26 is the parameter of tongue body position. It can be seen that in the raised/lowered dimension the difference between the mean ratings for the three groups is very similar. All three groups of hearing impaired speakers show a mean group rating of slight raising, compared with a median rating of the control group of neutral (Table 11). However, in the backed/fronted dimension where the control speakers show slight backing, at scalar degree 1, there is a difference between the three groups of speakers. The less intelligible speakers show <u>less</u> backing of tongue body than the more intelligible speakers. This result and its probable interaction on intelligibility alone and in association with the parameter of range of tongue body movements will be discussed in Chapter 5.

4.5 AUDIOLOGICAL CHARACTERISTICS OF THE GROUP

An important treatment of the results was to relate the speech characteristics of these speakers to their hearing loss. As described above in Chapter 3 the speakers had pure tone audiological measurements of their hearing. Full pure tone responses measured over 125, 250, 500, 1K, 2K, 4K, 8K Hz were available for both ears. The pure tone thresholds were reported above in Table 3 for Experimental Group I, Table 4 for Experimental Group II, and Table 6 for Experimental Group III. The terms severely/profoundly deaf are widely used in audiology but are often ill-defined. The terms are used here to separate those speakers who have severe hearing loss, but can be taught to use their residual hearing, from profoundly hearing impaired people whose loss is so great that it is difficult to amplify sufficiently to provide useful portable hearing aids. In the literature profound hearing loss usually refers to average losses greater than 100 db and severe hearing loss to losses between 85 and 100 db. In reporting these data the conventional abbreviations used in audiology have been used: L = left ear, R = right ear. Threshold and loss are always expressed in db.

In this study, hearing loss has been related to various parameters. The results are presented in the following form:

(a) Audiological characteristics related to intelligibility
(b) Audiological characteristics related to phonation type
(c) Audiological characteristics related to supralaryngeal and tension features

(a) Audiological characteristics related to intelligibility

Most of the hearing impaired speakers had 14 reported pure tone thresholds, i.e., for each speaker the threshold for each ear had been determined for 7 pure tones of different frequencies. The remainder had 12 reported thresholds. Data on this scale had to be simplified if correlations were to be attempted. The mean threshold for each ear (for each speaker) was determined. These thresholds showed the degree of hearing loss for each speaker. The thresholds in the better ear for each speaker were noted. These data of mean threshold for Right and Left ears are presented in Table 27 grouped into subgroups according to intelligibility ratings.

It can be seen that 20 speakers had a loss of greater than 100 db in their better ear, while 38 had a hearing loss of greater than 90 db in their better ear. The pure tone thresholds reported in Table 27 are also graphed in Figure M. This figure shows the range and mean hearing thresholds for these hearing impaired speakers whose intelligibility was rated 1 compared with the ranges and means of those whose intelligibility was rated 2, 3, 4 or 5. It also displays the range of low frequency hearing thresholds, i.e., thresholds for frequencies lower than 1000 Hz.

An examination of these data shows that those speakers with less hearing tend to have lower intelligibility ratings. This is especially true of speakers in Experimental Group I who had low mean thresholds, i.e., all worse than 85 db in the better ear. However, when the data from Experimental Groups II and III are examined it can be seen that they include speakers with less hearing loss, e.g. Speaker X has a mean L loss of only 77 db but still has an intelligibility rating of only 3,

TABLE 27

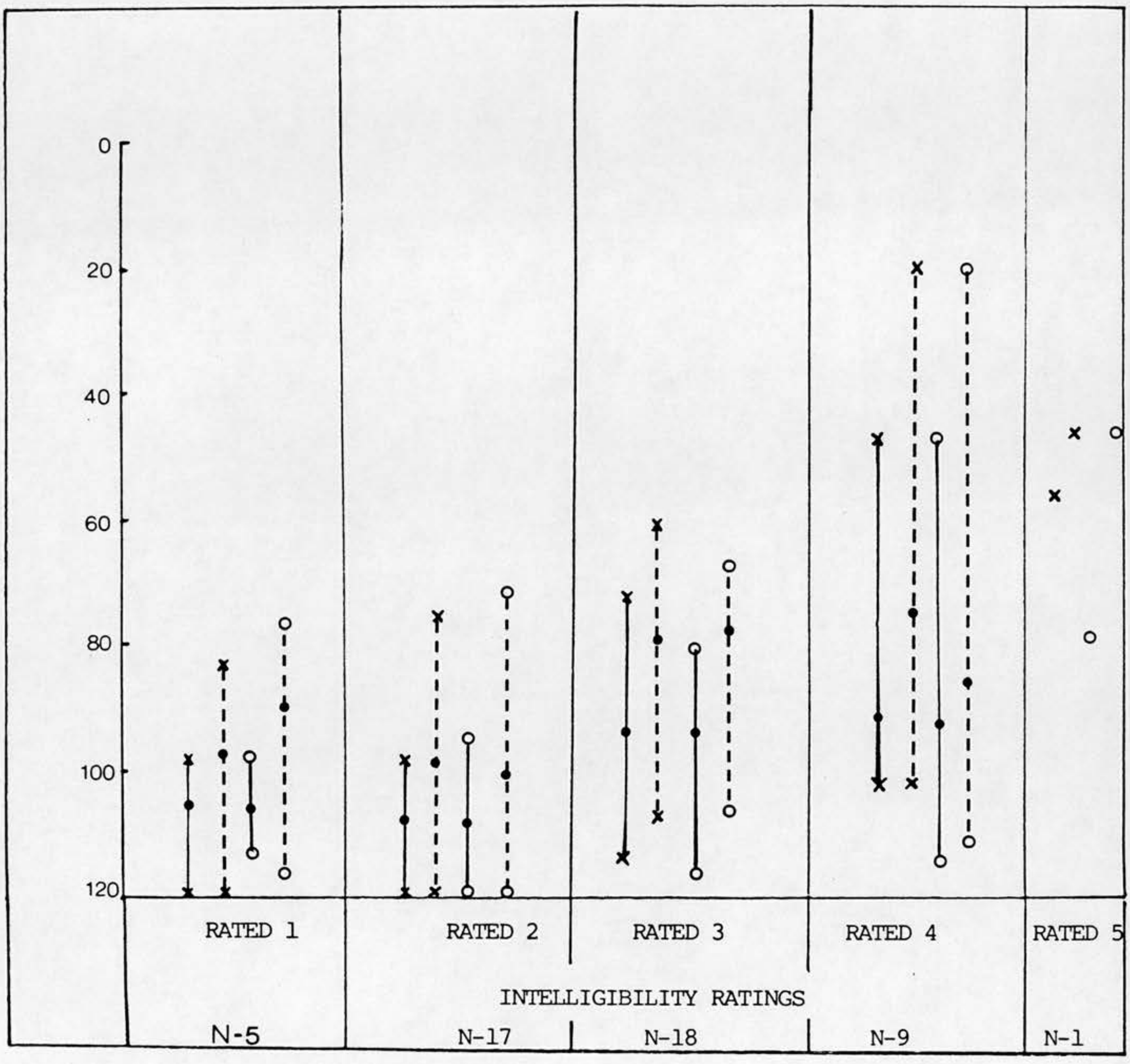
HEARING THRESHOLDS AND INTELLIGIBILITY RATINGS OF 3 GROUPS OF HEARING IMPAIRED SPEAKERS

	Speaker No.	L Mean threshold	R Mean threshold	Mean below 1K Mean L	Mean R
EXPERIMENTAL GROUP I					
Intelligibility 1	6	104	112	85	85
	8	104	101	86	80
	24	104	98	95	76
	64	98	115	111	116
	60	120	106	120	88
Intelligibility 2	36	110	120	96	120
	15	119	120	120	120
	7	116	114	113	113
	34	110	117	102	115
	31	114	96	110	100
	5	108	107	102	98
	2	106	99	98	76
	3	108	120	96	120
	54	115	113	108	105
	35	107	104	90	82
	23	119	120	120	120
	47	98	96	76	70
	46	109	114	98	111
	62	104	98	86	73
	49	101	113	83	106
Intelligibility 3	40	87	90	88	68
	1	94	96	71	71
	26	106	107	102	100
	4	111	96	103	73
	19	103	106	85	96
	22	104	114	85	86
	16	101	103	85	90
	33	103	99	84	73
	42	96	101	82	76
	52	94	91	78	73
	57	85	82	71	66
	41	101	96	80	100
	48	91	95	63	71
	59	104	105	90	93
	51 *	- 100	-	100	
Intelligibility 4	39	92	96	68	78
	67 *	105		105	
	9	106	99	95	75
	44	101	91	100	83
	71	94	116	63	112
EXPERIMENTAL GROUP II					
Intelligibility 2	A	112	112	100	100
	B	107	106	93	92
Intelligibility 3	C	113	115	82	87
	E	109	114	93	100
Intelligibility 4	D	105	92	80	85
EXPERIMENTAL GROUP III					
Intelligibility 3	X	77	117	63	120
Intelligibility 4	V	74	102	72	85
	W	56	57	65	70
	Y	61	63	25	25
Intelligibility 5	Z	62	83	52	52

* less than 12 reported thresholds

FIGURE M

THE RELATIONSHIP BETWEEN HEARING THRESHOLD AND INTELLIGIBILITY RATINGS FOR 3 GROUPS OF HEARING IMPAIRED SPEAKERS.



KEY:
o Right ear
x Left ear
——— Range and mean of hearing threshold
- - - - Range and mean of hearing threshold at low frequency only

whereas speakers 39, 67, 9, 44 and 71 have greater losses in their better ear but have higher intelligibility ratings. Similarly speakers V W Y have similar intelligibility ratings to 39, 67, 9, 44 and 71 but have less severe average losses. Thus, although these data confirm the view of Stuckless (1966) that degree of hearing loss is the single most important factor in determining the intelligibility of hearing impaired speakers, the data also confirm that this is not a simple relationship. Factors such as physical coordination, age of provision of appropriate amplification, type of school education, need for spoken language, etc. etc., will all affect the relationship between intelligibility and hearing loss. This complex of relationships will be discussed in Chapter 5.

There is strong evidence to suggest that it is the lower frequencies which affect the overall intelligibility of a hearing impaired speaker. The hypothesis is that if a hearing impaired speaker is able to hear the fundamental frequency of others and of himself he is likely to develop better rhythm and intonation, and that these parameters, coupled with appropriate lip patterns, aid intelligibility. To examine this hypothesis the thresholds of hearing in the better ear were averaged across 125 Hz, 250 Hz and 500 Hz.

It is the mean threshold of these low frequencies which separates those with higher intelligibility scores from those with very poor intelligibility. When the low frequency average loss for the better ear for those 9 speakers rated intelligibility 4 or 5 is examined it reveals a group average loss of 62 db. The average low frequency loss in the better ear for the 17 speakers rated intelligibility 2 is 96 db. The difference in the mean low frequency losses between the 9 and less intelligible speakers is a greater difference than that between their losses throughout the frequency range. This will be discussed below.

(b) Audiological factors related to phonation type

The data were examined to see if there was a relationship between the phonation type used by a speaker and his audiological characteristics. The speakers were divided into 7 groups according to hearing loss.

Group 1

Those with a mean hearing loss of greater than 100 db in the better ear <u>and</u> a mean hearing loss across the low frequencies which was also greater than 100 db.

Group 2

Speakers with a mean hearing loss of greater than 100 db and a mean loss in the low frequencies of greater than 90 db.

Group 3

Speakers with a mean loss of greater than 90 db and a mean loss in the low frequencies of greater than 80 db.

Group 4

Speakers with a mean loss of greater than 90 db and a mean loss in the low frequencies greater than 70 db.

Group 5

Speakers with a mean loss of greater than 90 db and a mean loss in the low frequencies of greater than 60 db.

Group 6

Speakers with a mean loss of greater than 70 db and a mean loss in the low frequencies of greater than 60 db.

Group 7

Speakers with a mean loss of greater than 50 db. and a mean loss in the low frequencies of greater than 60 db.

The phonation characteristics of the speakers in these 7 groups were then examined.

Table 28 shows the relationship between hearing loss and phonation type.

One might expect that those speakers with greater hearing loss would have more aberrant phonation characteristics. Thus for example one might expect the speakers using FALSETTO to be amongst the deafest groups of speakers. An examination of Table 28 shows that this is not the case. The 7 FALSETTO speakers are divided between 4 groups of hearing loss, although these are the 4 groups of more severely hearing impaired speakers.

Similarly one might have expected that the more deaf speakers would tend to have higher scalar ratings for CREAK and HARSHNESS. To see if this were the case mean scalar degrees for HARSHNESS, CREAK and WHISPER were calculated for each of the 7 groups of hearing loss. There was a slight difference in the distribution of more severe ratings of

TABLE 28

THE RELATIONSHIP BETWEEN HEARING LOSS AND PHONATION TYPE FOR HEARING IMPAIRED SPEAKERS

Group	Mean hearing loss	Mean low-frequency hg loss	Speaker No.	Scalar degree of phonation rating HARSHNESS	CREAK	WHISPER	FALSETTO
1 (n=9)	<100	<100	15	0	1	3	
			7	0	1	3	
			34	2	3	1	
			54	5	5	3	
			23	3	3	3	
			26	2	2	0	
			67	3	4	2	
			51	2	3	0	
			A	2	2	2	
			Mean	2.1	2.7	2.0	1
2 (n=8)	<100	<90	36	1	0	1	
			60	4	3	0	
			5	4	3	2	
			3	0	3	2	
			46	3	0	3	
			59	0	3	3	
			B	0	0	3	
			E	2	0	3	
			Mean	1.8	1.5	2.1	2
3 (n=13)	<90	<80	6	3	2	2	
			8	3	2	3	
			64	0	0	3	
			31	4	4	3	
			35	0	0	4	
			49	3	3	4	
			19	2	2	1	
			22	0	2	2	
			41	2	2	2	
			16	3	0	2	
			44	0	2	0	
			C	2	0	2	
			D	2	0	2	
			Mean	2.4	1.7	2.7	2
4 (n=10)	<90	<70	24	4	N	4	
			2	2	0	3	
			47	3	3	3	
			62	3	3	4	
			1	2	1	2	
			4	0	2	0	
			33	0	3	4	
			42	2	3	2	
			52	3	3	3	
			9	2	2	1	
			Mean	2.1	2.0	2.6	2
5 (n=5)	<90	<60	40	0	2	0	
			57	2	3	0	
			48	3	3	0	
			39	1	0	1	
			71	1	3	0	
			Mean	1.4	2.2	0.6	
6 (n=2)	<70	<60	X	0	3	2	
			V	0	0	2	
			Mean	0	1.5	2	
7 (n=3)	<50	>50	W	0	0	3	
			Y	2	0	2	
			Z	0	0	2	
			Mean	0.6	0	2.3	

HARSHNESS. Severe ratings of HARSHNESS occurring among those speakers with less hearing. There was a less clear distinction between the ratings of CREAK and WHISPER among the less and the more severely deaf speakers. A possible explanation for this close relationship between marked non-neutral settings of HARSHNESS and severity of hearing loss, and the relationship between use of FALSETTO and severity of hearing loss, as opposed to the less clear relationship between non-neutral ratings of WHISPER and CREAK and intelligibility will be discussed. The discussion below in Chapter 5 will explore the possible role of kinaesthesia in providing feedback for deaf speakers.

(c) Audiological characteristics of hearing impaired speakers related to VPA ratings, of tension features and supralaryngeal features.

The data were examined to see if there was a relationship between the audiological characteristics of hearing impaired speakers and their VPA rating of SUPRALARYNGEAL, LARYNGEAL and PHARYNGEAL TENSION. It was expected that there may be a relationship between tension features and audiological characteristics among hearing impaired people.

Table 29 reports the data for the speakers regarding hearing loss and tension features.

It can be seen from this table that the less deaf subjects, V, W, X. Y, Z from Experimental Group III had less laryngeal tension than the speakers who were more deaf. There was no observable relationship between the degree of hearing loss of these speakers and their supralaryngeal or pharyngeal tension characteristics. The relationship

TABLE 29

THE RELATIONSHIP BETWEEN HEARING LOSS AND TENSION FEATURES FOR HEARING IMPAIRED SPEAKERS

Group	Mean hearing loss	Mean low-frequency hg loss	Speaker No.	Scalar degree of phonation rating		
				LARYNGEAL TENSION	SUPRALARYNG. TENSION	PHARYNGEAL TENSION
1 (n=9)	<100	<100	15	3	2	3
			7	2	0	2
			34	3	2	1
			54	5	2	4
			23	3	3	3
			26	2	1	0
			67	3	2	2
			51	2	2	2
			A	3	3	3
			Mean	2.9	1.9	2.2
2 (n=8)	<100	<90	36	2	2	1
			60	3	5	5
			5	5	2	0
			3	4	3	3
			46	4	3	4
			59	3	3	5
			B	3	3	4
			E	2	2	2
			Mean	3.2	2.9	3
3 (n=13)	<90	<80	6	3	1	1
			8	L2	L2	2
			64	1	0	3
			31	2	1	2
			35	L2	2	3
			49	4	5	3
			19	1	2	2
			22	1	L1	2
			41	4	4	4
			16	4	0	0
			44	4	4	2
			C	2	3	4
			D	2	1	3
			Mean	1.8	1.5	2.3
4 (n=10)	<90	<70	24	4	4	N
			2	3	3	2
			47	4	3	4
			62	4	5	5
			1	2	3	N
			4	L1	2	1
			33	4	4	4
			42	2	3	3
			52	2	3	3
			9	1	1	2
			Mean	2.7	3.1	2.4
5 (n=5)	<90	<60	40	2	2	1
			57	2	L1	3
			48	3	3	3
			39	3	4	2
			71	3	4	2
			Mean	2.6	2.4	2.2
6 (n=2)	<70	<60	X	1	2	2
			V	1	1	2
			Mean	1.0	1.5	2
7 (n=3)	<50	>50	W	2	1	4
			Y	1	2	2
			Z	0	2	1
			Mean	1.0	1.6	2.3

between the finding that less deaf subjects had less LARYNGEAL TENSION and less HARSHNESS (Tables 28, 29) is discussed below in Chapter 5.

It was noted above that there are of course a range of other contributory factors to the intelligibility of hearing impaired speakers other than that of hearing loss. Factors such as intelligence, age of onset of the hearing loss, age of diagnosis, the provision and use of amplification, the type of educational regime which the speaker followed, will also affect a hearing impaired speaker's intelligibility.

1. Intelligence. There is in the literature conflicting evidence as to the effect of intelligence upon the intelligibility of the speech of hearing impaired children. However, all the subjects in this study had completed school courses and were either following courses of higher education or were in jobs where training of at least two years was necessary. The intelligence of these subjects can therefore be taken to be at the higher levels of intelligence. There are therefore no low intelligence subjects in the group and low intelligence is not a contributory factor to low intelligibility scores for these speakers.

2. Age of onset. There is a considerable difference between the speech characteristics of speakers with acquired hearing loss who have learned spoken language and speech skills normally and then lost their hearing (and self-monitoring skills), and congenitally hearing impaired speakers who have never acquired normal speech production and monitoring skills. The age at which a person becomes deaf greatly affects the ease with which the speaker is able to maintain his speech monitoring skills (e.g., Quigley 1974, Parker 1983). A speaker who loses his hearing in adult life will have different speech difficulties from a speaker who lost his hearing aged 3 years. However, it appears to be the case (Kretschmer 1974, Ling 1976) that children who lose their hearing as

early as 12 months will tend to have better speech skills than a congenitally born deaf child. All the hearing impaired speakers in this study are pre-lingually deaf. That is to say they all became deaf before the age of 2 years, before they had acquired spoken language. What is not known is whether there are any speakers who lost their hearing between birth and very early childhood. With subjects of this age, who were obviously children in the 'post-antibiotic' age, the likelihood of infantile infection causing deafness is greatly reduced from the incidence of earlier generations and if there are any such speakers among this group of subjects they will be very few in number.

A further important factor in determining the intelligibility of a hearing impaired speaker is whether he was educated in a school where there was heavy emphasis on the use of spoken language and instruction in speech production or whether the speaker had been educated in a school with little emphasis on speech and spoken language. Such information is not easily available. One of the difficulties in collecting this information, which was asked of all subjects at their interview, is firstly that many subjects had been to two, three or even four schools during their education with different communication philosophies. Many of the subjects reported that the communication philosophy changed during their school days. The schools (over 150 were recorded) were not of course all known to investigators and there was no way of establishing that all subjects reported the communication philosophy of their schools similarly.

3. Habitual hearing aid use is a further factor contributing to the probable intelligibility of hearing impaired speakers. Each subject was asked about his hearing aid use and was observed at the recording session as to whether he wore an aid/s. 31 of the 50 speakers wore

aid/s habitually. Of these 31, 16 were among the more intelligible speakers (rated 3 or 4 on the intelligibility scales). It is also true that most of them, 15 of the 21, were among the subjects with higher hearing thresholds.

Table 30 presents the data relating the habitual hearing aid use, intelligibility and hearing threshold. Hearing thresholds are divided into the 7 groups used above in Tables 28 and 29.

It can be seen from these figures that the more intelligible speakers use their aids regardless of their level of hearing threshold. Only 3 speakers with an intelligibility rating of 3 or 4 failed to use aids and conversely only 5 speakers with intelligibility ratings of 1 or 2 used aids at all.

This can be accounted for in two ways. Either the speakers were more intelligible because they used their aids (a common pedagogic argument used to encourage deaf children to use their aids). Or only speakers who felt they benefit ed from their aids used them, and that this group tended to be those with more hearing.

TABLE 30

THE RELATIONSHIP BETWEEN HEARING AID USE, INTELLIGIBILITY AND HEARING THRESHOLD FOR HEARING IMPAIRED SPEAKERS

Speaker No.	Intelligibility rating	Hearing threshold category	Aid use
6	1	4	x
8	1	4	x
24	1	5	x
60	1	2	x
64	1	3	x
15	2	1	x
7	2	1	x
34	2	1	x
54	2	1	x
23	2	1	x
35	2	2	x
5	2	2	x
3	2	2	x
36	2	2	✓
46	2	2	✓
31	2	3	x
2	2	5	✓
47	2	5	✓
62	2	5	x
49	2	4	x
A	2	1	✓
B	2	2	✓
51	3	1	x
26	3	1	✓
16	3	2	✓
59	3	2	✓
41	3	4	x
14	3	4	✓
22	3	4	✓
1	3	5	✓
4	3	5	✓
33	3	5	✓
42	3	5	✓
52	3	5	✓
48	3	6	x

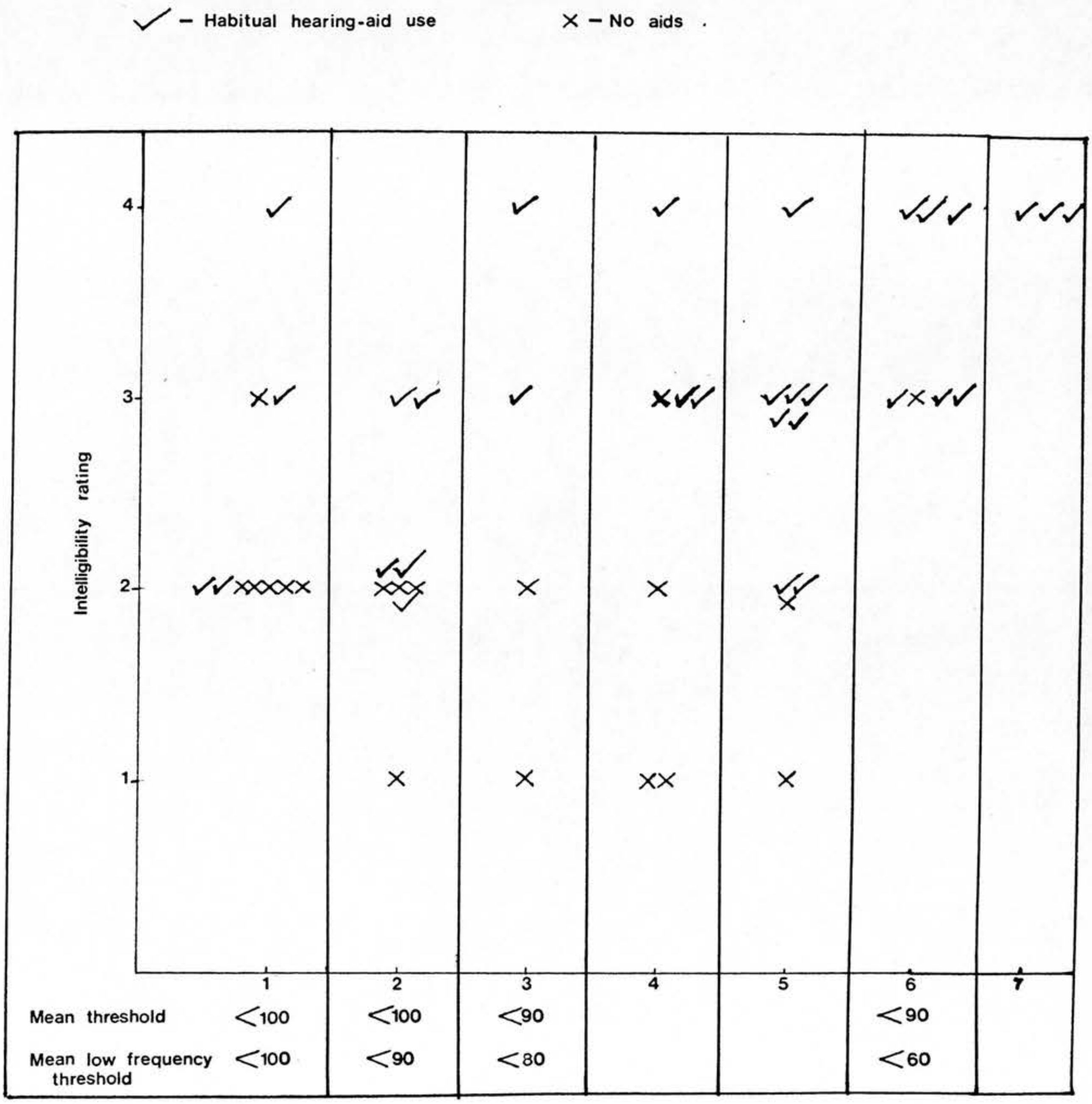
(continued)

(TABLE 30 - CONTINUED)

Speaker No.	Intelligibility rating	Hearing threshold category	Aid use
57	3	6	✓
40	3	6	✓
C	3	3	✓
E	3	2	✓
X	3	6	✓
39	4	6	✓
71	4	6	✓
67	4	1	✓
44	4	4	✓
9	4	6	✓
V	4	6	✓
W	4	7	✓
Y	4	7	✓
D	4	3	✓
Z	5	7	✓

FIGURE N

RELATIONSHIP BETWEEN HEARING AID USE, INTELLIGIBILITY AND HEARING THRESHOLDS FOR HEARING IMPAIRED SPEAKERS



CHAPTER 5

DISCUSSION

There have been frequent attempts to isolate the differences between the speech characteristics of a group of deviant speakers from those of a group of normal (control) speakers, and then to assert that these differences contribute to the unintelligibility of the deviant speaker. For the past hundred years various professional groups, from elocutionists to educators, from audiologists to actors, have attempted to describe the speech of the deaf and to decide how best to offer remedial help. They have frequently made objective measurements of certain speech parameters, in deaf and hearing speakers, and then tried to relate these measures to intelligibility. As Metz et al (1980) have expressed it, 'the speech intelligibility as assessed by a listener is the dependent variable and the physical parameters of speech the independent variables' (p. 72).

It is common practice to measure specific speech parameters, compare the measurements derived from a group of deaf speakers with those derived from a group of hearing speakers and then assume a causal relationship between intelligibility and those parameters which are different in the deaf group.

In Chapter 4 of this work speech parameters, such as pitch mean, pitch range, tongue, lip and jaw movements, tension features and phonation types, were described using the VPA for deaf and hearing subjects and compared with the intelligibility ratings of the deaf speakers. It is clear from the reporting of these results that simple correlations between specific parameters and intelligibility do not exist.

An examination of the results of this study will show that minimized RANGE of TONGUE BODY is very common and that in this respect the speech of deaf speakers differs from that of hearing speakers. Furthermore the results show that less intelligible deaf speakers as a group have more minimized RANGE OF TONGUE BODY movements than their more intelligible peers. However, if individual profiles rather than group trends are examined it is clear that this possible relationship between tongue body movement and intelligibility is not a simple one to one relationship. For example, speaker No. 6 has a VPA rating for RANGE of TONGUE BODY movements of MINIMIZED 3 and an intelligibility rating of 1; speaker No. 71 has a similar rating of MINIMIZED 3 for RANGE of TONGUE BODY movement but an intelligibility rating of 4. This apparent discrepancy is explained if other parts of these two profiles are examined. Speaker No. 6 (the much less intelligible of the two) in addition to MINIMIZED RANGE OF TONGUE BODY 3 has MINIMIZED RANGE OF JAW 3 and MINIMIZED RANGE OF LIPS 3 - in other words his minimized tongue movements are part of a generalized minimization of articulatory movement. In contrast speaker No. 71 with MINIMIZED TONGUE BODY RANGE 3 has no minimization of lips and jaw. In fact, far from minimizing speaker No. 71 exhibits slightly increased articulatory movements with ratings of EXTENSIVE LIP RANGE 1 and EXTENSIVE JAW RANGE 1. The profiles of speakers 6 and 71 are reproduced here in Figures O and P.

A further difference between these two speakers is apparent if the phonation type of each speaker is examined. Speaker 6 (the less intelligible) uses a HARSH 3 WHISPERY 2 CREAKY 2 voice whereas the

FIGURE O

VPA PROFILE OF SPEAKER 6

Vocal Profile Analysis Protocol

Speaker: 6 Sex: M Age: 19 Date of Analysis: Ph.D Tape: 2 Judge: J.M. SLW.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
			✓	Falsetto				✓		
			✓	Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness			✓	High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓			✓	Interrupted
2. Rate		✓	✓			Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓		✓	
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia	✓	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

FIGURE P

VPA PROFILE OF SPEAKER 71

Vocal Profile Analysis Protocol

Speaker: 71 Sex: F Age: 19y Date of Analysis: PhD Tape: 6 Judge: J.L. J.M. S.LW.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion	///	///	///			
		✓		Lip Spreading						
				Labiodentalization	///	///	///			
		✓		Extensive Range	///					
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw	///	///				
				Protruded Jaw						
		✓		Extensive Range	///					
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body	///	///				
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	///	///	///			
5. Velopharyngeal				Nasal	///	///	///	///		
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction	///	///	///	///		
7. Supralaryngeal Tension		✓		Tense	///	///	///			
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	///	///				
				Lax						
9. Larynx Position				Raised	///	///				
		✓		Lowered						
10. Phonation Type		✓		Harshness	///					
		✓		Whisper(y)	///	///	///			
				Creak(y)						
				Falsetto						
			✓	Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range	///					
	✓			High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

more intelligible speaker 71 uses WHISPERY 3 HARSH 1 voice. Despite the fact that the phonation type of both speakers is within the normal range, the combination of moderate HARSHNESS with noticeable WHISPER and CREAK used by speaker 6 contributes to a 'less normal, composite profile than the moderate WHISPER and minimal HARSHNESS used by speaker 71. In summary the MINIMIZED TONGUE BODY RANGE (at rating 3) of speaker 71 was an isolated minimization, unlike speaker 6, where the MINIMIZED TONGUE BODY RANGE (rating 3) was part of a general minimization of articulatury movement including MINIMIZED LIP MOVEMENT and MINIMIZED JAW MOVEMENT. In addition speaker 71 used a phonation type (WHISPERY slightly HARSH voice) which is very similar to the phonation type used by hearing people. In this respect too he differed from speaker 6 who used a WHISPERY noticeably HARSH and CREAKY voice. This is a more aberrant phonation type and contributed too to the greater unintelligibility of speaker 6.

This comparison of speakers 6 and 71 shows how impossible it is to make a simple correlation between specific parameters and intelligibility. The MINIMIZED TONGUE BODY RANGE of speaker 71 is much less contributory to poor intelligibility <u>in the context</u> of his other vocal profile features than is the MINIMIZED TONGUE BODY RANGE of speaker 6 in the context of his different vocal profile features.

Intelligibility is determined by a variety of components of a speaker's output. It is the combination of the components of a speaker's output, not the individual components themselves, which affect intelligibility. For this reason, combinations of components which are individually all within the 'normal range' may combine to produce non-normal combinations and contribute to unintelligibility.

The value of using a descriptive scheme such as the VPA, which looks at all long-term vocal settings, is that relationships between patterns of speech characteristics and intelligibility can be explained. Other less satisfactory assessments simply attempt to list the relationships between specific parameters and intelligibility.

Reported research, e.g. by Markides (1970, 1983), has sometimes attempted unsuccessfully to make correlations between specific speech parameters and intelligibility. Others, e.g. Monsen (1978), while reporting correlations, have emphasized that among hearing impaired speakers multiple correlations are usual. Monsen concludes from his research that, although intelligibility can be predicted by the 2 variables of firstly differences in VOT between /t/ and /d/ and secondly differences in 2nd formant frequencies of /i/ and /o/ with approximately 70% accuracy, this does not mean that only these variables affect intelligibility.

Osberger (1979) in her study of timing and intelligibility in deaf speakers recorded the speech of several deaf children and, in common with other reported literature, found that the deaf speakers tended to use more and longer pauses than hearing subjects. She then instrumentally adjusted the recordings to make the temporal characteristics of the recordings of the deaf children more like the temporal characteristics of hearing children. She found no improvements in the intelligibility of the recordings as a result of this manipulation of an apparently dependent variable.

The purpose of this study was to investigate whether the speech of the deaf could be described using the VPA and whether there were any common features in the speech of the hearing impaired speakers. Having established that the VPA can be used to describe deaf speech and can pinpoint some of the differences between less and more intelligible deaf speakers, this chapter will explore some of the remedial implications of isolating these characteristic speech parameters.

It has been demonstrated in Chapter 4 that the VPA can be used both to describe deaf speech and to identify certain features of speech which are common among hearing impaired speakers. The subjects in this study were all young adults. It would be useful to see if young profoundly deaf children and older profoundly deaf adults have similar VPA ratings to the young subjects of the present study. The hypothesis is that the descriptions of the speech of younger and older speakers would be very similar to that derived from the present study. The national survey of speech intelligibility ratings of 978 hearing impaired children conducted in the USA and reported by Trybus (1980) showed that speech intelligibility does not improve after the age of 7 years. It seems likely that the habitual long-term articulatory postures adopted by the hearing impaired child will be established by the time he is 7/8, or whenever he has achieved fluent spoken language. His habitual long-term postures will be maintained and show little change as the speaker ages, unless he is given specific instruction in speech production. The establishment of 'common VPA features' for hearing impaired speakers gives a valuable baseline against which remedial progress of an individual deaf speaker can be compared.

The results of this study show that those speakers with higher hearing thresholds tend to have higher intelligibility ratings and somewhat different VPA ratings. The ability to identify those VPA features which are common in more intelligible speakers (who often have more hearing) has important remedial implications. These features provide realistic remedial objectives. A teacher/therapist is able to compare the VPA of an individual with the VPA features which are common among intelligible deaf speakers and plan her intervention accordingly.

In Experimental Group III the five speakers were recorded before and after 16/20 hours of therapy. Their therapy was directed principally towards improving the prosodic skills of the speakers. The post-therapy profiles show that the therapy was successful in that all 5 speakers lowered their PITCH MEAN and in 4 of the 5 speakers they also had a less NARROW PITCH RANGE and less LOW VARIABILITY after therapy than before. (The fifth speaker showed the same ratings for PITCH RANGE and VARIABILITY before and after therapy.) Parker (1978) and Maki (1981) have shown that improved prosodic skills especially of the pitch parameters improve intelligibility. The improved pitch control of the 5 speakers after therapy was an important contributory factor to their improved intelligibility.

Therapy for these 5 speakers was not directed towards control of lip and jaw movements. However, in the post-therapy profiles it is clear that therapy had the tangential effect of reducing RANGE OF JAW MOVEMENT and lowering TONGUE BODY. It is suggested that with the increased confidence arising during therapy from the success which the speakers had, regarding their control of pitch parameters, that they concentrated less on their jaw and tongue movements. By reducing the effort directed towards jaw and tongue they in fact achieved a more appropriate long-term jaw setting and a better tongue body setting.

The principal disability of congenitally hearing impaired people has been described above. It is language impairment. Hearing impaired children do not develop language skills as readily as their hearing peers and even as young adults they still have incomplete knowledge of some of the syntactic rules of their language. The ease with which a hearing impaired person understands spoken and written language also of course affects his production of written and spoken language. These language difficulties lead to considerable educational difficulties for the majority of severely/profoundly deaf schoolchildren and are an important contributory factor to the low educational attainments of hearing impaired school leavers. The 50 young people in this study had all completed school and were either in higher education or a job which had required some training. They did not have any major language difficulties. Their main difficulty was one of intelligibility.

Improving the intelligibility of hearing impaired speakers must be seen in the context of their greater disability of poor language skills and any remedial planning for an improvement of intelligibility must take cognisance of this. Intervention programmes to improve the intelligibility of speakers with disordered speech divide into two principal areas. The first type of therapy is that which is directed towards a re-education of articulatory production, and the second type is that where suggestions are made to the speaker about compensatory articulatory patterns. For example, a hearing impaired speaker who has no back vowels but does contrast central with front vowels might be taught to use a more backed tongue position for those vowels (in English) which hearing people articulate at the back of the mouth. He can be taught through (a) placement, (b) feedback from visual display or hard copy, (c) contrastive drills, and other techniques. The therapy will involve 5 main stages: helping the individual to produce the target, then improving his ability to discriminate between the target and his former production, then drilling his production of the target so that it becomes effortless, then helping him to integrate this into speech and finally improving his self-monitoring. These basic procedures must be followed in any re-educative therapy.

In contrast there is a second relevant therapy technique for this group of speakers: that of compensatory movement. It may be that the hearing impaired speaker has developed a way of signalling a contrast using a different technique from that used by hearing speakers. For example, we have seen that most hearing impaired speakers have MINIMIZED TONGUE MOVEMENTS. Such a speaker may attempt to contrast the vowel /u/ from the vowel /i/ not by a shift of tongue body from back to front but by exaggerated rounding of the lips for /u/ and exaggerated spreading for /i/, while keeping the tongue body in a central position.

Therapy planning for improved intelligibility involves a balance between the objectives which will improve intelligibility, the compensatory patterns which the speaker has spontaneously developed and which are useful, and re-educative techniques to introduce some new articulatory patterns to the speaker. Comparing the Vocal Profile of a deaf speaker with common VPA features of both hearing speakers and intelligible hearing impaired speakers will help in deciding the balance between re-educative and compensatory aspects of an individual's therapy plan.

Therapy will only be successful with a healthy young deaf adult if the programme also takes into account other factors about the client - factors such as his motivation to use spoken language, his need and motivation to improve upon his current skills, his audiological profile, the type of amplification which he uses, his ability to attend regularly during a course of therapy and others.

A good therapy plan will take factors such as these into account and combine information about these practical issues with details derived from a vocal profile highlighting an individual's remedial needs.

There is also a range of more specific results which should be discussed. In Chapter 4 it was reported that the RANGE of MOVEMENTS of LIPS, JAW and TONGUE by hearing impaired speakers were significantly different from the RANGE characteristics of the hearing control group of speakers.

Most (97.5%) of the profoundly hearing impaired speakers in Experimental Group I were rated as having MINIMIZED MOVEMENTS OF THE TONGUE, compared with only 5% of the hearing subjects. This finding is commensurate with acoustic studies of deaf speech (e.g. Monsen 1978, Stevens et al 1983.) Monsen has demonstrated that the variation of the second formant correlates highly with ratings of speech intelligibility. Stevens et al (1983) comment on the same phenomenon and explain it thus:

> "deaf speakers seem unable to cause the tongue body to undergo much displacement in the front-back direction during speech production ... a consequence of this problem is a narrow range of movement of the second formant from one vowel to another" (pp. 47, 48).

The remedial implications appear to be clear. If a hearing impaired speaker can be encouraged to use a greater RANGE OF TONGUE MOVEMENTS, to enlarge his articulatory space, he will become able to use a wider range of vowels and thus improve his intelligibility. Indeed, when the Vocal Profiles of Experimental Group III were examined it was noted that they too had some miminized tongue movement but that it was not so marked as with the more severely deaf subjects. It is highly likely that encouraging a wider range of tongue movement will improve intelligibility, by enlarging the range of contrasts which the speaker has available to him.

The first line of caution to be taken before embarking on this apparently simple line of remedial speech work with hearing impaired speakers concerns the properties of the 1st and 2nd formants. Firstly, the 1st formant lies generally below 1000 Hz. It must be remembered that most hearing impaired speakers have higher thresholds of hearing in the lower frequencies of the speech range. It is thus more likely that the majority of hearing impaired speakers will perceive this change of low frequency signal, or at least perceive it in part. Thus it cannot be said with certainty whether the thrust of therapy is to improve the tongue body movement or to improve the auditory perception of vowel quality differences. It is likely that both methods are employed in successful therapy.

Secondly, one way of changing the 1st formant is by changing the shape of the oral aperture. Changing the shape of the oral aperture is highly visible and therefore an attractive aspect of speech learning for most hearing impaired speakers. Monsen (1983) has shown that, when a hearing impaired speaker has the choice between a visible and a less visible feature of speech, as with the choice of mouth aperture or TONGUE BODY POSITION in the production of vowels, the hearing impaired speaker invariably perceives the visible parameter rather than the less visible. In a programme of speech teaching designed to improve the vowel articulation of a hearing impaired speaker the teacher/therapist will find that a compensatory approach to therapy, i.e. concentrating on lip and jaw movement, is likely to be more effective than a re-educative approach concentrating on tongue body movements.

In an informal study the author worked with a group of 5 profoundly hearing impaired adults aged 19-32 years. All subjects had relatively poor intelligibility, with ratings of 2 or 3 on a 5-point intelligibility rating scale, but all had enough interest in improving their intelligibility to attend a night class. All 5 subjects had MINIMIZED RANGE OF TONGUE MOVEMENT and a programme of exercises was devided to improve their RANGE OF TONGUE MOVEMENTS. It was noted that the speakers had much less difficulty in learning to produce, and perhaps more importantly to use, contrasts which had visible differences, e.g. /i/ /a/, compared with those where there was a similar length difference but little visible component, e.g. /a/ /a/ Their compensatory techniques (lip and jaw movement) were effective in signalling a difference which hearing people produce using a different technique (tongue body movement).

It has been shown that the speakers in Experimental Group III were perceived as having less minimization of tongue body movement after therapy than before. It will be recalled that all VPA ratings in the study were done from tape recording, and it may be that the speakers were perceived to have less minimized tongue body movements but were in fact compensating with other articulations. It would be interesting to instigate a programme of therapy designed to help appropriately chosen hearing impaired speakers to increase their TONGUE BODY MOVEMENTS. An acoustic record could be kept of this therapy to monitor the formant changes which take place during this programme. A visual display system such as the Simultaneous Spectrographic Display (SSD) (Stewart, L., Larken, W., Houde, R., 1976) would be ideal for such a study, because the hearing impaired speaker could have real time, visual feedback of the acoustic properties of their changing speech patterns. et al

The Simultaneous Spectrographic Display (the SSD) is a dynamic real time display which takes an audiosignal from a speaker and converts this signal into a full dynamic spectrogram in a . screen. The full spectrogram is displayed with a choice of either a wide band (8K) or narrow band (4K) mode of presentation. The mode of presentation may be continuous with a continuous replacement of the signal on the screen or frozen with a short (variable length) passage of speech analysed and displayed. In addition to these possible variations, the width of the spectrum, and dynamic or static, the screen can also be split to allow the teacher/therapist to display their model on one half of the screen and remain there as a model against which the hearing impaired person could make comparisons.

The author had the opportunity to evaluate the efficacy of this equipment with hearing impaired young people and is convinced of its value with certain groups of deaf people. Maki (1980) discussed the use of SSD.

To understand the relationship between using VPA as an assessment tool alongside SSD as a remedial tool it is necessary to consider very broadly the place of visual display in the oral education of hearing impaired people.

The major factor which causes hearing impaired people to have poor speech skills is of course their lack of hearing. Deaf people do not hear models of speech production when they are acquiring language skills (they either do not hear at all or hear only imperfectly). Of equal importance is the fact that deaf people do not learn to monitor their own speech production appropriately.

Visual display techniques do <u>not</u> help hearing impaired children to develop language but they do offer help to the child (or adult) regarding the production of articulatory and prosodic skills. It is the view of the author that a VPA will pinpoint which long-term settings of a hearing impaired speaker are disturbed and she can then judge whether the particular setting can be helped by visual display. Most display equipment displays the teacher/therapist's speech giving the deaf speaker information about the visual representation of the adult model. Secondly they display the deaf speaker's own speech giving the deaf speaker visual feedback. This is of course visual feedback of his long-term settings rather than discrete segmental feedback.

Many visual display techniques display single channel information, for example the Visispeech (King et al, 1982) displays intensity and time or frequency and time; the Laryngograph (Fourcin, 1974) displays information about vocal fold vibration and time; the Voicescope (Wirz and Anthony, 1978) displays frequency and time. The advantage of simple displays is that the teacher/therapist can provide a clear unequivocal model showing a particular speech pattern. The hearing impaired person can then focus on this visual model for specific information.

Vocal profiles analysis is especially useful in visual display planning because of its emphasis on long-term speaker characteristics. The profile may pinpoint a long-term setting of raised larynx and the teacher/therapist can concentrate on this inappropriate setting while modelling a different pitch mean for the client.

Most accounts of the use of visual display stress the fact that hearing impaired children and adults enjoy using visual display on their own. They use the feedback provided to monitor their own production and to practise the production of new skills. Both model and feedback functions provide controlled visual imput regarding speech production to the deaf person.

The point made above concerned the use of visual display, specifically the SSD, to provide information about range of tongue body movements. The SSD is capable of such a display, unlike some of the single channel displays mentioned above, but the great disadvantage is the potential overload.

Because the SSD gives such full information there is the danger that the hearing impaired person would be unable to assimilate all the information offered, especially concerning a parameter such as tongue body position. With a parameter such as this they would be being asked to look at formant positions and transitions and disregarding other, possibly more prominent, display features such as hiss.

It is however clear to the author, having worked for some months with the SSD as a technique in the oral education of deaf speakers, that with a population of young, able, deaf adults this display would be ideally suitable for three reasons:

(a) Because it makes clear in visual terms the long-term speaker characteristics to the deaf client, characteristics which are evaluated by the VPA but are difficult to demonstrate to the deaf speaker using single channel displays. These characteristics can be made clear to the client by showing/explaining a VPA and showing/explaining the same settings on the SSD.

(b) This technique is ideal for giving models or feedback regarding tongue body position.

(c) This technique stresses the componential aspects of speech, thus mirroring the underlying theory of the VPA.

In using this type of display the teacher/therapist needs to maintain a balance between re-educating tongue body movements and encouraging other compensatory articulations.

The RANGE OF JAW AND LIP MOVEMENTS is also MINIMIZED in a large number of hearing impaired speakers. 60% of hearing impaired speakers in Experimental Group I showed MINIMIZED JAW MOVEMENTS compared with only 12.5% of the hearing subjects and 55% of them showed MINIMIZED LIP MOVEMENTS compared with only 7.5% of the hearing. These differences it will be remembered were statistically significant. It will also be recalled that Experimental Group III showed neutral settings of lip movement and jaw movement in their post-therapy ratings, making them similar in this respect to hearing speakers. The picture for speakers in Experimental Groups I and II becomes more complex in regard to the question of RANGE OF LIP AND JAW MOVEMENTS.

25% of the deaf speakers in Group I showed EXTENSIVE RANGE OF LIP MOVEMENTS compared with 5% of the hearing speakers and 20% of the deaf in Group I showed an EXTENSIVE RANGE OF JAW MOVEMENTS compared with only 2.5% of the hearing speakers. This difference in the occurrence of EXTENSIVE RANGE OF LIP and JAW MOVEMENTS between the deaf and hearing was also significantly different.

One explanation for this apparently contradictory result was given in Chapter 4, namely that those with an EXTENSIVE RANGE of LIP and JAW MOVEMENTS may be ones who had been educated through the 'oral regime' of deaf education and those with MINIMIZED RANGE of LIP and JAW MOVEMENTS had not. The reasons for suggesting this possible explanation are various. In the education of hearing impaired children, there are two principal views as to how best to develop the children's communicative competence. One view suggests that children should develop language skills through the oral medium, while an alternative view suggests that, because of the imperfections in using the oral medium with deaf children, they should be encouraged to develop language skills through total communication. These educational regimes were outlined in Chapter 1. In addition to this primary decision about how best to develop communicative abilities there is considerable variation in the method and extent of 'speech training' which is given to deaf children.

We lack an accurate label with which to describe this part of a hearing impaired child's development. Terms such as 'speech training' (Ewing et al 1964, Groht 1932), 'speech habilitation' (Whitehead and Subtelny 1976), 'speech work' (Fisher et al 1983), 'phonetic and phonological training' (Ling 1976) have been used in the literature. Some of these terms seem to the author to be less accurate than others or are idiosyncratic to the speech development regime being described. For example the views of Ewing and Ling are wholly different in their approach to developing intelligible speech in deaf children. Ewing et al (1964) and others such as McMahon et al (1976), who have followed the Ewing approach, would argue that the development of language and intelligible speech should be in tandem. They would say that when a child is learning a new word the child should be encouraged to listen, watch the face of the teacher/therapist, associate meaning, and only then say the word. The teacher/therapist would then modify the child's speech production of that word until it approximated the adult model. In direct contrast Ling points to the stilted speech production which a technique such as that outlined above can lead to. He suggests a completely different approach. He suggests that hearing impaired children should be allowed and encouraged to develop pre-verbal oral skills through babble and sound play. He argues that only when the hearing impaired child has developed easy babble routines with normal voice quality should the teacher/therapist attempt to develop meaningful speech. In Ling's terms the teacher/therapist moves the child from phonetic skills to phonological skills. The contrast is then between those who emphasize spoken language teaching and refine articulatory skills later and those, like Ling, who emphasize phonetic skills first.

It would be interesting to know the method and extent of speech work which has been conducted in school with these hearing impaired speakers. The hypothesis is that those speakers whose school curriculum included a lot of direct speech work, emphasising articulatory placement and articulatory movements, will be those who have EXTENSIVE RANGE of LIP and JAW MOVEMENTS. In such an oral regime the pupils are also likely to have had in their curriculum formal speech reading (or even lip speaking) classes, where lip patterns would have been stressed. It would appear likely that pupils in an oral regime will have had lip and jaw movements emphasized during both speech classes and speech reading classes and will become young adults likely to have increased LIP and JAW MOVEMENTS.

A further recommendation is that a group of young adult speakers whose educational history is well known should be investigated to see if there is any difference in the RANGE of LIP and JAW MOVEMENTS habitually used by those speakers who had early formal speech work and those who had little or none.

Hearing impaired speakers have a reduced or nil auditory feedback system with which they can monitor their speech production. In the case of the profoundly deaf speakers in Experimental Group I, we can be sure that they have very little (if any) auditory feedback available to them. It appears that, in the absence of auditory feedback, hearing impaired speakers rely on kinaesthetic feedback in order to monitor their speech performance.

The area of sensory feedback in the control of speech is one which has received recent interest in speech physiology research. The role of oral kinaesthesia as an important feedback mechanism alongside auditory feedback is recognized but ill understood. Oral kinaesthesia is thought to have several components. Firstly straightforward physiological feedback about anatomical placement. This is the sensory feedback derived from sensory nerve endings giving information about touch, pain or discomfort. This type of oral sensory feedback is sometimes referred to as oral gnostic skill. Secondly oral kinaesthesia utilizes proprioceptive feedback. This is feedback derived from the muscle cells themselves, giving information about the state of contraction and/or relaxation of the musculature. Research which has looked at feedback disturbances in dysarthric speakers (Darley 1982) has shown that proprioceptive feedback operates separately from sensory/gnostic skills. The third orosensory skill is that of being able to identify shapes in the mouth. This skill is called oral stereognosis. Finally the term orosensory feedback can be interpreted in a more cognitive sense, and concerns the ability of speakers to produce, on command, controlled speech output. Cognitive psychologists such as Butterworth (1980) have tried to explain the units of control. The unit of control is usually described as a time based unit often of several segments duration. When the sensory feedback of deaf speakers is considered it is necessary to describe the interplay between sensory/gnostic feedback, proprioceptive feedback and oral stereognosis. It is also necessary to consider whether the unit of control and feedback is the same as it is for hearing people. The great advantage of vocal profile analysis is that it enables the teacher/therapist to examine the long-term speaker characteristics of the deaf speaker's output and ipso facto the long-term feedback with which he is controlling his output. Clinical experience suggests that hearing impaired speakers do depend heavily upon oral gnosis and that this can be usefully taught as a remedial objective, to improve the speaker's ability to monitor his output (Wirz and Anthony, 1978). Adventitiously profoundly deaf speakers who retain good speech patterns can be considered to have well developed (and retained) oral gnostic and proprioceptive skills. Congenitally profoundly deaf speakers who develop good speech patterns in the absence of auditory feedback have developed both sensory gnostic and proprioceptive feedback mechanisms.

Bishop et al (1973) investigated the ability of hearing impaired speakers to identify shapes in the mouth. He found that those hearing impaired speakers who used predominantly manual communication were significantly less able to perform this task than hearing impaired speakers who used oral communication. However, those hearing impaired speakers who used oral communication had the same total error rate as the hearing subjects.

These results add weight to the argument that hearing impaired speakers who are able to use speech well will have not only better oromotor skills but also better orosensory skills than their less fluent peers.

In some ways the speech patterns of less intelligible hearing impaired speakers resemble the inaccurate placement and laboured coordination of the neurologically dyspraxic speaker. Edwards (1973) and Hayes, Johns and May (1978) among others have shown that the kinaesthetic skills of dyspraxic speakers, specifically for oral form identification tasks, is impaired.

It is difficult to decide whether orosensory abilities are poor when there is a history of poorly developed articulation or conversely whether the inability to develop good articulatory skills is because of the poor orosensory skills. As Bishop et al say:

"While the ability to refine speech performance is

> contingent upon the ability to integrate orosensory and oromotor activity, the development of this integrative ability in part at least depends on articulatory practice" (1973, p. 265).

One would anticipate from this that hearing impaired speakers will rely on kinaesthetic feedback to monitor their speech performance but that less intelligible hearing impaired speakers will have poorly developed kinaesthetic abilities.

The results of this study suggest that less intelligible profoundly deaf speakers attempt to boost their kinaesthetic awareness by increasing the muscle tension of their vocal tract. It was noted in Chapter 4 that hearing impaired speakers in Experimental Group I exhibited higher ratings of TENSION than did the hearing control group. This higher incidence of increased TENSION was evident at LARYNGEAL, SUPRALARYNGEAL and PHARYNGEAL levels of the vocal tract, and was significant at $P < .05$, .01 and .001 levels respectively. When the tension features of those hearing impaired speakers with more hearing (Experimental Group III) are examined, it can be seen that firstly they had less tension than the profoundly deaf in all 3 tension areas, and secondly that their supralaryngeal and laryngeal tension decreased as the result of therapy.

The tension feature which exhibited the greatest difference between the profoundly hearing impaired and hearing speakers was the feature of PHARYNGEAL CONSTRICTION. Almost twice as many hearing impaired speakers in Experimental Group I were rated as having PHARYNGEAL CONSTRICTION (87.5%) compared with 47.5% of the hearing groups.

It has frequently been reported that hearing impaired speakers have higher pitched voices than their hearing peers (e.g. Michel et al 1966, Angelloci 1962) and that this higher pitch is associated with a 'strident' quality (Markides 1983) and/or 'poor resonance' (Jones 1967). The feature of PHARYNGEAL CONSTRICTION as defined by the VPA refers to the quality derived from constriction of the pharynx using the palato-pharyngeous and stylohyoid muscles. A constriction of this musculature results not only in a change in the shape and subsequent function of the pharyngeal resonator but also in raising the larynx. A discussion of the co-occurrence of these features was given in Chapter 4.

In addition to the high incidence of non-neutral ratings of PHARYNGEAL CONSTRICTION many of the profoundly hearing impaired speakers in Group I also showed non-neutral settings of SUPRALARYNGEAL TENSION. Among those speakers who had non-neutral SUPRALARYNGEAL TENSION (92.5% of hearing impaired speakers) most were rated as having increased tension (85%).

Finally all profoundly hearing impaired speakers had non-neutral settings of LARYNGEAL TENSION, the great majority (95%) exhibiting increased LARYNGEAL TENSION. The explanation for this increased tension in all areas of the vocal tract is, the author suggests, related to the dependence which hearing impaired speakers have upon kinaesthetic feedback. Writers such as Ling (1976) suggest that if hearing impaired children were encouraged to engage in 'sound play' before meaning is associated with their articulatory patterns they would develop better kinaesthetic feedback.

> "Appropriate laryngeal and pharyngeal adjustments can only result if the child is encouraged to experiment with speech production in such a way that he experiences the wide range of motor-kinaesthetic patterns associated with different

degrees of laryngeal and pharyngeal tension" (Ling 1976, p. 229).

It is clear that the majority of profoundly hearing impaired speakers in Groups I and II had not had sufficient "experiences of a wide range of motor kinaesthetic patterns" and had thus not learned to use appropriate levels of LARYNGEAL and PHARYNGEAL TENSION. Their peers in Experimental Group III had, by a combination of auditory and kinaesthetic feedback, learned to monitor their articulatory tension more appropriately. This fact has considerable remedial implications. Most teacher/therapists recognize the important role of kinaesthetic feedback for severely and profoundly deaf speakers learning to monitor their speech production, even if it is still ill understood.

If, as seems to be the case, the hearing impaired speaker boosts the tension within his vocal tract in order to increase his kinaesthetic awareness, one of the teacher/therapist's principal tasks must be to encourage the speaker to reduce this tension.

It is enormously difficult to persuade a severely or profoundly deaf speaker, who has become dependent on high levels of tension to increase his kinaesthetic awareness, how little effort is needed in order to produce audible speech.

The author recalls deaf speakers making comments such as

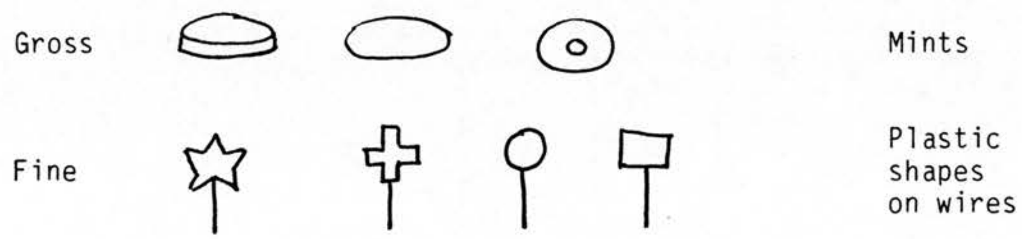
"Can you still hear that?"

"Is that enough (i.e. effort/tension) for you to hear?"

However, at the beginning of this discussion, two sorts of orosensory skills were outlined; firstly the basic kinaesthetic feedback and secondly oral stereognosis. Because it is so difficult to persuade deaf speakers to reduce the tension which has become an integral part of their feedback mechanism, perhaps a more useful remedial approach would be to develop orosensory skills through oral stereognosis training.

Hayes et al (1978) and Edwards (1973) have reported success with training of this type with dyspraxic speakers and there is, the author feels, encouragement that this form of indirect orosensory training may have a carry-over to a hearing impaired speaker's oral kinaesthesia.

The suggestion is that hearing impaired speakers would be encouraged first to recognise gross shape differences in the mouth. One technique which the author has used involves the use of differently shaped mint sweets; "polos" v. solid round mints, small "tic tac" mints v. larger "pan drops" etc. The task involves moving from gross to finer differences. Plastic shapes can be mounted on wire probes which can then be held in the mouth and identified by the deaf speaker. In a preliminary study the author used the following shapes:



It would be interesting to use this technique with hearing impaired children who have competent oral skills and see, firstly, if they improved in their ability to recognise shapes, and secondly, whether this improved ability was associated with a decrease in oral tension.

It is clear from the results reported in Chapter 4 that there is agreement among judges in their ratings of pitch parameters and, secondly, that there is a relationship between ratings of pitch and measurements of fundamental frequency. It is also clear from these same results that there appears to be some listener bias in some of these ratings. This bias is twofold:

(a) Listeners usually rate male hearing impaired speakers as having LOW PITCH MEAN and females as having HIGH PITCH MEAN. Ratings of the pitch mean of hearing subjects, however, led to some men being rated HIGH and some women LOW. This 'reversal of expectation' did not happen in the ratings of hearing impaired speakers.

(b) Having made a rating of NARROW PITCH RANGE the listener invariably couples this with a rating of LOW VARIABILITY of pitch.

To investigate the extent of this listener bias it would be interesting to devise an experiment where recordings of male and female hearing impaired speakers are analysed. The analysis adopted could be that procedure used in the RNID Speech Computer, which can determine the mean fundamental frequency of the sample. From these recordings, 5 female speakers with low mean F_o and 5 female speakers with high mean F_o, together with 5 male speakers with low mean F_o and 5 male speakers with high mean F_o would be recorded randomly onto an experimental tape. Listeners familiar with the VPA would then be asked to rate the PITCH MEAN of these 20 speakers. The results would show if there was any listener bias of the sort outlined above.

As stated above there was also a tendency for speakers who were rated as having a NARROW PITCH RANGE to have LOW PITCH VARIABILITY. Out of 13 female hearing impaired speakers in Experimental Group I, 11 were rated as having a NARROW PITCH RANGE and 9 of these as having LOW VARIABILITY. Of the 27 male hearing impaired speakers in Group I, 25 were rated as having NARROW PITCH RANGE and all as having LOW PITCH VARIABILITY. These findings lead to the question can PITCH RANGE and PITCH VARIABILITY be rated independently? It appears from the ratings of hearing speakers that it is possible to rate these features separately. Why then do they appear to be rated together for hearing impaired speakers? One explanation for this phenomenon may be that deaf speech is commonly thought to be 'monotonous' or 'boring' to listen to. The listener then hearing a hearing impaired speaker has a listening 'set' towards such a judgement. LOW VARIABILITY is the feature on the VPA most analogous with 'monotonous' and for this reason judges tend to rate the recordings as being of LOW VARIABILITY.

If experienced listeners were asked to rate PITCH RANGE and PITCH VARIABILITY independently, e.g. asking 3 judges familiar with the VPA to rate the PITCH RANGE of 10 hearing impaired men and 20 hearing impaired women, a further 3 judges could then rate the PITCH VARIABILITY. These separate judgements of PITCH RANGE and PITCH VARIABILITY could then be compared with ratings of 3 judges who had been asked to rate both PITCH RANGE and PITCH VARIABILITY. It is hypothesized that raters tend to be biased in their judgement of one of these parameters by the other.

It is evident from this study that deaf speakers have a nexus of speech differences. The results show how these differences can be separated from the speech of hearing speakers in a way which it is hoped will directly aid remedial planning.

CHAPTER 6

CONCLUSIONS

This thesis shows that it is important to look at the speech patterns of hearing impaired people using a non-segmental approach. The traditional way of looking at deaf speech has been either to describe the differences between various segmental aspects of deaf and hearing speech or to describe the segmental features of deaf speech.

This study took the view that segmental analysis alone did not adequately describe deaf speech, and chose to take a different direction by looking at the long-term features of the speech of deaf speakers. This descriptive approach is different from but complementary to segmental analysis. The voice quality of deaf speakers is strikingly different from that of hearing speakers; these differences are symptomatic of deafness. However, attempts to describe 'deaf voice' have been few and have been incomplete. In order to describe 'deaf voice', 50 vocal profiles of hearing impaired speakers were completed and analysed in an attempt to identify common features. The Vocal Profiles Analysis scheme was chosen because it describes long-term speaker characteristics using scalar componential perceptual judgements.

Many studies attempting to describe speech characteristics of deaf speakers have not been rigorous in the way in which they choose groups of deaf speakers as subjects. This study chose 50 young deaf adults and, within the enormous constraints of such a multivariable speaker group, sought to provide three carefully controlled groups of deaf speakers. From the 50 vocal profiles compiled in the study common features among the 3 deaf groups were identified.

These 'common VPA features' of the hearing impaired speakers were identified in 4 ways. Firstly by examining and describing the group data from Experimental Groups I, II and III, secondly by comparing the group data of the three experimental groups with the data of the hearing controls, thirdly by comparing the data from Experimental Groups I and II (the profoundly deaf) with the data from Experimental Group III (the less deaf) and fourthly by comparing the pre- and post-therapy data for the speakers in Group III who improved as a result of therapy.

The group data for Experimental Groups I, II and III were described in Chapter 4 and graphically presented in Figures E, F and G. Experimental Group I was a group of 40 profoundly hearing impaired speakers chosen as a very homogeneous group of deaf American speakers. Experimental Group II was a smaller group of 5 profoundly hearing impaired British speakers, their audiological characteristics, age and educational history closely resembling those of Experimental Group I. Experimental Group III was a small group of 5 young British subjects with less severe hearing losses than those in Experimental Groups I and II. The group data were presented by calculating the median point for each feature. The features common to all three groups of hearing impaired speakers were:

1. A slight degree of LIP ROUNDING
2. A BACKED TONGUE BODY position
3. A MINIMIZED RANGE of TONGUE BODY movements
4. Marked NASAL RESONANCE
5. Marked PHARYNGEAL CONSTRICTION
6. Moderate SUPRALARYNGEAL TENSION
7. Moderate LARYNGEAL TENSION
8. A slightly RAISED LARYNX position
9. Marked HARSHNESS

10. Marked WHISPERINESS

11. NARROW PITCH RANGE

12. LOW PITCH VARIABILITY

There are other features common to the two groups of profoundly deaf speakers but they are not being considered here. The 12 features listed above were common to <u>all</u> the deaf speakers regardless of degree of hearing loss and can be said to be the 'common VPA features' of hearing impaired speakers. However, before too definite claims are made, the second comparison suggested above must be made, i.e., comparing the group data of the three experimental groups with those of hearing controls.

Taking the 12 features common to all experimental groups as the basis of comparison, we find that the hearing speakers <u>do</u> <u>not</u> (as a group) exhibit:

1. LIP ROUNDING

3. MINIMIZED RANGE OF TONGUE BODY movements

5. PHARYNGEAL CONSTRICTION

8. RAISED LARYNX position

9. HARSHNESS

11. NARROW PITCH RANGE

or 12. LOW VARIABILITY

These 7 features seem to separate deaf from hearing speakers and must account for the quality frequently described as 'deaf voice'. The other 5 features which were common to all three groups of hearing impaired speakers also occur as group data features among the hearing speakers, but to a less marked extent.

In conclusion this study identified deaf voice as being: a harsh voice with more whisperiness than usual, with pharyngeal tension and more laryngeal and supralaryngeal tension than usual, and with a raised larynx position. Supralaryngeally deaf voice will have more backing of the tongue body and more nasal resonance than usual, with minimized tongue movements, lip rounding, narrow pitch range and low pitch variability. Figure Q illustrates 'deaf voice'.

Having identified in broad brush terms these characteristics of deaf voice it is then possible from the data in this study to identify those features which are common to profoundly deaf speakers rather than less deaf speakers. Looking first at supralaryngeal VPA features, it appears that profoundly deaf speakers have a non-neutral setting of RANGE OF LIP MOVEMENT whereas the less deaf (like the hearing) have a neutral setting of lip movement. This phenomenon is discussed in Chapter 5, where it is suggested that differences arise from the compensatory movements of deaf speakers. Whether a deaf speaker seeks to compensate for his poor lip patterns by either exaggerating or reducing these patterns will depend in part upon the type of oral education which the speaker has had. Less deaf speakers do not have to do this because they are more able to monitor their output auditorily.

Similarly RANGE OF JAW MOVEMENT is different among profoundly deaf and less deaf speakers. The less deaf speakers in this study showed neutral setting of jaw movement (after therapy) whereas the profoundly deaf speakers showed either extensive or minimized range of jaw movement. In both cases of RANGE, JAW and LIP RANGES were minimized by the American profoundly deaf and extended by the (smaller) British group of profoundly deaf. This difference is almost certainly accounted for by the fact that in the late 1960s and early 1970s, when all these deaf speakers were in primary school, oral education in the UK stressed lip patterns whereas only some of the Americans would have been at such schools.

VPA PROFILE OF DEAF VOICE

Vocal Profile Analysis Protocol

Speaker: .... Sex: .... Age: .... Date of Analysis: .... Tape: .... Judge: ....

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
				Breathiness						
				Creak(y)						
				Falsetto						
				Modal Voice		✓				

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II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

Deaf + Hearing	
'Deaf Voice'	

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Profoundly deaf and less deaf speakers all exhibited MINIMIZED RANGE OF TONGUE BODY movements but the degree of minimization was less marked among the less deaf. Above in Chapter 5 there was a discussion of the impossibility of attributing single features to increased or decreased intelligibility. It was demonstrated that two speakers with identical ratings for RANGE OF TONGUE BODY movements had very different intelligibility ratings because of the clustering of other aspects of their profiles. However, it does show that MINIMIZED RANGE OF TONGUE BODY movements is an important contributory factor to poor intelligibility, and it is not surprising that one of the differences between profoundly deaf and less deaf speakers was the greater MINIMIZATION OF TONGUE BODY MOVEMENTS among the more deaf.

Both profoundly and less deaf speakers exhibited slight LIP ROUNDING, some BACKING of the TONGUE BODY and moderate NASAL RESONANCE. As was discussed in Chapter 4, BACKED TONGUE BODY, RAISED LARYNX and PHARYNGEAL CONSTRICTION often co-occur and frequently this co-occurrence is associated with increased NASAL RESONANCE. This certainly seems to be the case with both profoundly and less deaf speakers. Both groups show BACKING of TONGUE BODY, PHARYNGEAL CONSTRICTION and RAISED LARYNX POSITION associated with marked NASAL RESONANCE. (In the post-therapy profiles speakers in Experimental Group III [the less deaf] did not exhibit RAISED LARYNX but were in this respect similar to the hearing controls.)

Looking next at tension features, it can be seen that both the profoundly deaf and less deaf speakers showed LARYNGEAL and SUPRALARYNGEAL TENSION but the less deaf showed tension only at the level displayed by the hearing control group. This increased tension among the profoundly deaf most probably arises from their effort to increase their kinaesthetic feedback. This point was discussed above in

Chapter 5. We can conclude that the less deaf did not need to depend so heavily on kinaesthetic feedback, and the consequent reduction of laryngeal and supralaryngeal tension contributed to the increased intelligibility of this group.

The final difference in the group data of profoundly and less deaf speakers is in the area of pitch control. Both groups of deaf speakers showed NARROW PITCH RANGE and LOW PITCH VARIABILITY but the less deaf showed these features to a less marked degree than the profoundly deaf. These features would probably lead both groups of speakers to be considered monotonous by those assessments which use the term.

Figure R displays the differences between the 'deaf voice' of the profoundly deaf and that of the less deaf.

The fourth and final way in which conclusions can be drawn from this study is to examine features which were changed by therapy. The five less deaf speakers in Experimental Group III all had 16/20 hours of therapy between the first and second recordings. It is important to be able to isolate which speech parameters are most amenable to therapy in order that therapy can be directed appropriately. The VPA analysis of this study allows this to be done.

It is clear from an examination of the pre- and post-therapy vocal profiles that EXTENSIVE RANGE OF JAW and RAISED TONGUE BODY were two supralaryngeal features which were changed by therapy. Both of these features were rated post-therapy as being similar to the ratings for hearing subjects. This allows the conclusion to be drawn that reduction in TONGUE BODY RAISING and in EXTENSIVE JAW MOVEMENTS contribute to improved intelligibility. It should also be noted that both these changes were effected without any direct therapy being directed to these parameters.

FIGURE R

VPA PROFILE OF THE DIFFERENCES BETWEEN PROFOUNDLY DEAF AND LESS DEAF SPEAKERS

Vocal Profile Analysis Protocol

Speaker: .... Sex: .... Age: .... Date of Analysis: .... Tape: .... Judge: ....

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion	S.					
				Lip Spreading						
				Labiodentalization		L				
				Extensive Range	D.					
				Minimised Range						
2. Mandibular	S.			Close Jaw						
				Open Jaw						
				Protruded Jaw						
				Extensive Range	L.					
				Minimised Range		D.				
3. Lingual Tip/Blade	S.			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
				Backed Body		S.				
				Raised Body			L.			
				Lowered Body						
				Extensive Range						
				Minimised Range	L.			D.		
5. Velopharyngeal				Nasal			L.	D.		
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal				Pharyngeal Constriction		S.				
7. Supralaryngeal Tension				Tense	L.	D.				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension				Tense	L.		D.			
				Lax						
9. Larynx Position				Raised	S.					
				Lowered						
10. Phonation Type				Harshness	L.	D.				
				Whisper(y)		L.	D.			
				Breathiness						
				Creak(y)						
				Falsetto						
				Modal Voice			S.			

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	D.			High Mean						
				Low Mean	L					
				Wide Range						
				Narrow Range	L		D			
				High Variability						
				Low Variability	L	D				
2. Consistency	S.			Tremor						
3. Loudness	S.			High Mean						
				Low Mean						
	L.			Wide Range						
				Narrow Range						
	L.			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	S.					Interrupted
2. Rate	S.					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	S				
Rhythmicality	S.				

Diplophonia

Other Comments:

KEY L = Less Deaf
D = Deaf
S = Same

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Therapy also had the effect of reducing the degree of NASAL RESONANCE and LOWERING the LARYNX. This dual change adds weight to the argument that NASAL RESONANCE, LARYNX POSITION, TONGUE BACKING and PHARYNGEAL CONSTRICTION greatly interact with each other.

The third area where therapy improved the speech of this group of speakers was in the area of pitch control. Before therapy they showed slightly HIGH PITCH MEAN whereas after therapy this had been reduced to a NEUTRAL rating and, although the speakers still exhibited slightly NARROW PITCH RANGE and LOW VARIABILITY this was less marked than before therapy.

The remedial implications of this are clear. Not all hearing impaired people choose to depend on spoken language as the major part of their communicative skills but, for those who do, they seek from teachers and therapists help with improving their intelligibility.

Traditionally teacher/therapists have had to rely on their own clinical experience as to how a hearing impaired speaker's segmental production related to his intelligibility. Inferences can of course be drawn between articulatory accuracy and intelligibility or between prosodic normacy and intelligibility, but essentially the teacher/therapist was left with the task of planning a remedial programme based on rather incomplete material; material which gave the teacher/therapist detail concerning the building blocks of speech (the segments) but gave her little detail of how these blocks were built (the long-term speaker characteristics). To take this building analogy further, this thesis has shown how a non-segmental assessment gives a clear indication of the structure of the building over and above the structure of the bricks.

The thesis describes 'deaf voice' and indicates how this description can be used as a basis for remedial planning.

It is well known that deaf speakers have difficulties. Assessments which are segmentally based merely reiterate this information. The Vocal Profile Analysis scheme, in contrast, identifies the long-term articulatory settings used by a deaf speaker and indicates where these need to be change in order to improve a hearing impaired speaker's performance. The remedial implications of using Vocal Profile Analysis with deaf speakers are considerable.

The specific remedial needs of each deaf speaker are different for each client. Skilful therapy consists largely of the ability to recognize these individual remedial requirements both in the planning and execution of therapy for each deaf speaker. The quantification allowed by using a Vocal Profile Analysis as part of the pre-therapy assessment gives the therapist a clearer grasp of the speaker's needs than do other available assessments.

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APPENDIX 1

VOCAL PROFILES OF EXPERIMENTAL GROUP I

Vocal Profile Analysis Protocol

Speaker: 1 Sex: F Age: 19y Date of Analysis: PhD Tape: 2 Judge: J.L., S.L.W., J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading	/	/				
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range	/	/	/	/		
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range	/	/	/			
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body	✓			Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	/	/				
5. Velopharyngeal		✓		Nasal	/	/	/			
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal	✓			Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense	/	/	/			
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/				
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type		✓		Harshness	/	/				
		✓		Whisper(y)	/					
		✓		Creak(y)	/	/				
				Falsetto						
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean	/	/	/			
				Low Mean						
		✓		Wide Range						
				Narrow Range	/	/	/			
		✓		High Variability						
				Low Variability	/	/				
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean	/					
				Low Mean						
			✓	Wide Range						
				Narrow Range	/	/	/	/		
		✓		High Variability						
				Low Variability	/	/	/			

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 2 Sex: F Age: 20y Date of Analysis: Ph D Tape: 2 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion	/	/	/			
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range	/	/	/			
2. Mandibular				Close Jaw	/					
		✓		Open Jaw						
				Protruded Jaw						
				Extensive Range						
				Minimised Range	/	/	/			
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body	/	/				
		✓		Backed Body						
				Raised Body	/	/				
		✓		Lowered Body						
				Extensive Range						
				Minimised Range	/	/	/			
5. Velopharyngeal			✓	Nasal	/	/	/	/		
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/				
7. Supralaryngeal Tension		✓		Tense	/	/	/			
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/	/			
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type		✓		Harshness	/	/				
		✓		Whisper(y)	/	/	/			
				Creak(y)						
		✓		Falsetto			✓			
		✓		Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean	/	/	/	/		
				Low Mean						
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/	/				
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean	/	/				
		✓		Wide Range						
				Narrow Range	/	/	/			
		✓		High Variability						
				Low Variability	/	/	/			

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate				✓		Fast
		✓				Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	✓		
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia	✓	

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 3 Sex: M Age: 19y Date of Analysis: PhD Tape: 2 Judge: JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion	/	/				
				Lip Spreading						
		✓		Labiodentalization						
				Extensive Range						
				Minimised Range	/	/				
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	/					
4. Lingual Body		✓		Fronted Body						
				Backed Body	/	/	/			
		✓		Raised Body						
				Lowered Body	/					
			✓	Extensive Range						
				Minimised Range	/	/	/	/		
5. Velopharyngeal		✓		Nasal	/	/	/			
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/	/			
7. Supralaryngeal Tension		✓		Tense	/	/	/			
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense	/	/	/	/		
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type				Harshness						
		✓		Whisper(y)	/	/				
		✓		Creak(y)	/	/	/			
				Falsetto						
		✓		Modal Voice				✓		

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	/					
			✓	Wide Range						
				Narrow Range	/	/	/	/		
		✓		High Variability						
				Low Variability	/	/	/			
2. Consistency		✓		Tremor	/					
3. Loudness	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/	/				

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 4 Sex: F Age: 20y Date of Analysis: PhD Tape: 2 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion	/	/				
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw	/	/				
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range	/					
3. Lingual Tip/Blade		✓		Advanced	/	/				
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body	/					
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	/	/	/			
5. Velopharyngeal				Nasal	/	/	/	/		
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/					
7. Supralaryngeal Tension		✓		Tense	/	/				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/					
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type				Harshness						
		✓		Whisper(y)	/	/				
				Creak(y)						
				Falsetto						
			✓	Modal Voice			✓			

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II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean	/	/				
				Low Mean						
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/					
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean	/					
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/					

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees: Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 5 Sex: M Age: 20y Date of Analysis: PhD Tape: 1 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Normal 1	Normal 2	Normal 3	Abnormal 4	Abnormal 5	Abnormal 6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range	/	/	/			
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body			✓	Fronted Body						
				Backed Body	/	/	/	/		
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	/	/	/			
5. Velopharyngeal		✓		Nasal	/	/	/			
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal	✓			Pharyngeal Constriction						
7. Supralaryngeal Tension	✓			Tense	/	/				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense	/	/	/	/	/	
				Lax						
9. Larynx Position		✓		Raised						
				Lowered	/					
10. Phonation Type			✓	Harshness	/	/	/	/		
		✓		Whisper(y)	/	/				
		✓		Creak(y)	/	/	/			
				Falsetto						
		✓		Modal Voice				✓		

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II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Normal 1	Normal 2	Normal 3	Abnormal 4	Abnormal 5	Abnormal 6
1. Pitch		✓		High Mean						
				Low Mean	/	/				
			✓	Wide Range						
				Narrow Range	/	/	/	/	/	
			✓	High Variability						
				Low Variability	/	/	/	/	/	
2. Consistency		✓		Tremor	/	/				
3. Loudness		✓		High Mean						
				Low Mean	/	/				
			✓	Wide Range						
				Narrow Range	/	/	/	/		
			✓	High Variability						
				Low Variability	/	/	/			

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees, Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 6 Sex: M Age: 19 Date of Analysis: Ph.D. Tape: 2 Judge: J.M. SLW.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS			SECOND PASS						
	Neutral	Non-neutral		SETTING	Scalar Degrees					
		Normal	Abnormal		Normal			Abnormal		
					1	2	3	4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
			✓	Falsetto			✓			
			✓	Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS			SECOND PASS						
	Neutral	Non-neutral		SETTING	Scalar Degrees					
		Normal	Abnormal		Normal			Abnormal		
					1	2	3	4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness			✓	High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS		SECOND PASS			
	Adequate	Inadequate	Scalar Degrees			
			Inadequate			
			1	2	3	
1. Continuity		✓			✓	Interrupted
2. Rate		✓	✓			Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓		✓	
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia	✓	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 7 Sex: M Age: 20 Date of Analysis: PhD Tape: 1 Judge: JM S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw	/					
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced	/	/				
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body	/	/				
		✓		Raised Body	/	/				
				Lowered Body						
			✓	Extensive Range						
				Minimised Range	/	/	/	/		
5. Velopharyngeal			✓	Nasal	/	/	/	/		
				Audible Nasal Escape				/		
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/				
7. Supralaryngeal Tension	✓			Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/				
				Lax						
9. Larynx Position		✓		Raised						
				Lowered	/	/	/			
10. Phonation Type		✓		Harshness						
				Whisper(y)	/	/	/			
		✓		Creak(y)	/					
				Falsetto						
			✓	Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	/	/				
		✓		Wide Range						
				Narrow Range	/	/	/			
		✓		High Variability						
				Low Variability	/					
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean	/					
		✓		Wide Range						
				Narrow Range	/	/	/			
		✓		High Variability						
				Low Variability	/	/				

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	✓		
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 8 Sex: M Age: 20y Date of Analysis: PhD Tape: 3 Judge: S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
			✓	Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓								
		✓		Creak(y)						
				Falsetto						
		✓		Modal Voice						

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓	✓			Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	✓		
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

ES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 9 Sex: M Age: 19y Date of Analysis: PhD Tape: 2 Judge: SLW, J.M

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion	/	/				
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range	/	/				
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range	/					
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	/	/				
4. Lingual Body		✓		Fronted Body						
				Backed Body	/	/	/			
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	/	/				
5. Velopharyngeal			✓	Nasal	/	/	/	/		
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/				
7. Supralaryngeal Tension		✓		Tense	/					
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/					
				Lax						
9. Larynx Position		✓		Raised						
				Lowered	/					
10. Phonation Type		✓		Harshness	/	/				
		✓		Whisper(y)	/	/				
		✓		Creak(y)	/					
				Falsetto						
		✓		Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	/					
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/					
2. Consistency	✓			Tremor						
3. Loudness			✓	High Mean						
				Low Mean	/	/	/	/		
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/					

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 15 Sex: M Age: 20 Date of Analysis: PhD Tape: 1 Judge: JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range	/	/	/			
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
				Extensive Range						
		✓		Minimised Range	/	/	/			
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	/					
4. Lingual Body				Fronted Body						
		✓		Backed Body	/	/				
		✓		Raised Body	/	/				
				Lowered Body						
				Extensive Range						
			✓	Minimised Range	/	/	/	/		
5. Velopharyngeal				Nasal	/	/	/	/		
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/	/			
7. Supralaryngeal Tension		✓		Tense	/	/				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/	/			
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type				Harshness						
		✓		Whisper(y)	/	/	/			
		✓		Creak(y)	/					
				Falsetto						
			✓	Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
				Wide Range						
		✓		Narrow Range	/	/	/			
				High Variability						
		✓		Low Variability	/	/				
2. Consistency	✓			Tremor						
3. Loudness				High Mean						
		✓		Low Mean	/					
				Wide Range						
		✓		Narrow Range	/	/				
				High Variability						
		✓		Low Variability	/	/				

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate						Fast
		✓	✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 16 Sex: F Age: 20y Date of Analysis: Ph.D. Tape: 3/1R Judge: JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range	/	/				
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range	/	/				
3. Lingual Tip/Blade	✓	•		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body	/	/	/			
				Backed Body						
		✓		Raised Body						
				Lowered Body	/	/	/			
		✓		Extensive Range						
				Minimised Range	/	/	/			
5. Velopharyngeal		✓		Nasal	/	/	/			
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal	✓			Pharyngeal Constriction						
7. Supralaryngeal Tension	✓			Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense	/	/	/	/		
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type		✓		Harshness	/	/	/			
				Whisper(y)						
		✓		Creak(y)	/	/				
			✓	Falsetto				✓		
			✓	Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean	/	/	/	/		
				Low Mean						
			✓	Wide Range	/	/	/	/		
				Narrow Range						
		✓		High Variability	/	/	/			
				Low Variability						
2. Consistency		✓		Tremor	/	/	/			
3. Loudness		✓		High Mean						
				Low Mean	/	/				
		✓		Wide Range						
				Narrow Range	/	/	/			
		✓		High Variability						
				Low Variability	/	/	/			

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia	✓	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 19 Sex: M Age: 21 Date of Analysis: PhD Tape: 2 Judge: JL JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body						
		✓		Raised Body						
				Lowered Body						
				Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position				Raised						
	✓			Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
				Falsetto						
		✓		Modal Voice		✓				

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
				Wide Range						
		✓		Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness				High Mean						
		✓		Low Mean						
				Wide Range						
		✓		Narrow Range						
				High Variability						
		✓		Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees: Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate						Fast
		✓	✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 22 Sex: M Age: 20y Date of Analysis: PhD Tape: 3 Judge: J.M. S.L.W

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion	////					
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range	////	////	////			
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw	////					
		✓		Extensive Range						
				Minimised Range	////	////	////			
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body	////	////				
				Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range	////	////	////	////		
5. Velopharyngeal				Nasal	////	////	////	////		
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	////					
7. Supralaryngeal Tension		✓		Tense						
				Lax	////					
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	////					
				Lax						
9. Larynx Position		✓		Raised						
				Lowered	////					
10. Phonation Type				Harshness						
		✓		Whisper(y)	////	////				
		✓		Creak(y)	////	////				
				Falsetto						
		✓		Modal Voice				✓		

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	////	////	////			
		✓		Wide Range						
				Narrow Range	////	////	////			
		✓		High Variability						
				Low Variability	////	////	////			
2. Consistency		✓		Tremor	////					
3. Loudness		✓		High Mean						
				Low Mean	////	////				
		✓		Wide Range						
				Narrow Range	////	////	////			
		✓		High Variability						
				Low Variability	////	////	////			

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate						Fast
		✓	✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 23 Sex: F Age: 20y Date of Analysis: PhD Tape: 4 Judge: J.L. S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency		✓		Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
				✓		Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 24 Sex: M Age: 21y Date of Analysis: PLD Tape: 3 Judge: J.L. J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
			✓	Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal	✓			Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type			✓	Harshness						
			✓	Whisper(y)						
				Creak(y)						
				Falsetto						
		✓		Modal Voice				✓		

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓			✓
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 26 Sex: F Age: 19 Date of Analysis: PhD Tape: 2 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal	✓			Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
				Creak(y)						
				Falsetto						
			✓	Modal Voice				✓		

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

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Vocal Profile Analysis Protocol

Speaker: 31 Sex: M Age: 21y Date of Analysis: PhD Tape: 1 Judge: JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type			✓	Harshness						
		✓		Whisper(y)						
			✓	Creak(y)						
		✓		Falsetto				✓		
		✓		Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees: Inadequate 1	2	3	
1. Continuity		✓		✓		Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓		✓	
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia	✓	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 33 Sex: M Age: 22 Date of Analysis: PhD Tape: 3 Judge: J.L. J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
			✓	Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
		✓		Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position				Raised						
		✓		Lowered						
10. Phonation Type				Harshness						
		✓		Whisper(y)						
			✓	Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	✓		
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 34 Sex: F Age: 19y Date of Analysis: PhD Tape: 1 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
		✓		Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
			✓	Falsetto			✓			
			✓	Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness			✓	High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	✓		
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia	✓	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 35 Sex: F Age: 20 Date of Analysis: PhD Tape: 4 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
	✓			Lip Spreading						
				Labiodentalization						
				Extensive Range						
		✓		Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
				Extensive Range						
		✓		Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body			✓	Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type				Harshness						
			✓	Whisper(y)						
				Creak(y)						
				Falsetto						
		✓		Modal Voice		✓				

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency		✓		Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
				✓		Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓		✓	
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 36 Sex: M Age: 22 Date of Analysis: PhD. Tape: 1 Judge: J.L., J.M., S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position			✓	Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
				Creak(y)						
				Falsetto						
				Modal Voice				✓		

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate		✓				Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 39 Sex: M Age: 20y Date of Analysis: PhD. Tape: 1 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
				Lip Spreading						
	✓			Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
	✓			Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
				Whisper(y)						
				Breathiness						
		✓		Creak(y)						
				Falsetto						
				Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate						Fast
		✓	✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 40 Sex: F Age: 23y Date of Analysis: Ph.D. Tape: 1 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading	▨					
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw	▨	▨				
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	▨					
4. Lingual Body		✓		Fronted Body						
				Backed Body	▨					
		✓		Raised Body	▨					
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	▨	▨				
5. Velopharyngeal				Nasal						
		✓		Audible Nasal Escape						
				Denasal	▨	▨	▨			
6. Pharyngeal		✓		Pharyngeal Constriction	▨					
7. Supralaryngeal Tension		✓		Tense	▨	▨				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	▨	▨				
				Lax						
9. Larynx Position		✓		Raised	▨					
				Lowered						
10. Phonation Type				Harshness						
		✓		Whisper(y)	▨	▨				
				Creak(y)						
				Falsetto						
				Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch				High Mean						
		✓		Low Mean	▨					
				Wide Range						
		✓		Narrow Range	▨	▨				
				High Variability						
		✓		Low Variability	▨	▨				
2. Consistency	✓			Tremor						
3. Loudness				High Mean						
		✓		Low Mean	▨	▨				
				Wide Range						
		✓		Narrow Range	▨	▨	▨			
		✓		High Variability						
				Low Variability	▨	▨	▨			

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
			▨			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicity	✓				

	Present	Absent
Diplophonia		

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 41 Sex: M Age: 21y Date of Analysis: PhD. Tape: 6 Judge: J.L. S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
				Extensive Range						
		✓		Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
				Extensive Range						
		✓		Minimised Range						
3. Lingual Tip/Blade				Advanced						
			✓	Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
				Whisper(y)						
		✓								
		✓		Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency		✓		Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 42 Sex: F Age: 21 Date of Analysis: PhD Tape: 4 Judge: JL JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
				Falsetto						
			✓	Modal Voice						

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 44 Sex: M Age: 19y Date of Analysis: PhD Tape: 3 Judge: JL JM. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
				Whisper(y)						
				Creak(y)						
				Falsetto						
		✓		Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓			
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 46 Sex: M Age: 22y Date of Analysis: PhD Tape: 6 Judge: J.L. S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
			✓	Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body						
				Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position				Raised						
		✓		Lowered						
10. Phonation Type		✓		Harshness						
				Whisper(y)						
		✓								
				Creak(y)						
			✓	Falsetto	✓					
			✓	Modal Voice	✓					

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral: Normal	FIRST PASS: Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees: Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees: Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate		✓				Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓			
Rhythmicality		✓			

	Present	Absent
Diplophonia	✓	

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 47 Sex: M Age: 20 Date of Analysis: PhD Tape: 6 Judge: J.L. J.M. S.A.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
	✓			Lip Spreading						
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
				Extensive Range						
			✓	Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
				Backed Body						
	✓			Raised Body						
				Lowered Body						
				Extensive Range						
			✓	Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
		✓		Falsetto			✓			
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate		✓				Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 48 Sex: F Age: 22 Date of Analysis: PhD Tape: 6 Judge: J.L. S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
	✓			Open Jaw						
				Protruded Jaw						
				Extensive Range						
		✓		Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
				Creak(y)						
				Falsetto						
		✓		Modal Voice	✓					

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 49 Sex: M Age: 19 Date of Analysis: PhD Tape: 6 Judge: J.L. S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
			✓	Backed Body						
				Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
			✓	Whisper(y)						
		✓		Creak(y)						
				Falsetto						
			✓	Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate						Fast
		✓				Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓			
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 51 Sex: M. Age: 20 Date of Analysis: PhD Tape: 4 Judge: J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
				Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 52 Sex: M. Age: 22y. Date of Analysis: PhD. Tape: 4 Judge: J.L. S.L.W. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
				Extensive Range						
		✓		Minimised Range						
3. Lingual Tip/Blade				Advanced						
			✓	Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
				Falsetto						
			✓	Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range						
		✓		High Variability						
				Low Variability						
2. Consistency		✓		Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
				Wide Range						
		✓		Narrow Range						
				High Variability						
		✓		Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate		✓				Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 54 Sex: M Age: 18y Date of Analysis: PhD Tape: 4 Judge: J.L. J.M. S.L.W

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
			✓	Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body			✓	Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type			✓	Harshness						
		✓		Whisper(y)						
			✓	Creak(y)						
				Falsetto						
		✓		Modal Voice				✓		

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency		✓		Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓			
Rhythmicality		✓			

	Present	Absent
Diplophonia		✓

Other Comments:

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Vocal Profile Analysis Protocol

Speaker: 57 Sex: M Age: 21 Date of Analysis: PhD Tape: 6 Judge: SLW. J.M.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading	▨	▨				
				Labiodentalization						
	✓			Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw	▨					
				Protruded Jaw						
	✓			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
				Backed Body						
		✓		Raised Body	▨	▨				
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	▨	▨	▨			
5. Velopharyngeal				Nasal	▨	▨	▨	▨	▨	
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	▨	▨	▨			
7. Supralaryngeal Tension		✓		Tense						
				Lax	▨					
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	▨	▨				
				Lax						
9. Larynx Position		✓		Raised	▨					
				Lowered						
10. Phonation Type		✓		Harshness	▨	▨	▨			
		✓		Whisper(y)	▨	▨	▨			
		✓		Creak(y)	▨	▨				
				Falsetto						
		✓		Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean	▨					
				Low Mean						
				Wide Range						
		✓		Narrow Range	▨	▨				
				High Variability						
		✓		Low Variability	▨	▨				
2. Consistency	✓			Tremor						
3. Loudness				High Mean						
	✓			Low Mean						
				Wide Range						
		✓		Narrow Range	▨	▨				
				High Variability						
	✓			Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	▨		

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 59 Sex: M Age: 19y Date of Analysis: PhD Tape: 6 Judge: JL JM SLW

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion						
		✓		Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw						
				Protruded Jaw						
				Extensive Range						
	✓			Minimised Range						
3. Lingual Tip/Blade				Advanced						
			✓	Retracted						
4. Lingual Body				Fronted Body						
			✓	Backed Body						
				Raised Body						
			✓	Lowered Body						
				Extensive Range						
		✓		Minimised Range						
5. Velopharyngeal				Nasal						
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension				Tense						
		✓		Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type				Harshness						
		✓		Whisper(y)						
		✓		Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
				Wide Range						
		✓		Narrow Range						
				High Variability						
		✓		Low Variability						
2. Consistency	✓			Tremor						
3. Loudness				High Mean						
	✓			Low Mean						
				Wide Range						
		✓		Narrow Range						
		✓		High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓		✓	

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 60 Sex: M Age: .... Date of Analysis: PhD Tape: 6 Judge: J.L. J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
			✓	Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
			✓	Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body	✓			Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type			✓	Harshness						
				Whisper(y)						
		✓		Creak(y)						
			✓	Falsetto			✓			
			✓	Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch			✓	High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓				Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			

	Present	Absent
Diplophonia	✓	

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 62 Sex: M Age: 19 Date of Analysis: Ph.D. Tape: 6 Judge: J.L. J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
			✓	Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension			✓	Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension			✓	Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
			✓	Whisper(y)						
		✓		Creak(y)						
				Falsetto						
			✓	Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓			✓	Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓			✓

	Present	Absent
Diplophonia		✓

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: 64 Sex: M Age: 19y Date of Analysis: PhD Tape: 4 Judge: SLW J.M

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion	▨	▨				
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range	▨	▨				
2. Mandibular		✓		Close Jaw						
				Open Jaw	▨	▨				
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range	▨	▨				
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	▨	▨				
4. Lingual Body		✓		Fronted Body						
				Backed Body	▨	▨	▨			
		✓		Raised Body	▨	▨	▨			
				Lowered Body						
			✓	Extensive Range						
				Minimised Range	▨	▨	▨	▨	▨	
5. Velopharyngeal			✓	Nasal	▨	▨	▨	▨		
				Audible Nasal Escape				▨		
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	▨	▨	▨			
7. Supralaryngeal Tension	✓			Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	▨					
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
				Whisper(y)	▨	▨	▨			
				Creak(y)						
				Falsetto						
		✓		Modal Voice	✓					

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	▨	▨				
			✓	Wide Range						
				Narrow Range	▨	▨	▨	▨		
			✓	High Variability						
				Low Variability	▨	▨	▨	▨		
2. Consistency		✓		Tremor	▨	▨				
3. Loudness	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range	▨	▨				
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	▨		
Rhythmicality		✓	▨	▨	

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 67 Sex: F Age: 18 y Date of Analysis: PhD Tape: 4 Judge: J.L. J.M. S.L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion	///	///				
		✓		Lip Spreading						
				Labiodentalization						
				Extensive Range	///	///				
		✓		Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw	///	///	///			
				Protruded Jaw						
				Extensive Range						
		✓		Minimised Range	///	///				
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	///	///				
4. Lingual Body				Fronted Body						
		✓		Backed Body	///	///				
		✓		Raised Body						
				Lowered Body	///					
				Extensive Range						
			✓	Minimised Range	///	///	///	///		
5. Velopharyngeal				Nasal	///	///	///			
		✓		Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	///	///				
7. Supralaryngeal Tension		✓		Tense	///	///				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	///	///	///			
				Lax						
9. Larynx Position	✓			Raised						
				Lowered						
10. Phonation Type		✓		Harshness	///	///	///			
			✓	Whisper(y)	///	///	///	///		
		✓		Creak(y)	///	///				
				Falsetto						
		✓		Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
		✓		Wide Range	///	///	///			
				Narrow Range						
		✓		High Variability						
				Low Variability	///	///				
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
				Wide Range						
		✓		Narrow Range	///					
		✓		High Variability						
				Low Variability	///					

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
			///			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	///		

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: 71 Sex: F Age: 19y Date of Analysis: PhD Tape: 6 Judge: J. L. J. M. S. L.W.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion	/	/	/			
		✓		Lip Spreading						
				Labiodentalization	/	/	/			
		✓		Extensive Range	/					
				Minimised Range						
2. Mandibular				Close Jaw						
		✓		Open Jaw	/	/				
				Protruded Jaw						
		✓		Extensive Range	/					
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
		✓		Backed Body	/	/				
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	/	/	/			
5. Velopharyngeal				Nasal	/	/	/	/		
			✓	Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction	/	/	/	/		
7. Supralaryngeal Tension		✓		Tense	/	/	/			
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/				
				Lax						
9. Larynx Position				Raised	/	/				
		✓		Lowered						
10. Phonation Type		✓		Harshness	/					
		✓		Whisper(y)	/	/	/			
				Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	✓			High Mean						
				Low Mean						
		✓		Wide Range						
				Narrow Range	/					
	✓			High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness				High Mean						
	✓			Low Mean						
	✓			Wide Range						
				Narrow Range						
				High Variability						
	✓			Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

APPENDIX 2

VOCAL PROFILES OF EXPERIMENTAL GROUP II

Vocal Profile Analysis Protocol

Speaker: A   Sex: M   Age: 24y   Date of Analysis: PhD   Tape: 2 item 5   Judge: SLW W.D.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness		I				
		✓		Whisper(y)						
				Creak(y)		I				
				Falsetto						
			✓	Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	Non-neutral: Normal	Non-neutral: Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality		✓	✓		

	Present	Absent
Diplophonia		✓

Other Comments:

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Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: B Sex: M Age: 22y Date of Analysis: PhD Tape: 2 item 2 Judge: SLW WD

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SETTING	Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial			✓	Lip Rounding/Protrusion	///	///	///	///		
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range	///	///				
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw	///	///				
				Protruded Jaw						
		✓		Extensive Range	///	///	///			
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body		✓		Fronted Body	///	///	///			
				Backed Body						
				Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range	///	///				
5. Velopharyngeal			✓	Nasal	///	///	///	///		
				Audible Nasal Escape				///		
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction	///	///	///	///		
7. Supralaryngeal Tension		✓		Tense	///	///	///			
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	///	///	///			
				Lax						
9. Larynx Position		✓		Raised						
				Lowered	///	///				
10. Phonation Type				Harshness						
		✓		Whisper(y)	///	///	///			
				Creak(y)						
				Falsetto						
		✓		Modal Voice			✓			

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II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SETTING	Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	///	///	///			
			✓	Wide Range						
				Narrow Range	///	///	///	///		
			✓	High Variability						
				Low Variability	///	///	///	///		
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity		✓	✓			Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

Vocal Profile Analysis Protocol

Speaker: C   Sex: F   Age: 23y   Date of Analysis: PhD   Tape: 1 item 8   Judge: SLW W.D.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range						
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	✓			Advanced						
				Retracted						
4. Lingual Body				Fronted Body						
				Backed Body						
		✓		Raised Body						
				Lowered Body						
		✓		Extensive Range						
				Minimised Range						
5. Velopharyngeal		✓		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal			✓	Pharyngeal Constriction						
7. Supralaryngeal Tension		✓		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense						
				Lax						
9. Larynx Position		✓		Raised						
				Lowered						
10. Phonation Type		✓		Harshness						
		✓		Whisper(y)						
				Creak(y)						
				Falsetto						
			✓	Modal Voice				✓		

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean						
			✓	Wide Range						
				Narrow Range						
			✓	High Variability						
				Low Variability						
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support		✓	✓		
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

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Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: D   Sex: F   Age: 21y   Date of Analysis: PhD   Tape: 2 item 4   Judge: SLW WD JM

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		✓		Lip Rounding/Protrusion	/	/	/			
				Lip Spreading						
				Labiodentalization						
		✓		Extensive Range	/	/				
				Minimised Range						
2. Mandibular		✓		Close Jaw						
				Open Jaw	/	/				
				Protruded Jaw						
		✓		Extensive Range	/	/				
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	/	/	/			
4. Lingual Body		✓		Fronted Body						
				Backed Body	/	/	/			
				Raised Body						
				Lowered Body						
	✓			Extensive Range						
				Minimised Range						
5. Velopharyngeal			✓	Nasal	/	/	/	/		
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/	/			
7. Supralaryngeal Tension		✓		Tense	/					
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/				
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type		✓		Harshness	/	/				
		✓		Whisper(y)	/	/				
				Creak(y)						
				Falsetto						
			✓	Modal Voice	✓					

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean	/	/				
				Low Mean						
		✓		Wide Range						
				Narrow Range	/	/				
		✓		High Variability						
				Low Variability	/	/				
2. Consistency	✓			Tremor						
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate	✓					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		✓

Other Comments:

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Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: E Sex: M Age: 21y Date of Analysis: PhD Tape: 2 item 3 Judge: SLW WD

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	✓			Lip Rounding/Protrusion						
				Lip Spreading						
	✓			Labiodentalization						
				Extensive Range						
				Minimised Range						
2. Mandibular	✓			Close Jaw						
				Open Jaw						
				Protruded Jaw						
		✓		Extensive Range	/					
				Minimised Range						
3. Lingual Tip/Blade		✓		Advanced						
				Retracted	/	/				
4. Lingual Body			✓	Fronted Body						
				Backed Body	/	/	/	/		
			✓	Raised Body						
				Lowered Body	/	/	/	/		
		✓		Extensive Range						
				Minimised Range	/					
5. Velopharyngeal		✓		Nasal	/	/	/			
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		✓		Pharyngeal Constriction	/	/				
7. Supralaryngeal Tension		✓		Tense	/	/				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		✓		Tense	/	/				
				Lax						
9. Larynx Position		✓		Raised	/	/				
				Lowered						
10. Phonation Type		✓		Harshness	/	/				
		✓		Whisper(y)	/	/	/			
				Creak(y)						
				Falsetto						
			✓	Modal Voice		✓				

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II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		✓		High Mean						
				Low Mean	/	/				
		✓		Wide Range						
				Narrow Range	/	/	/			
				High Variability						
				Low Variability						
2. Consistency	✓			Tremor	/	/	/			
3. Loudness	✓			High Mean						
				Low Mean						
	✓			Wide Range						
				Narrow Range						
	✓			High Variability						
	✓			Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	✓					Interrupted
2. Rate		✓				Fast
			✓			Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	✓				
Rhythmicality	✓				

	Present	Absent
Diplophonia		

Other Comments:

APPENDIX 3

VOCAL PROFILES OF EXPERIMENTAL GROUP III

Vocal Profile Analysis Protocol

Speaker: V Sex: F Age: 19y Date of Analysis: PhD Tape: Cassette 1-1 -2 Judge: S.L.W. W.D.

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		AB		Lip Rounding/Protrusion	A					
				Lip Spreading						
				Labiodentalization						
		AB		Extensive Range						
				Minimised Range						
2. Mandibular	A.			Close Jaw						
				Open Jaw						
				Protruded Jaw						
	A.			Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	A.			Advanced						
				Retracted						
4. Lingual Body	B			Fronted Body						
				Backed Body		A				
				Raised Body						
				Lowered Body						
		AB		Extensive Range						
				Minimised Range						
5. Velopharyngeal		A.	B.	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		A.B.		Pharyngeal Constriction			A			
7. Supralaryngeal Tension		A.B.		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		A.B.		Tense						
				Lax						
9. Larynx Position	A.			Raised						
				Lowered						
10. Phonation Type		A.B		Harshness		1				
				Whisper(y)						
				Creak(y)						
				Falsetto						
				Modal Voice		A.B.				

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch				High Mean						
		A.B.		Low Mean						
				Wide Range						
		A.B.		Narrow Range						
				High Variability						
		A.B		Low Variability						
2. Consistency	A.B.			Tremor						
3. Loudness				High Mean						
	A.B.			Low Mean						
				Wide Range						
	A.B.			Narrow Range						
				High Variability						
	A.B.			Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	AB.					Interrupted
2. Rate						Fast
	A.B.					Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	A.B.				
Rhythmicality	A.B.				

	Present	Absent
Diplophonia		A.B.

Other Comments:

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Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: W Sex: F Age: 18y Date of Analysis: PhD Tape: Cassette 1-4 -5 Judge: SLW WD

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial		A.B.		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
		A.B.		Extensive Range						
				Minimised Range						
2. Mandibular	A.	B.		Close Jaw						
				Open Jaw						
				Protruded Jaw						
	A.	B.		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade				Advanced						
				Retracted						
4. Lingual Body	B	A		Fronted Body						
				Backed Body			A			
		A B		Raised Body						
				Lowered Body						
		A B		Extensive Range						
				Minimised Range		A				
5. Velopharyngeal		A	B	Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		A	B	Pharyngeal Constriction						
7. Supralaryngeal Tension	A	B		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension	A	B		Tense						
				Lax						
9. Larynx Position	B	A		Raised	A					
				Lowered						
10. Phonation Type		B		Harshness						
		A B		Whisper(y)						
				Creak(y)						
				Falsetto						
				Modal Voice			AB			

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II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	FIRST PASS Non-neutral Normal	FIRST PASS Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch				High Mean						
				Low Mean	A					
				Wide Range						
				Narrow Range						
				High Variability						
				Low Variability						
2. Consistency	A.B.			Tremor						
3. Loudness	A.B.			High Mean						
				Low Mean						
	A.B.			Wide Range						
				Narrow Range						
	A.B.			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	FIRST PASS Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	AB.					Interrupted
2. Rate	A.B.					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	A.B.				
Rhythmicality	A.B				

	Present	Absent
Diplophonia		A.B.

Other Comments:

Vocal Profile Analysis Protocol

Speaker: X Sex: M Age: 28y Date of Analysis: PhD Tape: Cassette 1-6 -7 Judge: SLW WD

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial				Lip Rounding/Protrusion		A				
	B	A		Lip Spreading						
				Labiodentalization						
				Extensive Range						
	B	A		Minimised Range	A					
2. Mandibular				Close Jaw						
	B.A.			Open Jaw						
				Protruded Jaw						
				Extensive Range						
	B.A.			Minimised Range						
3. Lingual Tip/Blade				Advanced						
		AB		Retracted						
4. Lingual Body				Fronted Body						
		AB		Backed Body						
		AB		Raised Body			A			
				Lowered Body						
				Extensive Range						
	A B			Minimised Range						
5. Velopharyngeal				Nasal						
		A B		Audible Nasal Escape						
				Denasal						
6. Pharyngeal		A B		Pharyngeal Constriction		A				
7. Supralaryngeal Tension				Tense						
		A B		Lax						
B. Laryngeal Features										
8. Laryngeal Tension				Tense						
		A B		Lax						
9. Larynx Position				Raised						
		A B		Lowered	A					
10. Phonation Type		B		Harshness						
				Whisper(y)						
		A B								
		A B		Creak(y)			A			
				Falsetto						
		AB		Modal Voice	A B					

II PROSODIC FEATURES

CATEGORY	FIRST PASS Neutral	Non-neutral Normal	Non-neutral Abnormal	SECOND PASS SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		A.B.		High Mean						
				Low Mean		A				
		AB.		Wide Range						
				Narrow Range						
		A.B		High Variability						
				Low Variability						
2. Consistency	A.B.			Tremor						
3. Loudness	A.B.			High Mean						
				Low Mean						
	A.B			Wide Range						
				Narrow Range						
	A.B.			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS Adequate	Inadequate	SECOND PASS Scalar Degrees Inadequate 1	2	3	
1. Continuity	AB					Interrupted
2. Rate	AB					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	A B				
Rhythmicality	AB				

	Present	Absent
Diplophonia		

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
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Vocal Profile Analysis Protocol

Speaker: Y Sex: M Age: 28y Date of Analysis: PhD Tape: Cassette 1–3 Judge: SLW

" 2–1 WD

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	B.			Lip Rounding/Protrusion		A.				
				Lip Spreading						
				Labiodentalization						
	A.			Extensive Range						
				Minimised Range						
2. Mandibular				Close Jaw						
	A.B.			Open Jaw						
				Protruded Jaw						
		A.B.		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade				Advanced						
				Retracted						
4. Lingual Body		A.B.		Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
		A.B.		Extensive Range						
				Minimised Range						
5. Velopharyngeal				Nasal						
		A.B.		Audible Nasal Escape						
				Denasal						
6. Pharyngeal		A.B.		Pharyngeal Constriction						
7. Supralaryngeal Tension		A.B.		Tense						
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension		A.B.		Tense						
				Lax						
9. Larynx Position	A.B.			Raised						
				Lowered						
10. Phonation Type		AB		Harshness						
		AB		Whisper(y)						
				Creak(y)						
				Falsetto						
		AB		Modal Voice		A.B				

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch		AB		High Mean						
				Low Mean		A				
		AB		Wide Range						
				Narrow Range						
		AB		High Variability						
				Low Variability						
2. Consistency	AB			Tremor						
3. Loudness				High Mean						
	AB			Low Mean						
	AB			Wide Range						
				Narrow Range						
	AB			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	AB					Interrupted
2. Rate	AB					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	AB				
Rhythmicality	AB				

	Present	Absent
Diplophonia		AB

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
Phonetics Laboratory, Department of Linguistics, University of Edinburgh.

Vocal Profile Analysis Protocol

Speaker: Z Sex: F Age: 19y Date of Analysis: PhD Tape: Cassette 1-11 -12 Judge: SLW WD

I VOCAL QUALITY FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
A. Supralaryngeal Features										
1. Labial	A	B		Lip Rounding/Protrusion						
				Lip Spreading						
				Labiodentalization						
				Extensive Range						
	AB			Minimised Range						
2. Mandibular				Close Jaw						
	AB			Open Jaw						
				Protruded Jaw						
	A	B		Extensive Range						
				Minimised Range						
3. Lingual Tip/Blade	A	B		Advanced						
				Retracted						
4. Lingual Body		A B		Fronted Body						
				Backed Body						
				Raised Body						
				Lowered Body						
	A	B		Extensive Range						
				Minimised Range						
5. Velopharyngeal		AB		Nasal						
				Audible Nasal Escape						
				Denasal						
6. Pharyngeal		AB		Pharyngeal Constriction						
7. Supralaryngeal Tension		AB		Tense		A				
				Lax						
B. Laryngeal Features										
8. Laryngeal Tension	AB			Tense						
				Lax						
9. Larynx Position		AB		Raised						
				Lowered						
10. Phonation Type		AB		Harshness		I				
				Whisper(y)						
				Creak(y)						
				Falsetto						
				Modal Voice			AB			

II PROSODIC FEATURES

CATEGORY	FIRST PASS: Neutral	FIRST PASS: Non-neutral Normal	FIRST PASS: Non-neutral Abnormal	SECOND PASS: SETTING	Scalar Degrees Normal 1	2	3	Abnormal 4	5	6
1. Pitch	A			High Mean						
				Low Mean						
	A B			Wide Range						
				Narrow Range						
	A B			High Variability						
				Low Variability						
2. Consistency	A B			Tremor						
3. Loudness	A B			High Mean						
				Low Mean						
	AB			Wide Range						
				Narrow Range						
	AB			High Variability						
				Low Variability						

III TEMPORAL ORGANIZATION FEATURES

CATEGORY	FIRST PASS: Adequate	FIRST PASS: Inadequate	SECOND PASS: Scalar Degrees Inadequate 1	2	3	
1. Continuity	A B					Interrupted
2. Rate	A.B					Fast
						Slow

IV COMMENTS

	Adequate	Inadequate	1	2	3
Breath Support	A B				
Rhythmicality	A B				

	Present	Absent
Diplophonia		A B

Other Comments:

"VOCAL PROFILES OF SPEECH DISORDERS" Research Project. (M.R.C. Grant No. G978/1192)
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APPENDIX 4

DETAILS OF THE LISTENING EXPERIMENT

Instructions for Listening to the Mixed Tape

Please listen to this 15 minute tape. You will hear 10 deaf speakers reading one of 3 reading passages. The scripts of the passages are attached. It may help you to glance at these to have an idea of what the speakers are saying because most of them are unintelligible or only semi intelligible. Some of the 10 speakers are men, others women. Some are American others British. Please decide which are men and which women which American and which British. Do not try to understand each word the speaker reads as this will be very difficult.

Please tick appropriately.

		Male	Female	American	British
Item	A				
	B				
	C				
	D				
	E				
	F				
	G				
	H				
	I				
	J				
	K				

Reading Passages Used by Speakers in the Mixed Tape

1. The North Wind and the Sun.

   The North Wind and the Sun were arguing one day about which one of them was the stronger, when a traveller came along wrapped in a warm coat. They agreed that the one who could make the traveller take his coat off would be considered stronger than the other one. Then the north wind blew as hard as he could but the harder he blew the tighter the traveller wrapped his coat around him and at last the north wind gave up trying. Then the sun began to shine warmly and right away the traveller took his coat off, and so the north wind had to admit that the sun was stronger than he was.

2. The Rainbow Passage.

   When sunlight strikes raindrops in the air they act like a prism and form a rainbow. A rainbow is a division of white light into many beautiful colours. These take the shape of a long wide arc with its path high above and its two ends apparently beyond the horizon. There is according to legend a boiling pot of gold at one end, people look but no one ever finds it. When a man looks for something beyond his reach his friends say he is looking for the pot of gold at the end of the rainbow.

3. The Dog and Duck.

   "Paul, have you seen my gloves ?"
   "No, I havent"
   "Yes you have, you're holding them "
   "No I'm not, these are green gloves"
   "But the red gloves are yours"
   "Oh yes, and here are your wool socks, sorry"
   "It doesn't matter"
   "Where are my blue boots ?
   "Your boots", I think they're under the chair,
   the chair by the wall, No they're on the chair"
   "Oh yes thats lovely. I've finished packing.
   "Where are we staying ?"
   "At the Dog and Duck"
   "Is it big ?"
   "No, there are only 3 bedrooms".