CENTRAL AUDITORY PROCESSING AND ITS DYSFUNCTION IN CHILDREN

-A REVIEW OF LITERATURE

By.
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REGD NO. 2

An independent Project Work as part fulfilment for First Year M.Sc., (Speech and Hearinq) to the University of Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE—570 006.

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MAY - 1983

To

MY DEAR PARENTS WHO INSPIRE

C E R T I F I C A T E

This is to certify that the Independent Project entitled "Central Auditory Processing and its dysfunction in Children - A Review of Literature" is the bonafide work done in part fulfilment for First Year M.Sc., (Speech and Hearing) of the student with Register Number...

Director,
All India Institute of Speech & Hearing
Mysore - 570 006

C E R T I F I C A T E

This is to certify that the Independent Project Entitled

"Central Auditory Processing and its Dysfunction in Children - A Review of Literature"

has been prepared under my guidance and supervision.

(GUIDE)
JESUDAS DAYALAN SAMUEL,
Lecturer in Audiology
All India Institute of Speech
and Hearing, Mysore-6.

A C K N O W L E D G E M E N T

I am grateful to - -

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All the authors for taking excerpts from their works

Ms. Rajalakshmi R Gopal who helped me in finishing the job at a short notice.

All other off-stage helpers for lending their invaluable time in the completion of my work.

D E C L A R A T I O N

This Independent Project Entitled " Central Auditory Processing and its dysfunction in Children A Review of Literature" is the result of my own work undertaken under the guidance of Mr. Jesudas Dayalan Samuel, Lecturer in Audiology, All India Institute of Speech and Hearing; Mysore-6, and has not been submitted earlier at any University or Institution for any other Diploma or Degree.

Mysore REGISTER NUMBER.

Dated

C O N T E N T S

CHAPTER-I

INTRODUCTION

As each star differs in brightness, so do the children of men. Yet each serves its purpose in "one nation under God", and each is entitled to an opportunity to achieve his full potential to adjust to his environment - to grow physically, emotionally socially, intellectually and spiritually.

The pediatrician is the ultimate when it comes to the "whole child". Yet his expertise cannot be encyclopedic, and hearing in children form one such area. Audiologists or Hearing Scientists have taken up this area and named it as "Pediatric Audiology". Pediatric audiology is in its infancy and hence new knowledge in this area is needed.

The study of hearing mechanism and its dysfunction, is being extensively done, particularly in the field of pediatric audiology. External ear has been highly understood, middle and inner ears are about to be conquered, but auditory processing in the cortical areas and its dysfunction had not been studied till recent past. Hence we need to put all efforts to gather all the information that is available about the central auditory processing in children, and open the area for extensive research, to help the children suffering from such dysfunction.

The term central auditory function is used interchangeably with other terminology like central auditory ability, central auditory perception and central auditory processing. A deficiency in this area might be termed as central auditory dysfunction, as an auditory perceptual disorder, as a nonsensory auditory deficit, as an auditory language - learning disorder, or as an auditory processing problem. In fact, the lack of agreement in clinical practice and in the literature about what to call this phenomenon is a good indicator of the general lack of agreement and understanding about central auditory problems. (Keith, 1981).

Reading the literature on the topic is a most frustrating experience because of the many overlapping subcategories. Some components are included in a particular section by one writer only to be excluded by another. Hence, this attempt.

Central Auditory Processing

Hearing is a two - stage process: One stage is that of reception, the other is that of interpretation of the transmitted signal once it reaches the brain. Auditory processing is the name given to this second stage in the hearing process where the brain processes or interprets the auditory impulses it receives.

Eisenson (1972) defines it as "the process by which an individual organises and interprets sensory data he has received, on the basis of his past auditory experience".

Auditory processing may be described as the short-term processing and categorization of information received aurally; the process by which information is extracted and related to prior experience, the meaningful interpretation or discrimination of sounds and sound sequence (Butter, 1980).

The processes that take place beyond the level of the Vlllth cranial nerve, which are required for incoming sound to take on meaning, are commonly referred to as "Central auditory abilities" and the end product as "auditory perception". (Williamson and Alexander, 1975).

To conclude, the central auditory processing is the capacity to organize simultaneous or successive auditory elements into a definite pattern.

Aim of the present study

The present study attempts to put together the information available in the literature on the central auditory processing and its dysfunction in children, with the view of

(1) Improving the knowledge about what actually takes place at the cortical level in children.

(2) Emphasizing the need for the normative data and the standardized tests, in the Indian setup where multitudes of languages exist.

CHAPTER - II

BASIC CONCEPTS IN CENTRAL AUDITORY PROCESSING.

The primary fibers of the auditory pathway arise in the spiral ganglion. The spiral ganglion is located in the modiolus at the foundation of the cochlea. Distal fibers of the spiral ganglion are stimulated by the organ of corti, and the proximal fibers extend to form the cochlear nerve. The fibers of the cochlear nerve bifurcate and then terminate at the dorsal and ventral tonotopically arranged cochlear nuclei after entering the brain-stem at the junction of the medulla and pons.

The central auditory pathway begins at the synapsebetween the first - and - second - order neurons of the afferent pathway in the cochlear nuclei (Jerger, 1973)

The majority of the fibers from the cochlea decussate and may terminate in the trapezoid body, the superior olivary complex, or the reticular formation. Because of the ipsilateral and contralateral routing of the fibers from the cochlear nuclei to the superior olivary complex and the trapezoid body, a binaural phenomenon is initiated at this level of the brain-stem.

(Carhart, 1969)

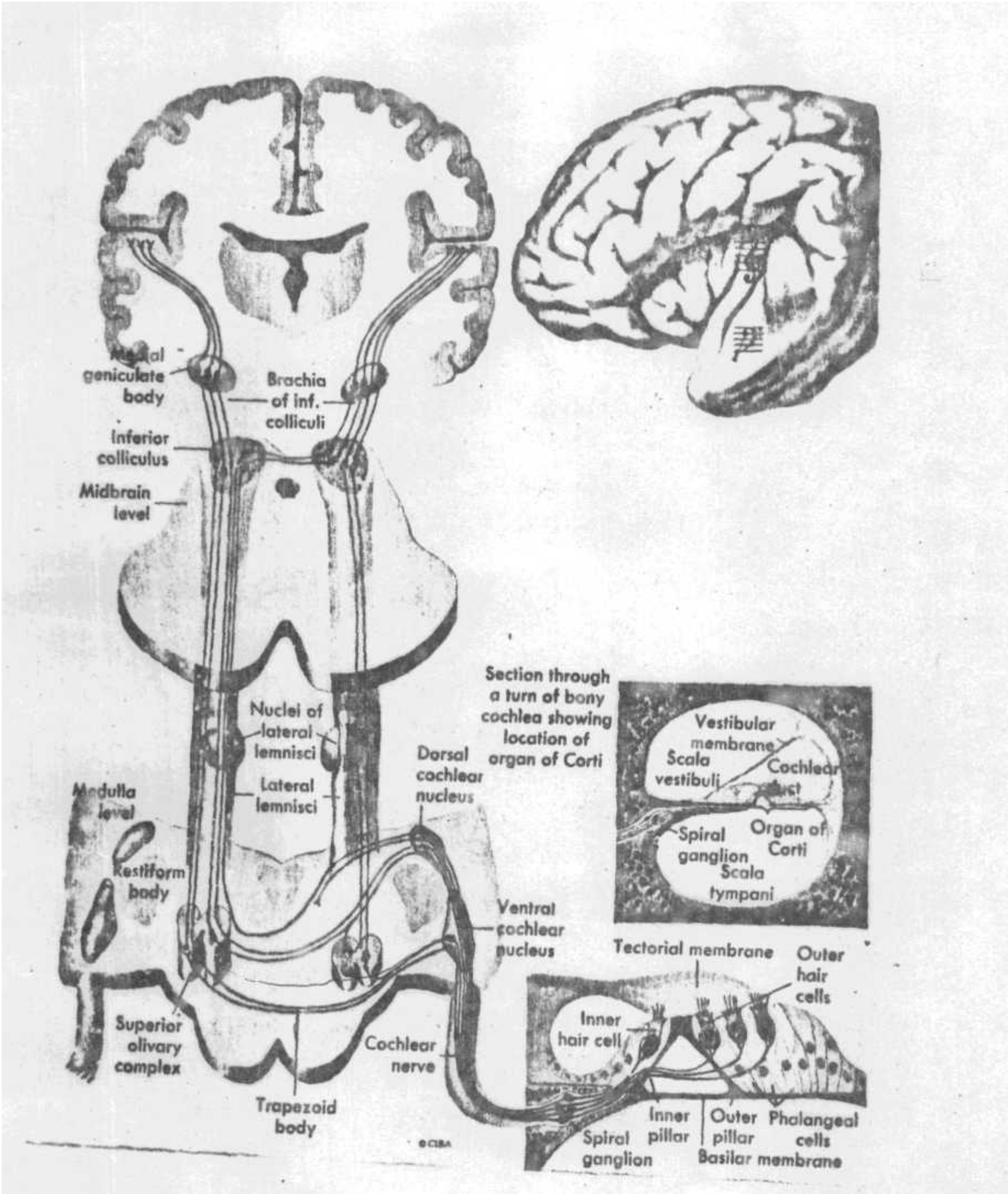

Fig. 1:- Central Auditory Pathway.

From the trapezoid and superior olivary complex, the vast majority of ipsilateral and contralateral fibers extend to the appropriate lateral lemniscus, inferior colliculus and medial geniculate body. At these levels, it is theorized that more recording of binaural and monaural stimuli occurs. (Carhart, 1969).

The reticular formation, also known as the reticular activating system (RAS), is a neural network in the central portion of the brain-stem. The ascending RAS, which dispatches projections upward to the surface of the cerebral cortex, receives sensory input from every sensory modality and is influential in neural integration. This network has been described as a general alarm mechanism which, when activated by incoming sensory stimuli, arouses the cortex so that incoming information can be interpreted.

Magoun (1963) refers to the RAS as discriminative infering that this system aids the cortex in selecting signals which are of focal importance while inhibiting others

Reticular Activating system and hearing disabled.

The ability of RAS in aiding the cortex in selecting signals has led to the postulation that learning disabled children may have reticular systems which fail in the discrimination task and allow too many sensory signals to stimulate the child. This could preclude cognition of signals which carry pertinent information. We can hypothesize that a faulty RAS. could also hinder the alerting process which is of paramount importance to the transmission of auditory information. An unalerted cortex is not prepared to perform efficiently. The inhibitory, facilitative and integrative functions may be disturbed in a variety of ways to account for the different types of behaviours observed in learning disabled children.

The medial geniculate body is the final subcortical level in the higher auditory system prior to fiber connections in the cortex. The third and fourth order neurons make synapse in the medial geniculate bodies and are considered the rostral termination of the brain-stem. (Carhart, 1969).

The human auditory system is finally represented by projections to both left and right temporal lobes from each ear. There is a general agreement that the crossed- pathways (contralateral) are the dominant pathways and the same - side (ipsilateral) pathways serve a secondary role. Thus each ear has a greater influence on its contralateral temporal lobe than it does on the direct ipsilateral temporal lobe. Basic to this discussion is the widely accepted fact that the left temporal lobe in most humans is dominant for linguistic processes while the right temporal lobe is dominant for non-linguistic functions. Although both ears have representation in each hemisphere, the dominance characteristic significantly influences central auditory functions. These concepts are basic to understanding central auditory processes.

The Auditory Cortex

The auditory cortex is located in the temporal lobes of the brain. There appears to be a primary area and a secondary area. The exact boundaries of these two areas have not been defined because as one moves away from the small area, which is unequivocally concerned with the processing of auditody information, the exclusiveness becomes less and less apparent. There is no clear boundary for those cells dealing with auditory data, but a progressive involvement in responsiveness to different types of data processing. Whitefield (1965) has summarized this characteristic of the auditory cortex:

The "auditory cortex" is hard to define, either anatomically or functionally. While certain areas are so predominantly connected with the rest of the auditory system as to be unequivocally auditory areas, surrounding regions become less and less certainly so, as we move farther and farther from the primary projection area.

In addition to the primary and secondary areas, other regions of the brain have been demonstrated to be responsive to stimulation of the auditory nerve. It appears, therefore, that a number of areas, not exclusively auditory, receive and process auditory information. Lenneberg (1967) has stated that with the exception of part of the occipital lobe, which is known to be the primary visual area, "There is no other ares in the human cortex which is both histologically distinct and unequivocally and uniquely related to one and only one motor or sensory function".

The Role of the Auditory Cortex

It appears to be involved with the recognition of complex patterns in auditory stimuli. It seems improbable that it is in any way concerned with recognizing the absolute measures of frequency and intensity (Goldstein, 1961) but rather with determining the relationship of these two parameters over time. The capacity to analyze the temporal components is referred to as the temporal resolving power of the auditory system. It is likely that the recognition of complex sounds is dependent upon cortical processing, while lower order neurons are involved in analyzing the frequency intensity components of the complex wave. Thus the cortex identifies the sequential pattering essential to speech perception, apparently stores electrical impulse patterns on a "hold" basis and performs other complex pattern - synthesis tasks.

The Bottleneck Principle

In VIII nerve and the lower brain-stem region, the "bottleneck principle" is an important diagnostic concept to be considered. This principle states that the transmission of complex stimuli such as speech comes across a labyrinth or "bottleneck" in VIII nerve and lower brain-stem area. If a lesion occurs in this tract, marked reduction in the comprehension of speech messages will be observed (Jerger, 1960).

The subtlety Principle

From the cochlear nuclei, the complexity of the central auditory system increases and the speech message can be transmitted to the auditory cortex by various routes. Because of these diverse paths and the redundant aspects of speech, lesions of the central auditory pathways tend not to manifest themselves on conventional audiometric tests. This has been referred to as the subttety principle (Jerger, 1960).

Redundancy and Central Auditory Disorders

Bocca and Calearo (1963) stated that if there is a lesion in the central auditory system, the speech signal with its generic external redundant characteristics will be transmitted and interpreted in the auditory cortex. Therefore, a central auditory disorder can be best detected if the redundant factors of speech are minimized sufficiently to challenge the integrity of the higher auditory centres.

Extra-Axial Vs Intra Axial Lesions

Jerger and Jerger (1975) have reported that patients with extra-axial lesions show abnormal audiologic results.for the ear ipsilateral to the lesion. In contrast, lesions involving the intra-axial brain stem region yield fairly normal results.

CHAPTER - III

THE CENTRAL AUDITORY PROCESSING MECHANISM

The theories that describe the normal perceptual processing are the feature detector models of speech perception. For example, Abbs and Sussman (1971) proposed a neurophysiological theory - that there are spatial arrays of receptor cells in the auditory system that act as feature detectors for speech sounds. These cell arrays are triggered by specific acoustic cues in the speech signal, such as frequency and intensity changes, rates of frequency change and so on. Abbs and Sussman suggest that these auditory feature detectors may be tuned to respond to formant transitions (a major identifying cue for consonants) in the same way that array of retinal receptors detect the feature of "Contoumess". To support their theory. Abbs and Sussman, cite evidence from animal research, which has found single neurons in the Cat's inferior colliculus that are directionally sensitive to frequency or amplitude modulated tones.

Other feature - detector models are based on psychoacoustical research with humans. The results of several studies suggest that the shift in perception following adaptation to certain phoneme categories could have been caused by "fatigue of feature detectors responsiveness".

This evidence, along with the neurophysiological data, suggest that we are equipped with finely tunned feature detectors that mediate cur perception of speech sounds. Though the exact nature of these feature detectors is still unknown, their presence could suggest a new approach to the study of perceptual impairments in language disordered children.

Semel (1970) has divided auditory perceptual processing into three basic stages.

Stage I - Responding to stimuli -

This stage involves (i) awareness or alertness
(ii) focus
(iii) figure - ground
(iv) discrimination

State-2 - Organizing the stimuli

This stage involves (i) sequencing
(ii) synthesizing
(iii) scanning

State-3 - Understanding the meaning

This stage involves (i) classification
(ii) integration
(iii) monitoring

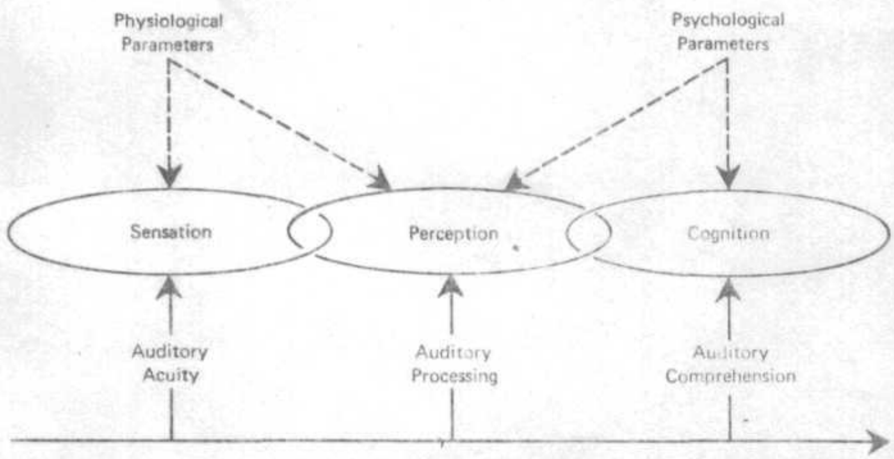

Figure 2 Auditory processing as a link in the chain of sensation-perception-cognition.

(Butler, 1980)

Flowers and Costello (1970) refers to another factor, resistance to internal and external distortion, as a central auditory ability. By resistance to internal distortion, they mean the ability of an organism to process information in spite of the fact that the message may be distorted due to a pathological condition or development deterrant.

By "resistance to external distortion" Flowers and Costello (1970) mean the ability of an organism to process information distorted by such things as a speaker's accelerated speech rate, foreign accent, or speech defect.

Witkin (1972) makes the point that perception should be distinguished from sensation and cognition. She concludes that auditory perception involves focus, attention, tracking, sorting, scanning, comparing, retrieving and sequencing.

According to Witkin, perception (auditory processing) is the intermediate link in the chain which begins with sensation and concludes with cognition. (Fig. 2)

Auditory processing is a very complex act involving a number of stages of perceptual analyses. Inherent in the processing of auditory stimuli is auditory attention, because

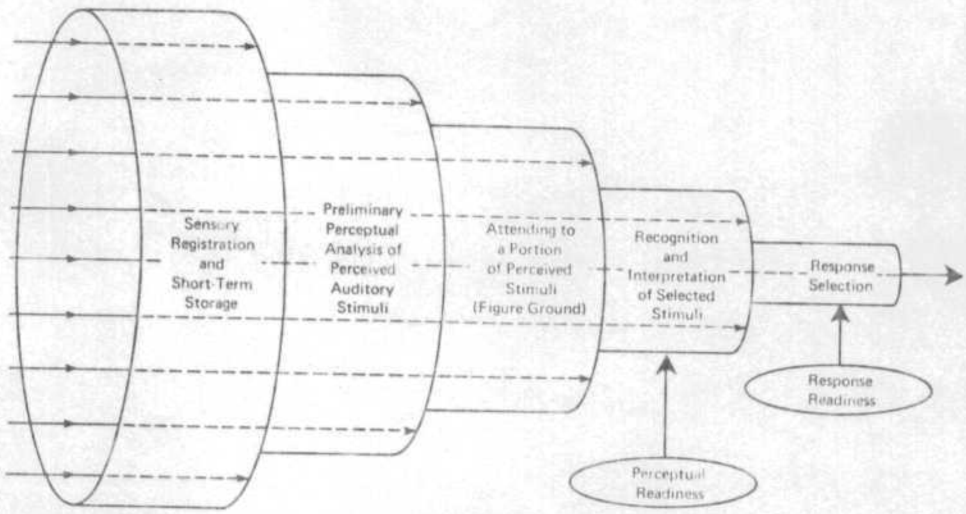

Figure 3 A model of auditory processing.

(Butler, 1980)

individuals are thought to control the choice of stimuli, which in turn, control their behaviour.(Fig.3)

The first stage involves the registration of a number of auditory stimuli (represented by arrows) at the sensory level and these stimuli are held in some type of short-term storage, as the auditory input is extended over time.

The next stage involves the process of selective filtering during which some incoming stimuli are accepted, whereas all other stimuli are either rejected or strongly attenuated, so as to prevent an overloading of the subsequent perceptual mechani

In the third stage, some portion of the auditory stimuli will take on "fore-ground" characteristics, and the other portions of the stimuli will recede into the auditory background.

Fourth stage involves the recognition and interpretation of selected stimuli. This ability is related to

(1) past experience,

(2) the likelihood that such a stimulus would occur,

(3) the significance, or meaning of the stimulus to the individual.

All of these factors contribute to a state of perceptual readiness, which according to Kahneman (1973) affects the selection of interpretations in "subjective perceptual experience".

The last stage of auditory processing, is that of response selection. In order for the correct response to occur, all the earlier stages must be completed satisfactorily.

For those with normal sensory and perceptual abilities, the response selected will be appropriate, given adequate cognitive functioning. For those who lack either the normal sensory and/or perceptual skills, the response may be inadequate or

inappropriate, even though cognitive skills are within normal range.

Sabatino (1969), in endeavouring to define and sequentialize the levels of auditory perception that appear to be critical to the learning process, proposed these four major dimensions;

(1) the recognition of sound elements as meaningful information - auditory recognition

(2) the retention of these units of information - Auditory retention.

(3) the integration of the symbolic relationships of these units as language concepts? - Integration and

(4) the comprehension of language symbols through the three previous stages or steps of auditory perceptual function- Auditory Comprehension.

Auditory Abilities Important to the Learning Process

Descriptive Term	Ability
Discrimination	To differentiate among sounds of different frequency, duration or intensity.
Localisation	To localise the source of sound.
Auditory attention	To pay attention to auditory signals especially speech, for an extended time.
Auditory Figure-Ground	To identify a primary speaker from background of noise.
Auditory Discrimiation	To discriminate among words and sounds that are acoustically similar.
Auditory closure .	To understand the whole word or message when part is missing.
Auditory blending	To synthesize isolated phonemes into words.
Auditory Analysis	To identify phonemes or morphemes embeded in words
Auditory Association	To identify a sound with its source.
Auditory memory; Sequential memory	To store and recall auditory stimuli of different length or number in exact order.

(Roeser and Downs - Auditory Disorders in School Children. The low identification Remediation) New York: Thieme - Stratton, INC, 1981.

CHAPTER - IV

DEVELOPMENT OF THE ABILITY TO PROCESS COMPETING STIMULI IN CHILDREN

The results of the dichotic listening experiments, using speech stimuli, have indicated that even the youngest age group tested shows a right ear advantage (REA).

(Nagafuchi, 1970)

The most general interpretation for REA in verbal dichotic experiments is that it reflects left hemisphere specialization for speech and language function. This interpretation has motivated a number of researchers to utilize dichotic listening procedures to investigate the developmental course of left hemisphere specialization for speech and language.

Although a few studies report a developmental increase in REA, the results of most developmental studies have revealed that the magnitude of the REA does not change in any linear fashion with increasing age.

The evidence thus far is in favour of the argument that lateralization for speech is established by age 3 and is not altered as a function of age.

Another measure that can be obtained from developmental studies of dichotic listening is an index of the child's ability to successfully process the competing stimuli. The first study that focused on this issue was conducted with children between the age of 5 and 12 years. (Berlin et al, 1973). The results showed that the ability to correctly perceive both competing stimuli (double correct) increased with age, whereas the REA did not show a developmental change.

The results of studies with children younger than 5 years suggest that they are likely to have low double correct scores.

The degree to which both of the dichotically competing stimuli are perceived correctly depends on the amount of transmission through the corpus collosum.

One gradient of maturation is based on the course of myelination in different structures in the brain. Myelination of the corpus - collasum begins at about the fourth month after birth and the process is not complete until about the age of 10.

With myelination viewed as an index of functional maturation, the lack of complete myelination may indicate that transmission of information between the two hemispheres is not maximally efficient before age of 10 years.

Yeni, Komshian & Brown (1982)

These findings thus suggest that there is a REA even in the youngest group, whose magnitude is not altered with age, and the ability to perceive dichotic stimuli, depend on the factor of myelination of the corpus collasum, which increases with age.

CHAPTER - V

TYPES OF AUDITORY PROCESSING PROBLEMS IN CHILDREN

Inspite of the confusing picture presented by the children having central auditory processing problem, some degree of classification is provided for the purpose of communication and clarity.

Musiek and Geurkink (1980) have described the common processing dysfunctions as follows:-

(1) Selective Listening Problem

The children with this problem demonstrate the inability to understand and focus on one auditory signal in the presence of many other auditory signals. Such children cannot understand the teacher if the classroom is noisy.

(2) Binaural Separation Problem

The children with central auditory processing problem show their inability to attend and integrate acoustic information presented to one ear and suppress the information simultaneously presented to the other ear. This function overlaps with selective listening skills but requires more use of lateralization cues and can be tested more specifically.

(3) Binaural Integration Problem

In a dichotic condition, children with perceptual problems will often favour one ear and understand that message but do poorly with the message to the other ear.

(4) Temporal - sequencing Problem

This is the most common type of processing problem seen in children, showing the inability to recognise the appropriate order of acoustic stimuli as they exist in time.

(5) Interhemispheric Interaction Problem

Because the left and right hemispheres perform different functions in auditory processing, communication between the hemispheres is necessary for optimal perception. The children with processing problem have difficulty with information exchange interhemispherically and they show a left ear deficit on dichotic tests and a bilateral deficit on pattern perception tests.

Speaks, et al (1975) draw three lines of evidence to suggest that auditory pathways from the weak ear and speech information presented to the weak ear are not completely suppressed during dichotic stimulation.

I. The presence of speech in the weak ear detectable during dichotic stimulation show that some speech information from the weak ear, perhaps critical for perception and perhaps not, do reach the cortical processing areas.

2. The lower dichotic scores for the strong ear than monotic scores for the strong ear show that the processing of speech from the strong ear during dichotic stimulation ear partially disrupted by information transmitted from the weak ear.

3. Occurance 6f blend errors more than nonblend errors demonstrate that the auditory pathway from the weak ear are not suppressed.

These findings leads to the speculation, that information transmitted along the auditory pathways from the weak ear is not only sufficient to cause occasional disruption of processing of the strong ear signal but that some information bearing signals from the weak ear are extracted during processing and are combined with other features from the signal in the strong ear to form the patient's response.

Transmission - Line Model

This model is based principally on the observation that there are greater auditory projections to each temporal lobe from the contralateral ear than from the ipsilateral ear. Thus, the contra-lateral pathway is dominant or in a sense, functionally prepotent.

Because of the lesion to the primary auditory areas of the right or left temporal lobe, signals from the two ears travel different in different transmission lines (ipsilateral for the weak ear? contralateral for the strong ear) and the difference in quality of the two lines is largely responsible for the imbalance in scores.

Ipsilateral - Suppression Model

This model was given by Milner, Taylor and Sperry in the year 1968. If ipsilateral pathways are suppressed, and if in-formation from either ear can only be transmitted by way of the contralateral pathways, than we must assume that the score for ear is low because the signal was partially or completely degraded in a direct sense by the affected area of the brain.

The essential contrast between the two models is that with ipsilateral suppression, the score for one ear is presumed to be low because the signal, forced to trovel the contralateral route, is degraded by the damaged area. With the transmission line model, the score is low because the signal is transmitted along the ipsilateral pathways in competition with information from the opposite ear that traveled the stronger contraleteral route.

There is a plausible alternative, since the two models are in no sense mutually exclusive; that is, the reduced score for one ear isthe joint product of direct degradation by the lesion (ipsilateral suppression model) and imbalance between auditory pathways (transmission line model). Until lesion effect: and transmission line effects can be unpacked, construction of models is at best tenuous and certainly premature.

CHAPTER - VI -

BEHAVIOUR OF CHILDREN WITH AUDITORY PROCESSING PROBLEMS

A teacher noted that children with auditory processing problem seems to be "in a jog" and they say "Huh"? all the time. In describing children with auditory processing problems Cohen (1980) listed the following observations:

1. Most are male (75%)
2. They have normal pure-tone hearing thresholds
3. They generally respond inconsistently to auditory stimuli
4. They have short attention span and fatigue easily when confronted with long or complex activities.
5. They are easily distracted by both auditory and visual stimulation.
6. Most are hyperactive.
7. They may have difficulty with auditory localization skills.
8. They often request that information be repeated.
9. They are often unable to remember information presented verbally, for both short-term and long-term memory.
10. They are often allergic to various things in the environment,
11+ They often have a significant history of chronic otitis media
12. They take a lot of time to answer questions.
13. They have difficulty in relating what they have heard to the words they see on paper.

14. They may have difficulty with gross or fine motor coordinations.
15. They may have speech, articulation or language problems.
16. They may also act frustrations that result from their perceptual deficits in the classroom or they may be shy and withdrawn because of the poor self-concept that result from multiple failures.

It should be noted that not every child with an auditory processing problem will exhibit all of the behaviour mentioned. The number of problems experienced by a given child will be anexpression of the severity of the auditory learning disability.

Physiology of Directional Hearing As a basis of Central Auditory Testing

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From a physiological point of view it is known that both cochlea are represented in each auditory cortical area and that binaural interaction may occur at all levels of the auditory system from superior olivary complex to auditory projection areas.

Hall (1965) using electrophysiological techniques, discovered that the bilaterally located nuclei of the superior olivary complex, which according to Rasmussen (1946) contains

cells with connections to or from the cochlear nuclei of each side, respond differntially to small differences in interaural time and intensity.

Neff (1961, 62, 64) asserted that the physical differences which are necessary for localization of sound in space remain in the form of "differences between new impulses and that for highly accurate auditory localization the nerve impulses from the two ears must interact at a low level".

The anatomical studies of Rosenzweig (1961) have shown that the first opportunity for nerve impulses from the two ears to interest, occurs in the superior olivary nuclei and maintained from there upto the cortex.

There is no doubt that the final accuracy of sound localisation depends on the proper functioning of the auditory areas of the cerebral cortex.

It is on this principle that tests of.auditory localisation and binaural audiometry suggested for ascertaining lesions of central pathways are based today.

CHAPTER - VII

AUDIOLOGICAL TESTS FOR THE ASSESSMENT OF AUDITORY PERCEPTUAL DYSFUNCTION IN CHILDREN

Audiologists have begun using central tests in the evaluation of auditory processing problems, with some success. Though it remains difficult to defect these types of auditory deficit, the use of central testing has permitted progress to be made.

The tests which are commonly used to assess the central auditory processing in children are briefly described as follows:

(1) Rapidly Alternating Speech Perception Test (RASP Test)

This test is a measure of brain stem disorders. Its design was based on a principle described by Bocca and Calearo (1963) and it was specifically developed by Lynn (1973).

This test requires the listener to repeat verbally simple sentences which alternate every 300 m.sec. between the right and left ears. The sentences are approximately 7 words in length. A total of 20 sentences are usually presented, 10 with the left ear leading and 10 with the right ear leadings (Fig.4)

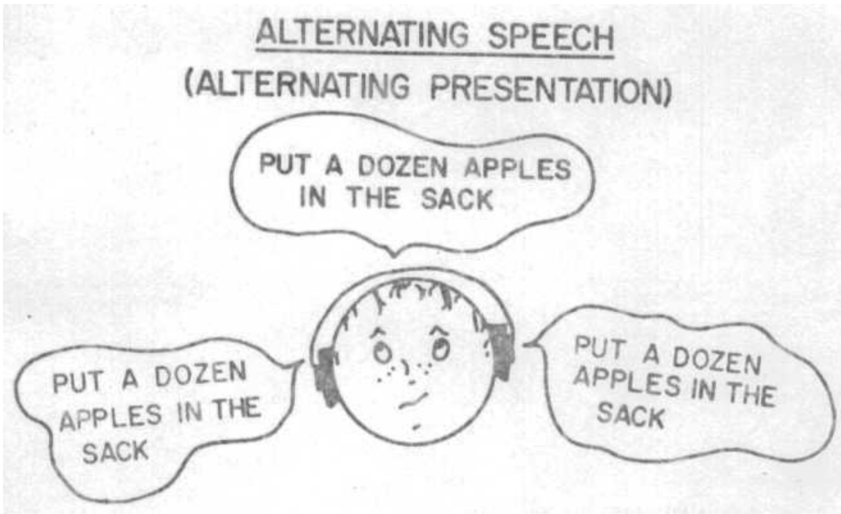

FIG. 4. Illustration of Alternating Speech

(Willeford, 1977)

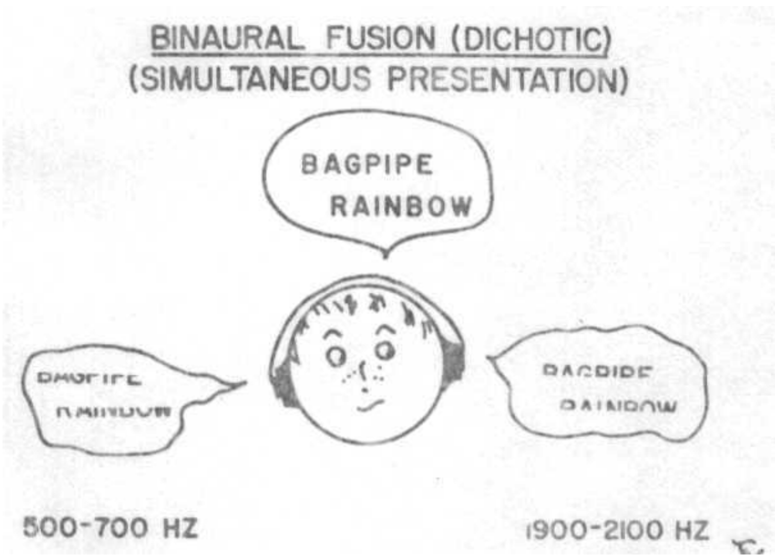

FIG. 5. Illustration of Binaural Fusion.

(willeford, 1977)

(2) Binaural Fusion Test

This test is also used to assess the brain-stem functioning* It was constructed by Ivey (1969). The test uses spondees filtered through a low band pass (500-700 Hz) and a high band pass (1900-2100 Hz). The low band-pass segment is presented to one ear. While the other ear is simultaneously presented with a high band-pass segment of that same word. (Fig.5)

The characteristics of the stimuli selected for their homogenesty from a large pool of words are such that either band segment, when played alone is quiet unintelligible; however, when the information is binaurally presented, the brain-stem is capable of fusing the information from each ear and the spondee is reported correctly.

Normal score is 75% or better/ when the two bands are played simulaneously. The children with brain-stem lesions do not re-synthesize the two dichotic segments into a meaningful word.

(3) Filtered Speech Test

This test is a measure of cortical functioning. It was developed by Bocca, Calearo and Cassinarl (1954), with the basis that distorting the speech by routing the speech signal through

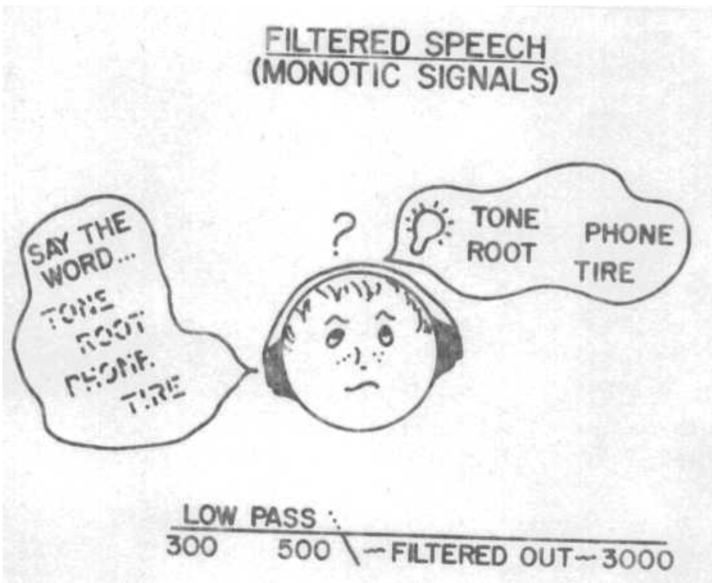

FIG. 6. Illustration of Filtered Speech.

(Willeford, 1977)

a low pass filter, would place greater demands on the integrative function of the auditory cortex, and would thus be more likely to demonstrate cortical dysfunction.

This test involves the use of CNC monosyllabic words which are passed through a filter which rejects acoustic energy above 500 Hz at 18 dB par octave. These words are presented monaurally and the child simply repeats the word. (Fig.6)

The normal subjects score 70% or better on this test;

whereas the patient with unilateral temporal lobe lesions score poorly in the contralateral ear.

(4) Duchotic Sentence Test

This test measures the cortical functioning. This test requires a sentence to be presented to each ear simultaneously. The "Primary" sentence is presented at 35dBSL while the "Competing" sentence is presented at a 50dBSL with reference to the spondee threshold. The subject is asked to respond to the primary message and ignore the competing message. (Fig.7)

Ex:

RE

Primary Sentence (35dBSL re PTA) — This watch keeps good time.

LE

Competing sentence (50 dBSL re PTA) — I was late to work today

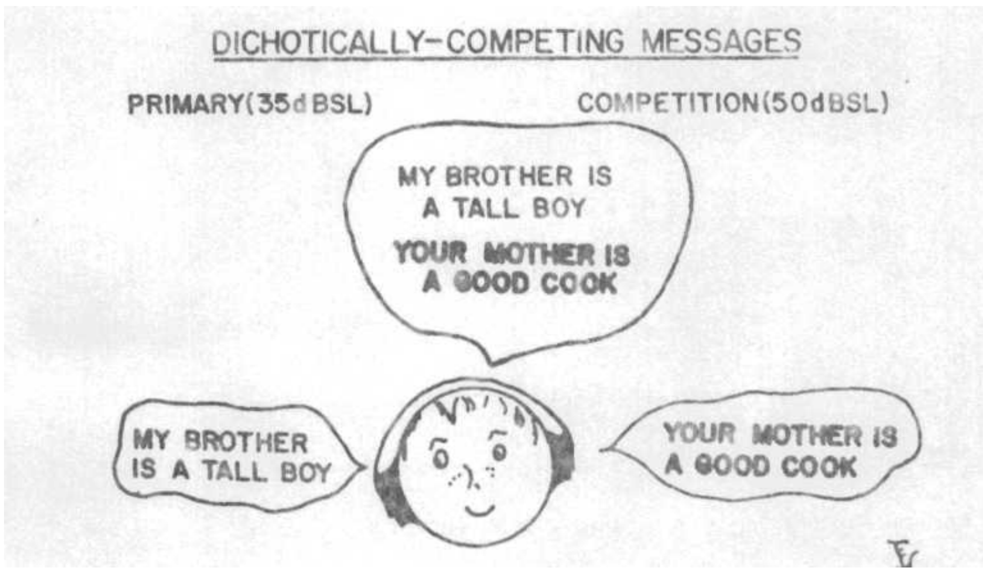

FIG.7. Illustration of Dichotic Sentences.

(Willeford, 1977)

Normal subject score well in either or both ears, whereas patients with cortical insult perform poorly in one ear.

(5) The staggered spondaic Word Test

The SSW test was developed by Katz (1962, 1968). Each test item is composed of two spondees with a staggered onset. The last half of the first spondee and the first part of the second spondeee are presented dichotically, while the remaining spondee segments are presented in isolation to opposite ears.

Right ear	Race	Hoarse
Left ear		Street Car

There were some limitations to the use of the SSW with children under 11 years of age. In comparison to the norms; there was more variability in performance for children younger than 11 years. In an attempt to reduce this variability, 20 most familiar items were selected from the standard 40 item test (List E C) to form a children's list (List C - E C). With the shortened version, errors and variability decreased from 7 to 11 uears of age with 11 years olds performing like normal adults.

(6) Spapedial Reflex Test (Ipsilateral and Contralateral)

It has been recently found that the reflex are for the stapedius muscle include the medial superior olive and the nucleus of the trapezoid body.

In a subject with a normal middle ear and normal brain-stem, whether the reflex is elicited by a contralateral tone or by an ipsilateral tone, we see virtually the same responses. In contrast, when a subject has a lesion of the central structures near the IV ventricle no reflex can be elicited by contralateral tones,but virtually normal reflexes are seen by ipsilateral recording of the reflex from the same ear in which stimulation is taking place.

It is recommended to use both ipsilateral and contra-lateral reflex recording in appropriate subjects (Jerger, 1960).

(7) Dichotic Digits Test

In this test, two digits are presented to each ear simultaneously (dichotically); The twenty, two - digit sets are presented and the child simply repeats all the digits that are heard.

Ex:- Left ear - 8, 6

Right ear - 4, 3 .

Brain—stem Auditory Evoked Response Audiometry

The BSER is the electrical response of the eight nerve and brain stem auditory nuclei to click stimuli. The BSER appear during the first 10 m.sec. following stimulus onset and consists of as many as seven waves when the stimuli are applied at slow repitition rates. At faster repitition rates, the wqsre V is the most prominent and stable event. Its latency varies systemmatically as a function of stimulus intensity and at a given intensity this latency decreases systematically with increasing maturity during the first year and a half of life.

BSERA has provided highly useful clinical information in the case of infants, who yeild confusing and inconsistent audiological results.

<u>Masking Level Differences in the Identification of Children with Perceptual Problems</u>

Sweetow, R.W. and Reddell, R.C., (1978) investigated to determine whether masking level differences (MLD's) could differentiate between normal children and children with suspected auditory processing problems. Results indicated that:

(1) there was no differences between MLD's for "normal" children and normal adults;

(2) there was no difference between speech MLD's for the two groups of children; however,

(3) tonal MLD's for the children with suspected auditory perceptual problems were significatly lower than those for the normal groups.

Thus the tonal MLD can be a strong addition to a central test battery, especially because it can be used with non-verbal children who cannot complete many tests because of limited linguistic skills, however, more research is needed on larger populations to confirm the effectiveness of the tonal MLD test.

Time compressed Speech Test

Time compressed speech discrimination measures have been used increasingly during recent years as one means of investigating auditory perceptual functions of the CMS. Only recently, however, have data became available concerning the performance of normal. Children on time compressed speech discrimination measures.

(Beasley, Maki and Orchi, 1976)

Beasley et al (1976) time compressed the word intelligibility by picture identification (WIPI) (Lerman, Ross and McLauchlin, 1965) and the PB-K 50 (Haskins 1949) speech discrimination measures and presented them at 24 and 32 dBSL to

60 children divided into three age groups of twenty, Comparison of the results with normative data indicated that performance of the two groups of children wan similar at the 30% time compression condition but the children with auditory perceptual disorders performed poorer at 0% and 60% time compression.

The results of research and the clinical employment of time-compressed speech have been encouraging and have provided the impetus for further pursuit of such stimuli with pathological populations.

Another approach, used primarily by speech language pathologists and reading and learning disability teachers, involves assessing auditory abilities assumed by them to be prereguisities to language acquisition or reading skill.

Auditory Attention:

This ability is best assessed by observing the child in comparison with peers. The child should have the ability to d irect attention toward a relevant acoustic stimulus speech or music and to sustain that attention for an appropriate length of time.

Auditory Figure-Ground

This class of tests is usually administered using a tape recording of speech in the presence of competing background speech or noise. The speech must be at a favourable signal to noise (S/N) ratio.

The tests presently available are:

(1) the Goldman - Fristoe - Woodcock (GFW) Auditory Discrimination Noise subtest - which uses a picture - pointing task to words recorded at +9dB S/N ratio.

(2) the Flowers - Costello Test of Central Auditory Abilities (CAA) competing Messages subtest, in which a single speaker gives the test items while the same voice is telling a children's story. The child points to a line drawing representing the appropriate completion of a sentence, such as "On Halloween, we carved a___________________________

(3) the composite Auditory Perceptual Test (CAPT) - given by Witkin (1973), assesses figure ground discrimination against competing sounds of music and speech.

Auditory Discrimination:

This class of tests is usually intended to measure speech sound discrimination abilities.

Wepman Auditory Discrimination Test described by Wepman, (1973), uses minimal word pairs, e.g. gear/beer, rub/rug, sick/thick.

The short test of sound discrimination uses syllable pairs.

The Discrimination by Identification of Pictures (DIP) test includes two picture showing bear/pear, fan/man, pup/cup etc. The word Intelligibility by Picture Identification(WIPI) test described by Ross and Lerman (1970), uses plates of six pictures and the Goldman - Fristoe - Woodcock (GFW) Auditory Discrimination Quiet subtest, uses four picture plates. As these picture tests rely on visual integrity, it is difficult to attribute any breakdown to auditory discrimination in the narrow sense.

Auditory Closure

This class of tests is intended to measure the child's ability to understand the whole word or message when part is missing or missed. One example is the auditory closure sub-test of the Illinois Test of Psycholinguistic Abilities (ITPA). In this test the child fills in missing parts of a word. For example, the examiner will say "airpla______", and the correct response is airplane.

A different approach to testing auditory closure is to eliminate certain frequency components of sound by electronic low pass filterings The Flowers - Costello CAA test include a low pass filtered speech*

Auditory Blending

This ability can be assessed using the Sound Blending subtest of the ITPA, the Roswell - Chall Auditory Blending text and the GFW sound blending test. The test is administered by presenting isolated sounds that make up a word. The child must combine these sounds to tell what the word.

Auditory Analysis:

This is the ability to identify phonemes, syllables or morphemes embedded in words (analysis) and it can be assessed by the syllabification subtests of the Stanford Diagnostic Reading Test and the syllabification of the Gates - McKillop Reading Diagnostic Test. The Auditory Analysis Test requires the subject to form a new word when a phoneme or syllable is removed from a larger word. For example, gate without g is ate, trial without t rail.

Auditory Memory:

Memory span can be assessed using the Wepmon and Morency Auditory Memory Span Test, in which single syllable nouns are presented in progressively increasing series from two to six words. Thiree trials at each level are given.

The Memory for content subtest of GFW Auditory Memory Test, uses a picture - pointing task, in which the child is asked to indicate the two pictures that were not named. The WISC Digit Span subtest uses numbers as stimuli.

Sequential Memory:

The ITPA Auditory Sequential Memory subtest and the Auditory Sequential Memory Test utilize digits and the child must recall the exact order of stimuli given;

CHAPTER - VIII

LIMITATIONS OF THE TESTS OF CENTRAL AUDITORY PROCESSING

Williamson and Alexander (1975) stress the following deficiences:

1. Tests that are now in use are in need of standardization and normative data with which to make comparisons when interpreting results.

2. For purposes of reliability and validity the examinee is subjected to a battery of tests which are fatiguing and time consuming (Katz, 1962).

3. Standardizing is made more difficult because of the complicated equipment usually requiring filtering devices, which are not readily available and whose characteristic vary from model to model.

4. A limited population for study is available.

5. The intellectual capacity, memory span and degree of motivation causes difficulty in establishing norms.

5. Finally, further investigation is warranted as to the effect a peripheral hearing loss may have on the results of tests for central auditory impairment (Willeford, 1969).

CHAPTER - IX

MANAGEMENT OF CHILDREN WITH CENTRAL AUDITORY PROCESSING DISORDER

Management of central auditory disorders is an area of uncertainty for persons in the fields of clinical audiology, auditory physiology, speech perception and auditory bioengineer-

Therapy objectives such as environmental localization, sequencing, rhythm, awareness, discrimination (gross and five) and memory tasks have been stressed in remediating auditory based learning disabilities.

Counselling the child, family, and educational personnel concerning auditory perceptual problems and controls for coping with the auditory world.

The research suggests that the language disordered children may be characterized by an impaired rate of processing for rapidly changing acoustic information. Since the speech signal as it is normally produced, consists of rapid changes in frequency and intensity, an obvious treatment implication is that the signal should be slowed down to facilitate its perception by the language disordered child.

A procedure most often used in research is the electro-mechanical method of producing time expanded speech. Slowing down the rate of speech input in this way has improved the sentence comprehension of young language disordered children (McCrosky and Thompson, 1973) and of children with auditory processing problems (Perk, 1977).

Beside speed, the perceptual defect appears to involve the discrimination of small, rapid changes in the acoustic spectrum. Hence these children must be trained to discriminate between speech sounds by increasing the contrast between them. This could be done, even for pairs of a similar phonemes by using synthesized versions of the sounds that maximally diffe-rent.

Teachers should always command the child's attention, if necessary, by either implementing verbal or physical cues such as calling his name prior to the instruction or lightly touching his shoulder.

Instructions should be presented in clear, well-articulated and simply constructed sentences. Periodic feedback will ensure whether the child is listening to the speech message.

With children having visual motor difficulties, the amount of written responses is reduced, an ideal device for this would be a tape-recorder.

Various seating arrangements in the class room should be tried in order to locate an area of maximum auditory reception. Sound attenuating earmuffs and earplugs can be useful in eliminating background noise, when the child is working individually at his desk or during any task where auditory competition is present. F.M. auditory training units have been used successfully with children who had central auditory deficiencies. These units provide favourable signal to noise ratios for enhanced reception of classroom instructions. The child should be given praise and reinforcement for even minimal improvement. Encouragement and support are key factors in developing patterns of success.

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