STANDARDIZATION OF SPONDEE WORDS IN HINDI TO BE USED IN THE STAGGERED SPONDIAC WORDS TEST

Register No : M 8920

A Dissertation submitted as part fulfilment for

Final year MSc., (Speech and Hearing]

to the University of Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006
MAY - 1991

DEDICATION

I Dedicate this Dissertation to -

My Papa' B.N.SAHAY and Mummy' USHA SAHAV
for being the most sensitive, caring,
loving and wonderful parents

My Sisters and Brothers
"ANITA", "SUJS", "SUBRAT" & "KISS"

My "Darling" AKANKSHA.....The
most lovable girl I've ever met.

My beautiful friends DEEPA, VANEETA
for their cruical and
profound help during this study

My would be____________

CERTIFICATE

This is to certify that the dissertation entitled **"STANDARDIZATION OF SPONDEE WORDS IN HINDI TO BE USEDIN THE STAGGERED SPONDIAC WORDS TEST"** *is the bonafide work in part fulfilment for the degree of Master of Science (Speech & Hearing), of the student with Register No. M 8920.*

MYSORE

1991

Director

All India Institute of Speech & Hearing
Mysore - 570 006

CERTIFICATE

This is to certify that the dissertation entitled

"STANDARDIZATION OF SPONDEE WORDS IN HINDI TO BE USED IN THE STAGGERED SPONDIAC WORDS TEST"

has been prepared under my supervision and guidance.

MYSORE
May 1991

DR.G.PURUSHOTHAMA
Guide

DECLARATION

I hereby declare that this Dissertation entitled: **STANDARDIZATION OF SPONDEE WORDS IN HINDI TO BE USED IN THE STAGGERED SPONDIAC WORDS TEST** *is the result of my own study, undertaken under the guidance of* **Dr.GPURUSHOTHAMA,** *Prof. & HOD Speech Pathology AH India institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.*

MYSORE
MAY 1991

Reg. No. M. 8920.

ACKNOWLEDGEMENT

I am highly indebted to **Dr.G.PURUSHOTHAMA,** *Professor, Department of Speech Pathology, All India Institute of speech and Hearing, Mysore, for his constant concern, encouragement invaluable guidance and support rendered to me at every difficult aspects and facets of this dissertation study.*

I am also thankful to him for willingly accepting to guide me for my dissertation.

*I thank Dr.**(Miss)*** **S.NIKAM,** *Director, AIISH, Mysore for having given me permission and oppurtunity to undertaken this dissertation.*

I thank **Dr.N.P.NATARAJA,** *Prof, and Head, Dept. of Speech Sciences, AIISH, Mysore, for the much needed encouragement and support given to me during this study*

I am thankful **toDr.M.N.NAGARAJA,** *Deputy Director (Tech) AYJNIHH and* **Dr.K.C.RAVISHANKAR,** *Head Dept. of Audiology AYJNIHH, Bombay for their constant concern and valuable guidance at difficult stages of my life and during this study.*

From the nook-n-corner of my heart I thank my sisters **ROSHNI (Pickles), AISHWARTA (Guloo) and RASHMI (Chimmi akka)** *for sharing my difficulties and making me more cautious and caiculative on every aspects. Thanks for being so sensitive and caring.*

My special thanks goes to my friends **NAM IT** A *and* **SUCH ITR** A *who worked so hard for completion of the study My salutes to them, without their help I don't think I would've been able to complete my dissertation.*

I am so thankful from the bottom of my heart to my sisters, **VIJATA, PRIYA, REKHA, MONIKA, ZAVER, RUKMINI, SHIPRA, JYOTI, MOUSHUMI, SUNITHA and MYTHRA** *"The ring leader" for their crucial help that they had extended their help for successful completion of the dissertation. I thank them for showering L ove and Affection on me. They were the real boosters. -*

I request my friends **KIRAN, SARATHA, SINDHU, SUMA, MALA, REEHA K., SHARMILA, GITU (Bhabhi), ARADHANA, SHYAM, CHAMPS, BHUNA, UMA, RITU, JOTINDER, PREMNATH, DUSHYANT, FARZANA, PRAGNA, SUMMATHI, SOWMTA** *and of courseN* ***ANDim*** *(Nandu) to oblige me by acknowledging my sincere, thanks for the help rendered to me at each and every difficult stages my study, i thank them giving me the moral encouragement and for their constructive criticisms which helped me to come out of my depressed moods and complete this dissertation.*

My *infinite thanks* **toNANDINI & MAITRIEE (RCE), KHIROD, SHARMA, SANJAY, BISWAS (Bombol Da), BHATTA DA, RAJU (Bewada), Mr. & Mrs.PEKKI, THAMAR (EC), SURI (MAMA)** *and* **MOHAN** *for their share* ***of*** *help*

There are many others who extended their he/ping hand especially my juniors to me in one way or the other during my stay at AUSH, i extend my heartfelt thanks to them.

Above all I wish to thank my family members for supporting me financially moralfy and emotionally. I thank god for giving me such a beautiful and close knitted family.

Last, but not the least i thank Ravishankar for changing the if legible looking material to a beautiful script in a short span of time.

"My Hat's off to you all"
Thanks for every thing!!!
I love you all

REG. NO. 8920

C O N T E N T S

INTRODUCTION

People with central auditory disorders present unique problems for their parents, their teachers, their peers etc, and for the many professionals who are called upon to evaluate and prescribe management for (a given person s) communicative problem in addition to resulting academic and social difficulties.

The problem faced or complained by such population may be one or the other of the following:

1. Tinnitus (subjective - often localized in the midline or in the head)
2. Auditory hallucinations and/or unusual auditory sensations.
3. Extreme difficult hearing in highly reverberant rooms or in a noisy background.
4. Trouble following complex auditory directions or commands.
5. Extreme auditory inattentiveness and high distractibility.
6. Trouble in localizing sound sources.
7. Marked decrease in the appreciation of music.

These type of population exhibit above problems inspite of the fact that they are found to have peripheral audirtory systems that operate absolutely normally in response to basic and traditional measure of auditory functions. For example people with central auditory disorders demonstrate excellent sensitivity on pure tone test except for a mild-to-moderate impairment at 8000Hz in an undetermined but substantial number of them (Pienhiro, 1976b, Willeford 1980a). They also typically have normal speech reception thresholds and they score within normal limits on standardized audiological tests of speech discrimination ability. Yet they have difficulty in understanding or utilizing auditory information on their academic and vocal environments and present case-histories describing behaviours that indeed support the suspicions of teachers, parents and peers that they do not use auditory information efficiently.

Speech in particular is altered by factors such as fundamental frequency, intensity, speed, articulation, voice inflection emotional emphasis, distance from the source and countless juxtaposition of words and their phonemic and subphonemic elements in continuous discourse. Finally, auditory signals for the purpose of human communication are often received in the presence of dynamically changing competetion from a host of other auditory signals pervading our daily living environments. Thus it seems truly miraculus that human are endowed with auditory capabilities that permit them to sort out desired signals from complex auditory environments and process them through an elaborate series of delicately balanced central auditory nervous system mechanisms. These mechanisms transmit, enhance or inhibit reshape, refine and/or modify them in numerous ways and ultimately assign recognition and meaning to them. The end results allows us to respond with meaningful behaviours, most especially to communicate though and ideas to learn and develop intellectually and emotionally.

Most people can and do perform this phenomenal test of communication with relative ease in an often complex and bewildering world in which sensory systems are bombarded with myriad signals. This fact inspires application for the intricately designed sensory and neural signals which human beings enjoy. However all or the foregoing factors conspire at times to deceive and confuse even the normal listener. Consider them how different (indeed how difficult) life must be for the individual with imperfections in that processing machinery. Through a variety of physical, mental, emotional or maturational limitation regardless of cause many people are unable to value efficient use of sensory information they receive from their environments.

Speech audiometry is a basic tool of audiological evaluation. Pure tone audiometry alone does not provide any information about the persons ability to hear above the threshold and hence should be supplemented by speech audiometry. Speech signals are used to measure threshold. Supra-threshold intelligibility process in lip reading, auditory training, success in otologic using and to aid diagnosis of peripheral and central disorders.

Auditory detection of central lesion is not a new area of inquiry. A great deal of interest was focussed on the problem of central auditory disorders as a result of the work by Bocca and Associates in 1954 and 1955. Since that time investigators have attempted to diagnose problems in the brain stem and cortex with auditory stimuli. Many techniques and refinements now appear in the literature.

Before attempting to evaluate the performance of an individual on a particular test it is essential to have normative data regarding the procedure in question. Since the earliest investigation the word perfect, reliable and valid indication of central auditory disorder has undergone considerable transition. The earlier preliminary studies employed speech materials which were somewhat difficult for normal listeners to identify. However there was enormous disturbance in performance for patients having central auditory disorders. Hence these tests were referred as "difficult" speech tests. By either using poor recording methods or eliminating a portion of the frequency spectrum or by introducing distortion, a large number of difficult speech techniques were employed by various investigators.

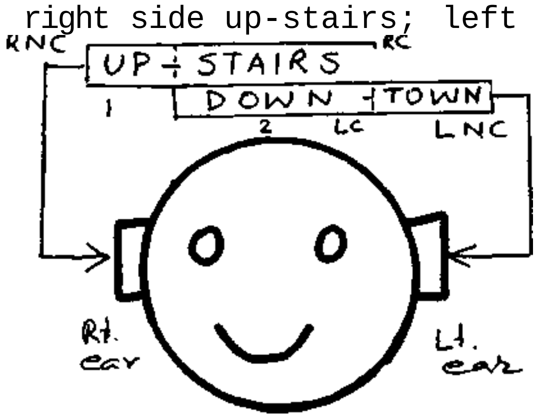
However there early tests while being highly effective in identifying central auditory disorders produced a dilemma for the clinician in diagnosing the specific area of damage, probably this was due to the wide variability in test performance.

An explanation was absent on the role of interaction of variables like peripheral distortion, intelligence, memory span, and other variables on the test performance. Consequently the problem appeared to be one of difficulty in handling the large number of false positives rather than demonstrating deviations. This need for techniques which would reduce the number of false positive findings later led to construction of testing procedures which employed more "stable" speech stimuli. Stability in this case refers to a high redundancy and familiarity content of speech stimuli. The staggered spondiac words (SSW) is a technique which makes use of such stable speech material.

The SSW test of assessing central auditory lesion in now being used in various parts of the world. Unlike other tests this test is an auditory procedures which is based on dichotic presentation of spondiac words in a staggered manner.

1.1 STAGGERED SPONDEE WORD TEST

The test consists of 40 items each item has two spondee words which are recorded in a partially overlapping manner. For example: On right side up-stairs; left side down-town.



These are presented through tape recorders when the tape is played the word "up" is presented to right ear. Now no signal in the left ear. When the word "stairs" is presented in general to the right ear simultaneously the word "down" is presented to left ear and then to left ear - the word "town" signal to right ear.

Here: RNC = right ear non-competing condition is "up"

R.C.= right ear competing condition is " "stairs"

L.C.= Left ear competing condition is "down"

LNC = Non-competing condition is "Town"

There are eighty (80) spondee words. Spondee words are presented 50dB above SRT and the subject is asked to repeat. Substitutions, omissions and additions are considered as errors.

The typical data sheet is like:

	A	B	C	D		E	F	G	H
	RNC	RC	LC	LNC		LNC	LC	RC	RCN
	up	stair	down	town		week	end	work	day
1					2				
3					4				
5					6				
7					8				
39					40				

At the end the total number of errors are noted down for each condition. The total number of errors in every condition are listed down.

Scoring:

Multiply each error by 2.5 to get the % score

RNC = el X 2.5

% of errors in RC = e2 x 2.5

% of errors in LC = e3 x 2.5

% of errors in LNC = e4 x 2.5

$$\text{Right ear score} = \frac{\text{el} \times 2.5 + \text{e2} \times 2.5}{2}$$

$$\text{Left ear score} = \frac{\text{e3} \times 2.5 + \text{e4} \times 2.5}{2}$$

Corrected SSW score: If the subject has peripheral hearing loss the performance will be affected.

So, corrected % of RNC = el x 2.5 DL right

DL = Discrimination loss

DL = 100 - discrimination loss

% of RC = e3 x 2.5 DL right

% of LC = e3 x 2.5 - DL left

% of LNC = e4 x 2.5 - DL right left

$$\text{right ear score (corrected)} = \frac{\text{el} \times 2.5 - \text{DL Rt} + \text{e2} \times 2.5 - \text{DL Rt}}{2}$$

$$\text{left ear score (corrected)} = \frac{\text{e3} \times 2.5 - \text{DL Lt} + \text{e4} \times 2.5 - \text{DL Lt}}{2}$$

$$\text{Total Score (corrected)} = \frac{\text{Rt} + \text{Lt}}{2}$$

Data

	Normal	Mild	Moderate	Severe
Total SSW score	-4-5	6-15	16-35	36-100
Ear score condition	-6-10	11-20	21-40	41-100
Score	-9-15	16-25	26-45	46-100

The obtained score is to be compared with the normative data. In right temporal lobe lesion, left ear shows moderate severe loss. In left temporal lobe lesion right ear shows moderate/severe loss.

Response bias: ear effect

The subject may commit mistake in the right ear first item 1,3 etc or right ear first item 2, 4 etc. If he makes more number of odd numbers item than even numbers item then ear effect is said to be present.

If sum of errors in ABCD or even numbered - columns - sum of errors in EFGH or odd numbered columns is greater then 5 them ear effect is said to be present. We should reject the column which shows more error and consider the column which shows less errors.

Then only 20 items will be there. So multiply each error by 5 to get percentage score i.e.,

el x 5, e2 x 5 etc

Order effect

In presentation order of words ABCD an EFGH (see typical data sheet).

The ABEF - represents responses to 1st spondee words and CDGH - represents responses to 2nd spondee word. If ABEF - CDGH is greater than 5 than order effect is presented. Subject commit more errors in 1st or 2nd spondee or vice versa. So the column which shows less errors is considered and multiplied by 5 to get % of peripheral hearing loss cases. The corrected score will be el x 5 - DL Lt; e2 x 5 -DL Lt etc. If the half of the test items are considered then its called as adjusted and corrected SSW scores.

The SSW test is not reliable one to be used with children below 10 years and over 60 years of age. It is because for childrens auditory system is not fully matured and in old people it is deteriorating though its matured. This being a dichotic test if there is deep lesions it will be interfering the interhemispheric auditory pathways. As we know the 2 hemispheres are connected by corpus callosum. If there is deep lesion, it affects corpus callosum so the transmission is affected. In right handed people, - speech is processed in left hemisphere. If we present speech to right ear it reaches to left and right hemispheres by corpus callosum. In deep lesions this is not possible. So ear ipsilateral to dominant hemisphere shows poor performance.

Reversal responses:

Reversal is when the subject repeats 2nd spondee word instead of 1st for eg: Stairs-up or "Town-Down" for up-stair and down-town.

Here also the ear contra lateral to the lesion shows poor performance.

Speech test in Indian language are already available [Hindi, Tamil, Telegu, Malayalam, Kannada... Kapur.Y.P. (1971); Shivshankar (1988)]. But those tests are not widely used because of nonavailability of norms etc. For those languages in which tests are not available standardized English and Indian English test are made use of to test the English knowing people. But this goes against the fact that the largest of the spoken languages in India is Hindi and we don't have any structured and reliable test in this languages. Hence, it is very difficult to test those who know only the native language Hindi. There is a great need to make the Staggered Spondiac Words (SSW) test available in Hindi for clinical purposes.

In this study it was attempted to standardize the spondee words in Hindi which is necessary for the construction of the Staggered Spondiac Words (SSW) test.

1.2 PURPOSE OF THE STUDY

The study was conducted for the following purposes:

1) To prepare a word list in Hindi for SSW test.
2) To standardize the material for clinical administration through establishing familiarity.
3) To provide guidelines for recording the material for SSW.
4) To provide two lists of spondiac words in Hindi.

There is no structured and standardized test in Hindi and therefore will be a useful addition to the battery of test available. It can be used with Hindi speakers who do not know English. It may be used also with the population whose second language is Hindi.

1.3 FAMILIARITY OF WORDS

I a SSW test the vocabulary should not be so difficult that it forms an improbable responses for most subjects on the other hand the test material should be familiar to the subjects. However it should not be so simple that is could be correctly guessed a high proportion of the time without being heard.

Redundancy of the speech material should neither be so great as to make it impossible to err on the items nor should it be so non-redundant that a simple hearing loss or mild auditory distortion could disrupt the patients performance.

It is important that the material should not be very long, so that a patient is penalized for inabilities unrelated to his central auditory lesion like memory span. However the material must be long enough to incorporate at least one language until because higher auditory functions is more easily challenged by abstract concepts such as language symbols.

The test should be short enough to avoid physical or psychological fatigue but long enough to ensure reliable performance.

REVIEW OF LITERATURE

Speech audiometry is indispensable part of battery of clinical audiometry. It evaluates the receptive communication function and not just the ability to distinguish sounds of certain frequency or intensity. A wide variety of speech materials have been used for speech audiometry to measure speech reception threshold and speech discrimination. The clinical use of speech in testing for possible hearing loss undoubtedly preceded the use of discrete tones by many years; but the quantification of speech audiometric tests has been fairly recent (Berger 1971).

Even though primitive auditory tests used speech as a stimulus they were not accurately done. It was the early part of nineteenth century when accurate hearing test were sought after an Acumeter - type of test instrument came into use, that speech tests were given more attention to develop systematically.

The investigators during the period (1804-1870) tried to classify hearing impairment on the basis of the following:

1) The distance at which the subject heard the speech better.
2) The ability to understand whispered speech and conversational speech.
3) The ability to perceive consonants and vowels (Feldmann 1970).

The Otologists were the first to make extensive use of speech materials in testing the hearing capacity of an individual (the voice and whisper test). But the intensities in these tests were not adequately controlled. The audiologist were the first to quantify the speech material and to make it a routine part of hearing testing.

It was Wolf (1871, Quoted by O'Neill and Oyer, 1966) who designed the first speech tests systematically. He had published a monograph describing the instrumentation and discussed his experience with speech tests. He made use of the consonants, syllables and words as test materials. He indicated intensity of the material in paces or distances from speaking source. In 1890 he was able to present words recorded on Edison wax cylinder to the patients ear through adjustable tubing. This permitted the control of intensity of recorded material.

Lucae (1904) had recommended to develop a test using nonsense syllables but this was rejected for its psychological short comings. He also recommended to record the particular word that has been correctly understood at a specified distance.

In 1910 the telephone industries became interested in the nature of stimuli transmitted over its systems. This led to the beginning of quantification of speech materials as test items. These materials were used not as materials for the measurement of threshold of speech but as a measure of intelligibility of the speaker using particular communication systems. The Bell telephone laboratories analysed the characteristics of speech sounds (vowels and consonants). During this period Campbell and Crandall (1920) developed the articulation list which consisted of a series of unintelligible words made up of consonant vowel consonant (VC) combinations. Each list consisted of fifty consonant - vowel, consonant (CVC) and five vowel consonant (VC) combinations. This was employed in testing the efficiency of telephone circuits. The words were either spoken through a microphone or recorded on disc and then were presented through a particular circuit. The result scores were based on the percentage syllable groups that were recognized by the listeners. The score was called "Syllable Articulation Score". In this context it is important to note that the term articulation is used audiologically for the function speech discrimination; but it has other cannotations for individuals whose orientation is in the field of speech (Newby, 1970).

In 1924 the first speech audiometer was introduced. Though it was of historical importance the credit for the development of systematic speech audiometry should go to Fletchers work. These speech audiometers were primarily used in identification audiometry Maico audiometer type R.S.

were also used in this period and they used number and picture words as test materials (Feldmann 1970).

Jones and Knudsen (1924) were the pioneers who included speech transmission system in their audio-amplifier which were used for audiometric purposes.

The use of nonsense syllable in the study of intelligibility is an analytical approach in which the interest is focussed on the intelligibility or repeatability of certain phonemic elements. The advantage in using nonsense syllables lies in the fact that they are devoid of meaning and hence the intelligibility is in no way dependent upon the vocabulary of the listeners (Hirsh 1952).

It is difficult to use nonsense syllables as the subject has an unconcious tendency to look for a meaning in the sound presented to him, and to look for a meaning in the sound presented to him, and to reproduce it as a known term (Lafon.J.C. 1966). So words which have meaning were preferred and monosyllabic words have been used in some of the later test that were developed.

"A test discrimination for speech" as opposed to the threshold must consist of relatively nonredundant items. Otherwise the multiplicity of clues available to the patient will obscure his inabilities to differentiate consonants and vowels accurately (Carhart, 1965).

For this reason monosyllabic words are preferred to conversational sentences. Monosyllabic words are sufficiently unpredictable and as such individual speech elements are perceived with relative independence. They are not so confusing as nonsense syllables which are so confusing as to baffle many subjects (Carhart, R 1945).

McFarlan (1940) was first to construct monosyllabic word lists. It was a test for children and consisted of monosyllabic words selected from the Thorndike and Gates word lists.

Egan, et. al., (1948) developed a series of tests to assist in the assessment of speech intelligibility. They were know as PAL-PB 50 words lists. From an original sample of twelve hundred mono-syllabic words, twenty list of fifty words each was constructed. The words were grouped on the basis of phonetical similarity of the first part of the word. They were selected to confirm the following criteria:

a) Monosyllabic in structure
b) Equal average difficulty
c) Composition representative of English speech and
d) Words in common usage.

These lists were judged to be of equal difficulty. The speaker was Rush Hughes and he spoke the test item and the number at a set intensity. The key or the test word following the item number was spoken at an intensity in relation to the carrier phrase at which it might normally occur. The actual test monosyllable did not at all occur at the same level although it has long been known the small variations in intensity may cause rather a large variation in discrimination for speech (Burger.W.K. 1971). Low signal to noise ratio also appears to be a critical factor in discrimination test variability.

In 1952 original (PAL) lists were modified by Hirsh, et. al., (1952) at the central institute for the deaf. The modifications were made because several difficulties have been reported mostly with respect to clinical use. The vocabulary that was assembled for 20 PB lists of 50 words each patients. Vocabulary appears to need reconstruction in dimension of familiarity (Hirsh 1952). This modified version is W-22 of CID. Familiar W-22 recording with Hirsh as speaker were produced. The CID modification included adding of more familiar words to those used in PAL-PB word list. The.modified version W-22 consisted of 120 words from PAL PB-50 and eighty new words. The two hundred words were divided into four basic lists (numbered 1-4) fifty words each and these in turn were scrambled into six orders in each.

The two types of PB lists (PAL and CID) differ with higher discrimination scores being obtained with W-22 tests. This is especially true if CID recordings of the early PB lists (Rush Hughes) recordings are used. Live voice presentation of the spondees will probably yield thresholds which are quite similar to those obtained with recorded spondees. However because of difference between speakers, inherent speaker variability and the non absolute aspects of intelligibility lists it is best to use the recorded version of PB lists" (O'Neill and Oyer, 1966).

The values obtained by the CID group were reinvestigated by Corso (1957) who used 139 trained listeners in his study. The various PB lists were presented at a level of 78dB SPL (re 0.0002 dynes/cm2). The obtained mean discrimination score was 97.68 percent. These results were in close agreement with original CID results (0 Neil and Oyer, 1966).

The PAL-50 lists the W-22 lists and to a large extent those test list developed since have paid some attention to familiarity of vocabulary is typically based on a whole or in part on the vocabulary studies.

Thorndike or Dewey (1923, Quoted in Beger, 1977) both of whom were concerned only with printed English word length and vocabulary in speech, however may differ considerably from that of printed English. It is also likely that word familiarity changes with time. Thus even if Thorndike and Dewey lists were representative of English speech which were not they would need revising to account for usage. Changes since their publications.

The phonetic balance like word familiarity was based on relative frequency of appearance of various sounds as they occur in English. It should be noted that the balancing of words phonetically within each word list has been concerned only with approximately the first 2/3rd of each word. The initial consonant or consonant blend and following vowel or initial vowel; have been computed in phonetic balancing. The usefulness of phonetic balance in discrimination testing has not been demonstrated regardless of its apparent logic. The balancing of vowels with in any test because of some difference in pronounciation will at best be approximate. It is necessary to investigate further the relevance of phonetic balancing and if the concept is found to be useful the balancing should be done according to speech data rather than according to printed material (Berger W.H. 1971).

Inspite of the popularity of W-22 tests there have been numerous efforts to further refine or to replace the W-22 records and lists. An important modification of these discrimination tests has been the use of half word lists. Several attempted to shorten these lists from 50 to 25 words. (Bowling 1959; Campaneli 1962; Elpern 1961 Resnick 1962; and Schultz 1968). The results showed high reliability and stability, when the scores on a whole list were compared with scores of 25 words selected from the same list. Grabb (1963) questions the statistical techniques employed in the construction of half word lists. No consideration was given to the level of difficulty, range of difficulty, phonetic balance and frequency of occurance of phonetic elements. The resulting lists correlated highly with full lists and with each other.

Tobias (1964) points that "phonetically balance" is not essential in a "useful diagnostic test". He feels that either half a list or full list they are serving in the same way and give the same results. To support his point, he quotes Grabb's (1963) own acceptance that PAL PB-50 word lists are better diagnostic tools even though they are not properly balanced than W-22 lists.

Martin (1956) is of opinion that the complete test may take not more than five minutes and so the extensive arguments over time - saving seem rather unnecessary. He convincingly concludes that till the controversy is resolved we may use the entire list for testing.

Fairbanks (1953) "Rhyme test" was the beginning of the testing with monosyllables in a closed test. Variation on the Rhyme test procedure have been proposed by Kruel et al (1960). A picture test is also made for children by Ross and Lerman (1970). This is known as word identification picture Index test (WIPI). A phonetically balanced Rhyme test was developed by Clarke (1965) including the phoneme differentiation in the medial position in addition of the initial and final. Schultz and Schubert (1969) realizing the inefficiency of W-22 developed the "multiple choice discrimination test".

Portman and Portman (1961) have reported that the recorded presentations avoid the flexibility in testing. To solve the extensive arguement over the recorded presentation versus the live presentations. Brandy (1966) made a study and he concluded "for the live mode of presentation there was a significant difference among lists one being significantly different from the other". For the recorded presentation the difference among lists failed to reach a significant level. This study shows that recorded presentations are more reliable than live presentation.

Use of a carrier phrase in speech audiometry according to Egan (1948) and Carhart (1952) is assumed to alert the listener for the test word and to allow the announcer to monitor his voice, but usually the exact content of the carrier phrase is not considered important when a carrier phrase is spoken prior to a list word the potential for phonemic interaction affecting intelligibility will be present (Gladstone and Siegenthaler 1971). Martin, et. al., (1962) discussed the non essentiality of the carrier phrase and said that it only confused listeners who had source discrimination problems. Nixon (1969) also has reported that carrier phrase does not affect the discrimination score. Kruel, et. al., (1969) found significant differences in scores as a function of carrier phrase. Gladstone and Siegenthaler (1971) studied the possible differences in intelligibility as related to different carrier phrases. They conclude that intelligibility with the phrase - "you will say" was the best perhaps because of the long vowel /ei/ at the end in contrast to other endings has a greater potential for being influenced by the phonemes of the word to follow and thus give additional cues to intelligibility. They add "the careful intelligibility testing will continue to incorporate consisted use of a familiar phrase".

The familiarity as a possible factor for influencing intelligibility has been a point of discussion from the days of Egan (1948). A word becomes familiar depending upon the frequency of use of word count.

Black (1952) reported that even among the common words more familiar words are more intelligible words. Black (1952) and Owens (1961) have also reported that "if a word is more familiar it is more intelligible".

While studying the effect of familiarity native language and their influence on perception. Sapon and Carrol (1957) concluded that there are differences between different language users in perception and discrimination of given sounds. The probability of perception of a given sound in a given environment is related to the language of the listener. Error in perception is also related to the language spoken by the listener.

Singh (1966) reported that confusion in perception depends upon the language spoken by the listener. This indicates the necessity of preparing the word list in the native language of the subject.

Lafon (1966) advanced the use of meaningful words as against the nonsense syllables as the subject looks for the meaning in the sound presented to him and to reproduce it as a known term. Miyamahi, et. al., (1973) have also stated that the linguistic experience of the subject affects the perception of sounds.

The data of Zahrezewski, et. al., (1975) suggest that nonsense words would test only 'recognizability" of the subject which is a subcortical phenomenon. The discrimination of speech which is a cortical function can be tested with monosyllables if they are meaningful words.

Realizing the importance of familiarity in speech discrimination, it would be necessary to prepare word lists in different languages in our country to test subjects in their own spoken langauges.

Kapur (1951) developed speech audiometric materials in Tamil, Telegu and Malayalam for measuring the discrimination ability. In Tamil though he succeeded in collecting the familiar monosyllables, the list failed to represent all the sounds which do occur in Tamil language and are used as distinctive features in the perceptive speech in today's Tamil (Soma Sundaram 1973). Since Kapur's list contains only fifty words it is difficult to avoid the practise effect in the subsequent presentations. The study was conducted only on three subjects and it will be rather difficult to generalize the performance.

The attempts of Swarnalatha (1972) and Nagaraja (1973) in standardizing PB word list in English and Indian population and developing a Synthetic Speech Identification test in Kannada respectively are worthy of mentioning but these tests are meant only for literates.

De (1973) developed a Hindi list to be used all over India. This test cannot be administered to non Hindi speaking population due unavailability and nonstability.

Mayadevi (1974) prepared a common word list using meaningless monosyllabic sounds to be administered all over the country. This list is also not recommended for the measurement of discrimination. Because the subject looks for the meaning in the sound presented to him and to reproduce it as a known term as shown by Lafon (1966). Secondly it tests only the ability to recognize instead of discrimination. Nagaraja (1986) prepared paired word list in Kannada is also worth mentioning.

2.1 PORE TONE TECHNIQUES

Sound localization tests

Sanchez-Longo and Forster (1957-1958) demonstrated impairment of the sound localization ability in the auditory field contralateral to the temporal lobe lesion in a group of brain-damaged subjects. These results suggest that the auditory cortex might have a role in forming the concept of auditory space.

Adaptation measures

Two tests of tonal adaptation are tone decay measures and fixed or sweep frequency measures Bekesy audiometery techniques evaluate the ability of the auditory system to maintain perception of a tonal signal over time. Tone decay of 30dB or more and Type IV (Rarely III) Bekesy traces may result from brainstem lesion or disease (Noffsinger et al, 1972).

Adaptation produced by brainstem lesions is usually moderate relatively languid and may appear bilaterally (Noffsinger, et. al., 1972), abnormal but not dramatic. Tonal adaptation can be a clue to brainstem dysfunction particularly when elicited from both ears.

Loudness tasks

The task such as the Alternate Binaural Loudness Balance (ABLB) test provide information on the way the auditory system translates intensity into loudness. Evidence is sought through a comparison of the signal strengths needed at each ear to produce a subjective sensation of equal loudness equally intense tone sounds (equally loud to normal listeners). Although there is little doubt that brainstem lesions occasionally interfere with by producing an abnormally slow growth of loudness (decruitment) in one ear this is sufficiently rare to make unprofitable the use of such procedures in an auditory battery aimed at detection of brainstem abnormality (Noffsinger, 1982).

Lateralization measures

Binaural lateralization almost certainly depends to an important degree on the functional integrity of the trapezoid body and the superior olivary bodies and their ability to transmit and analyze binaural information (Thompson 1983). Analysis of two-ear functions of the low brainstem which has capabilities ranging from streophonic perception to avoiding oncoming vehicles.

The most commonly used audiologic measure of binaural lateralization is a procedure which involves determination of the intensities needed at two ears for otherwise identical and simultaneous tones to create a subjective sensation of a tone image located in the cranial midline (Jerger and Harford 1960).

Noffsinger (1982) studied 140 patients with brainstem lesion. The tonal procedure correctly described brainstem abnormality in only 9% of these cases.

Temporal ordering tasks

Swisher and Hirsh (1972) used a paradigm where they presented two tones of different pitches and with various onset time differences. The two stimuli were presented either to the same ear or to opposite ears and the subjects were asked to indicate the order of the two tones.

Subjects consisted of young adults, older controls and three groups of brain damaged subjects including left brain damaged with fluent aphasia, nonfluent aphasia and right brain damaged with no aphasia. Fluent aphasics required the longest intervals to order stimuli particularly if the two stimuli were presented to the same ear. In subjects with right hemisphere damage the difference required to make temporal order judgements between two stimuli presented in the same ear were smaller and approximated those demonstrated by the control subjects in their investigation.

They did however show greater deficits when the tonal stimuli were presented to opposite ears.

Lackner and Teuber (1973) presented dichotic clicks to the two ears which varied in terms of their onsets. Their subjects included 24 veterans with left hemisphere damage and 19 with right hemisphere damage. They found that subjects with left hemisphere damage required a longer silent interval between the stimuli in order to perceive separation.

Efron, et. al., (1982-1985) conducted a series of experiments with nonspeech auditory signals and have demonstrated contralateral ear deficits in individuals with temporal lobe lesions for a variety of auditory task (eg. gap detection, sound lateralization and temporal ordering tasks).

Frequency (Pitch) pattern sequence test

This test was developed by Pinheiro and Ptacek (1977a). It is composed of 120 sequences with each sequence containing three tone bursts. In each sequence two of the tone bursts are of the same frequency, while the third tone burst is of different frequency. Thus a total of six different sequences are possible. The subject is asked to describe verbally each sequence heard. Patient with lesions of either hemisphere or of the inter hemispheric pathways have difficulty describing the monoaurally presented test sequences.

Masking level difference (MLD)

Identical low frequency tone is delivered to listener's ear and then just enough noise is added (which is also identical at two ears) to mask the tones. A mere reversal of the phase of the tone at one ear phone Vis-a-Vis the other will immediately make the tones audible again (Hirsh 1948). This release from masking due to interaural phase relationships is called a binaural Masking Level Difference (MLD).

The test protocol involves the presentation of either a pulsed tone, typically a 500Hz tone or spondee words to both ears, at the same time that a masking noise is being delivered binaurally. The patient is generally tested under two conditions. In the homophasic condition both the speech or pulsed tone and the masking noise are presented to both ears in phase. In the second antiphasic conditions one of the signals is presented out of phase while the other is held in phase (Pinheiro 1985).

Olsen, et. al., (1977) found that a greater release from masking could be demonstrated in both normal and impaired subjects if the $(S_o N_\pi)$ antiphasic condition was used. Lynn et al (1981) reported that patients with low brainstem involvement demonstrated little or no release from masking while no release with lesions higher in the Central Auditory Nervous System (CANS) tended to perform similar to normal control subjects.

Noffsinger, et. al., (1979) demonstrated a close correspondence between MLD and auditory brainstem response (ABR) test results. They found that patients with abnormalities in waves I, II, or III of ABR yielded small or absent MLDs, while patients with abnormalities of waves IV and V demonstrated normal MLDs.

Binaural beats measures

If tones of slightly different frequency (eg 500Hz and 493Hz) are delivered to an ear the subjective percept is a tone which is modulated at a rate equal to the difference in frequency between the tones (Oster, 1973). This auditory effect can be called monaural beats and is attributable in part to true physical interaction of the two tones. If the two tones are separated and one is delivered to each ear of a subject, a flutter is heard within the head.

It has been demonstrated that some subjects with brainstem lesions hear monaural beats but cannot hear binaural beats (Noffsinger, 1982).

2.2 ELECTROPHYSIOLOGICAL TESTS

Aural reflex test

The measurement of the crossed and uncrossed reflexes of the stapedial muscle to tonal stimuli is a test of brainstem disorder. It is simple and quick to administer. Jerger (1975) reported that the uncrossed (ipsilateral) reflexes should be present and the crossed (contralateral) reflexes absent when brainstem pathology interferes with the reflex arc suggesting interference with the reflex arc at the lower level of the brainstem.

Brainstem evoked response

It has been well documented that (ABR) is highly sensitive to VIIIth nerve tumors and most lesions of the low reduced at all scalp sites and no increase in Nl amplitude occurred with lengthening of the Inter Stimulus Intervals (ISIs). The P2 component however showed the same amplitude and refractory period.

In the investigation of central auditory dysfunction via middle or late evoked responses, electrodes placed over the temporal (T3, T4) or parietal (C3, C4) areas will help in defining the area of dysfunction (Kilney, 1985).

Auditory event-related potential (P 300)

This particular component known as "cognitive* potential is elicited by test paradigms that involve active participation on the part of the subject or client. Most frequently an "odd ball" procedure is used, whereby the subject is asked to count or indicate recognition of a rare stimulus, out of a background of frequent stimuli (Squires, 1983). The P-300 component originates from nonspecific unknown neural generators and presumably represents electrophysiological manifestations of strategies that are used by the central auditory nervous system (CANS) to permit an individual to selectively attend to relevant information. It has been suggested by Hillyard et al (1983) that reduction in the amplitude and/or delays in the latency of this component may indicate deficits in the later stages of processing.

Brain electrical activity mapping (BEAM)

In this BEAM images are constructed from both EEG and evoked potential data. The EEG data displays the spatial distribution of electrical activity in the delta, theta, alpha and beta frequency bands while the evoked potential (EP) data represents the dynamic changes in the electrical activity of the brain with time by sequential displays of images. The display techniques produces an animation effect which highlights the spread of electrical potential over the scalp.

Grillon and Buchsbaun (1986) have shown that auditory stimuli provide an EEG amplitude decrease in the alpha band which is greatest in the primary sensory cortex. Duffy, et. al., (1981) found abnormal results for visual evoked potentials in patients with confirmed cortical tumors. In 8 out of 11 patients, abnormally high Z values were found to coincide with locus of the tumor or its surrounding edema.

2.3 SHORT COMING OF PURE TONE TECHNIQUES

1) Adaptation measure cannot identify enough patients with known brainstem pathology to rank them high on a list of brainstem evaluators (Noffsinger, et. al., 1972).

2) In Loudness tasks although there is little doubt that brainstem lesions occasionally interfere with expected intensity/loudness relationship by producing an abnormally slow growth of loudness (decruitment) in one ear this is

reduced at all scalp sites and no increase in Nl amplitude occurred with lengthening of the Inter Stimulus Intervals (ISIs). The P2 component however showed the same amplitude and refractory period.

In the investigation of central auditory dysfunction via middle or late evoked responses, electrodes placed over the temporal (T3, T4) or parietal (C3, C4) areas will help in defining the area of dysfunction (Kilney, 1985).

Auditory event-related potential (P 300)

This particular component known as "cognitive" potential is elicited by test paradigms that involve active participation on the part of the subject or client. Most frequently an "odd ball" procedure is used, whereby the subject is asked to count or indicate recognition of a rare stimulus, out of a background of frequent stimuli (Squires, 1983). The P-300 component originates from nonspecific unknown neural generators and presumably represents electrophysiological manifestations of strategies that are used by the central auditory nervous system (CANS) to permit an individual to selectively attend to relevant information. It has been suggested by Hillyard et al (1983) that reduction in the amplitude and/or delays in the latency of this component may indicate deficits in the later stages of processing.

Brain electrical activity mapping (BEAM)

In this BEAM images are constructed from both EEG and evoked potential data. The EEG data displays the spatial distribution of electrical activity in the delta, theta, alpha and beta frequency bands while the evoked potential (EP) data represents the dynamic changes in the electrical activity of the brain with time by sequential displays of images. The display techniques produces an animation effect which highlights the spread of electrical potential over the scalp.

Grillon and Buchsbaun (1986) have shown that auditory stimuli provide an EEG amplitude decrease in the alpha band which is greatest in the primary sensory cortex. Duffy, et. al., (1981) found abnormal results for visual evoked potentials in patients with confirmed cortical tumors. In 8 out of 11 patients, abnormally high Z values were found to coincide with locus of the tumor or its surrounding edema.

2.3 SHORT COMING OF PURE TONE TECHNIQUES

1) Adaptation measure cannot identify enough patients with known brainstem pathology to rank them high on a list of brainstem evaluators (Noffsinger, et. al., 1972).

2) In Loudness tasks although there is little doubt that brainstem lesions occasionally interfere with expected intensity/loudness relationship by producing an abnormally slow growth of loudness (decruitment) in one ear this is

sufficiently rare to make unprofitable use of such procedures in an auditory battery aimed at detection of brainstem abnormality. No characteristic pattern implicating the brainstem occurs. Thus interpretation is usually limited to the judgement that something is wrong somewhere in the auditory system which ishardly a useful outcome (Noffsinger 1982).

3) In lateralization measures Noffsinger (1982) showed high miss rate in a study of large population with confirmed brainstem lesion.

4) Lesions to auditory centers and pathways in the brainstem and brain are not easily detected by pure tone tasks. This is understandable given the diversity and redundancy of the central auditory nervous system (CANS). There are simply too many ways for an acoustic signal as uncomplicated as a pure tone to be coded transmitted and decoded even in the presence of a significant damage to central auditory structures.

5) Problems with instrumentation.

6) Interference of tinnitus and/or unusual auditory sensation.

7) The general mode of communication is through speech. Speech being a higher level function - the results obtained by pure tone techniques can be hazardous in generalizing.

2.4 SENSITIZED SPEECH TESTS

Rationale

The theoretical basis of speech tests lies in the necessity of using strongly structured messages which constitute a repertoire that is adequate to test the functional properties of the channels and of the stations along with the central auditory pathways. It is certain that complex sound patterns better investigates the defects affecting integrative functions at the central level. Even under conditions of wrong transmission or wrong representation at the central level, the extrinsic redundancy at the level of the hearing station and centers ensure correct formal integration of the constituent elements of information. Bocca and Calearo (1963) say that the greater these two redundancies are the easier it will be to bring out minor integration disturbance due to non-critical deterioration either of the quality of message or of neurophysiological performance. Further more they theorize that the greater the peripheral redundancy the easier it will be to obviate errors due to defects of the peripheral receptor which are a source of uncertainty in the recognition of single phonemes but cause practically no hindrance to the reception of words and less still of sentences.

Observations with puretone and speech audiometry led to the formation of the "subtlety principle". This dictum states that the more central the lesion the more subtle is its manifestation (Jerger 1960). A dysfunction of central auditory system is quite elusive in its manifestation. Lesions in the peripheral auditory mechanism may be detected with conventional auditory tests. However, a deficit at the level of the first auditory center in the brainstem ie., the cochlear nuclei may be an exception to the subtlety principle. Such a lesion may infact be exhibited through the use of both routine audiometry and the peripheral auditory test battery (Carhart 1967). This may be because the cochlear nuclei are quite unique in that they constitute the only way station in the central auditory system where one does not find a representation of neural coding from both ears. Therefore lesion at this level may be manifested in a far less subtle manner. However, at higher auditory levels there is dual representation of both ears through numerous interconnections (Galambos 1958). Hence a lesion above the cochlear nuclei or even a hemispherectomy does not present information presented to either ear from reaching one of the interpretive centers (Noel D. Matkin and Wayne 0 Olsen 1971).

At the central level there appears a pattern of nervous activity which softens out and blurs the details and forms itself in the main according to the fluctuations of intensity, duration and to the relative values of these. The accuracy of this configuration depends on the activation of large number of structured relays (Bocca and Calerao 1963).

On the contrary, a single discriminative tone will activate at most a minute proportion of neural channels. Consequently it may be useless to try to explore the delicate defects of the functioning of these structures by means of a single discrimination tone. Therefore the method of exploration of the integrity of the central auditory system must use messages with a complex and integrated structure such as to provoke the partial type of activity that is characteristic of the auditory processes at the central level. All of this serves to justify the use of meaningful speech material in the study of different stages in the process of integration.

A lesion within the central auditory system reduces the number of neural channels available for processing speech. However, such a reduction in internal redundancy may not affect the ability of the listeners to understand speech of good fidelity to any substantial degree. Bocca and Calearo (1963) attribute this finding of the patient to compensate for disturbance in the central auditory pathways by capitalising upon the large number of redundant cues in speech stimuli. They later theorize and suggest that by reducing the redundancy contained within a sample of speech, the presence of central of dysfunction may be highlighted. Therefore, a number of test for the detection of central disorders have utilized speech in which the redundancy has been reduced by distorting it in any number of ways. The end result of such a reduction of speech redundancy is to increase the probability that even the normal listener may misinterpret some acoustic phonemes contained within the message (Noel D Matkin and Wayne 0 Olsen 1971). However in contrast it is expected that a lesion in the central auditory tracts will result in a significant increase in the number of errors made while decoding a distorted speech signal. Probably the increased difficulty encountered by the latter subjects is due to a dual reduction in redundancy; that is in the speech stimuli (extrinsic redundancy) and in the number of intact central auditory tracts available for processing a message (intrinsic redundancy).

The validity of all the speech tests can be jeopardised by disturbances at the level of language center; because it is, obvious that all speech tests depend on the correct activation of the language centers for a response to the stimulus. However isolated or associated language disturbances are easy to recognize and can be excluded, barring rare cases of agraphia by making the subjects to write his responses instead of repeating them. As such the activation of the language centers is a guarantee that the message has arrived as such at the cortex, thus testing all the stages of integration as far as the higher level. This cannot be said for the message, involving an elementary motor response, which can be provoked below the cortex (Bocca and Calearo 1963).

These are the reasons and/or justifications which confirm that speech audiometry specifically developed ("Sensitized" speech tests) is the most suitable way of detecting hearing disturbances at the integrative level ie., at the higher stage of the central auditory pathways.

Types of sensitized speech tests

The speech tests which are described are based on the principle of the reduction of extrinsic redundancy by various means, Lafon calls these test as "phonetic tests". Bocca, Tato, Quiros refer to these tests as "Sensitized speech tests' and Calearo and Bocca name these as "low redundancy speech tests". Distorted speech materials delivered monoaurally were the first central speech tests to be employed. The distortion may be accomplished by acoustic filtering, low fidelity and other means (Bocca, 1954; Goldstein 1956; Gleiner and Lafon 1957). A second technique is time distortion (Bocca 1956; Calearo and Lazzaroni 1957; Calearo and DiMitri 1958; Puricelli et al 1958 and Quiros 1961). The third major category is that of supplementary messages or integration (Matzker 1958; Calearo 1957; Hellema 1960 and Tillman et al 1966). These methods usually require the listeners to combine binaural sources of information in order to obtain an accurate response. A fourth approach to uncover central auditory disorders is the competing message technique (Kimura 1961, 1963, Feldman 1962; Katz 1962, 1963 and 1968 and Jerger 1964).

2.5 MONOSYLLABIC PROCEDURES - MONAURAL DISTORTED SPEECH TESTS

Frequency Distorted

In 1954 Bocca, et. al., delivered tests of phonetically balanced words using low pass filters (500Hz). The results showed that in all cases where lesions of the auditory cortex had been proved the discrimination curve was distinctly worse in the contralateral ear. Walsh and Goodman (1955) followed the same, and they could localize site of lesion. Goldstein et al (1956) used lists of monosyllables that were difficult to recognize because of the bad quality of recording. The results showed that in cases of hemispherectomy the discrimination score was 25 percent lower in the ear contralateral to the hemispherectomy as against the homolateral one.

Goldstein, et. al., (1960-61) reported depressed performance for a group of four patients on whom left hemispherectomies were performed. They noted essentially normal performance on pure-tone sensitivity tests for all four subjects both pre and post operatively. In addition speech recognition scores for well articulated speech were normal in all cases. When a poorer, presumably frequency distorted, recording of the phonetically balanced words lists (Rush Hughes recording) was used left ear scores were normal but right ear scores were depressed.

Jerger (1960, 1964b) administered a low pass filtered speech test along with other tests to three patients with temporal lobe lesions. He also found that performance was depressed on the low pass filtered speech test in the ear contralateral to the affected hemisphere.

In recent years the most extensive data using filtered speech monosyllabic recognition tests have been presented by Lynn and Gilroy (1972, 1975, 1976, 1977). These authors have reported on cases of documented lesions of the brain, consisting primarily of tumors of the temporal, parietal and frontal lobes that low-pass filtered speech can be successful in identifying brain lesions, but the specific location of the pathology may not be revealed by the test outcome. The majority of their patients who had temporal lobe tumors demonstrated the expected contralateral ear effect. However, the mean group difference between contralateral and ipsilateral scores has been reported to be as small as 10% (Lynn and Gilroy, 1975). Cases with tumor of parietal lobe, frontal lobe or interhemispheric pathways were typically reported to show normal results for filtered speech testing.

The most widely used filtered speech test in clinical practice today is the low-pass filtered speech subtest of the Willeford (1976) central auditory processing battery. This test consists of two 50-word lists of Michigan Consonant Nucleus Consonant (CNC) words which were selected to be highly intelligible to adults even when filtered. The words were low-pass filtered with a cut-off frequency of 500Hz and an 18dB per octave rejection rate. The recommended presentation level is 50dB the puretone average.

Time distortion

A second method of degrading or reducing the redundancy of speech signal that has been used in central auditory nervous system (CANS) assessments has involved procedures whereby the temporal aspects of the speech signal are disrupted or altered. This type of distortion typically has involved either interrupted accelerated or compressed speech.

In interrupted speech tests, portions of the message are removed by turning on and off periodically by means of an electronic unit (Licklider and Miller 1954).

Bocca (1958), Calearo (1963) and Antonelli (1963) were among the first investigators to use an interrupted speech tests to assess patients with CANS disorders. Using both words and sentences at a message on ratio (MOR) of 50% and any where from 1-40 interruptions per second (IPS) they found that patients with temporal lobe lesion showed poorer scores in the ear contralateral to the lesion. In addition, patients with brainstem lesions typically showed reduced performance in either one or both ears.

In a subsequent investigation Korsar - Bengsten (1973) presented Swedish sentences with a 50% message on ratio (MOR) and 7 or 10 IPS to a relatively large number of subjects. She found (1) Reduced performance in the contralateral ear if the lesions affected the primary auditory cortex; (2) a somewhat smaller but still prominent contralateral effect if the lesions were located in the temporal lobe in close proximity to the primary auditory region; and (3) Essentially no deficits in either ear if the lesions were in frontal or parietal lobes. She also found that patients with brain stem lesions which were localized to the right side showed markedly poorer scores in the ipsilateral ear when compared to contralateral ear. These investigations suggest that an interrupted speech test is sensitive to lesions in both the temporal auditory cortex and the brain stem.

The second method of temporal distortion that has been used in CANS assessment has been the accelerated or time-compressed speech method. Essentially three methods of accelerating or compressing the speech stimuli have been used. These include (1) having the speakers accelerate there speech (2) accelerating the recorded signal via a faster playback rate and (3) removing segments of signal electromechanically.

In 1956 Bocca reported on an audiometric accelerated speech test and suggested that this test provides a measure of:

1) Reaction time; 2) The speed of the transmission across the cortical synapses; and 3) The speed of the transmission along the auditory pathways.

Later similar results were obtained by Bocca and Calearo (1956) Calearo and Lazzaroni (1957) and Bocca Calearo and Cassinari (1957). According to Calearo and Lazzaroni a decrease in intelligibility of accelerated speech may be indicative of cortical lesions.

In a similar investigation by Calearo and DiMitri (1958) the speech presentation was periodically switched from one ear of the listener to the other. In studies employing this technique normal subjects were tested as well as patients with central auditory lesions. In normal purpose it was observed that the intelligibility of the speech message was decreased when the rate of switching from side to side was faster than 0.2-0.3 seconds and the message rate exceeded twice the normal speed (250 words per minute). In patients with central auditory lesions intelligibility decreased even though messages were given at normal speed either because of the increased reaction time or because of a decrease in the capacity to integrate these binaurally presented messages.

Beasley, et. al., (1972) generated tapes of compressed speech stimuli using the method of electromechanical time compression introduced by Fairbanks, et. al., (1954). Subsequent studies revealed that patients with diffuse temporal lobe damage showed substantially poor performance in the contralateral ear on NU-6 auditory word tests that were compressed by 60%.

The clinical application of the use of compressed monosyllables for detection of CANS disorders was demonstrated by Kurdziel et al (1976). They used 30% and 60% compressed NU-6 lists in the evaluation of 31 patients with brain lesions. The results of Kurdziel et al (1976) showed a marked reduced scores in the contralateral ear for the diffuse lesion group especially at 60% compression rate. In contrast the discrete lesion group showed normal overall performance bilaterally. The authors concluded that compressed speech testing is an effective method of identifying diffuse temporal lobe disorders but lacks the sensitivity to detect discrete anterior temporal lobe lesions.

Quaranta and Cervellera (1977) reported that none of their nine subjects with brain stem lesions showed reduced performance.

Baran (1985) found that compressed speech is a moderately sensitive test for intracranial lesions involving the temporal lobe. In approximately two-thirds of these subjects, performance was reduced in one or both ears. The more typical pattern, however was for reduced performance to be evident in the contralateral ear.

Modified logo audiometry

This procedure was proposed by Quiros (1960). Here lists of phonetically balanced bisyllables are presented to the two ears separately and a speech discrimination curve is plotted. Later the same words are delivered in groups of three, separated by a gap and new speech discrimination curve is plotted.

The results obtained using this procedure showed that in disorders of the central auditory pathways the two curves do not coincide and the curve obtained for the groups of words is unilaterally or bilaterally inferior. A poor unilateral curve indicated organic or functional disorder of the contralateral auditory cortex.

Quiros (1960) attributes the inferior performance obtained with groups of words to the greater effort of integration required for this kind of delivery; this according to Quiros (1960) necessitates greater attention since one is dealing with groups that are not normally used and with a rhythm different from that of ordinary language.

Speech - in - noise

A method of distorting and/or reducing the intrinsic redundancy of the speech message has been speech-in-noise tenting. Sinha (1959) was the first to use a speech recognition in white noise task to assess central auditory function in a group of patients with cortical lesions. He found depressed score in the ear contralateral to the lesion. Follow-up studies have demonstrated that monosyllables mixed with white noise can be successful in identifying brainstem as well as temporal lobe disorders.

Since that time several other investigators have used a speech-in-noise test for the assessment of CANS disorders (Dayal, et. al., 1966; Morales - Garcia and Poole 1966, 1972; Noffsinger, et. al., 1972; Heilman 1973; Olsen 1975; Fowler and Noffsinger 1984).

In most cases the test stimuli have consisted of monosyllables words which were presented at suprathreshold levels while either speech spectrum or white noise was presented to the same ear at approximately the same over all sound pressure level and signal-to-noise (S:N) ratio of +10dB. In evaluating individuals with potential CANS lesions, researchers typically have compared the performance of the ipsilateral and contralateral ears in terms of their relative breakdown as well as to the extent to which such breakdown exceeds that of normals.

Reduced recognition scores have been reported for the ipsilateral ear in VIIth nerve and extra-axial brainstem lesions in one or both ears for individuals with intra-axial lesions and in the contralateral ear in temporal lobe disorders.

2.6 UNDISTORTED MONOTIC TESTS

Performance - Intensity - PB Functions

Although traditional word recognition tests may not be useful in the assessment of CANS disorders, there have been a few investigations that have suggested that undistorted speech tests are sensitive to intracranial lesions if performance - intensity functions are derived (Jerger and Jerger, 1971; Dirks, et. al., 1977; Bess, et. al., 1979).

Jerger and Jerger (1975a) reported significant PI-PB roll-over (20% or greater) in 8 of 12 extra axial lesions and 4 of 8 intra-axial lesions. The rollover was generally observed on the ipsilateral ear for the extra axial lesions and the contralateral ear or bilaterally for intra-axial cases. In other studies related to brain-stem pathology significant PB rollover has also been found in patients with Multiple Sclerosis (Jerger and Jordan, 1980; Grimes et al, 1981; Hannley et al 1983).

Muller, et. al., (1985) report that in a study of 100 individuals with posterior temporal lobe damage PB rollover occured in less than 5% of the cases.

Rush hughes difference test

In this the patient score on Psycho Acoustic Lab (PAL-50 Rush Hughes) was subtracted from the CID W-22 (Ira Hirsh) score. Goldstein, et. al., (1956) studied four patients who were tested before and after left hemispherectomy. They found significantly reduced PB-50 scores (Mean = 45% error) more found for the contralateral ear while there was only a slight reduction of 20% for the ear ipsilateral to the removed hemisphere. The W-22 scores on the other hand remained at or near normal for all subjects yielding PB-50/W-22 mean difference scores of 32% in the contralateral and 16% for the ipsilateral ear.

Subsequent studies supported the work of Goldstein, et. al's, (1956) finding that the PB-50/W-22 comparison test is successful in the identification of temporal lobe and subcortical pathologies (Goetzinger et al 1960; Lily and Franzen, 1968; Stevens, 1978).

2.7 BINAURAL TESTS

Binaural Fusion

Fletcher (1929) reported that if speech components below lOOOHz were sent to one ear and components above lOOOHz to the other ear simultaneously, fusion would occur and good intelligibility would be obtained. Poor performance was observed for either ear separately. This binaural principle was first adopted by Matzker (1959). He used bisyllabic German words filtered into two frequency bands, 500Hz to 800Hz and 1815 to 2500Hz. The test procedure involved both dichotic (one frequency band-pass to each ear) and diotic (both frequency bands to the same ear) presentation. After administering the test to over 1700 patients. Matzker concluded that reduced binaural fusion scores are the result of damage or degeneration of the ganglionic cells of the brain stem.

Smith and Resnick (1972) studied four groups of adult patients normals, bilateral sensory - neural hearing loss (presumably cochlear), temporal lobe lesions and brainstem pathologies. Diotic scores were not significantly higher than dichotic scores for the normal, sensory-neural or temporal lobe group, indicating the presence of normal central fusion or integration. Positive findings, however were observed for all brain stem cases with Dichotic Binaural Fusion (DBF) results showing an 18 to 34% diotic enhancement.

Faint filtered speech

Another binaural procedure used to detect Central Auditory Nervous System pathology is the simultaneous presentation of low pass filtered and faint undistorted versions of the same speech material to opposite ears. Bocca (1955) reported that when using this method binaural scores were approximately equal to the sum of the two condition presented separately.

Jerger (1960a) reported on the use of the faint filtered procedure with PB-50 monosyllables, temporal lobe pathology patients who were shown to have binaural scores essentially equal to the better monaural score, demonstrating the absence of summation.

Rapidly alternating speech

This is a test in which verbal stimuli are alternately switched from ear to ear during presentation. Thus brief and relatively meaningless bursts generally from words or sentences arrive at each ear in a rapid sequences. Lynn and Gilroy (1977) have shown one version of this procedure which involves sentences to be particularly sensitive to certain lesions in the low pons and cerebellopontine angle region of adult subjects. Another sentence version which is the fourth and final test in Willeford Battery has been reported by Mittenberger, Caruso, Correia, Love, et. al., (1979) to reveal astonishingly poor performance in deep sea divers with decompression sickness (The "bend").

Masking level differences

A final binaural CANS test in which monosyllables can be utilized is the masking level difference (MLD). The MLD can be defined as an improvement in the threshold for a signal in noise whenever the signal or the masker is reversed in phase. Although pure tones or spondees are normally used as the target stimulus, monosyllablic words can also be utilized. In this instance an improvement in speech recognition rather than threshold is expected for the antiphasic conditions.

Cullen and Thompson (1974) examined relationship between MLD and speech recognition for normals and four subjects with temporal lobe resections. By presenting CVC monosyllables at

60dB SPL and noise at 63dB SPL, they showed that normals demonstrated an approximate 20 to 30% improvement in speech recognition for the antiphasic condition with the greatest improvement noted when the signal was out of phase. The temporal lobe resection patients performance did not vary significantly from that of normals supporting the notion that the MLD is the result of a subthalamic interaction.

2.8 DICHOTIC TESTS

A finer method of presenting monosyllablic speech for central auditory assessment is dichotic presentation. The term dichotic refers to the simultaneous presentation of two different speech signals to separates ears of the listener. As with most other speech tests designed to detect Central Auditory Nervous System pathology when dichotic speech is presented to individuals with temporal lobe lesions reduced performance is expected for the ear contralateral to the disorder.

Dichotic digits

In the dichotic digit tests numbers from 1 though 10 (excluding 7) are paired and presented in groups of two or three. The patient is required to repeat all digits which are presented in a single grouping (four or six). Typically 40 to 72 digits are presented to each ear and a percentage correct score is derived. Normals usually score close to 90% (slightly higher if only two digits pairs are used), with a group right ear advantage of 2 to 6% (Dirks 1964; Brunt and Goetzinger 1968; Musiek 1983a; Mueller et al 1985).

Kimura (1985) developed a model that could be used to explain the function of the central auditory nervous system in the perception of dichotically presented stimuli. The model is based on the premise that the contralateral auditory pathways in men are more numerous and/or stronger than the ipsilateral pathways. In cases where there is only monoaural input to the auditory system, either pathway is capable of initiating the appropriate neural response to allow accurate perception of the speech signal. In dichotic situations however, in the contralateral ear whenever test stimuli are presented in a competing dichotic paradigm, ipsilateral deficits are expected if the left or dominant hemisphere for speech is affected.

Sparks, et. al., (1970) provided additional evidence that supports Kimura's theory. They used both dichotic digits and words in evaluating 20 left and 20 right brain - damaged adults. Results demonstrated the expected 'contralateral" ear deficit for both the left and right brain - damaged subjects. They also found that the ipsilateral scores for the right brain-damaged subjects were substantially higher than the ipsilateral scores of the left brain-damaged subjects. The reason that this occured (ie., ipsilateral left ear deficit) may be because the fibres of the corpus callosum had been compromised in many of these subjects. Similar ipsilateral deficits were noted in other subjects with hemispheric lesions by Damasio and Damasio (1979). These results appear to support the contention that the left temporal lobe is "specialized" for speech and that damage to this hemisphere is likely to result in bilateral deficits on dichotic speech tests (Speaks 1975; Sidtis 1972).

Musiek (1983) introduced a revised version of the dichotic digits test in which two rather than three digits are presented simultaneously to each ear. Musiek (1983) reported that 18 out of 21 patients with intracranial lesions (9 brain-stem, 12 hemispheric) showed abnormal performance in either one or both ears on the dichotic digit test. Results of comparative study by Musiek (1985) that investigated the relative sensitivity of three dichotic tests (Dichotic digits, staggered spondiac words and competing sentences) in the assessment of CANS disorders in 12 subjects with brain-stem involvement and 18 subjects with cortical lesions showed that the dichotic digits test yielded slightly more abnormal findings for both groups than did either one of the two remaining tests.

Approximately one year after Kimura's introduction of dichotic speech paradigm into field of central auditory assessment, Katz (1962) introduced a unique modification of this psychophysical test procedure. His staggered spondiac word test (SSW) is among the best known and most frequently used dichotic speech tests.

2.9 SENTENCE TESTS

Synthetic sentence identification

Sentences are utilized in competing message paradigms for measuring functions in the central auditory system (Jerger and Jerger 1974; Jerger and Jerger 1975, Speaks 1975). The rationale for developing this technique was to avoid the use of single words and single-syllable words in particular. If was felt that such short auditory signals have important limitations in evaluating the capacity of central nervous system. They used a closed message set to minimize the subjects dependence on linguistic skill. Thus the subject could identify the stimulus sentence from among a group of sentences which had controlled lengths and informational content (Speaks and Jerger 1965; Jerger et al 1968). A particular group of synthetically determined sentences were selected from among various word order sentence of third order approximation an length (Jerger and Jerger 1974, 1975).

Jerger and Jerger (1975a) administered SSI materials to a series of patients with carefully defined intra-axial brainstem lesions. In the first mode, tape recorded synthetic sentences were presented by male voice to one ear while the other simultaneously received a narrative by the same speaker about selected events in the life of David Crochett. Following this techniques the ears receiving the message and competition, respectively were reversed. The second test combined the sentences and the combination of connected discourse was presented first to one ear only and then to the other. In both the binaural and monaural procedures various message to competition ratios (MCRs) were measured. The two procedures were referred to as contralateral competing message (CCM) and ipsilateral competing message (ICM) tasks. With sentences presented at levels yielding 100% performance generally at about 50dB sensation level (SL) MCRs were varied in 20-dB steps from OdB to 40dB for the CCM condition for equal sound pressure levels (SPLs) to competition about 40dB above the primary message and in lOdB steps from +10 to -20dB for ipsilateral competing message (ICM) condition.

The results from the study of Jerger (1975) 11 patients with carefully defined intra-axial brainstem lesions who were given both the CCM and ICM tasks were strikingly dissimilar for two versions of the test. All the 11 exhibited very poor performance on the ICM test; 6 of them in each ear and 5 of them just on the contralateral ear. No patient performed poorly on ipsilateral ear alone. Performance scores on these patients averaged 37% on both ipsilateral ear and contralateral ear when averaged across MCRs of 0,-10 and -20dB whereas normals averaged 76%. The ICM results together with those for CCM test showed that 8 out of 11 patients by sharp contrast had normal scores on the CCM, even at the most difficult MCR of -40dB.

Jerger and-Jerger (1975) in an another investigation gave their findings as for brain stem patients the SSI procedure show poor performance for ICM and relatively good performance for CCM. The ICM deficits are observed on contralateral ear only and CCM performance is within normal limits on both ears. For temporal lobe patients the SSI procedure yields poor performance on both ICM and CCM. The ICM deficits are observed on both ears and the CCM deficit is observed on contralateral ear only.

Natural speech sentences

Willeford (1968) developed a competing sentence test (CST) for the specific purpose of evaluating central auditory function.

The purpose in developing the CST was to avoid dependence on identification of highly transient single words particularly monosyllabic words. Such words place a premium on one's concentration and attention. Another reason was the desire to simulate language constructions one might encounter in everyday life. It was thought that the test might provide insight into a subjects ability to process standard forms of spoken language, without penalizing the patient with low intelligence, illiteracy, physical abnormality that might compromise their maximum test performance.

For the most part, this test has been used in the assessment of children with auditory processing disorders.

However, there have been some investigations that have looked at the performance of individuals with central auditory nervous system (CANS) disorders on this test (Willeford 1977). These studies have shown that approximately one-half of the subjects studied with brainstem lesions demonstrated abnormal performance in the ear ipsilatefal to the lesion. For subjects with temporal lobe lesions, contralateral deficits were noted for individuals with posterior temporal lobe lesions, while for the most part no deficits were noted in subjects with anterior temporal lobe lesions.

There are many other tests which have been used for the detection of central auditory disorders. However many of the following tests are not in common use in the audiologic clinics. They are faint discrimination of words at 30dB, discrimination at 50dB, tone flicker, speech with alternate masking index (SWAMI) and auditory tracking tests.

Most of the techniques investigated to date have employed relatively unstable speech stimuli namely English monosyllabic words or their equivalents. Hence it is not surprising that consistent normative data are lacking probably as a result of the heterogenety of the test items and of the great amount of variability among individual listeners. Little emphasis tests has been placed on the absolute test score in difficult speech test.

Because of the expenditure of testing time necessary to cope with factors of unreliability investigator have been unable to shorten their diagnostic measure. Rather extensive test batteries have been utilized by several research workers in order to provide the added reliability and accuracy in diagnosis. since all of these approach, tend to be time consuming, they may increase the possibility of psychological and physiological fatigue in the patient (Katz 1962).

In addition to variable inherent in particular subjects such as age, intelligence, attention span etc, most of the current methods are difficult to interpret in the presence of peripheral aural pathology. This is because the peripheral hearing loss has an unpredictable influence upon the test procedure and furthermore the possibility of confounding important information concerning the status of "cortical hearing" may be enhanced.

Considering all these points it was later concluded by many (Jerger 1975, Musiek 1985), that staggered spondiac word (SSW) test is a very consistent auditory test.

2.10 WHY SSW TEST IS A PREFERRED TEST?

The scoring and interpretive procedures on the staggered spondiac words test have been refined over the years as more and more data have accumulated.

The dichotic technique in staggered spondiac words test appears to be highly sensitive to the presence of lesions in many parts of the central nervous systems.

The staggered spondiac words test is particularly powerful when all of its quantitative and qualitative indicators are used.

The raw and corrected scores are the quantitative indicators, while the response biases which give the most sensitive localizing information are (a) reversals (b) ear effects (c) order effects, which are the qualitative indicators. The corrected SSW score is calculated by simply subtracting the percent of error on a standard discrimination test from the Raw-SSW score. It helps in neutralizing the influence of peripheral hearing distortion.

The peculiar response bias pattern have also diagnostic significance in indicating various sites of brain dysfunction.

The staggered spondiac words test has been used in conjunction with the competing environmental sound (CES) test for the purpose of improving the prediction of the involved hemisphere.

On average the time required to administer the test is approximately 10 minutes which is less compared to other tests.

2.11 THE STAGGERED SPONDIAC WORD TEST

The staggered spondiac word test was first described by Jack Katz in the year 1962. Since 1962 large amount of information has been gathered on the usefulness of this test.

Development of the Staggered spondiac word (SSW) test began in 1960 when Katz upon hearing Matzker's work, sought to develop an audiologic task that was less vulnerable to artifacts of individual differences unrelated to central disturbance (Katz 1962). He was particularly concerned that peripheral hearing loss had an unpredictable effect on tests such as Matzker's. It was reasoned that stable speech material might provide greater certainty in the diagnosis because of the likelihood of clear cut normative data and relative resistance to associated or coincidental auditory deviations of a peripheral nature. Spondiac words (defined as familiar words consisting of two monosyllabic words with equal stress on each) were to be used as stimuli. Spondees are almost perfectly intelligible at presentation levels just above the speech average threshold even when peripheral sensitivity is depressed and phonetically balanced (PB) word discrimination is moderately reduced. The stability of spondiac words were expected to provide a high degree of test -retest reliability.

It was felt that lesions at various points of the central auditory nervous system would produce different effects on auditory perception which might be differentiated as from tests of the peripheral system which are specific to different disorders (Eg, cochlear Vs VIII nerve). The staggered spondiac words test was constructed to elicit a complex response in order to obtain various quantitative and qualitative bases for analysis. The 40 items contained both competing and noncompeting words. This construction allowed comparison of responses for competing Vs noncompeting items, right Vs. left ear unilateral errors etc. A person who consistently missed the third monosyllable for example would be functioning differently from someone who had bilateral errors or no pattern of errors at all.

Katz, et. al., (1963) published the first results for different etiologic groups (ie., normals, unilateral healed trauma conductive and sensory neural hearing loss cases). Sensory neural cases with reduced scores but a Pearson's coefficient of 0.93 was obtained between WDS and SSW. This established the relationship between raw SSW and WDS scores in peripheral cases resulting in the unique and one of the most important strengths of the SSW test. A similar correlation (r = 0.92) was reported by Katz (1968).

Clinical norms for total ear and condition scores were published by Katz in 1968. In a blind study an impression relationship between audiologic and radiologic localization was demonstrated with excellent differentiation between auditory reception (AR) cases with moderate or serves C-SSW scores and non auditory (NAR) cases with normal or mild scores.

Katz (1970) reported that individuals with brainstem disorders made errors in the ear ipsilateral to the affected side. He also reported that VIII nerve and low brainstem cases yielded more errors on WDS than SSW adding greater significance to highly over corrected C-SSW scores.

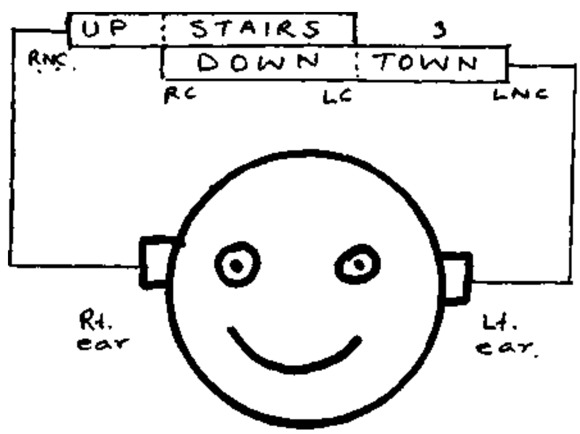
Katz and Pack (1975) demonstrated that reversals are found in patients with dysfunction in the pre and post central gyri and anterior temporal lobe. Katz et al (1975) showed that by comparing SSW performance with that of the competing environmental sound test (CEST) the hemisphere of cortical dysfunction in patients with widely depressed scores may be identified.

In 1965 Myric obtained normative information for children on the staggered spondiac words test (SSW). In 1981, 1982, 1983 and 1985 the norms based on a national sample of normal children were published (Katz, et al 1981; Katz, 1982, 1983a, 1983b, 1985). This allowed for greater certainty in the analysis of children's staggered spondiac word (SSW) test scores and response bias for identification of auditory perceptual dysfunction in learning disabled children.

Technique and presentation

Each item consists of two spondees with the first monosyllable of the first spondee arriving without competition to one ear. The second monosyllable of the first spondee and the first monosyllable of the second spondee are presented dichotically arriving simultaneously to either ear.

The second monosyllable of the second spondee reaches seconds ear in a noncompeting fashion. The words are spoken slowly with a pause between monosyllable. The ear receiving the first monosyllables are alternated, so that, of the 40 items 20 begin with right ear stimulation while the remaining 20 are "left ear first". The first and the last monosyllables of an item also form a spondee. Patients who have difficulty on a competing word may use the available noncompeting one so that they may be unaware that an error has been made.



The items are presented at 50dB sensation level (SL) relative to three frequency speech average of each ear thus compensating for sloping high or low frequency hearing loss. Presentation levels can be adjusted for individuals with tolerance problems, or increased for sharply sloping losses. It is not presented at levels below 50dB hearing level (HL). If there is a crossover because of good bone conduction for patients with conductive hearing loss cases, this would simulate a diotic test condition which is more difficult than dichotic (Goldman and Katz 1968). A presentation level of 9-

30dB SL is used when air-bone gaps exceed 20dB (Jack Katz and E.White unpublished observations).

Since presentation are common for word discrimination score (WDS) particularly in retrocochlear disorders it is administered on the same day as SSW. For maximum reliability recorded WDS is preferable. From the stand point of validity live voice (WDS) results may tend to make staggered spondiac word performance look more "central" when the correction is made.

Reversals

Normal listeners respond in the temporal order in which the monosyllables are presented. If a patients response is not readable on the test form, from left to right numbers are placed under each monosyllable indicating the order in which they are repeated. Reversal are frequently observed in brain-damaged patients (Katz 1968, Katz and Pack 1975), learning disabled children (Stubble field and Young 1985) and autistic individuals (Wetherby, et. al., 1981). Reversals are also seen although not necessarily diagnostically significant, in nonorganic sedated or otherwise unmotivated subjects.

Ear and order effects

Goetzinger, et. al., (1961) states that in adults discrimination ability decrease as age increases and this difficulty is associated with changes involving all levels of the auditory mechanisms. This was tentatively supported in an unpublished study by Katz, Bales, and Fisman on the age effects of performance word test. This study suggests an increase in both peripheral and central dysfunction beyond the age of 60 years. Furthermore, the authors observed a considerable individual difference in performance among subjects in the 60 and 70 age groups. In his unpublished thesis Myric (1965) observed a superior right ear performance on the staggered spondiac word test when the subjects were children and the author observed no difference between the two ears in the adult control group.

Katz (1968) writes that ear performance is generally a more accurate indicator of central auditory function than either any of the staggered spondiac words conditions or total score. Furthermore, the authors writes that defective performance in one ear suggests a dysfunction in the contralateral hemisphere. However ear preferences were absent in normal listeners on staggered spondiac word test.

The order effect might be thought of as a memory effect. In this case there is a preponderance of errors on the first or the second spondee regardless of the fact which ear received the first stimulus, or vice versa. Similarly there is an other response bias wherein two different configurations of errors are exhibited for the right ear first items as opposed to left ear first items. This is referred as the pattern effect.

Ear and order effects and reversals are uncommon in normal individuals. In the presence of normal (SSW) scores significant ear and order effect should be interpreted with caution (Katz and Pack 1975; Brunt 1978). Arnst (1981) found that 98% of normals (N=86) did not have significant ear effects and 99% of the normals failed to show order effects The three subjects with significant effects had normal C-SSW scores. Ninty - eight percent of Arnst's sample had fewer reversals. Normals are expected to reverse on no more than one item (Katz and Pack 1975). The two subjects who did reverse did not do so after reinstruction.

Normal performance

For people with normal peripheral and central auditory function the (SSW) is an easy tasks in which ear laterality effects are invariably demonstrated by a right ear advantage (in left hemisphere - dominant individuals). The ear advantage seen on the SSW test is clinically insignificant (Brunt and Goetzinger 1968). Indeed this is one of the major reasons why SSW test is clinically useful. Because the test is so simple for a wide range of population it is useful even for subjects with lower intelligence, the hard of hearing, stutterers learning disabled and elderly (Arnst and Katz 1982). Non native speakers perform poorer than the native speakers on the SSW tests (Rawiszer, 1979). Children below the age of 12 and adults older than 60 are treated difficulty in evaluating SSW performance.

PERIPHERAL HEARING LOSS

Conductive hearing loss: Patients with conductive hearing loss perform normally on the SSW test (Katz et al 1963). In a study of 17 cases Katz (1978b) found that 14 (82%) scored in the normal category, 2 (12%) over corrected. Interestingly 40% had reversals (mean number = 8), 20% had ear effects and 7% had order effects.

Cochlear hearing loss: Because of high correlation of Raw-staggered spondiac word and word discrimination score in cochlear cases one can expect a normal (N) or slightly over corrected (0) C-SSW score. In 42 bilateral cases 90% yielded N or O-SSW categories (Katz 1978b). Of 22 unilateral cases 68% fell into there categories while 27% had mild (Mi) scores and 4% had moderate (Mo) scores. This shows that unilateral and bilateral cases perform slightly differently.

Reversals were more prevalent in unilateral (36% of unilateral Vs 12% of bilaterals) Overall 16% of cochlear cases had ear effects and 28% had order effects.

Arnst (1980a) advocated caution in the consideration of results when hearing loss is greater than 40dB. He found that the relationship between R-SSW and WDS was not as strong in this group as with milder hearing losses.

C.N.S. DYSFUNCTION

Auditory reception center (ARC): The first two articles of SSW test (Katz, 1962; Katz, et al, 1963) used skull trauma and cerebral palsy cases to look for a 'contralateral effect" of temporal lobe insult. In 1964 Epstein a neurologist found that the large peaks of errors on SSW in the ear contralateral to brain lesions were demonstrative of disorders of the temporal lobe in general but specifically Heschls Gyrus the Auditory Reception Center (Arnst and Katz 1982). When a moderate or serve total ear condition (TEC) is obtained for C-SSW scores an auditory reception (AR) problem is suspected (especially if the A-SSW does not contradict the locus).

Non auditory reception center: Any region of the cerebral hemisphere other than auditory reception (AR) centers is considered NAR. Persons with NAR dysfunction will show mild or even normal TEC scores and various response biases. The lesion to "silent areas' do not typically affect SSW performance (Eg. Occipital lobe). Positive results on the SSW test can be taken to indicate dysfunction but of course absence of significant findings does not necessarily rule out brain dysfunction.

Nerve VIII and low brainstem: Lesions of the eight cranial nerve can have profound effect on word discrimination. The nature of SSW test stimuli is that scores on the R-SSW are often better than WDS scores in nerve VIII cases. As a result when WDS is substracted from R-SSW the C-SSW is highly negative or over corrected in the ipsilateral ear.

Low brainstem lesions will usually produce an over corrected score in the ear ipsilateral to the lesion. Katz (1976) shows a mean C-SSW ear score of -28 in the ipsilateral lesion of nerve VIII cases and -13 in low brainstem cases. Both groups had contralateral ear means of -1. Differentiation between these two groups might be aided by the use of auditory brainstem response or electronystagmography.

High Brainstem: An upper brainstem lesion will usually show less distortion on WDS than a disturbance in an anatomically lower region, but, poorer performance on the SSW test (Katz 1976, 1978a). The result is a moderately or severely depressed C-SSW score in the ear ipsilateral to the lesion. As the size of lesion increases a more bilateral effect might be seen.

Jerger and Jerger (1975) reported unreliable SSW test results in brainstem cases - some positive, some over corrected and some normal. Katz (1978a) reported a mean ipsilateral ear score of 53 and a mean contralateral ear score of 4 in high brainstem cases. High brainstem cases are differentiated from the other loci causing moderate or severe SSW scores by the presence of subtle retrocochlear signs on other audiologic measures (eg, tone decay, binaural fusion).

Cerebellum: Cerebellum cases seem to behave as would cases with lesions in any other location.

Corpus Callosum/Anterior Commisure (CC/AC): The corpus callosum and anterior commisure are bundles of fibres deep in the brain which transfer information between the hemisphere. Disruption of these pathways will interfere with or abolish this interhemispheric interaction. "Split-brain" patients yield large left ear deficits on classical dichotic listening tests. (Milner, et. al., 1968; Sparks and Geschwind 1968; Springer and Gazzaniga 1975). Musiek and Wilson (1979) reported on a patient with normal SSW test results prior to sectioning of the corpus callosum. On post commisurectomy this patient yielded a severely depressed left ear score.

A patient with a lesion of the interhemisphere pathways can show SSW results identical to those of a patient with dysfunction of the right hemisphere AR center (moderate or severe left ear score). In order to differentiate the locus of dysfunction in such cases the competing environmental sound (CES) test was developed (Katz, et. al., (1980). Competing Environmental sound test employs familiar sounds for which the right hemisphere is dominant in a dichotic mode. Thus in a "Split-brain" patient one might find a depressed score in the nondominant right ear for environmental sounds and a depressed score in the nondominant left ear for words. Katz et al (1980) reported such a "Crossed " pattern in most of the nine cases with verified corpus callosum tumors.

METHODOLOGY

In evaluation of central auditory functioning, the use of mere conventional auditory test battery is found to be inadequate. Special speech tests will help in the detection of central auditory disorders. The Staggered spondiac words test is one of the most widely used test for the detection of central auditory dysfunction.

The present study was to prepare the material in Hindi for the staggered spondiac words, test.

MATERIAL

In English two monosyllabic words (spondees), combine to form familiar paired words for example, "base-ball" and "ice-cream". There are many commonly used spondee word combination in Hindi like, "Jaat-Paat" and "Aas-Paas" . Such familiar spondee words are used as materials in the present study for the construction of the staggered spondiac words test in Hindi.

The study was to prepare two lists of words which should satisfy the following conditions:

a) Represent the common vocabulary of the Hindi language.

b) Be familiar to all subjects and

c) Should be appropriate to evoke a uniform response from all the people - tested except for the clinical groups - irrespective of their age, sex, education and occupational background. There is no available familiarity word list in Hindi. It was required to make a preliminary list.

A total of 406 spondee words were collected from Hindi books, magazines, periodicals, newspapers and from individuals. They were listed to be rated by the subjects (Appendix-A).

SUBJECTS

Subjects of age range 10 years to 67 years were randomly selected. The subjects had volunteered to rate the familiarity of the words in the list. The subjects were both from urban and rural areas.

Out of 192 subjects 113 were males with a mean age of 23.7 years. The remaining 79 subjects were females of a mean age of 24.35 years. They came from different occupational backgrounds and included students agriculturalists, businessman, officials and others.

The students formed most of the subject group (136). The subjects had a fairly good exposure to the language Hindi. They were living in Hindi speaking areas and were using that language.

PROCEDURE

The word lists were distributed to the subjects, on which they were required to rate the familiarity. Instructions to the subjects were printed on the first page of the list. The subjects were instructed to grade the spondee words by marking an (x) in the appropriate box provided against each spondee word depending on their own familiarity with the word (Appendix-A).

The subjects were asked to grade on five point scale and return it to the investigator. The rating was to identify each word as a) Most familiar; b) Familiar; c) Not very familiar; d) Unfamiliar; and e) Doubtful.

The data was collected in cities like Bombay, Nashik, New Delhi, Allahabad, Goa and adjoining rural places around these cities.

RESULTS AND DISCUSSION

The data collected was analyzed by giving weightage scores as judged by the subjects for the 406 spondee words. The weightage scores given as follows like -Most familiar (+3); Familiar (+2); Not very familiar (+1); Unfamiliar (-1); and Doubtful (No score).

The weightage scores for each item were summed up. Out of 192 subjects 159 (83%) rated the item "Jhar-Ponch" as the most familiar spondee word and 148 subjects (77%) rated item "Danta-Beej" as the most unfamiliar spondee word. Between these two rated scores of most familiar and most unfamiliar items the spondee words were arranged in their decreasing order of familiarity.

Following the item selection rules the Mean was taken out of the total items weightage score and the Standard Deviation was determined for the ungrouped data (Garret 1965). The Mean was found to be 300.14 and the Standard Deviation was found to be 86.13. The words which fell between the two Standard Deviation near the Mean were selected and the words falling beyond the limits were discarded either as "too easy" (for example "Khana-Peena" "Kam-Kaaj"(खाना-पीना, काम-काज) or "too difficult" (for example, "Jan-Shakti"(जन-शक्ति,) "Leepa-Poti(लीपा-पोती).

Out of those words falling near the Mean two lists of 80 words each were randomly by fish-bowl method (See Appendix-B - I and II) made by selecting words.

DISCUSSION

An exhaustive list of Hindi spondee words was prepared which included all the words from the lists given by earlier investigators. In addition to this other new words taken out of Magazines, Periodicals, Newspapers and Individuals was used in standardizing the familiarity of the spondee word list.

The subjects were selected in away that the sample represent the different strata of Hindi speaking people.

The words selected fulfill the basic purpose of the study providing sufficient number of spondee words (80) for the test which were not available earlier. In addition to this two lists were made of the familiarity words which are clinically very useful. The availability of an alternative list helps rule out the practice effect in testing.

The words selected provide appropriate and adequate material in terms of familiarity. The words being not too difficult that it clicits inprobable responses, on the other hand the list material is not "too simple" that it could be correctly guessed a high proportion of the time without being heard. Even in terms of redundancy it enjoys a moderate position.

The lists available in Hindi have many words, in them which are not spondee words in the true sense. For example,

"Sawdhan" "Chaaploos"(सावधान "चापलूस) are single words with unequal stress in them. These kind of words are avoided in the present list.

After the analysis it was found that the old lists had many of the high familiarity words for eg., "Maa-Baap" **"Fal-Phool"**(फल- फूल) **"Chup-Chaap"**(चुप-चाप)**etc.** There were also many of the low familiarity words such as "Nok-Jhonk" **"Tal-Tool"**(टाल - टूल) **"Lok-Laaj"**(लोक-लाज)**etc.** These words were excluded from the present list.

Finally when comfronted with a problem while testing using a particular word list and it becomes necessary to do the testing after a small gap of time then the second word list will be helpful. Even it can help in the cross-checking of the findings with the other list.

RECORDING

Generally the recording has to be done in such a way that (a) the spondee words from list A is to be recorded on the Channel-1 of the tape and spondee words from list B to be recorded on the channel-2 of the tape, to facilitate their presentation separately to the ears and (b) the second part of the spondee word from list A and the first part of the spondee word from list B to be overlapped to be heard in the two ears separately but at the same time.

Instruments

A four track stereophonic Magnetic spool Tape recorder with omnidirectional microphone (M534) and monitoring Headset (W760) with standard magnetic tape is to be used for preliminary recording. A stereo cassette deck with standard cassette can be used for final recording of test items of SSW and the materials for speech reception threshold (SRT) and speech discrimination tests.

Environment

The recording is to be carried out in a quiet, noise free room. Final dubbing of the test tape cassette is to be done in a sound proof room.

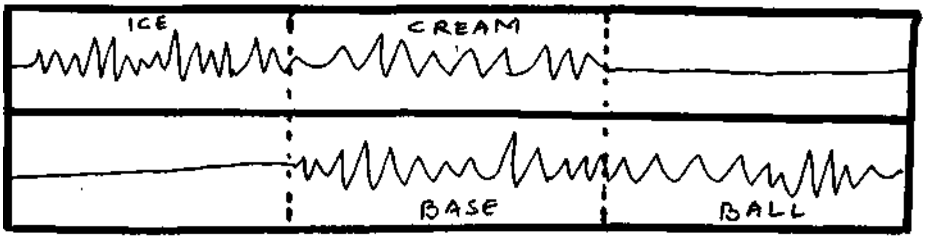
Speaker

All items of the test are to be spoken by a Hindi native speaker. His/her dialect in connected discourse should described as Hindi common to all the Hindi speaking population and region of India. He/she should be have an experience in the monitored live voice technique of speech audiometry as an audiologist.

Recording facility available in India with a computer

```
        7.5KHz LPF      12 bit ADL
                        16000Hz
       +----------+    +----------+   +----------+
      -+          |    |          |   |          |
 O     |  S.I.U   +----+  A.D.C.  +---+ COMPUTER |
      -+          |    |  D.A.C.  |   |          |
       +----------+    +----------+   +----------+
        Speech          Analog to     edit the speech
        interface       Digital       waveform
        unit            converter &
                        vice versa
```

The program which may be used for the recording is "Dichotic" (used at All Institute of Speech and Hearing, Mysore). The speech material is to be through a standard omni-directional microphone where the acoustical signal in converted into electrical signal. This will pass through the "speech interface unit" which preferably should have 7.5KHz low pass filter and the rejection rate of 36dB/octave. This electrical signal is digitized at the rate of 16000Hz by the analog to digital converter and then is again after digitizing is converted into analog wave form. Now the "Data O2CN" is fed to the computer and the wave form is edited as a dual beam wave form as shown in figure.



"x-Axis" indicating time

To facilitate the spondee words from list A list is to be recorded on Channel A of the tape and spondee word from list B is to be recorded on channel B of the tape for the presentation separately to the ears and

The second part of the spondee word from list A and the first part of the spondee word from list B is to be overlapped to be heard in the two ears separately but at the same time.

The time-sequencing of the presentation of the second part of the 1st spondee and 1st part of the second spondee words simultaneously can be done with the help of the Marker. The equal spacing of the words for their presentation in different ears can also be done with the help of marker. This is done by looking at the visual monitor displaying time scale on the X-axis and shifting the wave form by sampling out the time gap.

SUMMARY AND CONCLUSION

The science of hearing is highly indebted to speech audiometry for its assistance in identification, diagnosis and specification of site of lesion in hearing impairment. Differnt types of speech materials have been developed in recent times and speech tests have gained very important place in audiological evaluation.

The available speech materials, tests in English and other languages are not suitable for a large population that communicates through the language Hindi. Only a very small portion of the population follows English and other languages in which the tests for Central Auditory Dysfunctions (CAD) are available.

In India Abrol (1971) was the first person to develop speech materials in Hindi. Later Nagaraja (1972), Swarnalatha (1972) developed a Synthetic Sentence Identification test (SSI) in Kannada and speech materials in English for English speaking population in India respectively.

Kapur (1971) had introduced a word list in Tamil, but, it was considered inadequate because of its short comings in phonetic composition and lack of standardization.

De (1973) constructed another word list in Hindi and Dayalan (1976) developed a phonetically balanced word list in Tamil language which are worth mentioning. Nagaraja (1987) developed the staggered paired words test in Kannada for Central Auditory Testing.

Shivshankar (1988) developed a Competing Sentence Test in Kannada and Binaural Fusion Test in Kannada, Telegu and Hindi. Reliability and clinical validity of these tests are yet to be ascertained.

The present study was undertaken as a first step in an attempt to construct a test Staggered Spondiac Words test in Hindi for Central Auditory Testing.

This was done overcoming all the drawbacks of the previous list to provide a means to test people who follow only Hindi or whose proficiency in Hindi is greater than any other language.

For the construction of the Staggered Spondiac Words test one needs 80 spondee words and also two word list of 80 words each are preferable. The word list given earlier by Abrol (1971) and De (1973) did not have sufficient number of words for the construction of Staggered Spondiac Words test (SSW).

The present study was involved collection of spondee words and dealing with identification of familiarity of the spondee words.

The words were selected out of magazines, periodicals, newspapers, individuals etc and were distributed to 192 randomly selected subjects. The subjects included 79 females and 113 males. The subjects were selected considering the fact that it should represent each and every strata of population. The subjects graded the given words depending upon the familiarity of the word. By this way the words were arranged in decreasing order of familiarity after analysis.

After determining the mean and standard deviation the words which were "too easy" and Too difficult" were rejected. One hundread and sixty words were selected out of remaining words which were falling near the Mean randomly by "Fish-Bowl" method.

LIMITATIONS

1. The study used relatively a small population.
2. Only literates were the subjects.
3. Regional variations in the dialect of Hindi is not taken into account.

RECOMMENDATIONS

1) Further standardization of the material with people from other part of India in terms of linguistic variation.
2) Can be used for other speech Audiometric tests.
3) Recording and standardization of the word list with clinical population to developing the norms and include the Staggered Spondiac Words test (SSW) in the battery of test for Central Auditory Dysfunction in India.
4) Intensive development of the Staggered Spondiac Words (SSW) test in Hindi including precise recording and clinical trial may be done.

APPENDIX-A

PROFORMA USED IN RATING THE FAMILIARITY OF TEST WORDS

Sex: Age:

Education: Date:

Occupation:

Mother Tongue:

Sl. No.	Word	Most familiar	famil-iar	not very famil-iar	unfami-liar	Doubtful	Score

Please put a tick mark in the appropriate column.

1. घास - फूँस
2. लेन - देन
3. चार - आना
4. प्रात: - काल
5. गाजा - बाजा
6. धर्म - वीर
7. दूर - पास
8. सज - धज
9. सोम - वार
10. गीत - कार
11. राजा - रानी
12. छान - बीन
13. प्रेम - पत्र
14. चार - पाँच
15. ठंडा - गर्म
16. उल्टा - सीधा
17. काका - काकी
18. लोक - लाज
19. राम - नाम
20. बचा - खुचा
21. चाल - ढाल
22. खींच - तान
23. ऊपर - नीचे
24. तोड़ - फोड़
25. हार - जीत
26. छोटा - बड़ा
27. ठाठ - बाट
28. अच्छा - खासा
29. टेढ़ा - मेढ़ा
30. नेता - गण
31. भूल - चूक
32. चल - फिर
33. ऊँच - नीच
34. मत - दान
35. सूखा - गीला
36. राज - काज
37. हेर - फेर
38. दौड़ - धूप
39. देव - लोक
40. टूट - फूट

41. नर्म - गर्म
42. दान - पात्र
43. गीत - विधि
44. सुर - ताल
45. जन - संख्या
46. मुँह - माँगा
47. अगर - बत्ती
48. रहा - सहा
49. गाय - भैंस
50. खान - दान
51. प्रश्न - पत्र
52. गुन - गान
53. उल्टा - पुल्टा
54. चरण - स्पर्श
55. लैन - दैन
56. दाव - पेंच
57. डील - डौल
58. जोड़ - तोड़
59. तार - घर
60. पुत्र - हीन
61. पति - व्रता
62. दीप - माला
63. जन - हित
64. कार - बार
65. धूम - बत्ती
66. याद - गार
67. साव - धान
68. धन - मन
69. सूझ - बूझ
70. जली - कटी
71. ध्यान - बीन
72. घोड़ा - गाड़ी
73. आज - कल
74. नदी - नाला
75. चार - पाँच
76. देश - भक्त
77. सज - धज
78. सिर - पैर
79. छेड़ - छाँड़
80. चाचा - चाची

1. ठीक - ठाक
2. जन्म - तिथि
3. आगे - पीछे
4. रुपया - पैसा
5. छोटा - मोटा
6. अच्छा - बुरा
7. अच्छा - खासा
8. भीम - काय
9. दिन - रात
10. धूम - केतु
11. कहा - सुना
12. रंग - ढंग
13. गुल्ली - डंडा
14. चीर - फाड़
15. अस्त्र - शस्त्र
16. राम - नाम
17. जी - जान
18. धूप - छाँह
19. आव - भाव
20. धीरे - तेज़
21. नंगा - नाच
22. भला - चंगा
23. मत - भेद
24. द्वार - पाल
25. मेल - जोल
26. देश - द्रोह
27. डाक - खाना
28. आन - बान
29. थका - मांदा
30. पत - झड़
31. दया - माया
32. रात - भर
33. जन्म - दाता
34. धर्म - गुरू
35. पत्र - मित्र
36. पशु - धन
37. आना - कानी
38. पुत्र - वधु
39. गुम - नाम
40. कार - बार

41. छोटा - बाबू

42. रोक - टोक

43. साँठ - गाँठ

44. टाल - टूल

45. घंटा - घर

46. दिया - बत्ती

47. दीप - माला

48. बेटा - बेटी

49. धक्का - मुक्का

50. रंग - रेली

51. प्राण - दान

52. धूम - ताप

53. जली - कटी

54. सुख - दुःख

55. हल - चल

56. हार - जीत

57. आता - जाता

58. आस - पास

59. शोर - गुल

60. सच - मुच

61. लाल - पीला

62. माप - तौल

63. खट्टा-मीठा

64. छूत - छात

65. कटी - पतंग

66. दस - बीस

67. तन - मन

68. बेटा - बेटी

69. यहाँ - वहाँ

70. अन्न - दाता

71. घूम - फिर

72. देख - रेख

73. काम - काज

74. ताप - घर

75. पाठ - शाला

76. हँसी - खुशी

77. खेल - कूद

78. घट - बढ़

79. नोट - बुक

80. सज - धज

BIBLIOGRAPHY

ABROL B.M. (1971): Establishment of Pilot Rehabilitation unit in Audiology and Speech Pathology in India, Final Report, All India Institute of Medical Science New Delhi.

American Speech Language and Hearing Association (1982) Joint committee on infant hearing statement, ASHA, 24, 1071-1018.

ARNST D, & KATZ.J (1982): Central Auditory Assessment; the Staggered Spondiac Word test, San Diego: College Hill Press, New York.

AZZI, AZZO (1964): Clinical application of binaural audiometry, International Audiology, 3, 197-205.

BALAS, R.F. and SIMON G.R. (1964): The articulation function of Staggered Spondiac Word list from a normal hearing population. Journal of Auditory Research, 4, 285-289.

BALAS, R (1971): Staggered Spondiac Word test; support; annals of Oto-Rhino-Laryngology, Vol.18, 134-19.

BARR, D (1972): Auditory perceptual disorders spring field. 11. Charles C Thomas.

BEASELY D, & RINTELMANN A (1979): Central Auditory Processing. In Rintelmann W (Ed), Hearing assessment Baltimore, University Park Press, 321-349.

BEASELY D & FREEMAN B (1977): Time-Altered speech as a measure of central auditory processing. In Keith (Ed), Central Auditory Dysfunction, Grune and Stratton, 129-173, New York.

BERGER K (1969): A speech discrimination task using multiple choise key word instances: Journal of Auditory Research, 3, 247-262.

BERLIN, C, CHASE R., RILL A AND HAGEPANOS T (1965): Auditory findings in patients with temporal lobectomies, American Speech and Hearing Association, 7, 386.

BERLIN C. & LOWE S (1972): Temporal and Dichotic factors in central auditory testing. In Katz J (Ed), Hand book of Clinical Audiology (ed-1) Baltimore, Williams and Wilkims, 280-312.

BLACK JOHN W. (1952): Accompaniments of word intelligibility. Journal of Speech and Hearing Disorders, 17, 409-417.

BLACK J.W. (1957): Multiple choice intelligibility tests. Journal of Speech and Hearing Disorders, 22, 213-235.

BOCCA, E AND CALEARO E (1963): Central Hearing Processes. In James Jerger (Ed), Modern Development in Audiology, Academic Press, New york.

BRUNT, M.A. (1972): The Staggered Spondiac Word test in J.Katz (Ed), Hand book of Clinical Audiology, Williams and Wilkins, Company, Baltimore,

CALEARO, C (1962): Binaural tests; periodically switched speech. International Audiology, 1, 212-217.

CARHART R. & TILLMAN (1970): Interaction of Competing Speech Signals with hearing losses. Archives of Otolaryngology, 91, 273.

CARHART R, (1965): Monoaural and Binaural Integration against Competing Sentences. International Audiology, 3, 5.

DAYALAN, J.S. (1976): Development and Standardization of Phonetically Balanced Test Materials in Tamil Language. Unpublished Master's Dissertation, University of Mysore.

DE QUIROS, J.B. (1964): Acclerated Speech Audiometry; An Examination of Test Results. Translations of the Biltone Institute for Hearing Research No.17, June.

FELDMAN H. (1962): Binaural hearing, International Audiology, 1, 222-223.

GROEN J & HALLEME A. (1963): On the diagnosis of Central Deafness in children. International Audiology, 2, 103-107.

HIRSH I et al (1952): Development of materials for speech audiometry. Journal of Speech and Hearing Disorders, 17, 321.

HIRSH I. (1952): Measurement of Hearing McGraw - Hill Book Company Inc. New York.

JERGER J. & JERGER S. (1956): Extra and Intra axial brainstem auditory disorders, Audiology, 14, 93-117.

JERGER J. (1973): Modern development in audiology (Ed), Academic Press, New York.

JERGER J. & JERGER S. (1974): Auditory findings in brainstem disorders, Archives of Otolaryngology 99, 342-350.

JERGER J. & JERGER S. (1975a): Clinical validity of Central Auditory Test, Scandinavian Audiology, 4, 147-163.

JERGER J. (1960): Audiological manifestation lesions in the auditory nervous system. Laryngoscops, 70, 417-425.

KATZ, J & PACK G. (1975): New development of differential diagnosis using Staggered Spondiac Word test. In N Sullivan (Ed), Central Auditory Processing Disorders. Omaha, University of Nebraska, 85-107.

KATZ, J (1978a): Clinical use of Central Auditory Test. In Katz J. (Ed), Hand book of Clinical Audiology (ed-2) Baltimore, Milliams and Wilkins, 233-240.

KATZ, J. (1970): Audiologic diagnosis; Cochlea to cortex, Memorah Medical Journal, 1, 25-28.

KATZ, J., BASIL R.A. & SMITH J.M. (1963): Staggered Spondiac Word test to detect central auditory lesions, Annals, Otol. 72, 980-918.

KATZ, J. (1968): The staggered Spondiac Word test. An interim report. Journal of Speech and Hearing Disorders, 33, 132-146.

KATZ, J. (1962): The Staggered Spondiac Word test for assessing the intergrity of the central auditory nervous system. Journal of Auditory Research, 2, 327-337.

LYNN & GILROY (1972): Neuroaudiological abnormality in patients with temporal lobe tumor; Journal of Neurological Science, Vol.17, 167-184.

MATKIN NOEL D & OLSEN W. (1971): Differential audiometry; detection of central auditory disorders. In Darrel E Rose (Ed), Audiological Assessment, Prentice Hall Inc., Englewood, Cliffs, New Jersey.

MUSIEK F.E. & BARAN J.A. (1987): Central Auditory Assessment; Thirty years of challenge and change. Ear and Hearing, Vol.8, No.4, Williams and Wilkins Co, New York.

NAGARAJA M.N. (1987): Staggered Paired Word Test in Kannada, Doctoral Thesis, Bangalore University, Bangalore, India.

SHIVASHANKAR N. (1988): Central Auditory evaluation in post-traumatic syndrome. Doctoral Thesis, Bangalore University, India.

SWARNALATHA (1972): The development and standarization of speech material in English, for Indian, Unpublished Master's Thesis, University of Mysore.

TURNER L. (1966): A normative study on the SSW test for various age group, Unpublished Master's Thesis, University of Kansas.

WILLEFORD. J. & BURLEIGH J. (1978); Auditory perception in children with learning disability. In Katz (Ed), Handbook of Clinical Audiology, (ed-3) Baltimore, Williams and Wilkins, 410-425.

WILLEFORD, J.A. & BURLEIGH, J. (1985); Handbook of central auditory processing disorders, in children. Grune and Stratton, New York.