P E R C E P T U A L   P R O C E S S E S

U N D E R L Y I N G   S P E E C H

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CONTENTS

SUMMARY AND BACKGROUND

This study seeks to examine the role of perception in the acquisition and maintenance of speech and language. In particular, the influence of tactile kinaesthetic feedback is investigated with special reference to deviant acquisition of speech.

The terms "speech" and "language" are often bracketed together in much of the literature, (Crystal 1973) thus underlining current views on their interrelationship in linguistic coding. For the purpose of clarification it is suggested that the following definitions will serve to differentiate the two aspects of communication.

"Speech" is usually taken to refer to the specifically verbal component of human communication. As well as articulation it encompasses metalinguistic features of stress, intonation and rhythm.

"Language" can be defined as an agreed system of arbitrarily determined symbols whereby human beings (or animals) are enabled to communicate one with another. Language extends beyond speech and is, of course, not necessarily verbal. Mime and gesture, for example, can on occasion prove to be entirely explicit.

Reference has also been made to tactile kinaesthetic perception and this term (or simply kinaesthesis) is interchanged with the term proprioception in the work of many authorities (Annett 1967, Berry 1970, Brain 1963, Hebb 1972). In a personal communication, Jenkins (Professor of Oral Physiology, University of Newcastle upon Tyne) indicates that in fact the term kinaesthesis represents a more specific facet of proprioception, but that it is generally acceptable to use either form.

The definition which is used throughout this text is that of Guyton (1972) viz. 'The conscious recognition of the orientation of the different parts of the body with respect to each other'.

THE STUDY

An investigation of the speech and language skills of twenty children aged four through six years with repaired cleft lip and palate was carried out and their performance was compared with a group of subjects with normal oral structure. In addition, tactile kinaesthetic ability was investigated in both groups.

The results of the study lead to the consideration of its implications in relation to a wider range of speech and language disorders (developmental dyspraxias and dysphasias).

Some principles on which programmes of remediation might be based are discussed.

This study was carried out mainly in the Birmingham Dental Hospital Children's Clinic and in the Orthodontic Clinic at the Corbett Hospital, Stourbridge. All the cleft palate children had originally undergone surgical treatment at the Regional Plastic Surgery Centre. Thus their medical and dental history was broadly similar.

Although this background provided the source of the immediate study, the setting in fact ranges over a much wider area in terms of time and experience.

Traditional emphasis on motor aspects of speech has for some time appeared to impose limitations on the efficacy of remedial programmes. The gradual acceptance and application of cybernetic principles to speech have brought about a recognition of the importance of sensori motor processes as essential concomitants of linguistic coding. With this reorientation of emphasis it is possible to find rational explanations for many of the symptoms of disordered language which have caused bewilderment and which hitherto have proved so intransigent to remediation. At the present time, knowledge of perceptual processes underlying speech is still no more than minimal and much investigation must continue. But as William James wrote, "Without continuing enquiry there is no progression." Enquiry will continue and one hopes that progress will be a result of this.

SENSORY PROCESSES INVOLVED IN SPEECH

(i) Sensation and Perception

Production of speech depends upon the synthesis of input from a number of sensory modalities, auditory, kinaesthetic and visual.

The importance of differentiating between sensation and perception has been emphasised by Hebb (1972). He defines sensation as the activity of the receptors and their effect on transmission of nervous impulses along different pathways to the sensory cortical area. Perception is the mediating process which occurs as a result of sensation. Thus sensation is an altogether much simpler process physiologically than is perception. Hebb describes it as 'the incorporation of sensory information into the thought processes'.

In summary therefore, while there is agreement that a close relationship exists between the two processes, the term sensation pertains to peripheral stimulation through afferent pathways, whereas perception represents a further elaboration of the information received.

In some disorders of speech, sensory pathways remain relatively intact and breakdown occurs at a more central level as a result of perceptual dysfunction.

Of the three modes of input mentioned, visual pathways are more directly concerned with other forms of communication viz. reading and writing. It has been reported though that children with severe visual impairment tend to be retarded in language acquisition.

Communication is a circular activity and though you will notice that descriptive terms such as 'input' and 'output' have been used this terminology impose a degree of artificiality upon the processes in that both are in reality interdependant and over-lapping.

(ii) Audition

Auditory perception represents one of the most vital functions underlying language acquisition. It is generally accepted that very early vocalisation, (pre-linguistic babbling) is probably biologically determined; in other words, that there may be innate endowment for speech. Lenneberg (1967) presents very strong evidence in favour of this view by describing the interlocking of maturational milestones which prevail even in the fact of severe impairment and also by the fact that intensive training does not appear to hasten language development in early stages of development. Lenneberg's work supports the work carried out at the Massachussets Institute of Technology. This work, pioneered by Chomsky and developed further by McNeil (1967, 1969 and 1971) is based on the proposition that the level of language acquisition achieved in the majority of children by the age of three and a half to four years refutes the notion that development of language is purely the result of learning. It is suggested that the child is innately endowed with a degree of competence for language (this is termed a Language Acquisition Device) which enables him to process language according to rules which are innate and universal.

These views have given rise to much dispute and controversy most notably from Behaviourists led by Skinner (1957), Mowrer (1960) and Staats (1968). They contend that language is acquired on a stimulus response basis and is solely the result of learning. Mowrer carried out work with mynah birds from which was developed the Autistic Theory of Language Acquisition. This suggests the child's vocalisation is at first random but that a particular pattern tends to produce a reward. This pattern is known as a tact, because it is made in the presence of the reward. Progressively the particular pattern is vocalised in the hope of producing the reward; this is a mand. Thus articulate speech develops by a selective process of reward and reinforcement.

Sufficient grounds for maintaining the opposed standpoints will ensure the continuance of this controversy for some years to come.

Auditory acuity represents only one small link in the auditory chain and one which in many cases is readily responsive to remediation once a diagnosis has been made. It has been shown (Whetnall and Fry 1954) that children with severe congenital hearing impairment babble normally in the early stages, but that instead of this vocalisation taking on imitative characteristics as in the case of normally hearing children, there is a gradual fading out of sound.

Other variables relate to time, duration, discrimination and memory. Breakdown or failure of development in these parameters will result in severe impairment of comprehension even though acuity may be within normal limits.

Extreme conditions of auditory imperception amount to a total agnosia for sound. Two children in recent experience exhibited these symptoms in that neither of them was able to respond or to recognise sounds, verbal or otherwise. Yet both children when assessed by means of Evoked Response Audiometry demonstrated that auditory acuity was normal to within a thirty decibel loss. Education by methods appropriate for teaching of the deaf would not have been of any value. In fact, one of these children is now responding well to a visual language learning programme (McGowan and Ward 1972).

Auditory Discrimination

When auditory acuity is normal there may still be impairment of other aspects of audition. One of these is auditory discrimination. Jacobson and Halle (1956) in a review of Jacobson's concept of distinctive features in relation to language development outline an increasingly complex hierarchy in the differential features used in utterance. e.g. the most simple contrast lies between /p/ and /a/ and in early linguistic usage this combination either singly or duplicated as in /pa pa/ predominates. Although Jacobson is describing output one may deduce that a hierarchy of discrimination takes place in a somewhat similar manner receptively and that somehow from the flow of sound which assails the child's ears these are the earliest patterns to be discriminated.

The ability to discriminate auditorily is dependant upon recognition of duration, intensity and frequency. Vowels, for example, rely heavily on duration and intensity, whereas consonants differ more in their frequency range. The difference between two words may be critically determined as, for example, in the case of the words /pat/ and /bat/, where the only difference lies in the time of the onset of voice between /p/ and /b/.

The English language contains about forty different classes of sounds (phonemes). Within these forty sounds, however, there is a much wider range of personal and individual variation (allophones). In order to discriminate effectively, therefore, the listener must be able to differentiate one phoneme from another, and at the same time be able to generalise right across the spectrum of other productions of that phoneme, for example /r/. The realisation of this may vary according to the position it assumes in a word and by the influence exerted upon it by adjacent sound patterns. There is a marked difference perceptively between /run/, /bury/ and /crack/.

Traditionally, investigations of the ability to discriminate auditorily have tended to be found on the subjects facility for recognising differences between two sounds, e.g. /s/ and /sh/ (a sound by sound basis). The 1971 edition of Travis Handbook of Speech Pathology cites no fewer than twenty four such research projects. The results are confusing to say the least, in that they reflect a diversity of score. It would seem that current neurolinguistic theory may obviate some of these difficulties in that the basic contention of these writers differs from the traditionalist view. (Ladefoged 1967, Laver 1970, Liberman et al 1967). Discrimination takes place as part of a dynamic ongoing process. The interpretation of speech as consisting of a series of static and discrete sound units is not a physiologically tenable one. Berry (1972) states 'the best that the human auditory system can do is to respond to certain complex features; it would not conceivably undertake a complete analysis of such phonetic unit'. The most likely unit of coding is the tone group (Laver 1970). This is described as a stretch of speech which lasts on an average for about seven or eight syllables and which contains one very pronounced syllable on which a change of pitch occurs. The tone group is the carrier of the intonation pattern and is probably closely related to the innate physiological pulse carrying neural rhythm postulated by Lenneberg (1967).

Another problem posed in a discussion of auditory discrimination is that of the different processes involved in intra as opposed to inter personal discrimination. This is a feature which calls for much wider investigation. Clinical experience shows that some children are adept at correctly identifying two modes of production of a word or phrase, the one being the accepted version, the other an imitation of the incorrect production. At the same time, these children show a poor ability to match their own production with either the correct or incorrect version and exhibit random choice of either version. A possible explanation lies in the slightly more complex neuro-physiological operations involved in internal feedback as opposed to external feedback.

The function of discrimination cannot very easily be considered separately from those of sequencing and memory.

Eisenson (1970) states that in listening, a child must be able to make competent judgements with reference to the temporal order ofinput. Experiments which have been carried out with speech impaired patients (Efron 1963, 1967) have shown that they required an appreciably longer period in which they could recognise order of sound presented as compared with non-language handicapped subjects. This was as much as one second compared with 50 to 60m.seconds in the normal subject.

Hirsch (1967) has described two features of auditory sequencing. They are:-

(a) duration - this is the critical time which separates one speech from another, so that differentiation can take place, as for example in the syllables /ba/ and /wa/ where both consonants show very similar frequencies and the vowels are identical. Other investigations rather on the lines of those described by Efron have been carried out on children with developmental language disorders. As with adult aphasics, it was found that these children required a considerably lengthened interval in order to appreciate difference.

(b) Serialisation - in processes of language coding one has to be able to deal effectively with ongoing events in the light of what has gone before and of what is anticipatory. Spoken language is essentially ephemeral in nature. This skill develops as a function of maturation. The small child's difficulty in sequencing polysyllabic words is not regarded as a defect. Everyone is familiar with difficulties like /hitopopamus/ but perhaps less so with /gymstatnics" produced by a four year old ecstatic about the events in his new nursery school.

The third feature of audition is that of memory and storage. In any oral discourse there is a time span during which perceived words must be stored so that the context can be established and comprehension take place. Some people experience difficulty with this and developmentally it is a skill which is later acquired. It is probably the constraints of auditory memory which account for the telegraphic utterances which are a normal stage of language development.

With neurological maturation and aided by interaction with the environment, through processes of expansion, and modelling, the child is eventually enabled to achieve syntactic models which approximate to those of adults.

Miller's (1967) essay 'The Magical Number Seven, Plus or Minus Two' comments on the constraints of Auditory Memory. It was found that there was a limitation of about seven items (or chunks) of information which could be contained at one time in the memory span. Miller suggests that reorganisation of information into recognisable patterns can result in an apparent lengthening of the span. As an example he cites the case of the radio telegraphist who when first learning to receive morse code messages perceives each dot and dash as discrete events. With practice, however, the incoming signals assume a pattern and he is thus able to process successfully more information at any one time.

(iii) Proprioception

This is the sense by which we recognise body movement. Proprioceptive impulses form part of the servo feedback mechanism involved in speech. That is to say they are sensory motor pathways. In the context of speech, these impulses arise in the stretch muscles of the oral structures, the tongue, lips, palate etc. Guyton (1972) described sensory engrams which exercise control over motor gestures. These are patterns of skilled motor function which are acquired early in life. Once established they become automatic, but sensory feedback still exercises a corrective monitoring function over such patterns of activity.

The part played by proprioception has tended in the past to be understated. Although in teaching the profoundly deaf to speak, some attention was given to this aspect, nevertheless visual feedback was emphasised to a greater extent. In normal speech, audition was considered to be the primary sensory pathway. Yet a baby's first perception of noise is likely to be based upon proprioceptive feedback. Few people now believe that the prelinguistic babbling patterns are in any way a phonemic rehearsal for subsequent speech. They afford prosodic experience to the child. We consider that prosody, i.e. the melody of language embodying stress, timing and pitch, is the foundation on which intelligible speech is built. Lenneberg (1967) describes this rhythm as 'the carried of language'.

Ladefoged (1967) stresses the importance of tactile and kinaesthetic feedback both in perception and production of speech. This is illustrated by reference to an experiment in which subjects were required to read a passage under conditions of reduced auditory feedback and then reduced tactile feedback. When auditory feedback was cut out the vowel sounds were affected in length and quality, there was inappropriate nasality and tendency to increase pitch. Intonation showed a falling pattern.

Elimination of tactile feedback produced a greater disorganisation of articulatory processes. There was difficulty in producing /s/ and /z/ in words; /t/ and /d/ showed unusual articulation. As a result of these experiments, and other similar data, Ladefoged considers that it is no longer valid to ascribe primacy to the auditory modality. In general, people have difficulty in discriminating auditorily before they are able to produce the sounds they are attempting to differentiate. 'We understand what we hear because we can speak'.

Brain (1968) in a discussion of physiology of speech, cites the work of Liberman and his colleagues at the Haskins Laboratory in which they state that perception of speech in the final analysis depends on the proprioceptive stimuli which arise from the movements of articulation. These ideas were further developed by them in a later and now famous, and somewhat controversial paper, on Perception of the Speech Code (1967).

Novikova (1963) describes a study of electrophysiological responses of deaf children in silent reading of written material which showed an appreciable increase in tongue muscle activity during the reading period as compared with normals. Lashley (1951) described the same phonemena in relation to normally hearing subjects but found evidence of this only under conditions of strong arousal. Gammon et al (1971) also describe effects on speech of combinations of anaesthesia and auditory masking. Their findings coincide broadly with those of Ladefoged. Speech became altered, but not unintelligible. This suggests that once articulatory patterns are established, through learning they are self perpetuating. We are affected by the diminution of monitoring control and the ability to self correct is thereby impaired. Errors which they specifically noted when tactile kinaesthetic feedback was interrupted related to misarticulation of anteriorly placed sounds, i.e. bilabial and labiodental sounds.

Morley (1972) refers to the effector system of speech as being dependent on and continuously controlled and monitored by the receptor processes through sensory feedback. She regards the development of an adequate phonological system as being partly dependant on the repetition of early sensori motor experience. This experience occurs very early in prelinguistic vocalisation when the child is first beginning to select and recognise individual sounds from the tumult of noise which surrounds him. This early babbling serves two purposes; the first for the enhancement of sensory motor feedback and the second by laying the foundations of prosody on which articulate speech can be superimposed.

Most people are familiar with the difficulties experienced in articulating and in carrying out actions like drinking and eating following a block anaesthetic in dentistry. This provides an excellent example of the effect of interruption of proprioceptive feedback. There is no motor impairment of muscles involved but there is a failure to programme synergies of movement correctly because of absence of the monitoring function exerted by sensory processes.

The Russian writers Kozevnikov and Chistovich (1965) describe the "syntagma of speech", i.e. the meeting together of sensory processes. The role of proprioception in the creation of this syntagma is strongly emphasised. Assessment of its importance was attempted through the creation of an electropalatograph which recorded action potentials of tongue muscle. Initially the presence of somewhat cumbersome gadgetry in the mouth created conditions under which a subject would experience considerable difficulty in speaking normally. A more adaptable and sophisticated electropalatograph has been described by Hardcastle (1970) in which a pictorial representation of tongue muscle activity is projected on to a television screen. This would seem to be an area of investigation which could be pursued with rewarding results and the latest findings (in press) are likely to prove of considerable interest.

Guyton (1972) describes deficits of sensory judgement which arise from damage to the somatic sensory area. Among these are:-

(i) impaired ability to judge shapes or forms of objects (astereognosis)

(ii) impaired ability to judge textural difference

(iii) impaired ability to judge fine gradations of temperature.

The first two functions have been the subject of much investigation with special reference to speech function.

Chase (1970) indicates the need for the development of new research strategies in the search for a better understanding of the nature of sensori motor oral function.

Abnormality of movement of the articulatory organs may cause impairment of shape and texture discrimination. This is exemplified by reference to the cleft palate group studies. It is possible that the compensatory tongue movements which are adopted very early on may produce changes in the sensory transducers. Disturbance of sensory pathways will incur motor dysfunction because as has already been stated, early stages of motor learning are greatly influenced by somatic input. Cerebral palsied children suffer very marked sensory motor dysfunction of this nature over and above the motor (dysarthric) disability. In later life, Parkinsonistic patients also provide evidence of sensory motor deficits.

(iv) Vision

The third important sensory modality is that of vision. This does not have the same direct influence on early speech production though it is relatively common to find congenitally blind people with abnormal prosody. Children who are unable to code incoming visual stimuli are likely to have difficulties of comprehension.

Berry (1970) in three case studies gives examples of deviant visual function as a concommitant of other sensory deficits co-occurring with severe speech disorder.

Visual coding requires the ability to discriminate to sequence and to retain patterns in much the same manner that other sensory systems do. Comprehension is the result not only of auditory and kinaesthetic input but also of visual perception of paralinguistic gestures which accompany verbal speech. The young baby understands the smile which accompanies the mother's soothing voice.

As with other modalities, visual perception is at first global and the extrapolation of significant characteristics of objects is largely the result of maturation. There is an interaction between speech processes and visual perception in development. The young child uses a general name for objects which share broadly common characteristics. Thus he classifies all four legged creatures as 'goggies', (Lewis 1968) and it is only later when a process of increasing perceptual discrimination is taking place that sub-categories are appreciated.

Vernon (1962) refers to the adult's increased ability to recall shapes if they are labelled as resembling familiar objects. Most students can recall this aid in their efforts to memorise diagrams in revision for Examinations. Visual perception is, of course, even more an essential feature in acquisition of reading and writing skills, but a detailed examination of these lie beyond the scops of this study.

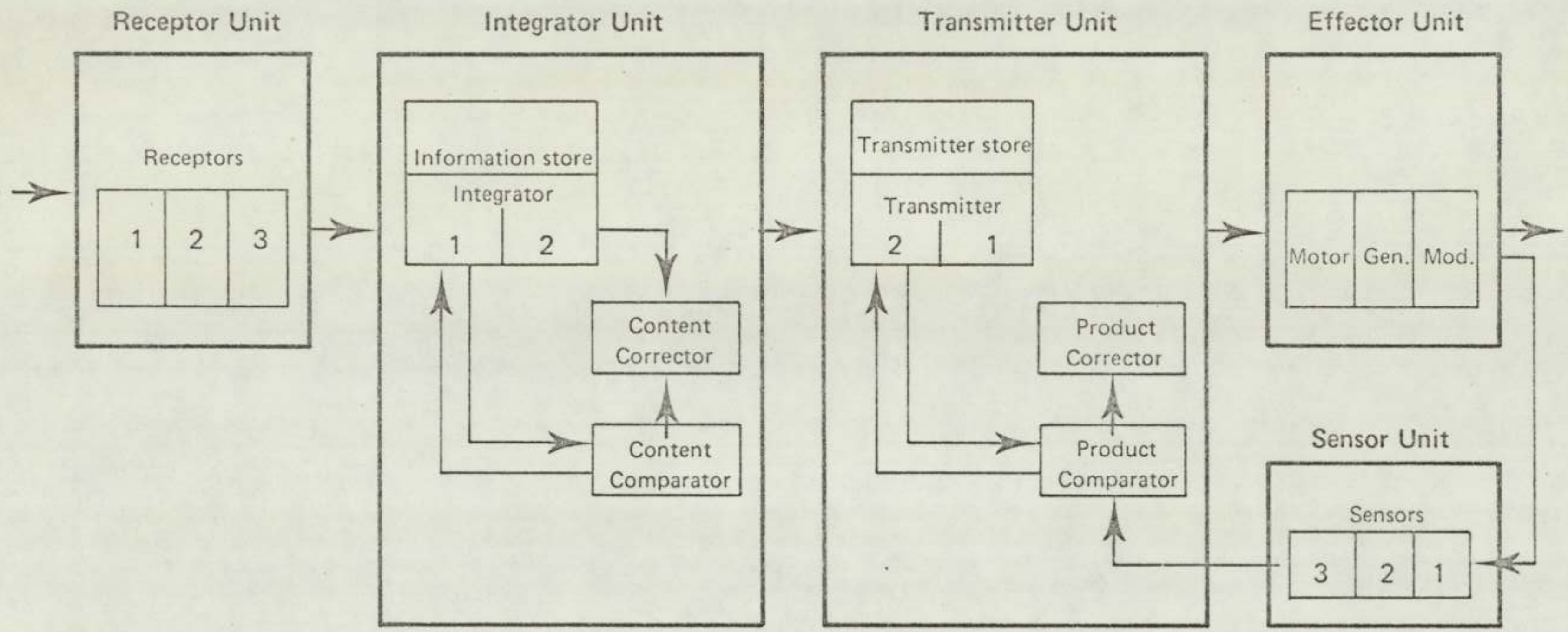
2. FEEDBACK

This chapter attempts to describe the processing of language with reference to input, association and output. The limitation of present knowledge imposes a speculative character to some of the ideas put forward, and therefore certain areas where further investigation is required are indicated. To quote Whitaker (1971) writing on a similar subject, 'Any model should be an attempt to integrate some good ideas with some blatantly speculative ones for the purpose of initiating further study'.

(i) Servo Mechanisms

Speech has been described in terms of cybernetic theory. Fairbanks (1954) was one of the earlier writers to delineate such a model. Briefly this model posited an input, a comparator and an output. The input corresponded to sensory processes, the output to the motor aspects of speech and the comparator sub-served a monitoring function in such a way that information and error signals could be fed back into the central language system for appropriate action to be taken.

More recently, Annett (1969) has described at length the influence of feedback on various aspects of learning. His definition of a servo-mechanism as 'a machine which is controlled by the consequences of its own behaviour' accords with the notion of speech in terms of cybernetic theory. Annett's model includes a source of power, a sensor which measures output, and a feedback loop which translates the output measure into a signal which can control the input.



CYBERNETIC ANALOGUE OF SPEECH SYSTEM (after Mysack)

Speech as a Servo System

A more detailed description of the application of sucha model to speech is provided by Mysack (1966). The comparison is based on a model which can be represented diagramatically (facing).

Such a model constitutes a multiple loop system, which provides for internal and external feedback. A multiple loop system represents a cycle of activity which is influenced by subsystems within the overall pattern of activity. The internal loop is concerned with the formation, production and monitoring of the individual's own speech, the external loop provides information about listener reaction either in terms of verbal feedback or through paralinguistic processes, e.g. facial expression.

Feedback operates on two levels. There is the semantic level which is concerned with the monitoring of the content of the utterance. If, for example, one greets a friend as 'Robert' when his name is in reality, 'David', a correction in terms of content has to be made. The second level is the phonological one and this is concerned with the actual production of words used. In such a case, one might, for example, greet one's friend as '<u>L</u>obert', after which a phonetic correction would be necessary.

The present study is concerned principally with this phonological level of coding, and therefore semantic aspects are not described in any detail.

It is possible to draw a reasonably close comparison between coding processes which take place in speech and models of servo-systems. The input source in speech is represented by:-

The receptors: These refer to the eye, whose source of input is light, the ear, which is receptive to sound waves and the mechanical end organs the proprioceptors which respond to sensations of movement. The role of these receptors has already been described in some detail in the previous section.

The following stage of input takes place in:-

The integrators: The Phase I integrator represents the preliminary integration of sensory processes. It is concerned with the recognition, selection and inhibition of incoming stimuli. Neurologically, this stage of coding most probably takes place within the reticular activating system and in the primary sensory areas of the cortex. Although the principal function of the R.A.System is that of arousal, Moruzzi (1949), more and more, recent advances in neurophysiology ascribe an organising function to this particular system. Livingstone (1954) distinguishes it from the traditional sensory routes by the fact that it appears 'to represent a much more plastic and diffuse system in which the input from many sources can be integrated and modulated before it reaches the cortex', whereas the traditional sensory routes are concerned with the rapid transmission of highly specific information. This view finds support in Lindsley's (1958) work and also from Jefferson (1958). The reticular activating system consists of a mass of nuclei connected by pathways which are found throughout the medulla, pons and midbrain.

The Phase II integrator represents the conceptual process of coding. It is concerned with the interpretation and elaboration of percepts which have passed through Phase I integrator. This is represented neurologically in the secondary sensory areas of the cortex, and in the inferior parietal area. Provision is also made for storage of incoming information which can be made available for subsequent retrieval. The psychological correlate is probably short and long term memory. An example may serve to clarify the role of the integrator. Suppose that while a lecture is being given the fire alarm is sounded. The sound is recognised and may be integrated with other signals, e.g. the smell of burning, the sight of smoke. These cues are associated with meaning, viz. 'There must be a fire'. (Phase II) This provokes immediate action in the form of an oral instruction to the class. Additionally this information will be stored for future recall. Penfield and Roberts (1959) monograph on Speech and Brain Mechanisms illustrates the capacity of the central nervous system for storage and evocation of past events, when electrical stimulation is applied to the appropriate sensory area.

The output component of the servo mechanism corresponds to the transmitting and effector elements of speech.

<u>The transmitter</u>: Here again Mysak has subdivided this section. The Phase II component is responsible for the provision of appropriate words, i.e. the content element, while Phase I is concerned with the actual motor processing of the chosen words. It is at this juncture that the necessary sequence of events for vocalisation and articulation are programmed. Anatomically, Phase II is represented by Brocas area and the temperoparietal area and Phase I represents the primary motor speech area. A too rigid mapping of these areas, however, imposes an over narrow view of brain mechanisms. Neuropsychological aspects will be discussed further by reference to Luria's work in this field.

The effector: This is represented by the components of the vocal mechanism, i.e. the egressive pulmonic air stream, the vibrating vocal cords in the larynx and the movements of the organs of articulation which serve to interrupt the vocal note in order to produce patterns which are acceptable as speech.

The sensor unit: This forms the last section of the loop and provides a feeding back of information to previous stages of coding so that necessary comparisons and corrections can be made. The three sensor elements represent the three modalities from which information is obtained, auditory, visual and tactile kinaesthetic. Thus at each stage in the formulation of speech, the speaker receives information regarding the content and manner of his own utterance. Additionally, visual feedback is supplied by listener reaction. Feedback serves to monitor utterances, so that necessary ongoing corrections can be made. It also allows for modification of future speech in the light of environmental response.

As previously stated, this study is more especially concerned with the phonological level of utterance rather than with syntactic and semantic levels. That all levels are interdependent is undoubtedly true, and many cases of deviant phonology also show aberrant syntactic and semantic patterns. Conversely where the language disorder is primary, there may be evidence of phonological deviance.

It is important to remember that speech is an ongoing dynamic process with feedback operating simultaneously along with decoding and encoding activities. The nature of this activity which is both anticipatory and retrogressive is revealed by the errors which occur sometimes in speech when there is a momentary aberration in the sequence of events. Spoonerisms - 'You have tasted your worm!' - provide good examples. In the field of pathology it is particularly interesting to trace the origins of these 'misutterances' in cases of jargon aphasia. Rochford (1970) and in press has analysed a large number of such samples.

The analogue of a servo-mechanism of this type as applied to speech processes is a highly simplistic one. The complexities of the mechanisms underlying speech are still largely unknown, and perhaps the most that one can achieve is to suggest functional equivalences which may exist between information theory and the neurological sciences.

3. NEUROPHYSIOLOGICAL CODING

(i) Localisation v. Non Localisation

Contingent upon the examination of neurological correlates is an issue which has brought about much debate in the field of neurology. This is the localisation, as against the non-localisation theory of cerebral function. Very generally, those taking an extreme localisation stand, maintain that cerebral function is contained in clearly demarcated zones which are adapted for specific functions. The eminent neurologist, Henry Head, writing in 1926, established a theory of aphasia which sought to correlate specific forms of linguistic function with previously delineated area of the brain. Such a view opposes that which describe cerebral function in holistic terms. The intricacies of each theory are not the concern of this discussion, and it is sufficient to say that in the ensuing description, a qualified localisationist view is favoured. The qualifying factors take into account individual variation within brain structure and the ability of the brain within certain limits to reorganise function. The importance of the interrelating pathways between anatomical loci subserving certain functions is also stressed.

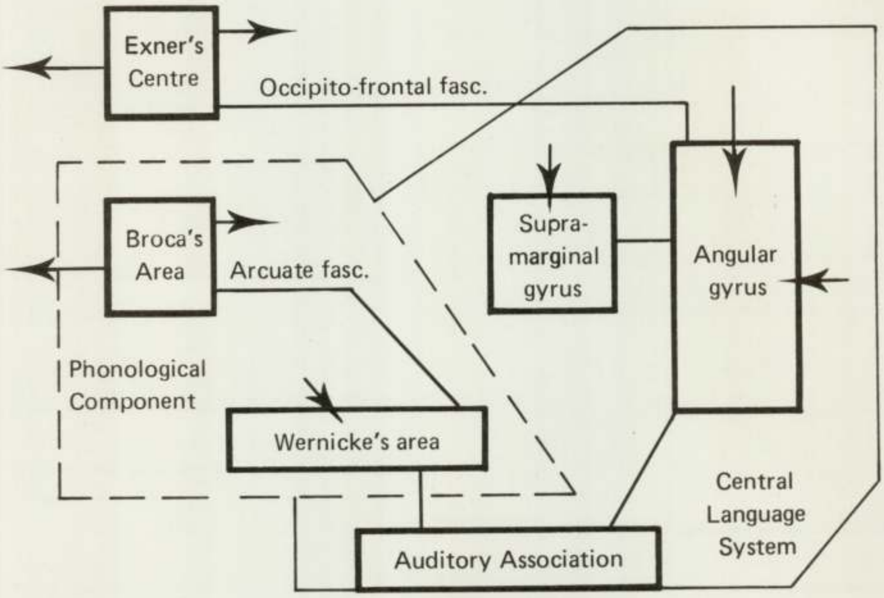
Much of our knowledge of the neurology of speech is derived from the study of pathology. Lenneberg (1967) among others has made reference to the limitations of such a study. The specific points he makes are that lesions arising from cerebral vascular accidents involve considerable areas of cerebral tissue, extending beyond the immediate focal area, and therefore yield little specific information about localisation of speech and language centres.

Traumatic lesions, the effect of which has been extensively described by Russell and Espir (1961) and Luria (1969) provide more exact information, but these authors also make the proviso that there may be attendant secondary pathology beyond the discernible damaged area, which may influence results. Nevertheless, statistical evidence based on data which has been put forward by workers over the past two years appears to justify the assumption of comparison. To quote Whitaker (1971), 'Many brain lesions produce an impairment of brain function. Loss and impairment thus provide positive evidence for the neurological reality of the functions, under the conditions noted'.

Lenneberg concludes that while in man there may be no 'absolute' language area, there are some areas which are very frequently involved in language disturbance and there are other regions which are never so involved.

Bearing in mind these limitations, one of the most comprehensive reviews of brain mechanisms underlying language has been provided by Luria (1970). This arises from extensive studies of disturbed language function, as a result of direct trauma, mainly due to gunshot wounds.

Luria's later work (1973) has developed his theories of the neuro-psychology of normal language. He contends that investigation of speech must be based firstly upon 'a sufficiently precise view of the psychological structure of speech processes and their individual components and secondly (upon) a properly directed search for the physiological conditions essential for the normal organisation of these components of the complex speech structure'.



ANATOMICAL SCHEMATIC OF THE CENTRAL LANGUAGE SYSTEM
(after Whitaker)

(ii) Analysers

All forms of mental activity involve functional systems which are based on the combined activity of afferent and efferent neurological structures. Speech is thus seen as the outcome of a constellation of zones which work together and which are interdependent.

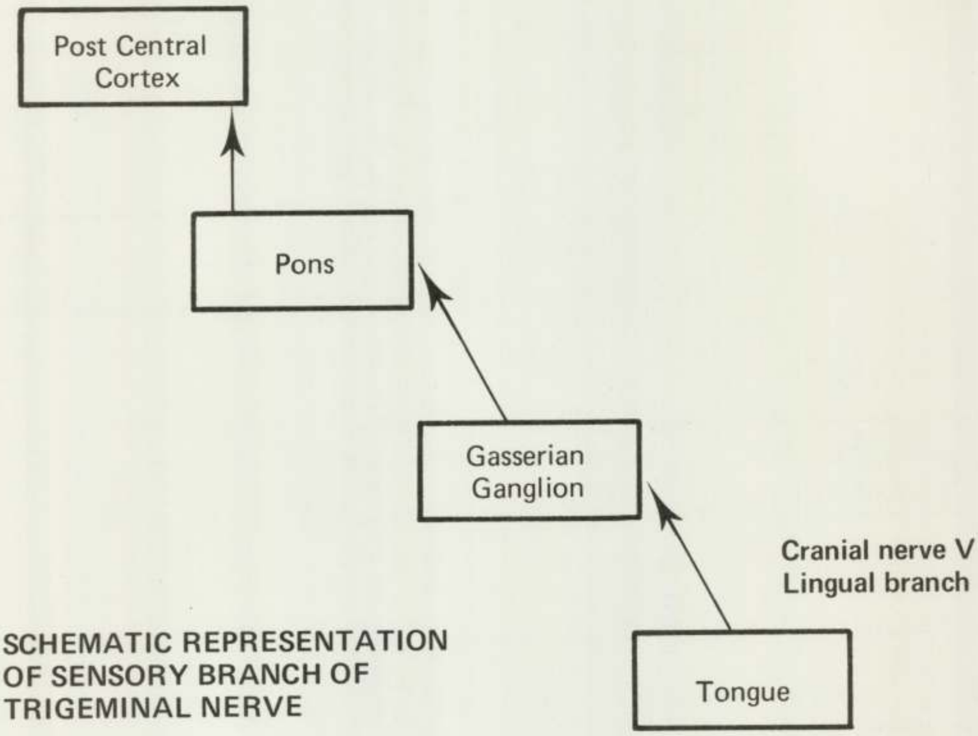
These constellations were designated, Analysers by Pavlov. The cerebral Cortex represented the 'central juncture' of these analysers.

In processes of decoding, signals received from the environment are broken down within the analysers in order that restructuring by integration with signals processed in other cortical analysers can take place as outlined in the previous chapter. Coding of speech is thus contingent upon the association and processing of the input from three principal modalities viz. the visual, auditory and tactile kinaesthetic channels. This can be schematically represented (facing).

Linguistically, coding operates on hierarchical levels of phonology, syntax and semantics. In the present study those neurophysiological systems directly concerned with the phonological level of speech will be described in more detail than those concerned with the generation of the syntactic and semantic components.

(iii) The Motor Analyser

Luria describes the postcentral parts of the motor cortex as being of great importance in the programming and organisation of impulses from the other analysers for the precise execution of motor activity in speech. Impulses from proprioceptive end organs follow a course from



SCHEMATIC REPRESENTATION
OF SENSORY BRANCH OF
TRIGEMINAL NERVE

the oral structures along the lingual branch of the trigeminal nerve. From the main sensory nucleus of the trigeminal nerve, fibres emerge to join the dorsal column pathway in the spinal cord, this passes through the hind and mid brain where it is known as the medial lemniscus. Each medial lemniscus, after decussation, terminates in a complex of nuclei located deep in the thalamus. From this area, third order components of the feedback loop are the hypoglossal nerve and motor branches of the trigeminal and facial nerves. The motor and sensory areas of the cortex overlap to a considerable extent, so that the sensory area exerts considerable influence over motor activity. This particular overlap is emphasised by the work of Penfield and Rasmussen (1950) who found that the parts of the post central area having the greatest influence on the execution of motor acts were those which related to the articulatory and phoniatric organs. This outline describes the classical interpretation of the route taken by tactile and proprioceptive impulses. Doubt has been expressed about this by more recent investigations which ascribe a sensory component to the hypoglossal nerve traditionally regarded as a purely motor nerve (e.g. Cooper 1960). Hardcastle (1970) refers to this view and suggests that it is possibly the hypoglossal and not the lingual nerve which is concerned with proprioceptive feedback. On the other hand, Kawamura (1970) maintains the traditional view and provides supportive evidence by reference to disturbance of the tongue movements after sensory denervation of the lingual nerve in the rat.

With reference to distribution of the peripheral sensory receptors, studies have shown these to be concentrated mainly in the anterior part of the mouth. Dixon (1961) found that the anterior part of the tongue was particularly well endowed with receptors for tactile and proprioceptive feedback. This is interesting in that this present study is mainly concerned with deviant production of sounds requiring movement of anterior parts of the tongue, viz. /t/, /d/, /s/, /sh/.

If kinaesthetic impulses are disrupted by lesion, the afferent basis of movement becomes impaired. Where the pathology is confined to the primary motor sensory area, the defect may be minimal and only apparent in the execution of simple movements. If the adjoining secondary sensory cortex is involved, however, severe defects of praxis will occur. In this case there is a failure in the ability to programme sequences of movement. This was well illustrated by a patient who in the absence of any paresis had great difficulty in carrying out the sequence of movements necessary to enable him to sit on a chair. In relation to speech, there is impaired awareness of the positioning of the lips and tongue with resultant confusion in the production of sounds. At its most extreme, there is no articulate speech, but in milder forms articulation will be deviant in the manner and place of production. A more detailed description of the nature of the speech disturbance will be presented when articulatory dyspraxia is considered further.

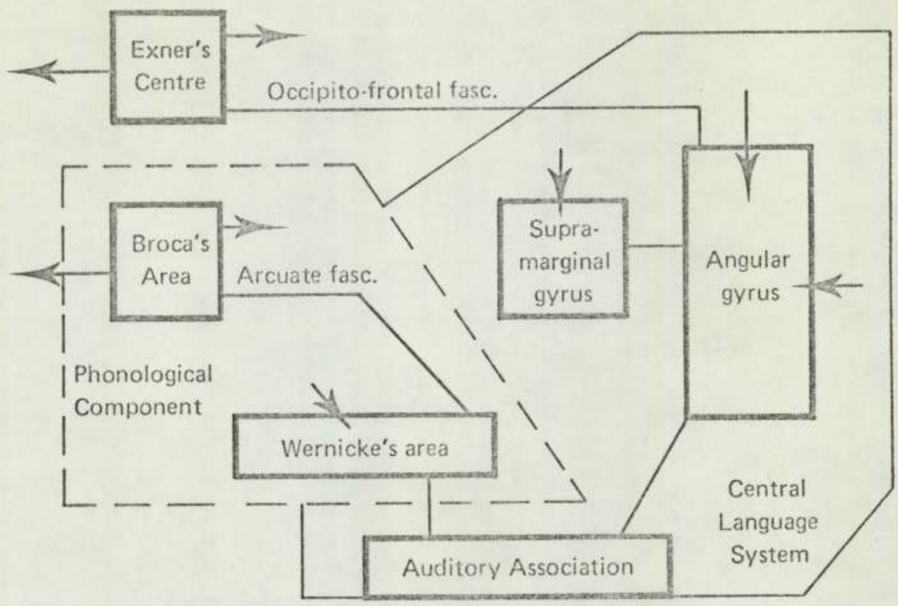
Astereognosis: the inability to recognise objects by touch is a feature of lesions occurring in this area. Chase in his concluding remarks at the Symposium on Oral Sensations and Perception, (Bosma 1970), observes the importance of sensory factors in early motor learning. He suggests that initially auditory factors may be of first importance for speech acquisition, but that the resulting motor feedback patterns in all probability constitute 'the predominant neurological substrate of the emerging system of motor speech commands'.

A limitation or impairment of motor ability may give rise to structural changes in the sensory pathways rather in the manner that deprivation of light has a damaging effect on retinal cells and on areas of the visual cortex.

Tye type of speech difficulty described contrasts with that which arises from lesions occurring in the pre-motor system. This area which also forms an important element of the motor analysers is concerned with the temporal ordering of expressive speech.

Reference has previously been made to units of coding. Laver (1970) has suggested that the discrimination and production of speech on a sound by sound basis is no longer an acceptable idea. Production as with perception of speech more probably involves unified sequences of movement. When there is dysfunction of the pre-motor system, speech is characterised by an inability to move fluently from one segment to another - progression is rather on a sound by sound basis. There is also impairment of inhibitory mechanisms so that perseveration of sounds occurs frequently. In conditions involving the secondary pre-motor speech zone (Brocas' area), the disorder will be more profound and there is a lack of inner structure of speech. Hughlings Jackson has described this as a failure to formulate thoughts into propositions. Such speech as there is becomes telegraphic in nature, and perseveration may extend to whole sentences.

The motor analyser, i.e. the pre- and post- central motor areas has strong connections not only within itself but also with the temporal, the inferior parietal and the occipital zones.



ANATOMICAL SCHEMATIC OF THE CENTRAL LANGUAGE SYSTEM
(after Whitaker)

(iv) The Auditory Analyser:

The Central Auditory pathway has its origin in the hair cells of the organs of Corti. Some preliminary discriminations of frequency and intensity takes place within the cochlea, but finer discriminations are effected further along the auditory chain. The most refined degree of frequency tuning appears to take place in the medial geniculate bodies and in the inferior colliculus, while intensity coding is probably completed at a lower level in the cochlear nucleus (Butter 1972).

From the organ of corti, nerve fibres ascend to cochlear nuclei situated in the medulla. They synapse and some decussate in the trapezoid body to the opposite side to end in the superior oliviary nucleus. Others pass upwards through the lateral lemniscus to the inferior colliculus. At this point, some fibres again cross over the other side of the brain, and then proceed to the medial geniculate nucleus where all the fibres synapse. The auditory tract then spreads out to form the auditory radiation until it reaches the temporal lobes of the cerebral hemispheres (Guyton 1972).

This constitutes the primary auditory cortex. Signals from each ear are represented here, but despite the equal distribution of signals, there is some indication that only linguistically meaningful signals are processed by the dominant hemisphere and that other kinds of acoustic signals, e.g. noise or music are analysed in the non dominant hemisphere. Heschl's Gyrus is mostly concerned with the preliminary tonal analysis of incoming sound. Increasingly complex discrimination of the type which is essential for the recognition of ongoing speech is the function of the secondary auditory zones (Wernick's area). This zone 'permits the secondary organisation of auditory perception' (Luria). Lesions in this area will lead to defects of auditory analysis. Phonemic sequences of sound are organised in a system appropriate to the language of the community and it is an essential condition of comprehension that one should be able to differentiate the incoming signals. A breakdown of this ability results in receptive aphasia. While the recognition of individual sounds may remain intact, the fact that these cannot be analysed and differentiated leads to an impairment in comprehension. Another disorder which arises from lesions of the secondary temporal cortex is a disturbance of auditory memory and of sequencing. This is characterised by an inability to retain even a short series of sounds or syllables. Efforts to reproduce them result in confusion of the total pattern and of the sequence of sounds within that pattern. Inevitably these conditions produced are associated with deficits in expressive speech; there may also be corresponding disorders in writing and in reading.

(v) The Visual Analyser:

This is concerned principally with the analysis and synthesis of incoming visual signals. In the language modality there is a failure to recognise the written word. This impairment may range from difficulty with individual letters through to a complete agnosia for written language, or even for pictorial representations. Difficulties of this type are associated with the lesions of the left secondary occipital cortex whereas lesions occurring in the corresponding area on the right side produce deficits of recognition of objects visually, even though tactile recognitions may remain complete. This impairment may also extent to the recognition of people. Another form of deficit is that known as simultaneous agnosia. When presented with a picture of two objects, the patient is unable to attend to more than one visual stimulus at a time. Because of visual recognition difficulties, writing is also impaired.

An interesting analysis of naming difficulties was carried out by Tsevetkova (1972). In pathological states it appears that naming errors preponderate in relation to concrete objects rather than in relation to qualities or actions. It was also noted that in most cases the substitute names which were evoked belonged to the same general category. Later experiments revealed marked defects in the recognition of visual representation of these objects. In identification, copying, or spontaneous drawing of the objects, patients experienced great difficulty. These experiments suggest that visual representation is an important factor in one's ability to name objects.

Except in so far as visual processes represent one aspect of the synthesis of perception, they are not the particular concern of this study, hence the function of the visual analyser is described rather more summarily than are those subserving motor activity and audition.

Through the analysers there is a strongly developed framework of connecting links which ensures that transmodel correspondences can be made effectively. Geschwind (1965) has studied in depth the results of disconnexions both between the different association areas and also transcortically through the corpus callosum. His papers on 'Disconnexion Syndromes in Animals and Man' traced the effects of lesions occurring in connecting links between the auditory and visual association cortex and the auditory and motor cortex and the limbic system found in animals. As the limbic system is the 'emotional centre' of all things concerned with survival this is not surprising, but the differential development of these connections, Geschwind ascribes to man's development of speech.

Luria too emphasises the interdependence of the various analysers. In his description of temporal lobe syndromes he states that the attendant speech deficit is not the product of disordered auditory function alone, but that the motor analysers also play a vital part in speech recognition. With reference to aphasic disorders he cites recent work by Tsevetkova (1968). Patients who were unable to formulate simple sentences were provided with a visual linear representation of each successive word, in this case blank cards. This external visual aid facilitated the production of the sentence. Additionally it was shown that in the original attempt without external aid, there were no E.M.G. impulses recorded from the lips and tongue, but that in the externally supported attempt, distinct impulses appeared prior to the articulation of the sentence. This experiment would appear to underline the interconnexion of sensory modalities in the production of speech.

The secondary cortical zones which have been described exhibit a high modal specificity. There is, however, another cortical area which represents an even more sophisticated level of perceptual integration. This is the inferior parietal region which forms the boundary of overlap for visual, auditory and proprioceptive sensation. Anatomically this area includes the Supramarginal and Angular gyri.

Geschwind (1965) has stated that maturation of this area is a prerequisite for development of language. In fact, full maturation in terms of myelination of the tracts leaving and entering this area is rarely completed before the age of seven. It is also an area which is developed exclusively in man, and has no exact equivalence in other primates. Lesions sustained in this area lead to disorders of the reception, and analysis of information. The ability to comprehend this information as a whole is diminished. While simple narrative speech may be followed, more abstract speech involving complex grammatical relationships is not understood. There is an attendant problem in naming and classically, these patients exhibit praphasias, either literal, where a similar sounding word is produced - chip for chair - or verbal when a word of similar category is used, e.g. sofa for chair.

It is hoped that the foregoing review of cerebrophysiological systems as applied to one aspect of speech behaviour has sufficiently emphasised the dynamic and interdependent nature of the mechanisms concerned. The description of the cytoarchitecture is not intended to suggest that certain functions of speech can be contained within confined boundaries. To quote Berry 'No language repositaries can be found in the cortex. No engrams for words or syntactic rules can be tapped in cortical cell assemblies'. The intention has been rather to try by description to indicate the areas of the brain which work together in order to effect the complex activity involved in the production of speech.

4. LINGUISTIC CODING

So far an attempt has been made to describe speech processes in terms of cybernetic theory. Neurophysiological mechanisms underlying these processes have also been discussed. A third aspect which requires consideration is that of linguistic coding and its possible correspondence with these other features of communication.

A hierarchial structure can be imposed upon language. It has been described as a system which is organised in such a way that the units at one level can combine to form units on a succeeding level. Traditionally three 'strata' have been described. These are phonological, morphological and that pertaining to words and sentences. The second and third levels encompass syntactic and semantic aspects of language.

Phonology is concerned with the study of the sound system of a particular language (Crystal 1971). It is a study which understandably is often confused with that of phonetics. One difference lies in the fact that phonology attempts to describe sounds with reference to that of a given language, whereas phonetics is concerned with a more generalised study of sound systems. Phonology is therefore a derivative of phonetics and traditionally this has been the principal method whereby individual sound systems have been described.

The work of the Prague School pioneered by the Russian linguist Trubetskoy and further developed by Roman Jacobson has sought to emphasise the more abstract qualities of sound systems by developing the notion of contrastive descriptions. This means that instead of detailed acoustic and articulatory information on each sound, the features by which it may be contrasted with other sounds are described. Thus the phonemes /p/ and /b/ for example, are opposed in terms of voicing, aspiration and tension. Common features are that they are both bilabial, plosive sounds. More recently, there have been attempts to describe the sound systems of all languages in terms of twelve paired contrasts of this type. This development is undoubtedly one which is influenced by the work of the generative transformational grammatists. They (notably Noam Chomsky) postulate the existance of a universal set of rules underlying all grammars; it would seem that phonologists are currently engaged in the search for parallel 'phonological universals'.

Adequate definitions of morphology have proved elusive, largely on the grounds of metaphilosophical arguments as to what constitutes 'a word'. The present most commonly accepted definition of a morpheme is that it is the smallest meaningful unit on which grammatical structure can be built. Though in many cases it constitutes what we recognise as a 'word' it is not synonymous with this. In the sentence 'The girl ate the grapes slowly', morphemes are denoted thus:

The
girl
ate
grape
-s
slow
-ly

The inclusion of the morpheme -s confers plurality and the suffix -ly changes the adjective /slow/ into an adverb thereby effecting grammatical change.

Syntactic and Semantic elements of speech have been the subject of much new thought over the past twenty-five years and current theory has departed far from traditional parsing procedures which were once an essential feature of any English Language Course in schools. Probably the most radical change is the adoption of the ideas of Transformational Grammar (Harris 1957, Chomsky 1957). This supposes the derivation of an infinitely large number of sentences from a relatively small number of 'kernel' sentences by the operation of transformational rules. The 'kernel' sentences constitute the deep structure and the infinity of sentences which can be generated from these form the surface structure of a language. Lyons (1970) points out the advantage, inherent in such a grammar, in so far as on the one hand it allows one to recognise the similarities between superficially distinct sentences; as an example he quotes:-

John ate the apple.

The apple was eaten by John.

Both sentences share a common deep structure. On the other hand one can differentiate between surface similar structures.

The phase 'the growing of the trees' might for example apply to:

The trees growing, or to

The growing of the trees (by someone).

Here the deep structure differs. Correletive with the theory of deep surface structure is that of Competence and Performance, also developed by Chomsky. Competence is that fundamental knowledge which a person has of his language while Performance relates to his actual use of that language. This concept is strikingly illustrated in the example of two differing types of deviant language. The deaf child may have a measure of competence for his language, but the constraints of impaired hearing may prevent his developing adequate performance. In contrast, a severely mentally handicapped child may exhibit reasonable performance while he lacks competence. He is limited in his ability to generate new sentences, i.e. to propositionalise.

These definitions represent a highly simplistic account of ideas which have given rise to much discussion and controversy over the past decade. Any attempt to unravel the complexities of these arguments would be inappropriate in the context of this discussion which is more directly concerned with an overview of language processes in so far as they relate to perception.

Production of speech is dependant on the effective operation of a neural and linguistic code. Incoming acoustic signals are translated into patterns which correspond to the listener's previous experience of speech. This constitutes the decoding process and embodies the act of recognition. Recognition imposes upon the brain the function of a scanning mechanism. On the basis of past experience, a process of matching and comparison of incoming bits of sound takes place. It is possible that this scanning activity relates to the phonological rules of distinctive features which Jacobsen has described. Certainly initial decoding is very much a screening activity and other than one whereby each separate piece of incoming acoustic information is examined in isolated detail. Far more probable is a process of decoding in neural stretches (Laver 1970) though the precise length and composition of these structures is somewhat uncertain. That there is no necessity to attend to all incoming stimuli is well illustrated by the rules which govern English usage. Following the initial phoneme /k/ for example, only a certain number of sounds are acceptable, /km/ for example, does not occur in English, whereas /kr/, and /ka/ or /ki/ are all possible. As the decoding process proceeds there is increasingly predictability, because of the narrowing in the range of permissible variants. Thus, by the time the speaker has uttered about fifty per cent of a sentence, in many cases the listener need no longer attend to the remainder (Fry 1968). The listener is further aided by intonational and rhythmic cues and by contextual conditions. Sometimes this leads to an erroneous estimate of a person's ability to comprehend. It is, for example, not unusual to find medical notes on stroke patients which indicate good comprehension on the part of the patient. What has happened is that the doctor attired in his white coat, complete with tongue depressor etc., has seen the patient and said 'Open your mouth'. This situation is one of high predictability and the patient may have responded correctly, though suffering severe comprehension problems in other aspects of language.

Encoding is equally dependent upon the operation of these rules. Fry discusses this as a continuing but not continuous process. In the formulation of any utterance there needs to be first of all the programming of the appropriate lexical items which in turn have to be organised in acceptable syntactic forms. Production therefore, tends to take place in 'short bursts'. Words which we use frequently and which have a high predictability are easily produced; (these are known as form words) while content words, those which convey more information, involve pauses. This accords with Laver's view of the unit of coding being a tone group, that is 'a unit of speech which lasts, on average, for about seven or eight syllables and which contains only one very prominent syllable on which a major change of pitch occurs in intonation'.

Again there appears to be some correspondence between this neural stretch carrying the rhythm of speech and the organising neural rhythm proposed by Lenneberg to which there has been reference previously.

Another important aspect of linguistic coding is the ongoing corrective monitoring activity which takes place throughout speech. This occurs both in self-correction and in listener correction. It relates the open and closed loop feedback system described earlier.

To summarise; in these three chapters, speech has been considered from three inter-relating standpoints. Initially production has been compared to a servo system whereby complex feedback information is relayed so that monitoring and corrective action can take place.

In psychological and neurological terms, these feedback circuits represent the perceptual input and integration within the central nervous system, which is a necessary preface to the programming activity involved in production of speech.

Linguistically, these processes are equated with operations involved in the coding of incoming verbal information and with the organisation of this data into appropriate (linguistic) hierarchies for the production of speech.

II

THE STUDY

1 STATEMENT OF HYPOTHESES

The description of perceptual processes underlying language leads one to question the possibility that impairment of these processes may be related to language deviation or arrest. Much work has been carried out on the role of hearing in relation to speech and language, but there has been less attention paid to tactile kinaesthetic processes and their influence. The investigation of these in the context of other language skills forms an intrinsic part of the design of this study.

The main research hypothesis states that children with cleft palate and/or cleft lip show different linguistic performance on phonological and syntactic levels when compared with a peer group of non cleft palate subjects.

From this research hypothesis the following operational hypotheses may be formulated:-

(i) the difference in language performance is not related to intellectual ability

(ii) the cleft palate group will differ significantly from the hypothesised national means in the following measures of language:

(a) Phonology
(b) Comprehension)
(c) Expression) Syntax Semantics

(iii) the normal group will not differ significantly from the hypothesised national means in the above measures of language.

(iv) the cleft palate group will show significantly different scores from the normal group in all the above measures and also in a measure of oral stereognosis.

(v) the level of scoring on one measure of language ability within a group will predict the level of scoring on another.

2 CLEFT PALATE

Nature and Classification of Cleft Palate

Perceptual dysfunction is associated with many varying manifestations of deviant speech and language. Development conditions of aphasia, dyspraxia and dysarthria may occur as a result of a failure of integration of perceptual processes (Eisensen 1971, Edwards, 1973, Joos 1973, Lenneberg 1967 and Morley 1972). Many of these language disorders form part of the symptomatology of the syndrome of minimal brain damage. This term is one which is conveniently used 'to include a number of different syndromes or patterns of difficulty which are the result of some kind of impaired functioning of the brain' (Rutter 1967). The general terms in which this definition is couched are indicative of the very great difficulty which exists in providing definite diagnoses in the absence of hard neurological signs of brain damage. The same difficulties apply to the descriptions of speech and language disorders which occur.

The speech of a group of children presenting with the syndrome of minimal brain damage was examined at the Charles Burns Clinic, Birmingham, and attempts were made to evaluate the particular features of deviance. Any definite classification proved untenable, partly because of the very large number of variables which had to be considered and partly because of the somewhat diffuse and changing patterns of language disorder which pertained even within individual children.

These difficulties led to the decision to investigate the speech and language of a more easily defined group, namely that of a selection of children whose primary defect was that of cleft palate and lip.

Cleft lip and palate is a congenital condition which is often genetically determined. The incidence of cleft palate as calculated in different parts of the world varies. Fogh-Anderson (1942 Denmark) reported an incidence of 1.47 per 1,000 births. McMahon and MeKeown (1953 Birmingham) found a total of 1.30 per 1,000 births, while Knox and Braithwaite (1963 Northumberland and Durham) reported 1.42 per 1,000 live births. With lower mortality rates, better cosmetic surgery and resulting improved marital prospects the incidence is increasing slightly. In many cases the condition is hereditary. The exact mode of genetic transference is unknown, but at least in the case of cleft lip, and cleft lip and palate, inheritance is by means of a recessive gene which indicates that there is also an additional precipitating factor. Isolated cleft palate does not follow these rules of inheritence and is in fact embryologically different from the other two conditions. Fogh-Anderson (1942) carried out what is probably the most extensive investigation of a cleft palate population in Denmark. Family histories revealed that there were hereditary factors present in 27% of cases of cleft lip only, 41% in cleft lip and palate, and 19% in isolated cleft palate.

Precipitating factors which have been cited are multiple and range through maternal dietary deficiency, the influence of drugs and maternal infection, e.g. rubella. Stress has also been indicated as a possible environmental condition. Olin (1960) noted that there was a higher incidence of clefts in white children than in coloured, and a possible reason was advanced on the basis of a higher frustration tolerance in the Negro woman. This theory appears to be highly speculative.

Cleft Palate arises because of interference in the unification of the embryonic processes which later form the face and nose. Stark (1961) has noted that there is in the cleft palate embryo, an absence or diminution of mesoderm; this is the tissue layer responsible for formation of bone, cartilage and muscle. Morley (1970) also discusses the condition as possibly being due to a 'failure of growth and penetration of the epithelial wall by the mosederm'. There is still, however, some conflict of opinion regarding the aetiology.

(i) Traditional Speech Disorders

Traditionally the most characteristic disorder of speech in the cleft palate population has been that of excessive nasal resonance. Impairment of ability to create an effective velopharyngeal seal because of the structural abnormality of the palate may give rise to audible nasal escape of air during the act of speaking. Effective articulation of English necessitates that one should be able to close off the nasal cavity, at least to some degree, except for the production of the consonants /m/, /n/, /ng/. This closure is brought about by the spincteric action of the soft palate and the pharyngeal walls. Where the musculature in this area is diminished or absent, the sphincter is ineffective and thus an excessive nasal quality is imparted to the voice. Disproportion between the relative size of the naso and oropharynx may be an additional factor resulting in excessive nasality.

Attempts to overcome the nasal escape give rise to deviant articulatory patterning, the most characteristic of which are the presence of glottal and pharyngeal substitutions.

Morley (1970) in an analysis of typical defects of cleft palate speech lists the following features as being descriptive of the condition:

nasal escape of air

nasal tone

nasal grimace

nasopharyngeal snort

glottal stop

pharyngeal fricatives

incorrect articulation and substitutions

Investigation of the speech of twenty adults aged nineteen and over who had undergone secondary repair of the palate revealed that twelve of them showed four or more of these features in their speech*. This description presents a picture of the traditional pattern of cleft palate speech. In most cases these patterns are directly attributable to the structural and functional anomalies resulting from the cleft.

(ii) Associated conditions

There are also other conditions which are associated with cleft palate and which may influence production and comprehension of speech.

Most commonly there is an associated hearing loss. Nober (1967) reporting on hearing problems in cleft palate subjects, cites nineteen studies carried out in the U.S.A. The data indicates the presence of

*Part of a joint study presented by Mr. D. Allan at a Meeting of British Plastic Surgeons at Royal College of Surgeons, London December 1970 (unpublished) some degree of hearing loss, ranging between 13% and 90% in individual studies with a mean for the entire series of studies of 50%. The predominating hearing impairment is of the conductive type as opposed to a sensori-neural loss, and this usually occurs as a result of otitis media. This accords with the higher incidence of upper respiratory infection found among cleft palate children. The hearing loss ranges through all frequencies. Unless it is severe though, it probably does not constitute a prime factor in relation to the speech difficulty, though it may be an additional problem in the remedial programme.

Investigations of intellectual development indicate that the distribution of intelligence in the cleft palate population more or less reflects that of the general population. This view is illustrated by two studies (Drillen et al 1966, and Illingworth and Birch 1956). The table indicates in the case of the first study, that the largest distribution occurs between I.Q. range 90 to 100, and in the second study an equal number, 40% occurs in the I.Q. range below 80 and between 90 and 110.

As compared with the normal population there is a weighting at the lower end of the I.Q. scale. This is, however, explained to some extent by the fact that these studies did not exclude subjects where the cleft palate may be one feature of a syndrome in which mental retardation may be another. Examples of syndromes where this could occur are Treacher Collins, Kleinfelter and Pierre Robin. It is accepted that in these conditions the cleft may represent just one of a multiplicity of other malformations.

EVALUATION OF INTELLIGENCE OF CLEFT PALATE SUBJECTS

	N	AGE RANGE	% I.Q. DISTRIBUTION			YEAR	TEST
			80	90/110	111		
Illingworth and Birch	80	4-16	40	40	20	1956	Terman Merrill
Drillien et al	129	3-5	33	49	18	1966	Terman Merrill and Gesell

Because of the structural deviation, much attention has been paid to the articulatory aspects of the speech and language disorder. There is, however, some evidence of delay and deviant development of syntactic and semantic structures. Pannbacker (1971) provides an overview of investigations carried out in the fields of comprehension and expressive language skills. Unfortunately, many of the studies are based on somewhat inadequate test instruments, particularly in relation to measurement of expressive speech. They appear to rely on rather tenuous precepts such as mean length of response and vocabulary size. Current linguistic teaching indicates that such information is of limited value. Probably the most comprehensive investigation of language skills was that carried out by Smith and McWilliams (1968) in which they used the Illinois Test of Psycholinguistic Abilities (Experimental Edition). Findings based on 136 children aged between three years and eleven years showed depressed scores in all nine subtests. Saxmann and Bless (1973) have recently reported their findings on investigation of language skills in a group of cleft palate children aged between 3 and 8.11 years. Vocabulary size compared with a normal non cleft group was approximately the same. On a measure of syntax comprehension and expression, however, there were differences, the cleft palate group scoring less well.

There is some evidence that cleft palate children suffer a delay in the onset of speech and also that their phonological systems differ markedly from those of their normal peers. Westlake, writing on Speech Learning in Cleft Palate children draws extensively on the studies of two workers (Bzoch 1956 and Olson 1965). Information obtained from parents indicated that many cleft palate children were more silent in the early stages of prelinguistic babbling. With reference to the overall amount of vocalisation which occurs later in imitative babbling it appears that this compared well with that of the normal child. There was, however, a marked difference in the range of consonants and vowels heard. Glottal and velar sounds predominated for a longer period in the vocalisation of the cleft palate group. In normally developing phonological systems there is much more evidence of anteriorly produced sounds.

(iii) Current Disorders of Speech

In more recent years, an articulatory pattern which is somewhat different from those previously described has been observed, and it is the investigation of this which forms the basis of this study.

The possibility of articulatory disorders developing for reasons other than direct structural malformation has been mentioned by several workers. (Morley 1970, Berry 1970). Improved surgical techniques and the fact that reconstructive surgery now takes place at an early age before faulty patterns of resonance can become established has to some extent eradicated disorders traditionally associated with cleft palate. Of the original forty-two children between the ages of four and six whose speech was investigated for this study, only seven were excluded on the grounds of excessive nasality with glottal and pharyngeal realisation of consonants.

It seems possible, however, that once the gross features of defect have been obviated, other deviations become more apparent. The table produced by Morley (facing) indicates the shift in the articulatory position for the realisation of the consonant /s/ over a period of twenty years.

<u>CLEFT PALATE</u>

Consonant substitutions for (s)	60 children with repaired cleft palates seen 20 years ago (1948)	88 children with repaired cleft palates seen during last 7 years (1961-67)
Not attempted	10	5
w	-	-
f	-	-
(th)	-	2
ts	-	-
weak attempt	-	9
slight defect	-	8
l	-	-
(sh)	-	17
l (lateral) (s)	-	11
c (fricative in k position)	2	18
s (nasal)	20	5
Nasopharyngeal	-	2
h	-	-
Pharyngeal	27	8
TOTAL	60	88
Anterior substitutions	1.6%	25%
Medial substitutions	3.3%	52%
Posterior substitutions	78%	17%

TABLE SHOWING DEFECTIVE ARTICULATION OF (S) IN CHILDREN WITH CLEFTS OF THE PALATE.

MORLEY 1970

The present group of children all realised the /s/ consonant in one or other of the positions indicated in the Anterior and Medial sections of the second column of the table. Other deviations included palatal fricative realisation for alveolar plosive sounds /t/ /d/ and lateral substitutions for /s/ /sh/ and the affricates (ch) and (j).

In this type of speech there is characteristic deviate tongue movement and in particular a neglect of use of the tongue tip. For production of these consonants the tip remains low behind the lower incisor teeth and the approximation is effected by using the front part of the tongue. The phonemes /t/ and /d/ are therefore realised as palatal fricative sounds, phonetically annotated and /s, , t , d / are realised as It is suggested that this specific pattern of difficulty may be the result of differences in perceptual coding which occur in cleft palate subjects and that the defect is in fact more akin to that of a developmental dyspraxia. Berry (1970) writing on this topic indicates that a deficiency in motor proprioceptive circuits 'reduces the cleft palate child's ability in patterning articulatory movements and facial gesture'. Clinical evidence based on observation of four hundred young children with repaired cleft palates corroborates her contention of impaired tactile kinaesthetic perception. Stark (1954) suggested that a lack of volume of facial muscles indicated a diminished innervation of this area. Morley states that in the development of articulation, the sensori motor experiences of the cleft palate child, must of necessity differ from that of a child with a normal palate. She also considers the possibility that the speech difficulty may be in the nature of an articulatory dyspraxia.

Other causes underlying this speech patterning have been put forward, examined and disputed. It has been suggested that in clefts involving the alveolus, sensitivity might be reduced by presence of scar tissue. However, this particular deviance has personally been found to occur in at least two subjects who had no cleft of the alveolus. The position of the embryonic tongue in relation to the anomalous palatal structures has also been considered. Here, however, there is dispute in so far as some authorities contend that the foetal tongue is found in an abnormally high position in the mouth, whereas contradictory evidence contends that it is abnormally low.

Foster and Greene (1960) found a just significant correlation between the incidence of lateral defects and a collapse of the upper dental arch, but these findings do not explain the presence of palatal substitutions commonly associated with the lateral defects.

Morley states that there is insufficient evidence to establish that either a failure of forward growth of the maxilla or the presence of an irregular arch and dentition are responsible for articulatory deviations.

A more fruitful line of enquiry may be in the investigation of compensatory feeding and sucking mechanisms employed by the cleft palate infant. In order to create the negative pressure within the oral cavity which is necessary for the effective channeling of food, the tongue needs to act as a piston. Even when a prosthetic feeding plate is provided to facilitate sucking,it is possible that tongue movement may be deviant. Articulatory movements are seen as modifications of primitive chewing, sucking and swallowing patterns. It therefore seems feasible to regard the subsequent articulatory defect as being the result of deviant sensori motor patterning set up by these compensatory movements early in life (Edwards 1970). Westlake (1968) regards this as a possible explanation for the presence of articulatory defects.

He reasons also that reluctance to use the tongue tip in cleft palate subjects may be due to diminished electro physiological motor potentials in that area and that this may be related to a lag in kinetic readiness for speech.

3. DESIGN OF THE EXPERIMENT

(i) Subjects - Experimental Group

For the purpose of investigating in more detail the types of speech difficulty previously described, a group of children with clefts of the lip and palate was selected. Thirty eight were seen initially. Those children were drawn from the age range 4.0 to 6.0. They all belonged to the Caucasian ethnic group and were offspring of English speaking parents. This last factor excluded the possibility of 'other language' influence on their speech.

Two principal facts determined the selection of children within this age group. By the age of four in normal language development, phonological patterns are stabilising and approximating more closely to adult models. Within this age group there is also available a range of standardised tests which facilitates the quantifying of language performance.

On the other hand, the imposition of a two year range limit has meant that the numbers studied within the group have been small. This is inevitable bearing in mind the relatively low incidence of the condition (Birmingham - 1.32 : 1000 births).

The subjects were drawn mainly from the Birmingham area with a few coming from the West Midlands. All of them were currently under review at either the University of Birmingham Dental School or at the Corbett Hospital, Stourbridge. They were for the most part attending the clinics for observation.

All the children had suffered congenital clefts of the lip and palate which had been successfully repaired. Classification of the clefts was based on the Kernahan and Stark model (1958). This relates the malformation to three categories.

Group I: which comprise clefts of the lip,possibly involving the alveolus but not extending posteriorly beyond the incisive foramen.

Group II: clefts of the soft palate which may extend anteriorly to the hard palate but not beyond the incisive foramen.

Group III: clefts of the primary and secondary palates.

All the subjects in this study fell into group three. Tables giving detailed information of the clefts are included in the appendix.

In each case repair of the lip and palate had been completed by the age of 2.6, and in most instances before the age of 2.0. There remained the possibility of secondary surgery for improvement of appearance of the nose and lip at some later stage. This is a common practice and does not usually influence speech being more directly related to cosmetic aspects.

Occlusal patterns of the Cleft Palate Group

As might be expected, a large number of the cleft palate group (15) showed evidence of Class III (Angle's Classification) occlusion. This occurs when the lower teeth close over the upper teeth (the so called overshotlower jaw). In some cases the condition was associated with a unilateral or bilateral collapse lingually of the upper dental arch. Studies carried out by Foster and Greene (1960) investigating the co-occurrence of lateral speech defects in these conditions found a just significant correlation in the case of dental arch collapse but no significant relationship in the case of Class III occlusion with lateral 'open bite'.

Subjects - Control Group

This comprised seventeen children (12 male and 5 female) with normally developing speech and who were within the same age range as the experimental group. These children formed part of a large sample population who attended the Dental Hospital regularly to participate in an ongoing growth study. None of these subjects had markedly abnormal occlusal patterns.

(ii) Measures employed in selection

Preliminary criteria of selection sought to control the study for measures which could possibly influence adversely language acquisition.

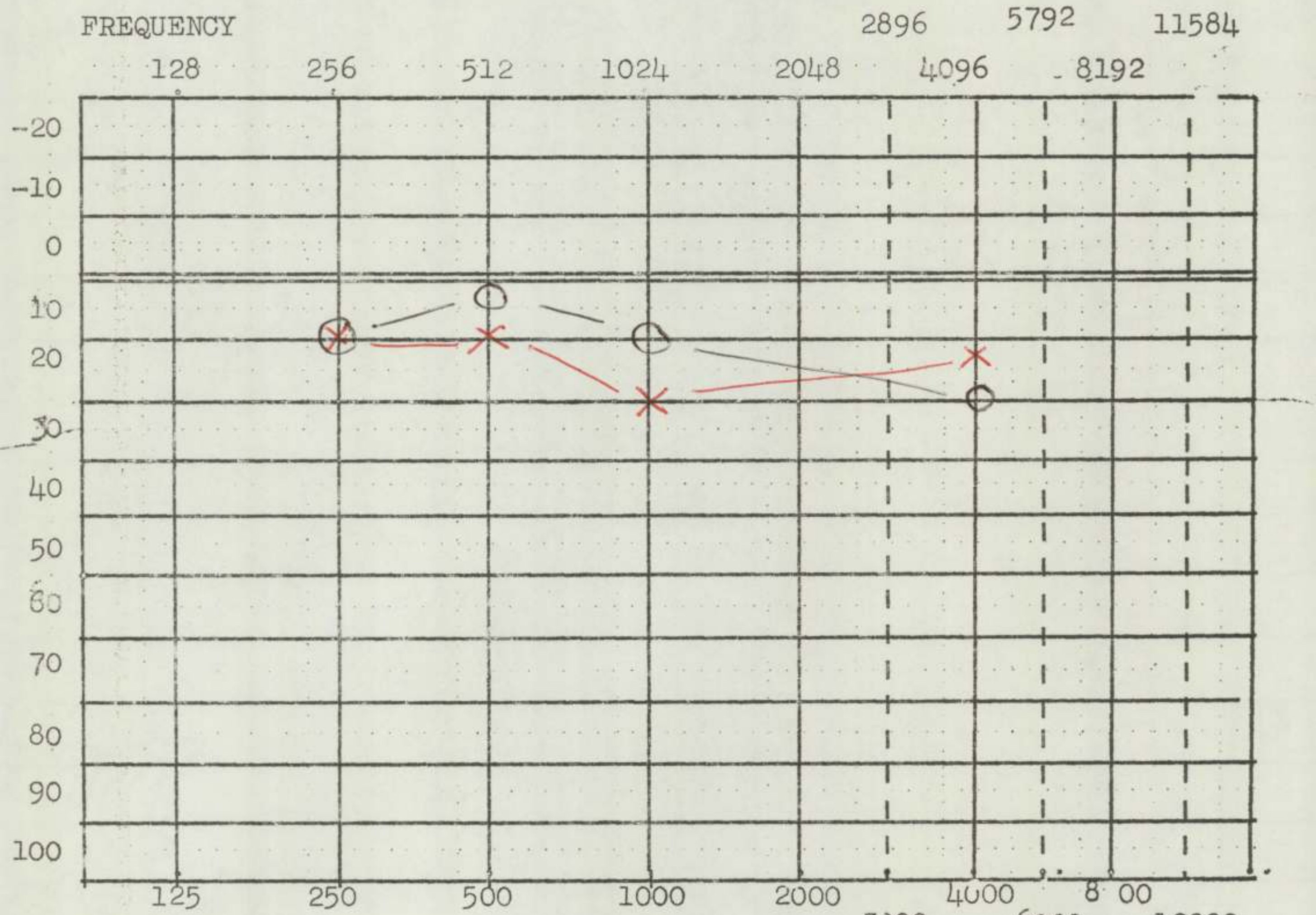
The first of these was hearing. All the subjects were assessed by means of pure tone audiometry on an Amplivox (   ) machine. Hearing acuity was assessed on four different frequencies: 250HZ, 500HZ, 1000HZ and 4000HZ. In accordance with general practice an audiogram which demonstrated a hearing loss of not more than 25 decibels throughout all frequencies was not regarded as being a significant factor in relation to deviant speech. Detailed findings are appended.

Number of patient: .... Date: ....

Name: ....

Instrument make: .... Type: ....

Serial number: ....



(MASKED/UNMASKED)

AIR CONDUCTION

RIGHT O--O--O

LEFT X--X--X

SETTING OF: ....
MASKING CONTROL

Setting

SIGNATURE OF RECORDER: ....

Hearing tests had been carried out previously on members of the Control Group either in Welfare Clinics or at school. In all cases it was found to be within normal range.

A typical audiogram is illustrated.

Intelligence and its assessment presented a more serious problem. Had a prescribed range of intelligence constituted a critical factor in the findings,it would have been necessary to have used a measure which would have provided evaluation such as is obtained for example from the W.P.P.S.I.* It was not in this case considered necessary to utilise such a refined measure and the decision not to do so was influenced to some extent by practical considerations. In the first place it was almost impossible to arrange for this number of children to undergo extensive testing procedures which would have had to be administered by a then sadly depleted psychological service. Secondly, at this relatively young age there was anxiety not to inflict too much pressure upon a group of children who had already endured considerable trauma through surgery and hospitalisation. Advice on the solution was sought from the tutor, Mrs. Margaret Newton, and from Dr. Klaus Wedell at the Centre for Child Study, University of Birmingham. As a result, it was decided that a performance test such as the Seguin Form Board would provide a sufficient guideline of general ability. The value of such a test is that it provides the administrator with information about the way in which a child approaches the problem, his ability to attend and the rate at which he appears to learn. Information about spatial and motor difficulties is also provided. No attempt was made to assign any specific intelligence

*The Wechsler Pre-School and Primary School Intelligence Scale.

measure to the results, the notion of a global I.Q. figure based on such flimsy evidence being refuted. Mittler's paper (1964) in particular emphasises the limitations of Form Board Assessment. He cautions against their use as predictive measure particularly when taken in isolation and underlines their unsuitability as quantative measures. They only serve to give some general idea of the degree of intellectual handicap.

The Reynell Developmental Language Scales are considered by some to include measures of cognitive functioning. Although Reynell (personal communication) maintains that they are purely measures of linguistic ability it is admittedly very difficult to treat this as a discrete entity unconnected with intelligence.

Other considerations were socioeconomic status and sex. The former was not thought to be a significant factor in so far as incidence of cleft palate is equal throughout all social classes in this country. With regard to sex, it will be seen that in the final group selected, males outnumbered females by 16 : 4. In most conditions of speech disorder the ration of male to female is about 2 : 1. The present distribution is weighted in favour of males. The condition of cleft palate follows the same rule. With the exception of isolated cleft palate (Group II), where there is a female preponderance, Fogh-Anderson (1942) found that the overall ratio by sex was 2: 1 in favour of males. It is noted that there are no Group II (isolated cleft palate) cases in the present group.

As it was essential to exclude any subject whose speech showed excessive nasality and/or glottal or pharyngeal realisation of consonants, a preliminary assessment of articulation was carried out using the Edinburgh Articulation Test. This test will be described in detail later.

Within the original group of 38, 18 were excluded from the further investigations for the following reasons:

6 showed patterns of immaturity in speech

4 had defects of nasal resonance

4 had a degree of hearing loss over and above that allowed

2 were of low mental ability

2 had other malformations; (Spinabifida, and Pierre Robin syndrome)

5 had speech and language within normally accepted limits

Note: the total figure is greater than 18 because some children were included under two or more conditions.

There were thus 20 children whose speech showed patterns of deviations predominantly associated with lateral and palatal realisation of consonants. It was decided to investigate their speech and language comprehension and performance more intensively.

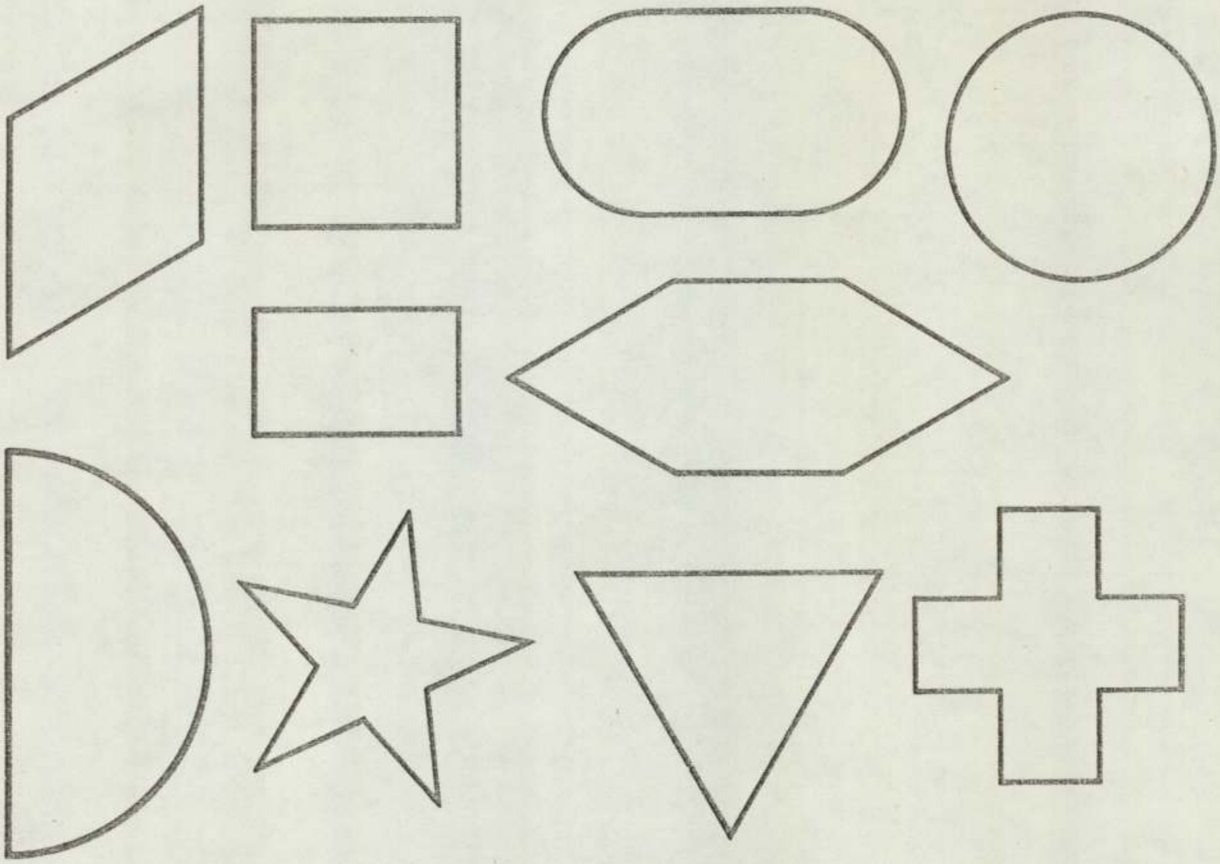
(ii) Measures used in the experiment

The Edinburgh Articulation Test - as a measure of phonological development and to indicate atypical realisation of phonemes.

The Reynell Developmental Language Scale - as a measure of comprehension and of expressive language.

A test of Sterognostic Ability which was adapted for this situation.

Seguin Form Board Test.



SEGUIN FORM BOARD

In addition some subjects in the control group were subjected to desensitisation of the tongue and alveolus by topical anaesthesia. Utterance was then recorded on a double beam storage oscilloscope. Results will be discussed, although it is not possible to quantify them.

Auditory Discrimination. Originally it had been intended that the Wepman Test of Auditory Discrimination should constitute one of the measures. This is a test involving recognition of 40 paired stimulus words, one of each pair differing in one feature only. Response is on a same/different basis. For the age range under investigation, this proved to be a somewhat tedious procedure and it was noticeable that as the test proceded responses became random and unpredictable and the children grew restive. It was decided therefore not to continue with this assessment.

The Seguin Form Board is part of the Merril Palmer Scale of Intelligence. It consists of 8 wooden blocks of varying shapes (see diagram) which fit into appropriate slots on the board.

The task involves the insertion of the forms as quickly as possible in the appropriate places. Evaluation is based either on the total number of errors made or on the best time out of 3 trials. The latter method of scoring was used in the present study. Norms are provided for 6 monthly age intervals from 2.9 to 6.0 years. Where the timed score did not fall less than the equivalent of 6 months below the mean for the chronological age, the result was allowed.

The Edinburgh Articulation Test (E.A.T.) This test was published in 1971, and is the result of work carried out in the Department of Linguistics and Phonetics in Edinburgh University. There are not many standardized tests available which measure phonological development. In fact, the choice in this case narrowed to one of three. Of the other two, the Templin test was rejected principally on the grounds of its unwildiness, but also because it included American items which would be unfamiliar to a British child, e.g. 'gopher'. The Renfrew Articulation test was attractive in so far as it was easy to administer, but phonetically it does not replicate with sufficient accuracy the articulatory patterning which one might expect to hear in children's speech.

Disadvantages of the E.A.T. are that it has been standardized on a population of Edinburgh children and there are, therefore, some regional differences in acceptability of certain words. 'Soldier' is an obvious example; where a Scottish child would use a final /-r/ sound, most English children finalise by a neutral vowel / /. There are also some unresolved questions in relation to the qualitative analysis. For this purpose, however, the quantitative analysis supplied the necessary information because those subjects with many features of immaturity in their speech were excluded in the first screening.

The test is based on the child's naming 41 pictures presented to him. Each item is designed so as to present certain phonetic features which occur in spoken English and the total series represents a phonetically balanced inventory. Scoring for the quantitative measure is on a right/ wrong basis. Imitated or spontaneous answers are acceptable. The total number of items yield a possible raw score of 65. This is converted to a standard score with a mean of 100 and a standard deviation of 15. One can also obtain an articulatory age score from the number of items scored correctly. Samples of the score sheets are included in the appendix.

The present investigation is based on standard scores. In addition detailed descriptions were made of the phonetic realisations of the phonemes /t/, /d/, /s/, /sh/, /ch/, /j/.

The Reynell Scales are designed to assess the developmental level of verbal comprehension and expression. They provide information about the degree of retardation of language development. Subtests reflect the child's competence and performance in linguistic hierarchies. The Expressive Test for example gives information on language structure through from early vocalisation to use of complex sentences. Another section tests vocabulary development from a concrete situational basis to the more abstract. There is also an attempt to assess the child's ability in creative language. Perhaps the choice of material (Lady Bird pictures) accounts for the fact that this section is not altogether successful. Children with elaborated echoic speech have been found to perform very well in this section yet are known to have poorly developed propositional speech.

The Comprehension Scale follows the successive stages of development of verbal comprehension from the first global understanding of prosodic features through to testing the child's ability to assimilate a large number of different verbal concepts. Reynell states that this differs from com plexity as determined by sentence length in that it necessitates the assimilating, relating and sequencing of a variety of different syntactic structures.

By analysis of the ways in which the tasks are carried out, these tests give clear indications of the nature of deviant development. Because the receptive/expressive scales are discrete there is also an indication of whether the difficulty lies predominently in decoding or encoding of language. The tests cover an age range of 6 months to 6 years with an area of greater sensitivity from one to 5 years. During the standardization of the tests, a small but consistent difference was apparent in the scores obtained for boys and for girls. It was decided, therefore, to provide separate norms. There are 2 comprehension scales, one being a modification of the other and intended for use with physically handicapped children. The test uses pictures, miniatures of objects, and objects.

Norms are provided in three forms, age scores, standard scores and graphs, the latter providing information in terms of ongoing assessments. Sample scored sheets are included in the appendix.

Considerable experience in use of this test with a wide range of children confirms its usefulness as an analytical tool in the study of language failure. It is comparatively easy to administer and proves very attractive to most children except those with grave attention problems. With the possible exception of one child who showed marked disparity between expression and comprehension, none of the children examined came into the category of non-creative speakers described earlier.

Stereognostic Ability. Deficits of sensory judgement with special reference to judgement of shape and position are associated with sensori motor impairment and in particular with anomalies of the inferior part of the parietal lobes. Brain (1961) and Nielson (1965). A symptom of such a lesion is the inability to judge forms or shapes of objects and to discriminate between varying textures. The classical neurological test for this involves manipulation and recognition of objects like keys, coins, etc. The evaluation of oral stereognosis, however, requires more specially adapted tests.

In the present study, it was considered important that this parameter of perception should be investigated in view of anatomical data of oral regions and its application to subjects with impaired oral tactile kinaesthetic ability. Dixon (1953) found that distribution of afferent nerve endings in the tongue was most densely concentrated in the anterior region. The present group of children under investigation all showed most marked deviation of articulation in relation to consonants involving the use of the tongue tip, e.g. s, t, d. The possibility of impaired functioning of this aspect of sensori motor feedback had therefore to be considered.

There have been a number of studies involving ability to discriminate shapes intraorally (Bosma 1967, 1970), and these have yielded interesting if somewhat confusing results. Before describing the procedure adopted in this study it seems worthwhile to examine some of these in more detail.

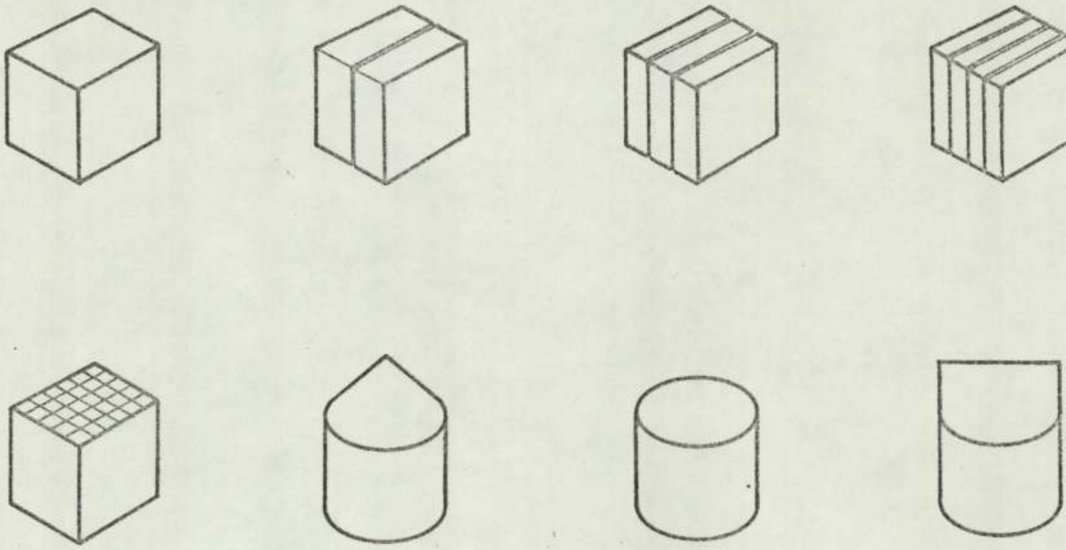
Hochberg and Kabcenall (1967) carried out an experiment on 30 normal and 12 cleft palate adults using a series of 10 metal shapes, 5 cubes which varied in shape only. The subjects were required to manipulate each stimulus intra-orally and then attempt to identify it against one of an enlarged duplicate set placed in front of them. Results indicated significantly superior ability in the normal subjects in perception and recognition, both for stimuli varying in texture and for those varying in shape. While the normal subjects perceived both sets of stimuli equally well, the cleft palate group found texture slightly more difficult to perceive than shape variation.

All the subjects reported that oral stereognosis depended primarily on tongue movements and that the palate served merely as a rigid surface against which the tongue could manipulate the object.

Ringel et al (1968) reported a test carried out on 28 adult students with defective articulation and on 20 normal adults. This test was designed to elicit oral recognition of 10 plastic forms varying only in shape and size. The shapes were presented in pairs. Whereas Hochberg and Kabcenall's experiment was dependent on visual recognition of the corresponding oral stimulus, in this experiment the subject was required to match the shapes on a same or differentbasis. This method had the advantage that it was able to evaluate stereognostic ability alone and not as an intermodel skill as in the first experiment. Findings indicated significantly diminished ability to discriminate correctly among the defective articulation group, and with that group those with more severe difficulties obtained lower scores than did those with mild defects.

Macdonald and Angst (1970) based a study on investigation of a wide range of consonants produced by nursery school children and related them to their stereognostic ability. They found virtually no relationship between the two measures. These workers also reported the case of a 20 year old male spastic quadriplegic whose stereognostic ability was severely impaired, but who,nevertheless, had good motor control of speech.

This study conflicts with other findings. A possible explanation is that in some individuals auditory perception may be of paramount importance, that is to say, not all articulatory defects occur necessarily as a result of anomalous oral sensory feedback. Another factor is the



STEREOGNOSTIC SHAPES

actual size 1/16"

individual's own ability to compensate. It has been observed that very often the measurable impairment is not in direct relation to the degree of handicap.

For the present investigation, a series of acrylic models based on those described by Hochberg and Kabcenall was used. (see illustration)

Each 'shape' was constructed so that one dimension was at least 5 mm. Suture thread was looped through a central cavity to avoid the possibility of the child involuntarily swallowing the stimulus. It was decided that in order to achieve unimodal discrimination, recognition should be on a same or different basis.

As this test represented a modification of existing tests, both in the number of items presented and in the manner of presentation, a pilot run was conducted to determine the feasibility of this modification.

Fifteen children between the ages of 4 and 6 attending primary schools were selected to carry out the test. Of these, 3 had difficulty of recognition on 2 items. In the case of one child,it was thought that the concept of 'same and different' had not been understood, and revision of instructions resulted in correct responses.

For the study,the children were given 2 demonstration items and were allowed to compare their responses with a visual presentation of the paired stimuli to confirm or contradict the response. If there appeared to be doubt about their understanding of 'same and different' initially, this concept was demonstrated by reference to other articles, e.g. 2 crayons (same) and a toy car and a train (different).

The paired stimuli wereplaced in the child's mouth one at a time for a period of up to 5 seconds each. The child was asked to 'feel' them with his tongue and then to report whether they were the same or different. Care was taken to ensure that palpation involved manipulation by the tongue only.

Five pairs differing in texture were presented first, and then 5 pairs differing in shape. Pairing was randomised, but once the sequence had been determined this was maintained for all the children. The score was the best result of 3 separate trials.

With regard to proprioceptive feedback, evaluation of this proved difficult. For really effective blocking in the oral region,it is necessary to administer an extensive oral anaesthetic. This is a painful procedure and although such experiments have been carried out, the subjects have always been adult volunteers. The ethics of subjecting a number of young children to such a procedure are questionable. An alternative method yielding a qualitative result was therefore used and this will be described later. For the future, the development of an electropaletograph in the Department of Phonetics and linguistics in Edinburgh University (Hardcastle 1970, 1972) offers the hope of more accurately quantifying tongue movement under various conditions. The electropalatograph consists of a thin acrylic artificial palate in which are embedded a number of electrodes. Tongue movements activate these electrodes and the information is transmitted to a visual display screen where there is a replication of the tongue movements. Thus a continuous record of articulation sequences is available and comparisons can be made between movements involved in normal and deviant production of sounds.

Another possibility is the use of spectrography, but the results here are at present too variable to allow for quantification.

There have been several studies of the effects on speech of interruption of tactile kinaesthetic sensation. Scott and Ringel (1971) compared the production of subjects whose speech was altered by nerve block anaesthetisation with that of dysarthric patients, i.e. those suffering from a predominantly motor impairment. Among the deviations reported in oral sensory deprivation were retraction of the tongue in the production of stops, less constriction than was normal for production of /s/ and /sh/ and a reduction of fine tongue tip pointing. Speech, however, remained intelligible. These authors support the view that articulatory activity is autonomous for the basic gestures underlying speech, but that degrees of phonemic refinement are dependant on feedback. In particular information from afferent oral pathways seems an essential for the successful execution of 'certain labial apical and blade refinements'.

Gammon et al (1971) attempted to assess the relative importance of auditory, tactile and kinaesthetic feedback by combinations of oral anaesthesia and auditory masking. Their results indicated that cut out of auditory feedback affected the range of articulation, voice pitch, intensity and quality. This observation was borne out in the present study. Attempts were made to record on an oscilloscope changes in speech when auditory feedback was blocked by the introduction of a masking white noise. There was such marked increase in amplitude and rise of frequency that the trace could not be adequately recorded with the equipment available.

Gammon and his co-workers found marked misarticulations following oral anaesthesia. A phonetic analysis revealed that the general trend was for a backward movement of placement for sounds normally produced at the front of the mouth. Vowels were virtually unaffected. With regard to prosody, stress and juncture were not abnormal in either condition. This accords with Koheznikov and Christovich's findings that these aspects of production were largely free of feedback.

Rhythm did however become irregular and the writers refer to Lenneberg's postulation of a central rhythm generator and suggest that interruption of feedback may in some way interfere with the co-ordination between speech rhythm and that occuring in brain activity.

As has been previously indicated it was not considered advisable to replicate experiments involving nerve block anaesthesia with a group of young children. A study of the effects of topical anaesthesia on the speech of a number of the control group yielded interesting results. The children were asked to say the phoneme /s/ before and after the application of Xylotox cream to the anterior third of the tongue and to the alveolar region. The two performances were recorded on a double beam storage oscilloscope and the resulting patterns were photographed, using a polaroid camera. 9 photographs are included in the appendix; 6 show marked differences in the 2 traces. After the application of the Xylotox, there is a flattening out of the frequency and of amplitude peaks in the production. Listener evaluation indicated that /s/ became more diffuse and palatalised. Two of the subjects produced a typical trace both with and without the anaesthetic. The eighth photograph is that of /s/ production by an experienced speaker. During performance following application of the anaesthesia a conscious effort was made to modify tongue movement to counteract palatalisation. Nevertheless on the right side of the upper trace, some flattening out of peaks is discernible.

These photographs do no more than provide interesting pictorial records of possible changes of production under conditions of altered sensory feedback. Comparative measurement is not possible because of the differing volumes at which the sounds were produced. The development of the technique would be worthwhile in giving some objective measurement of acoustic changes. All previous experiments have relied entirely on listener evaluation for analysis of results and this is not always satisfactory. Obviously there would have to be some effective control of volume before one could begin to quantify the results. One would also have to ensure the use of a less temperamental oscilloscope than was used in this study!

These were the measures which were used in the experiment. Results will now be tabulated, evaluated and discussed.

4 RESULTS OF THE EXPERIMENT

COMPOSITION OF CONTROL GROUP

1. R.A.	25.8.66	Male
2. I.C.	22.6.67	Male
3. S.B.	14.7.67	Male
4. R.C.	19.1.67	Male
5. A.C.	5.4.68	Female
6. E.D.	4.10.66	Female
7. D.D.	17.4.67	Male
8. P.E.	30.8.66	Female
9. P.C.	25.6.67	Male
10. M.H.	15.5.68	Male
11. A.H.	22.9.66	Male
12. C.H.	12.4.67	Female
13. A.M.	1.8.66	Male
14. G.M.	20.4.67	Male
15. S.M.	24.9.68	Male
16. D.T.	30.1.68	Male
17. A.E.	27.1.68	Female

N = 17

Male = 12

Female = 5

COMPOSITION OF CLEFT PALATE GROUP

1. D.B.	8.2.67	Male
2. N.B.	30.4.66	Male
3. P.D.	18.4.66	Male
4. J.F.	20.5.67	Male
5. L.H.	26.2.67	Female
6. E.H.	28.4.72	Female
7. A.H.	6.7.66	Male
8. D.L.	2.7.67	Male
9. P.N.	7.4.66	Male
10. M.P.	11.9.66	Male
11. I.W.	3.11.67	Male
12. W.W.	27.2.68	Male
13. K.W.	20.7.68	Female
14. A.W.	18.8.67	Male
15. M.W.	5.3.67	Male
16. N.M.	9.7.68	Male
17. M.G.	17.5.67	Male
18. J.H.*	5.8.65	Female
19. J.S.	3.1.67	Male
20. V.A.	11.3.66	Male

N = 20

Male = 16

Female = 4

* J.H. was given these tests early in 1971, before the main study was underway. At that time she qualified by age for inclusion.

MERRILL PALMER (SEGUIN) FORM BOARD

CONTROL GROUP

	TRIALS			BEST
	I	II	III	
R.A.	36	34	34	34
I.C.	39	37	39	37
S.B.	40	39	40	39
R.C.	38	38	39	38
A.C.	56	56	58	56
E.D.	36	35	37	35
D.D.	49	46	46	46
P.E.	36	38	40	36
P.C.	40	41	40	40
M.H.	60	58	59	58
A.H.	37	38	40	37
C.H.	44	42	41	41
A.M.	39	39	40	40
G.M.	40	41	40	40
A.M.	51	53	53	51
D.T.	45	46	50	45
A.W.	47	44	48	44

MERRILL PALMER (SEGUIN) FORM BOARD

CLEFT PALATE GROUP

	TRIALS			BEST
	I	II	III	
D.B.	39	35	38	35
N.B.	40	36	47	36
P.D.	42	36	38	36
J.F.	40	42	40	40
L.H.	39	38	38	38
E.H.	48	43	39	39
A.H.	36	36	34	34
D.H.	38	35	35	35
P.N.	36	36	37	36
M.P.	35	34	35	34
I.W.	69	67	69	67
W.W.	65	64	-	64
K.W.	53	51	55	51
A.W.	37	39	35	35
M.W.	48	39	37	37
N.M.	-	84	-	84
M.G.	50	48	48	48
J.H.	35	37	37	35
J.S.	37	37	40	37
V.A.	40	39	39	39

REYNELL DEVELOPMENTAL LANGUAGE SCALES

CONTROL GROUP

	COMPREHENSION	EXPRESSION
R.A.	118	109
I.C.	121	115
S.B.	115	116.5
R.C.	107.5	113.5
A.C.	125.5	127
E.D.	107.5	101.5
D.D.	128.5	101.5
P.E.	115	103.5
P.C.	101.5	101.5
M.H.	119.5	113.5
A.H.	118	116.5
C.H.	112	113.5
A.M.	118	116.5
G.M.	103	103
S.M.	100	104.5
D.T.	106	101.5
A.W.	101.5	118

REYNELL DEVELOPMENTAL LANGUAGE SCALES

CLEFT PALATE GROUP

	COMPREHENSION	EXPRESSION
D.B.	116.5	115
N.B.	121	115
P.D.	66.5	104.5
J.F.	127	109
L.H.	124	128.5
E.H.	55	94
A.H.	109	112
D.H.	96.5	101.5
P.N.	107.5	103
M.P.	106	96.5
I.W.	86.5	80.5
W.W.	103	137.5
K.W.	103	73
A.W.	85	76
M.W.	55	55
N.M.	92.5	69.5
M.G.	66.5	63.5
J.H.	113.5	106
J.S.	85	76
V.A.	97	76

EDINBURGH ARTICULATION TEST

CONTROL GROUP

R.A.	98
I.C.	118
S.B.	106
R.C.	97
A.C.	107
E.D.	102
D.D.	90
P.E.	102
P.C.	97
M.H.	113
A.H.	105
C.H.	95
A.M.	110
G.M.	86
S.M.	99
D.T.	101
A.W.	122

EDINBURGH ARTICULATION TEST

CLEFT PALATE GROUP

D.B.	87
N.B.	42
P.D.	46
J.F.	76
L.H.	97
E.H.	76
A.H.	86
D.H.	64
P.N.	94
M.P.	68
I.W.	85
W.W.	91
K.W.	75
A.W.	99
M.W.	81
N.M.	89
M.G.	72
J.H.	80
J.S.	60
V.A.	72

STEREOGNOSIS

CONTROL GROUP

	TEXTURE	SHAPE
R.A.	5	5
I.C.	4	5
S.B.	4	5
R.C.	5	3
A.C.	4	4
E.D.	4	5
D.D.	5	5
P.E.	5	5
P.C.	5	5
M.H.	5	3
A.H.	4	4
C.H.	2	3
A.M.	4	4
G.M.	5	4
S.M.	4	5
D.T.	4	4
A.W.	4	4

STEREOGNOSIS

CLEFT PALATE GROUP

	TEXTURE	SHAPE
D.B.	4	3
N.B.	2	2
P.D.	2	3
J.F.	1	2
L.H.	3	3
E.H.	3	2
A.H.	2	3
D.H.	4	5
P.N.	3	4
M.P.	2	0
I.W.	3	2
W.W.	3	2
K.W.	2	3
A.W.	3	4
M.W.	2	1
N.M.	3	1
M.G.	2	0
J.H.	4	5
J.S.	3	3
V.A.	2	3

TABLE 5 RANGE OF SCORES, MEANS AND STANDARD DEVIATIONS

(i) Performance. Seguin Form Board

	Range	Mean	S.D.
Experimental Group	34-67 secs	41.40	9.55
Control Group	34-58 secs	42.12	7.08

(ii) Age of Groups

	Age Range	Mean	S.D.
Experimental Group	49-72 mths	63.75	7.18
Control Group	51-67 mths	60.82	5.78

(iii) Articulation E.A.T.

	Range	Mean	S.D.
Experimental Group	42-99	77.05	15.49
Control Group	86-122	102.82	9.36

(iv) Verbal Comprehension R.D.L.S.

	Range	Mean	S.D.
Experimental Group	55-127	95-80	21.82
Control Group	100-128.5	112.79	8.76

(v) Expressive Language R.D.L.S.

	Range	Mean	S.D.
Experimental Group	55-128.5	94.60	22.42
Control Group	101.5-127	109.97	7.58

(vi) Stereognosis. Texture

	Range	Mean	S.D.
Experimental Group	1-4	2.65	0.81
Control Group	2-5	4.29	0.77

(vii) Stereognosis. Shape Discrimination

	Range	Mean	S.D.
Experimental Group	0-5	2.55	1.39
Control Group	3-5	4.29	0.78

Experimental Group N = 20

Control Group N = 17

TABLE 6 ANALYSIS OF DATA FOR SIGNIFICANT DIFFERENCES BETWEEN GROUPS

(i) Performance. Seguin Form Board

Experimental Group	Mean = 41.40
Control Group	Mean = 42.12

t = .249 (not significant)

(ii) Articulation. E.A.T.

Experimental Group	Mean = 77.05
Control Group	Mean = 102.82

t = 5.824 p .01

(iii) Verbal Comprehension. R.D.L.S.

Experimental Group	Mean = 95.8
Control Group	Mean = 112.80

t = 2.927 P .01

(iv) Expressive Language. R.D.L.S.

Experimental Group	Mean = 94.60
Control Group	Mean = 109.97

t = 2.622 P .05

(v) Stereognosis. Texture Discrimination

Experimental Group	Mean = 2.65
Control Group	Mean = 4.29

t = 6.074 P .01

(vi) Stereognosis. Shape Discrimination

Experimental Group	Mean = 2.55
Control Group	Mean = 4.29

t = 4.45 P .01

Significance Levels df = 35

.05 = 2.03

.01 = 2.72

TABLE 7 CORRELATION OF VARIABLES

(i) Articulation with Verbal Comprehension

	r	Significance
Experimental Group	0.15	.260
Control Group	0.14	.290

(ii) Articulation with Expressive Language

	r	Significance
Experimental Group	0.04	.430
Control Group	0.60	.005

(iii) Articulation with Texture Discrimination

	r	Significance
Experimental Group	0.31	.05
Control Group	-0.18	.24

(iv) Articulation with Shape Discrimination

	r	Significance
Experimental Group	0.10	.325
Control Group	-0.06	.41

(v) Verbal Comprehension with Expressive Language

	r	Significance
Experimental Group	0.63	.001
Control Group	0.38	.06

(vi) Verbal Comprehension with Texture Discrimination

	r	Significance
Experimental Group	0.06	.41
Control Group	0.05	.430

(vii) Verbal Comprehension with Shape Discrimination

	r	Significance
Experimental Group	0.29	.105
Control Group	0.03	.451

(viii) Expressive Language with Texture Discrimination

	r	Significance
Experimental Group	0.21	.19
Control Group	-0.33	.094

(ix) Expressive Language with Shape Discrimination

	r	Significance
Experimental Group	0.41	.05
Control Group	0.40	.05

(x) Texture discrimination with Shape Discrimination

	r	Significance
Experimental Group	0.55	.006
Control Group	0.26	.15

Experimental Group	r = .444 at .05 level
	r = .561 at .01 level
Control Group	r = .482 at .05 level
	r = .606 at .01 level

TABLE 8 COMPARISON OF GROUPS WITH STANDARDIZED TESTS

(i) Articulation. E.A.T.

Experimental Group	t = 6.67 (p .01)
Control Group	t = 1.43 (p .05)

(ii) Verbal Comprehension. R.D.L.S.

Experimental Group	t = 1.07 (p .05)
Control Group	t = 5.5 (p .01)

(iii) Expressive Language. R.D.L.S.

Experimental Group	t = 1.20 (p .05)
Control Group	t = 5.23 (p .01)

TABLE 9 RELATIVE FREQUENCY OF SCORES OBTAINED BY BOTH GROUPS EXPRESSED IN PERCENTAGE

	Articulation		Verbal Comprehension		Expressive Language	
	X	Y	X	Y	X	Y
42.47	10	–	–	–	–	–
48.53	–	–	–	–	–	–
54.59	–	–	10	–	5	–
60.65	10	–	–	–	5	–
66.71	5	–	10	–	5	–
72.77	25	–	–	–	20	–
78.83	10	–	–	–	5	–
84.89	20	5.9	15	–	–	–
90.95	10	11.8	5	–	5	–
96.101	10	29.5	10	17.5	10	5.9
102.107	–	29.5	15	23.5	15	35.3
108.113	–	11.8	10	5.9	10	29.4
114.119	–	5.9	10	29.5	10	23.5
120.125	–	5.9	10	11.8	–	5.9
126.131	–		5	5.9	5	–
132.137	–		–	–	5	–

	Shape Discrimination		Texture Discrimination	
	X	Y	X	Y
0	10	–	–	–
1	10	–	5	–
2	25	–	40	5.9
3	35	17.6	40	
4	10	35.3	15	52.9
5	10	47.1	–	41.2

Experimental Group	X	N = 20
Control Group	Y	N = 17

5 EVALUATION OF RESULTS OF TESTS

Initially a comparison was made between the two groups in relation to scores obtained on the Seguin Form Board Test. This was considered essential in so far as these results would determine the nature of subsequent statistical analysis. A significant difference between the two groups on the variable of intelligence as defined by performance would have necessitated the use of measures of covariance in all further inter group comparisons.

Results on a 't' test for independent samples revealed no significant difference between the two groups (t = .109).

The experimental group X and the sample group Y were then compared independently against national norms for those tests which had been standardized. These were the Edinburgh Articulation Test and the Reynell Developmental Language Scales. The E.A.T. has a mean score of 100 with a standard deviation of 15 points.

For the purpose of this study Reynell scores were converted to the same base as the Edinburgh Scales so that the mean on these scales was also 100.

Scores on the E.A.T. showed no significant difference between the control group Y and the national norms, but there was a significant difference (p .01) in relation to the Experimental Group X.

On the R.D.L.S., results were somewhat inconclusive.

The scores obtained on verbal comprehension in relation to Group X, showed no significant difference (p .05), while those for Group Y revealed a significant difference (p .01). The same conditions applied in the case of the Expressive Language Scores.

One possible explanation for this anomaly lies in the wide spread of the scores achieved by Group X in this test, (SD 21.81 and 22.42 respectively).

Reference to the frequency of scores obtained (Table 9) shows that on the verbal comprehension scale, the spread was between .54, i.e. -3 SD and .126; i.e. +1.85 SD. The same tendency is shown in the expressive language scales (range from -3SD to + 1.9SD). Group Y scores tended to be clustered in a narrow band between 101 - 131 for both bests. While socio-economic status was not considered to be relevant factor in this study, nevertheless one must consider the possibility that parents who are prepared to co-operate on a long term study (Dental growth) may tend to belong to social classes were linguistic skills are considered to be of some importance. The Reynell Scales were,on the other hand, standardized on a population which slightly favoured Social Groups, II, III and IV.

Another important factor is interpretation of results is the small number in each sample. This means that any marked single deviation will influence the mean score to a significant extent.

Inter-group comparisons indicate significant differences on all measures.

Analysis of the data by 't' tests for small independent samples shows significant difference. (p = .01) between X and Y scores on the Articulation, Verbal Comprehension and Stereognostic Tests and a significant difference (p = .05) on the Expressive Language Scale. Reference to the Relative Frequency of Scores (Table 9a) shows that for the E.A.T. 100% of Group X scores lie below 100, while over 50% of Group Y scores are in the range above 100.

For the verbal comprehension scores, 65% of Group X are in the 54-107 range, as compared with 10% of Group Y. 55% of Group X fall below 100 on the Expressive Language Scale, while Group Y shows a concentration of approximately 70% in the range 96-113.

Within group variables were compared to determine whether there might be significant correlations between the different tests. The Pearson measure of correlation was employed for this purpose.

Reference to Table 7 shows that a significant correlation between Articulation and Testure discrimination (p = .05), between Verbal Comprehension and Expressive Language (p = .01) and between Expressive Language and Shape Discrimination (p = .05) and between Shape and Texture Discrimination (p = .01) for Group X.

Group Y shows significant correlations between the following measures:-

Articulation with Expressive Language (p = .01)

Verbal Comprehension with Expressive Language (p = .05)

Expressive Language with Shape Discrimination (p = .05)

Thus, in two similar paired measures both groups show significant correlations.

With reference to the correlation between Articulation and Texture discrimination in Group X, these findings accord with those of Ringell and Steer (1968) which revealed diminished ability to discriminate orally among a defective articulation group as compared to a normal speak group.

It is not clear why there was not a corresponding correlation between articulation and shape discrimination. The means for shape and texture discrimination were 2.55 and 2.66 respectively, but in the case of the former there was a greater spread of scores. SD = 1.39 as against 0.81 for the latter. The correlation co-efficient was 0.10 ($p = .325$): ($r = .44$ at .05 level).

The correlation between expressive language and shape discrimination is an interesting one. A search of the literature fails to show any published results of other investigations of these measures. Most research into oral stereognosis has been confined to its relationship with articulatory skills. These findings would,however, reinforce the contention that oral perception is an important feature in relation to the development of expressive language. (Studdert Kennedy forthcoming).

Analysis of the data makes it possible now to reappraise the operational hypotheses which were stated in Chapter

(i) The first of these stated that linguistic skills were not related to intelligence as measured on a performance scale.

The null hypothesis:-

Ho : FBx FBy (FB = Form Board)

can be rejected and the alternative hypothesis:-

Hi : Rbx = FBy

can be accepted.

(ii) Articulation skills of Group X will differ significantly from those of Group Y.

The null hypothesis:-

Ho : Mx = My (Articulation)

can be rejected and the a ternative hypothesis:-

Hi : Mx My (Articulation)

can be accepted.

(iii) Verbal Comprehension of Group X will differ significantly from that of Group Y.

The null hypothesis:-

Ho : Mx = My (V.C.)

can be rejected and the alternative hypothesis:-

Hi : Mx My (V.C.)

can be accepted.

(iv) Expressive Language of Group X will differ significantly from that of Group Y.

The null hypothesis:-

Ho : Mx = My (E.L.)

can be rejected and the alternative hypothesis:-

Hi : Mx My (E.L.)

can be accepted.

(v) Oral discrimination of shape and texture in Group X will differ significantly from this ability in relation to Group Y.

Ho : Mx = My (Stereognosis).

The null hypothesis can be rejected and the alternative hypothesis:-

Hi : Mx My

can be accepted.

(vi) There will be a measure of positive correlation between each of these tests when measured within groups.

Ho : $r_1 \neq r_2$

The null hypothesis can be rejected only with reference to the following within group measures:-

Articulation and Texture Discrimination

Verbal Comprehension and Expressive Language

Éxpressive Language and Shape Discrimination

Shape and Texture Discrimination

Articulation and Expressive Language

The alternative hypothesis

$$r_1 = r_2$$

can be accepted for each of these paired measures.

(vii) The scores obtained for the Control Group Y on measures of Articulation, Verbal Comprehension and Expressive Language will not differ significantly from the national norms for these measures.

The null hypothesis:-

Ho : My ≠ Mx (Articulation)

can be rejected and the alternative hypothesis:-

H_1 : My = Mx

can be accepted.

For measures of verbal comprehension and expressive language the null hypothesis cannot be rejected.

6 SUMMARY AND CONCLUSIONS

Analysis of the data indicates that a measure of relationship exists between some aspects of linguistic skills which have been investigated in this study.

There is evidence to show that some cleft palate children show impaired ability in all the measures of language tested when compared with normal children. This impairment is most marked in relation to articulatory performance; for measures of verbal comprehension and expressive language the data is less conclusive (see also Saxman 1973). Diminished performance does not appear to be a function of any structural anomaly.

One inference which may be drawn from the data is that linguistic impairment in these subjects could be related to sensory motor feedback and in particular to tactile kinaesthetic feedback.

Although the study is limited by the constraints of a small sample and by less than comprehensive facilities for assessment of feedback, it has nevertheless seemed to underline the need for much more extensive longitudinal investigations of language acquisition in the cleft palate population. Findings of such an investigation could have implications for the better understanding of other developmental language disorders. These implications will be discussed briefly in the final chapter.

III

DISCUSSION AND IMPLICATIONS OF STUDY WITH REFERENCE TO FUTURE INVESTIGATION

This study has been concerned with the investigation of language skills of a defined group (children with repaired cleft palates). The first part of this thesis has described perceptual processes underlying speech. In the second part a small study was carried out in an attempt to relate one perceptual modality viz. tactile kinaesthesia to language skills in a group of children who evinced deviant articulation.

The findings give some indication that such a relationship exists. The experimental group showed inferior ability in tasks of oral stereognosis involving shape and texture discrimination. This group was also less able in measures of expressive language as well as in specific articulatory tasks when compared with a group of children not thus handicapped.

Statistically a positive correlation was found between the experimental group's scores on measures of articulation and of expressive language with aspects of stereognosis.

The study was inconclusive in relating sterognosis to language comprehension. This is not to say however, that proprioception may not be an important factor in the process of language development.

These findings may perhaps be regarded most valuable as an indication of the need for further and more detailed investigation of the part played by this particular sensori-motor channel in relation to spoken language.

Unfortunately circumstances did not allow for any investigation of auditory perception and its relationship to language comprehension and production. This means that to some extent the title of the thesis implies a much more comprehensive enquiry than has in fact been carried out. Auditory function has however been reported elsewhere to a greater extent than has proprioception, though there is need for further investigation of discriminatory, sequencing and memory skills if remediation is to be more effective. The anomaly of intrapersonal as against interpersonal auditory discrimination is one about which we know little at present. The individual's inability to monitor his own utterance while having normal ability to monitor other people's speech is perplexing. Further development of audiovisual techniques as indicated by Fourcin (1973) may afford some explanation in the future.

The relationship between stereognostic ability and expressive language which was noted in the experimental group may have some aetiological significant for other forms of deviant language behaviour. In particular, the condition of developmental articulatory dyspraxia first described by Morley in 1954 would appear to include some of the features which have been noted in the cleft palate group.

Traditionally articulatory dyspraxia has been regarded as deriving principally from motor dysfunction. Attention has been focussed on articulatory production with special emphasis upon the differential features as compared with those of dysarthria and expressive dysphasia.

Arising from this viewpoint, therapeutic programmes have included many items relating to auditory training, this being regarded as the most effective means of monitoring tongue movement.

More recently, the condition has been described in terms of sensory perceptual impairment and in particular of tactile kinaesthetic dysfunction (Rosenbeck et al 1973, Darley and Johns 1970, Morley and Fox 1969).

Ongoing investigation at the Mayo Clinic (Yoss 1972, 1973) provides additional confirmation of the sensori motor nature of this disorder. Examination of auditory perceptual function in 15 cases revealed below average competence, but the subjects compared favourably with others suffering from articulatory disorders which were 'non practic' in origin. Furthermore a follow up study after two years gave indications that those patients who had received therapy based on intensive auditory training programmes 'showed lack of significant improvement'.

An interesting feature of the Mayo clinic studies in the neurological report on these subjects is the finding that most of them showed reduced E.M.G. responses of the tongue. This accords with the evidence previously cited of reduced tongue tip E.M.G.

potential in cleft palate subjects (Westlake) and of the important part played by proprioceptors in the tongue tip area (Dixon).

Verbal dyspraxia is marked by a reduction in the range of phonemes used and by a lack of consistency in their realisation. Alveolar sounds (t, d) may be substituted by velar sounds (k, g,) (loch). While the place of realisation may be consistent there will be variation in the manner of production, stop consonants acting for fricatives and vice versa (Edwards 1973).

Comparison with the cleft palate subjects shows some similarities. As with the dyspractics there was a backward shift in articulatory patterning; this did not extend to the velar area but was palatal so that [t,d] -> [ç̟ ʝ̟] and [s] -> [ɬ or ç] In each case there was a fricative realisation of a stop consonant but unlike the dyspractics this remained consistent.

A characteristic of dyspraxia is that sequencing of sounds, words and sentences may also be affected. There was no evidence of sequencing anomalies in the cleft palate group.

In neither condition does prosody appear to be adversely affected. This fact can be related to the idea that prosody is controlled principally by auditory feedback, whereas articulation is reliant upon oral kinaesthetic feedback.

An over all view of these conditions taken in relation to the foregoing description of perceptual processes subserving speech indicates that there may be underlying common causative factors which could relate to a dysfunction of sensori motor patterning and in particular of tactile kinaesthetic patterning. The importance of integration of perceptual functioning has been emphasised and therefore the complementary role of audition requires consideration though it may not be a prime factor in this particular pattern of disorder.

In the study, the cleft palate group performed poorly on tasks involving oral stereognostic discrimination. There is also evidence (Yoss 1973) that dyspraxic patients experience very similar difficulties in these tasks.

Experimental work involving two point oral discrimination also yields similar results in both groups (Rosenbeck et al 1973).

The cleft palate group showed some impairment of verbal comprehension and expression. Greene (1967) contends that dyspraxia is always accompanied by a language as well as articulatory disorder. Support for this view comes from the work undertaken at the Haskins Laboratory by Liberman and his fellow workers. Their paper 'The Motor Theory of Speech Perception' (1967) first put forward the idea that the child developing speech learns auditory discrimination through its own articulatory patterning. Studdert-Kennedy (personal communication and forthcoming) argues that the developing phonological system derives from personal experience.

A consideration of these disorders in the light of our knowledge of the part played by tactile kinaesthetic feedback may have practical implications in the planning of remedial programmes. Evidence cited by Yoss (1973) in her follow up study reveals a lamentable lack of improvement as a result of traditional therapeutic methods based on auditory and motor training.

This is not to say that auditory training should play no part in therapy, but rather that its importance should be regarded more in the light of integrative processes of perceptual function.

Clinical programmes based on increasing awareness of intraoral activity and of sequential lingual movement have appeared to meet with some success both in someof the cleft palate subjects and of dyspraxic patients. An adaptation of the PNF (proprioceptive, neuromuscular facilitation) method used with cerebral palsied patients would suggest one possible way of initiating a remedial programme. This involved stimulation of articulatory organs by alterations in temperature (the use of ice) and by increasing awareness of textures (rough and smooth).

Knowledge of the neurophysiology and the neuropsychology of perception, particularly with reference to auditory and tactile modalities is very restricted. Still more so is the knowledge of integrative function of these processes. Psychologists have focussed much of their investigatory attention on visual perception over a number of years. Improved technology should now make easier the task of investigating other perceptual processes which are basic to verbal communication.

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R.D.L.S.

Verbal Comprehension Scale 'A'

Name: [redacted] KW.

Date of birth: 20 · 7 · 68

Date of test: 11 72

Age: 4·4

Raw score	47
Age level	4·4·
Standard score	0·2

Comments:

Examiner: ME

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Section	*Item*	*Question*		*Score*
1	1	Selective recognition of word or phrase.		✓
	2	Adaptive response to familiar word or phrase.		✓
	3	Looks at one familiar object or person in response to naming.		✓
2	1	Where is the	ball	✓
	2		brick	✓
	3		brush	✓
	4		cup	✓
	5		doll (dolly)	✓
	6		car (motor)	✓
	7		sock	✓
	8		spoon	✓
3	1	Where is the	horse (gee-gee)	✓
	2		dog (doggie)	✓
	3		baby	✓
	4		cat (pussy)	✓
	5		lady (mother) (mummy)	✓
	6		man (father) (daddy)	✓
	7		boy	✓
	8		girl	✓

Section	*Item*	*Question*	*Score*
4	1	Put the doll on the chair.	✓
	2	Put the spoon in the cup.	✓
	3	Put the brick on the plate.	✓
	4	Put the car in the box.	✓
5	1	Which one do we sleep in	✓
	2	go for a ride in	× ?
	3	write with	✓
	4	cut with	✓
	5	cook with	× Knife
	6	sweep the floor with	✓
6	1	Which one barks	✓
	2	catches the mice	rabbit
	3	cooks the dinner	✓
	4	has the longest ears	✓
	5	is eating	✓
	6	is sitting down	dog
	7	is carrying a bucket	✓
	8	has a gun	✓
	9	sails on the water	✓

Section	Item	Question	Score
7	1	Find a yellow pencil (crayon).	✓
	2	Show me the biggest balloon.	✓
	3	Turn the little table upside down.	✓
	4	Put the penny (money) underneath the cup.	✓
	5	Show me which button is not done up.	–
8	1	Which horse has a collar on?	✓
	2	Put the brown hen beside the black hen.	✓
	3	Show me how the man walks into the field.	×
	4	Show me the horse which is eating the grass.	✓
	5	Put one of the pigs behind the man.	✓
	6	Make one of the horses walk through the gateway.	×
	7	Put the little black pig beside its black mother.	× ← reverse.
	8	Pick up the smallest white (pink) pig and show me his eyes.	✓
	9	Put the farmer and one of the pigs in the field.	✓
	10	Put all the pigs in the box and give me a brown horse.	×
9	1	This little boy has spilt his dinner. What must he do?	pick it up ✓
	2	This little girl is nearly late for school. What must she do?	NR
	3	The little girl hits her brother. What does he do?	Hit her ✓
	4	The baby has fallen and hurt his knee. What does his mother do?	NR
	5	The car is nearly running into the little boy. What must he do?	run ✓

Total score (*Maximum* 58) 47

R.D.L.S.

Expressive Language Scale

Name: [redacted] KW.

Date of birth: 20 . 7 . 68

Date of test: 1 72

Age: 4 · 4

	Raw score
Language structure	15.
Vocabulary	16
Content	6
Total	37.

Age level	2 · 11.
Standard score	−1 · 8.

Comments:

Examiner: ME

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LANGUAGE STRUCTURE

Item		*Score*
1	Vocalisation other than crying.	✓
2	Single syllable sound.	✓
3	Two different sounds.	✓
4	Four different sounds.	✓
5	Double syllable babble.	✓
6	One definite word.	✓
7	Expressive jargon.	✓
8	2–3 words.	✓
9	4–5 words.	✓
10	6–7 words.	✓
11	9–12 words.	✓
12	Word combinations.	✓
13	20 or more words.	✓

LANGUAGE STRUCTURE

Item		*Score*
14	Sentences of four or more syllables.	✓
15	Words other than nouns or verbs.	✓
16	Correct use of:	
	(*a*) pronouns	
	(*b*) prepositions	
	(*c*) questions other than by intonation.	
17	Correct order of words in sentences. No words omitted.	×
18	Use of complex sentences.	×

Total score (*Maximum* 18) 15.

VOCABULARY

Objects		*Score*
1	ball	✓
2	spoon	✓
3	cup	✓
4	sock	✓
5	brush	✓
6	doll	✓
7	car	✓
Pictures		
8	chair	✓
9	house	✓
10	flower	✓
11	letters	✓
12	window	✓
13	drinking	✓
14	writing	x
Words		
15	apple	x
16	book	x
17	dress	Put on you ✓
18	shop	x get them put it
19	sleeping	a bed. x
20	washing	making clothes clean. ✓
21	cold	feel cold. ✓

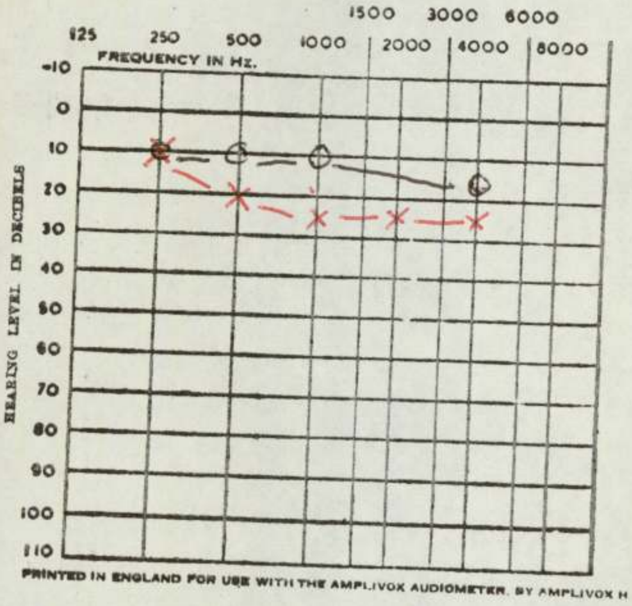
Total Score (*Maximum* 21) 16.

CONTENT

Picture		Score
1	Laying the table boy. girl. ?. on table.	2.
2	Hanging the washing putting clothes on here.	2.
3	Shopping lady. present.	1
4	Digging potatoes	
5	In the shed wheelbarrow lawnmower. garden - broom.	1
	Total score (*Maximum* 20)	6.

BONSHAW HOUSE

SPEECH THERAPY CLINIC



PATIENT: [redacted]

D/B ______________ AGE: ______________

TESTED BY: STUDENT; ______________

YEAR ______________

SUPERVISING THERAPIST ______________

CONDITIONS OF TEST: ______________

____

____

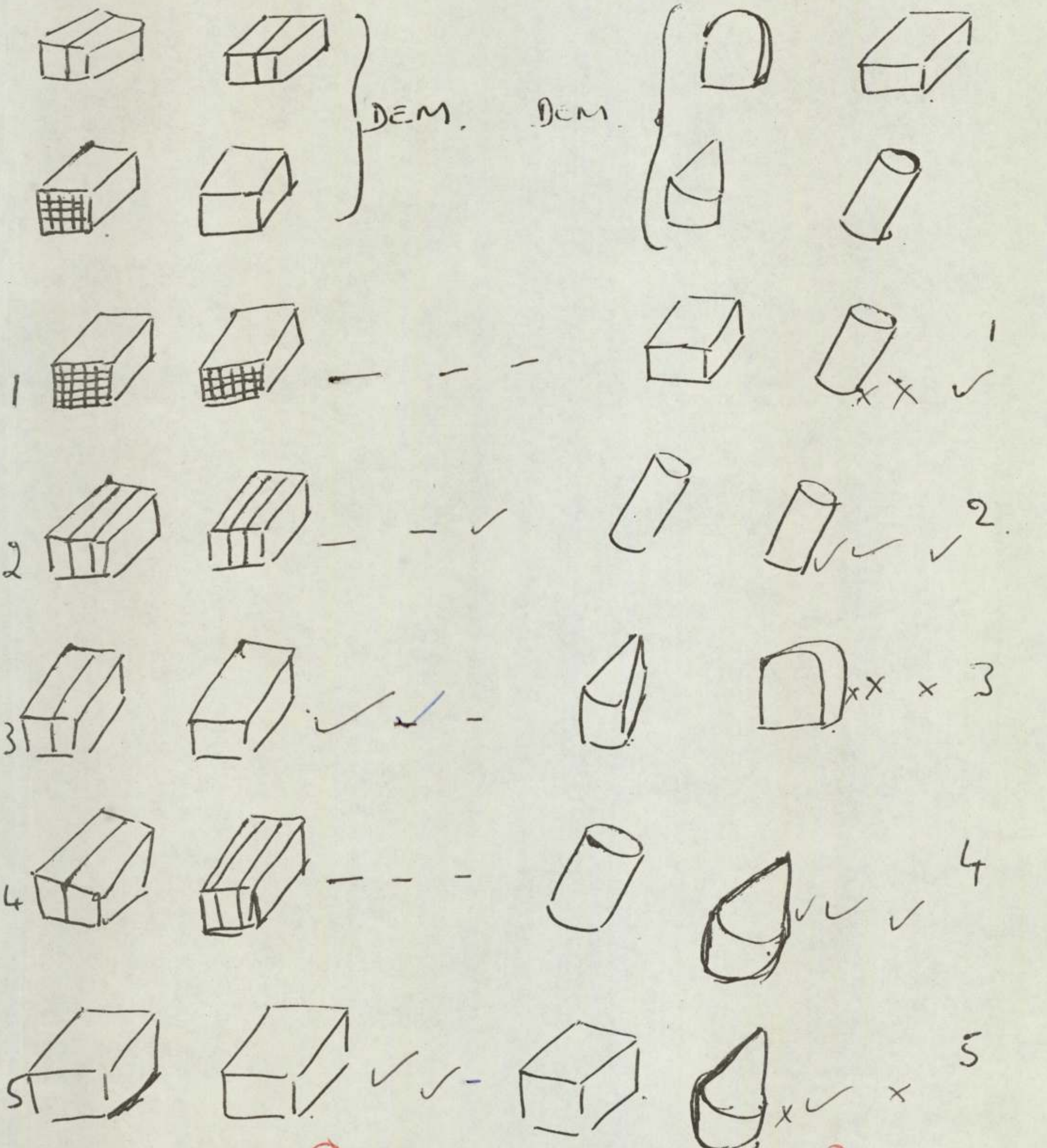
REMARKS: ______________

____

RIGHT 0 AIR ______________

LEFT X BONE ______________

NAME [redacted] DATE OF TEST 11 – 72



NO. CORRECT - 2 2. 1 NO. CORRECT 2 3 3

KW. EDINBURGH ARTICULATION TEST/ QUANTITATIVE ASSESSMENT SHEET

Name [redacted] Sex ______ Test given by ______

Address ______ Place of Test ______

Date of Birth 20 · 7 · 68. Date of Test 22 · 72. Age 4 9/12.

monkey	ŋk	✓	
tent	t	Kj	
	nt	G	
fish	ʃ	ɬ	
train	tr	tj	
umbrella	m	✓	
	b	✓	
	r	o	
	l	✓	
milk	m	✓	
	lk	vk	
stamps	st	ɬ	
	mps	ms	
queen	kw	kvʷ	✓
clouds	kl	kj G	
	dz	z	
Christmas	kr	kj	
	sm	m	
	s	ɬ	
bridge	br	bj	
	dʒ	dz	
flower	fl	✓	
chimney	tʃ	✓	
	mn	mm	
smoke	sm	m	
	k	✓	

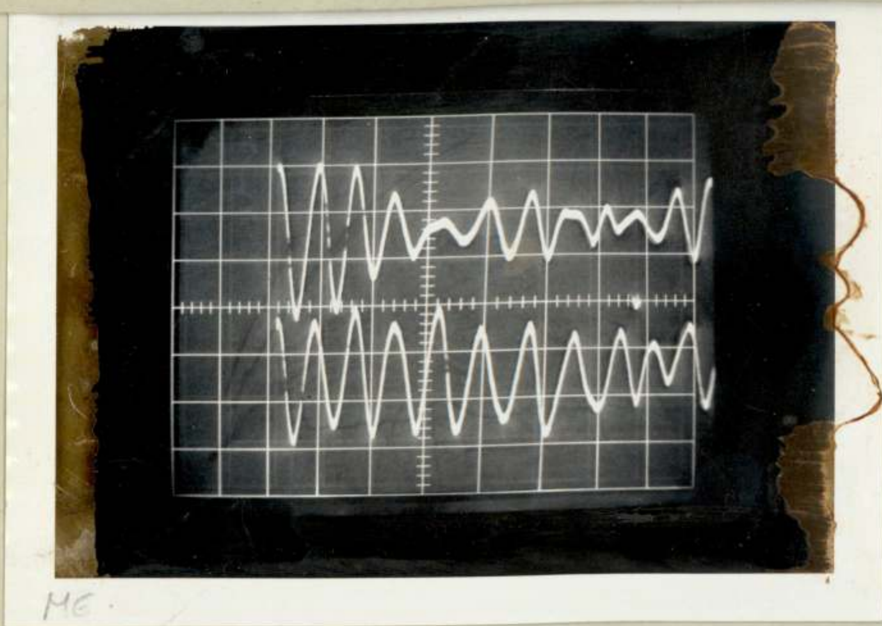
sleeping	sl	ɬ	
	p	✓	
wings	ŋz	nd	
garage	g	✓	
	r	–	
	dʒ	–	
aeroplane	pl	p	
spoon	sp	ɬ	
	n	✓	
toothbrush	θbr	–	
	ʃ	ɬ	
red	r	j	
	d	(gj) ɟ	
bottle	tl	kl	
birthday	rθd	–	
horse(ie)	h	✓	
feather	ð	d	
elephant	l	j	
	f	✓	
	n	✓	
	t	✓	
soldier	s	ɬ	
	ldʒ	–	
	r	– ✓	
glove	gl	gj	
	v	✓	

finger	f	✓	
	ŋg	✓	
thumb	θ	f	
watch	w	✓	
	tʃ	tɬ	
string	str	–	
	ŋ	n	
three	θr	✓	
teeth	θ	✓	
pencil	p	✓	
	ns	ɬ	
	l	u	
yellow	j	✓	
	l	✓	
sugar	ʃ	ɬ	
	g	✓	
Indian	n	✓	
	d	✓	
	j	✓	
	n	✓	
matches	tʃ	ɬ	
	z	–	
scissors	z	–	
desk	d	(gj) ɟ	
	sk	–	

lateral & palatal realization. Raw Score 30.

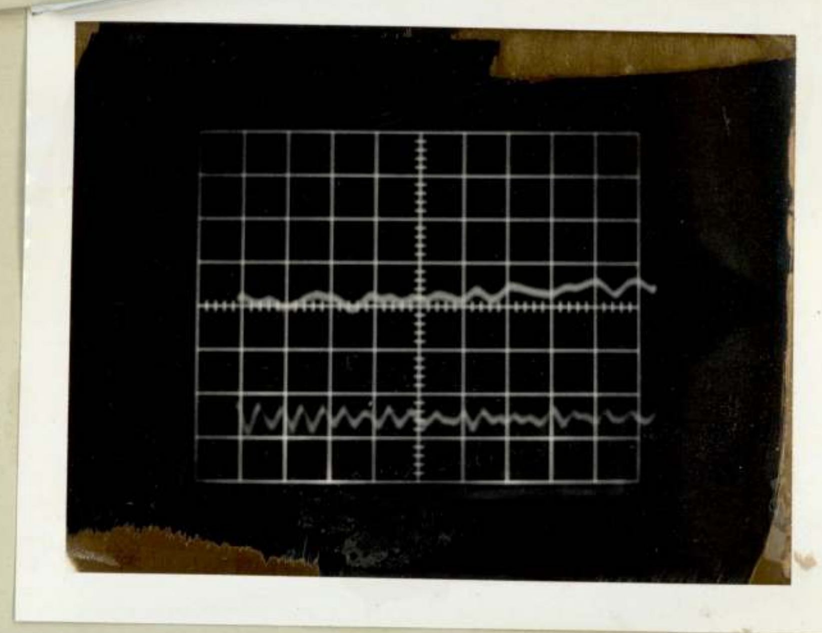
/t-/ /-t/. /s/ /s-/ /-sk/ SS 76.

/-d/ /-tʃ-/



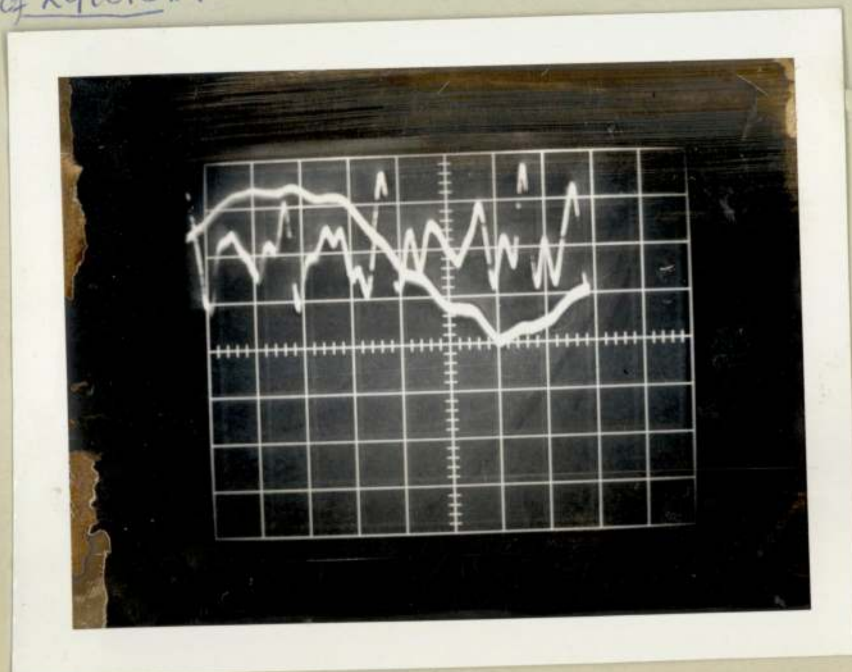
Oscilloscope.

Traces showing production of /S/ before & after application of Xylotox cream.



Upper. Trace. post Xylotox.

UPPER. TRACE. represents Production of /S/ following Administration of Xylotox.
Note. slight flattening of peaks. on right side.
(Experienced, speaker.



Flattened. trace represents post application of Xylotox.