SPEECH IDENTIFICATION IN CHILDREN: A COMPARISON BETWEEN COMPUTER AND CD PRESENTATION

(REGISTER NO. M0117)

An Independent Project submitted in part fulfillment of the first year
M.Sc (Speech and Hearing), University of Mysore, Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
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Certificate

This is to certify that the Independent Project entitled "SPEECH IDENTIFICATION IN CHILDREN: A COMPARISON BETWEEN COMPUTER AND CD PRESENTATION" is a bonafide work done in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No. M 0117).

Mysore

May, 2002

Director
All India Institute of
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Certificate

This is to certify that the Independent Project entitled "SPEECH IDENTIFICATION IN CHILDREN: A COMPARISON BETWEEN COMPUTER AND CD PRESENTATION" has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

GUIDE

Mysore

May, 2002

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Declaration

This independent project entitled "SPEECH IDENTIFICATION IN CHILDREN: A COMPARISON BETWEEN COMPUTER AND CD PRESENTATION" is the result of my own study under the guidance of Dr. Asha Yathiraj, Reader 8s Head, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any other University for the award of any Diploma or Degree.

Mysore Register No. M 0117

May, 2002

Dedicated to

The Divine Grace

&

My Parents

t̪wame:va mat̪a: čapit̪a t̪wame:va

t̪wame:va band^{h}u ča sak^{h}a: t̪wame:va

t̪wame:va vidya: dravinam t̪wame:va

t̪wame:va sarvam mama deva deva

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*"**Children** are the most wholesome part of our race, the sweetest for they are the freshest from the hands of God. Whimsical, ingenious, mischievous, they fill the earth with joy and humour.... "*

Thanx to all the cute buddies, their parents and teachers, without whom this study would not have been possible.

I take this opportunity to express my sincere gratitude to ***all my teachers*** *for all the knowledge and a promising career......*

Yeh ***Chandni*** *— we 've done it!*

The fun and the fear,

The laughter and the tear,

Will I remember.....Thanx yaar.....

Vimi - *Thanx for accepting me as I am!*

Chays - *U have been a supporting pillar (not that of ooc!) to me. A thanx would not be enough....*

Dels — I *'discovered' a friend in U!*

Mili - *The differences still keep us going..... I know we've shared some special moments together!*

Vavaoka *— glad we are friends.*

Komal - *Glad that our paths crossed. Simply adore U......*

Sethu *- Enjoy every moment with U inspite of the respiratory distress that U cause!!*

Jayash *&* ***Gupta*** *- Thanx for the timely help.*

Hey **smarty** *- You are a wonderful koti! U mean a lot and so does U'r friendship!*

Ranga *- My neighbour and friend - will remember the trouble U put me into (by laughing of course!)*

Gopi — U'r readiness to help has brought me a long way. Thanx!

My **B.Sc friends** *('98-2000) - I haven't forgotten U guys. . . . .Miss the fun we had together......*

Kiru *&* ***Anita*** *— U'r timely advices have helped me lots. Thanks!*

Appa *&* ***Amma*** *- words cannot suffice what you mean to me. 1 owe you for what I am today!*

Gokul— *Ur critics and views have inspired me a lot.....*

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To all **the sung and the unsung Samaritans,** *thanx a lot for helping me in U'r own little ways....*

I thank the **almighty** *for giving me the strength throughout this project.*

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INTRODUCTION

Audiologic tests using speech stimuli are essential in the evaluation of patients with hearing and communication problems because speech represents the class of sounds most important to effective daily function. Results from routine pure tone tests often do not reflect either the potential or limitations in receptive auditory communication of adults and children with hearing losses (Martin, 1987).

Speech audiometry offers a means to assess an individual's auditory perception of speech in a quasi systematic manner (Olsen and Matkin, 1979). Speech audiometric measures are used routinely in an audiologic evaluation and contribute in a number of important ways. Stach (1998) listed these contributions as

- measurement of threshold for speech
- cross-check of pure tone sensitivity
- quantification of supra threshold speech recognition ability
- assistance in differential diagnosis
- assessment of central auditory processing ability
- estimation of communication function.

Mendel and Danhauver (1997) noted several other uses of speech perception tests. They are: (a) to provide a measure of how well listeners understand speech, (b) to reflect the degree of communication handicap created by

Hearing loss, (c) to provide information for planning and managing auditory (re)habilitation, (d) to monitor listeners performance through the therapeutic Process, (e) to assess the success of different types of medical and surgical treatments, (f) to monitor subject's performance in research paradigms, (g) to classify the degree and type of hearing loss, (h) to be used as a baseline measure For other test procedures and (i) to be used in various forms for research.

The assessment of a young child's ability to understand speech is an essential feature of a comprehensive audio logic evaluation. Speech testing in children is an area that has yet to be fully developed, although research is underway to rectify this situation (Martin, 1987).

Many children are too shy to speak in the test room environment, and articulation problems are common in children. Hence, it may be difficult for the Audiologist to assess speech perception abilities in children as done with adults. The most practical method of testing speech perception in children has been to use some form of picture identification task.

While administering such a task, clinicians must consider several variables. These variables include vocabulary and language competency, chronological age, Cognitive abilities and extrinsic variables like appropriate response task, utilization of enforcement, certain methodological variables such as open versus closed set tests and tape recorded versus monitored live voice presentation (Mendel and Danhauer, 1997).

There are considerable advantages in using recorded speech rather than live voice for audiometric purposes. Some of them include standardized composition of words, standardized presentation and test retest reliability (Rupp, 1980).

The practicing audiologist can also identify advantages for monitored live voice presentation as more flexible pacing to a subject's speed of response, flexibility in choice of words necessary because of severe identification problems, natural use of language other than English, elimination of concern over possible wear on the disc or tapes that might introduce distortion in signal and noise into the test system (Rupp, 1980). However, the American Speech Language and Hearing Association Guidelines (1988, cited in Silman & Silverman, 1991) suggest that recorded presentation of test material is the preferred procedure. Recorded speech material can be presented through a tape recorder or a computer.

For many years, the different speech materials for diagnostic and scientific purposes have been available on analog tapes. Often when testing speech intelligibility, play back of the test stimuli from analog tapes cause troublesome measurements. Since analog components are quite sensitive to ambient conditions, complete control of the set-up, including calibration of signal to do so, can lead to unreliable results. Unfavorable conditions can also arise from magnetic smudging of the tape head, which results in high frequency attenuation of the test signals and with time, the sound quality from analog tape may be impaired by copy effects and the like. Furthermore, if experiments are repeated, it is only possible to change the order of presentation by recording the test stimuli on tape, in different orders. It is also difficult to arrange adaptive presentation of test in a simple way (Keidser, 1991). However, the above disadvantages can be averted through digitized recording.

Speech recognition materials have been digitized and stored in hard drive of the computer. Words can be played in sequence with the user selectable time delay between presentation and any test item could be presented at random by clicking on the word. Standardized recorded speech stimuli can be presented with flexibility of live voice (Newby and Popelka, 1992).

Since digitized material can be presented through compact disc (CD) player and a computer, it is essential for a practicing audiologist to know which is better. The aim of the study is to compare the speech identification scores obtained by presenting Kannada speech material through a CD player and computer while testing children. In addition the effect of presentation level, age and interstimulus interval on speech identification scores will also be studied.

Need for the study

1) It is essential to know if there are any differences in test results while using computerized speech material when compared to presenting the stimuli through CD.

2) In the literature, there is hardly any information regarding the comparison between computerized speech material and CD material. If there are no differences between CD and computerized material, either of them can be utilized in a clinical set-up. If there is a difference, depending on which presentation mode is better, it would be recommended that the audiologists' use that particular method in their clinical set-up.

3) Currently there has been no study utilizing computerized speech tests for Indian languages for regular clinical purpose. Hence it is essential to do so.

REVIEW

Speech audiometry is an important element in a complete audiological evaluation. Martin (1987) gave a number of useful and valuable functions of speech audiometry. They include determination of degree of hearing handicap, type of hearing disorder, general site of pathology including auditory processing difficulties. Speech audiometry is also an aid in determining the type of rehabilitative measures needed and their prognoses. In addition, it is an aid in verifying the reliability of pure tone test results.

SPEECH TESTS FOR PAEDIATRIC POPULATION

Speech signals are obvious selections as stimuli for the assessment of hearing sensitivity in children. There is evidence that speech items were in use as early as 1883 (Meyerson, 1956) to determine hearing thresholds. It was pointed out that an important reason for performing speech audiometry with children is that speech items have a higher face validity (Bunch, 1934, cited in Martin, 1987). Children pay closer attention to verbal than to non-verbal stimuli (Hardy and Bordley, 1951). This fact increases the probability of accurate responses from children whose language skills allow the use of speech as test stimuli.

Mentally retarded children show an arousal to speech stimuli at significantly lower intensities than they do to pure tones (Clawson, 1966, cited in

Martin, 1987). Children find speech tests easier and less abstract than pure tone tests and are willing to participate in the former (Olsen and Matkin, 1979).

Measurement made during speech audiometry includes tests for threshold estimation and suprathreshold function. Threshold assessment provides only an indicator of the sensitivity of hearing. Suprathreshold measures provide an indicator of how the auditory system deals with sound at higher intensity levels (Stach, 1998). The most common suprathreshold measure in an audiologic evaluation is that of speech identification. Various other terms have been used analogously with speech identification. These include recognition, articulation, discrimination, intelligibility, understanding and perception (Penrod, 1972).

Speech identification is important for at least two reasons. The first reason being that it provides an estimate of how well a person will hear speech at supra-threshold levels, thereby providing one of the first estimates of how much a person with a hearing loss might benefit from a hearing device. It is also important as a screen for retrocochlear disorders (Stach, 1998).

There are many tests for the evaluation of speech intelligibility in children (Ross and Lerman, 1970; Elliot and Katz, 1980; Moog and Geers, 1990). Some of them have been developed for the Indian population (Abrol, 1970; Kapur, 1971, cited in Nagaraja, 1990; Swarnalatha, 1972; Mayadevi, 1974; Samuel, 1976; Mathew, 1996; Rout, 1996; Vandana, 1998; Prakash, 1999 and Raashida, 2000).

Clinicians concerned with assessing children must consider several variables that can influence test outcomes and affect the reliability and validity of paediatric speech perception procedures.

From the review of literature, the variables that affect speech identification scores can be classified as those related to the speech stimuli, recording of the stimuli, presentation and response strategies.

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I. VARIABILITY OF SPEECH STIMULI

(a) TYPES OF SPEECH STIMULI

A wide variety of speech materials have been employed in the construction of speech tests. These have included nonsense syllables, phonemically balanced monosyllable words, bi-syllable words (including both spondaic and unselected stress patterns), sentences and continued discourse (Fletcher and Steinberg, 1929, cited in Jamielson, 1972).

Nott'Sense syllable

Nonsense syllables can be used to test speech identification ability. The advantage of use of nonsense syllables is that they are non-redundant (Carhart, 1965) and are easier to construct (Egan, 1948). They also eliminate the linguistic cues that contaminate the test performance and are independent of listener's vocabulary (Berger, 1971).

The disadvantage is that they are unfamiliar to children and confusing to the listener (Carhart, 1965). Hence, nonsense syllables are usually not used with children.

Monosyllabic words

Monosyllabic words are less analytic unit of speech and are more easily repeated than nonsense syllables (Egan, 1948). They are preferred because they are non-redundant and are meaningful, not as confusing as nonsense syllables (Carhart, 1965). Tobias (1964) stated that monosyllabic words are useful in that they are a specific form of speech because they are a good representation of everyday conversational speech.

A number of monosyllabic word list have been developed for paediatric population. The popular ones are: the Phonetically Balanced Kindergarten 50 (PBK 50) (Haskins, 1949), Word Intelligibility Picture Identification Test (WIPI) (Ross and Lerman, 1970), the North Western University Children's Perception of Speech (NU-CHIP) (Elliot and Katz, 1980). In India, a monosyllabic word list for children in English was developed by Rout in 1996. The other Indian authors who used monosyllables as their stimuli are Swarnalatha (1972) and Raashida (2000). Prakash (1999) developed a monosyllabic word list for children in Tamil.

Bisyllabic words

The development of bisyllabic list for speech identification testing is mainly due to language restriction. Some languages do not have concrete monosyllabic words, thus making it necessary to use bisyllabic words.

They are less analytic than monosyllables and provide additional cues for intelligibility (Hirsh, 1952).

There are various speech identification tests using trisyllabic words as stimulus material, such as, Children's Spanish Word Discrimination Test (Comstock & Martin, 1984), Glendonold Auditory Screening Procedure (Erber, 1982); PLOTT test (Plant, 1984); Early Speech Perception (ESP) (Moog & Geers, 1990); Speech Perception Test in Tamil and Telugu (Kapur, 1971); Disyllabic test in Malayalam (Kapur, 1971); A Picture Test of Speech Perception in Malayalam (Mathew, 1996); Speech Identification Test for Kannada speaking children (Vandana, 1998).

Sentences

Sentences are considered to be more valid indicators of intelligibility. The relation between word lists used in measurement of intelligibility and the continuous flow of words encountered in conversations is not clear. They somehow do not typically assess word recognition. Even though sentences represent the spoken communication, they are not frequently used, because of the difficulty involved in the construction of such tests (Penrod, 1972).

The sentence tests constructed for the paediatric population are as follows: The Paediatric Speech Intelligibility Test (PS1) (Jerger and Jerger, 1980); The Bench Kowal and Banford Sentence List (Bench, Kowal and Banford, 1979); A Sentence Test for measuring Speech Discrimination in Children (Weber and Redell, 1976); Synthetic Speech Identification test in Kananda (Nagaraja (1977); The Common Objects Token Test: A sentence test for profoundly hearing-impaired children (Plant and Moore, 1992).

Thus, while evaluating the paediatric population, the age, language level and the purpose of testing should be considered while selecting the test stimuli to be administered.

(b) CALIBRATION OF SPEECH STIMULI

The importance of calibration as a means of specifying the physical properties of the stimulus and evaluating the stability of test instrumentation used in auditory assessment is well established. Implementation of a comprehensive calibration procedure for use in speech audiometry requires that the clinician (1) understands the need for specification of the speech signal, and related instrumentation in the test environment, (2) adheres to the current standards and (3) develops uniform and functional clinical calibration procedure to ensure the accuracy of speech test results and transfer of clinical information between facilities (Tucci, Ruth and Schoeny, 1978).

Calibration of complex signals requires a different calibration procedure than that used for pure tone testing. As speech is a dynamic signal that results in difficulty determining a precise level, a 1 KHz tone is used to set the audiometer level so that the output from the earphone is 20 dB above the hearing level dial value for a TDH-50 earphone. When recorded materials are produced, a calibration tone precedes the stimuli. Otherwise, examiners will be unsure of exactly what decibel level is being used during stimulus presentation. The calibration tone should be set to beat at zero on the v-u meter (ANSI, 1996, cited in Thibodeau, 2000).

When calibrating the sound field-testing, many factors that must be accounted for. These include distance from the speaker; azimuth; ear canal resonance; head shadow; and standing waves (ASHA, 1991, cited in Thibodeau, 2000). Though the threshold for speech will be lower in the sound field than under phones on account of the advantages of ear canal acoustics, the calibration values are such that the sound field and earphone testing are equated (Thibodeau, 2000).

(c) WORD FAMILIARITY

Various authors have indicated that word familiarity is an important variable in speech identification testing (Hutton and Weaver, 1959; Owens, 1961; Carhart, 1965). According to these authors, it is the responsibility of the audiologist to select materials that are linguistically appropriate for the patient. The use of items that are not in the vocabulary can result in low scores leading to unnecessary testing, misdiagnosis or mismanagement.

Egan (1957) noted that the correlation between intelligibility and familiarity decreases with practice and that these tests are not intended for delivery to naive listeners. Several researchers found that lists characterized by greater familiarity are significantly more intelligible than those that are less familiar (Owens, 1961; Peterson and Lehiste, 1962; and Schultz, 1964). Devaraj (1983) has reported similar findings in India.

In closed-set tasks, careful consideration must be taken in determining the kind of response foils used. That is, particular response foils may be unfamiliar to the subject or may appear as unrealistic options for the stimulus, and will not be chosen as the response (Mendel and Danhauer, 1997).

Myklebust (1964) reported that children who have a profound hearing loss since birth will usually have a much narrower vocabulary than normal children of their own age. Thus, the familiarity of a word needs to be viewed in the context of the people to whom test is to be administered.

Owens (1961) reported that a person with high intelligence and superior verbal ability would find more test words familiar and can take advantage of available phonetic cues resulting in higher identification score than a person with lower level of intelligence and low verbal ability.

Stimulus familiarity is a function of the number of stimulus items in the test. Licklider and Miller (1965, cited in Mendel and Danhauer, 1997) reported that as the number of stimuli decreases, the amount of familiarity or practice effect increases. Thus, it is important that a sufficient number of stimulus items be used for each test. That is, when testing involves multiple presentations of stimuli to the same patient, it is necessary to have an adequate reserve of equivalent forms and lists of the test to avoid familiarity and practice effects. The more stimuli and alternative test forms used, the less is the effect of familiarity.

In general, most authors agreed that the test item should be familiar to the target population. The test items should be appropriate to the age of the child. In addition, the test items should be selected based on the verbal abilities of the child.

(d) LIST LENGTH

The number of item is the primary determinant of test reliability and is thus one most important characteristics of speech test (Dillion and Ching, 1995). Having large number of items may create problem while testing young children with short attention span. For this reason, many tests have been designed with a small number of items, twenty or less (Thorton and RalTin, 1980). The interest in using less lengthy list is based on saving time and decreasing the fatigue of the listener and tester (Stockdell, 1980).

Grubbs (1963) pointed out the reliability in the use of half-lists of 25-words to determine the discrimination ability of the patient. It was considered, however, that if a 25-word list could be derived that correlated highly with the original phonetically balanced list, and assuming it was sufficiently reliable, there should be no objection to its use since it would be producing an accurate estimate of the results that would have been obtained from the original full lists (Deutsch, Lawrence and Kruger, 1971).

If one is to derive two shorter lists from a longer list of test items, it is more reasonable to do so on the basis of item analyses of the words within the list than to divide a list arbitrarily half way point, or an even-odd numbered item basis. Runge, Hosford-Dunn (1985) recommended using lists that are rank ordered by difficulty and terminating testing after 10 words if no error occurs or after 25 words if there are no more than four errors.

Beattie, Shihovec and Edgerton (1978) suggested that half-list testing could be an effective screening procedure to determine if full list testing is advisable. Speech discrimination scores obtained from half-list and full list speech stimuli were analyzed for both taped and monitored live voice (MLV) presentation modes. The analysis showed that both MLV and taped stimuli exhibited very similar variability and 96% of the half-list scores were within 6% of full list scores.

Raffin and Thornton (1980) observed that half-list or full list variability is dependent on the severity of intelligibility impairment. The test construction is affected by the limited language abilities of the hearing-impaired children, the restricted word knowledge of children with profound hearing-impaired, especially if the items must be picturized to elicit a response from the child (Osberger, 1995).

Campanelli (1962) and Rintelmann (1974) observed good agreement between scores for the two 25-word lists and between half-list and full list scores.

Similar findings have been reported by Mathew (1996), Rout (1996), Vandana (1998) and Prakash (1999), who have constructed speech identification tests for children. They had used half-lists. Each half-list was phonemically balanced and had a familiarity that was similar to the full lists. These investigators have suggested to use half-list while testing children as the test results are similar with half-list and full list administration.

There are many tests available for children with varied number of items ranging from five [Auditory Number Test, Erber. (1980); Mc Cormick Toy Test, Mc Cormick (1977)] to as many as fifty [North-Western University Children's Perception of Speech (NU CHIPS), Elliot and Katz, 1980)].

From the above studies, it can be concluded that in children, number of items should be less to retain the attention span and at the same time should be valid.

(d) USE OF BACKGROUND NOISE OR SPEECH COMPETITION

In many clinical and research situations, some type of background noise is used in competition with speech perception test materials. This noise may be presented in various forms such as white, speech or environmental noise, speech babble of a number of talkers, or background competition of a single talker. Both audiotape and CD recordings of various types of noises are now available commercially. The type of masking noise has been shown to affect the performance in word recognition testing (Lovrinic, Bungi and Curry, 1968; Wiliams and Herker, 1968; Garslecki and Mulac, 1974). Cohen and Keith (1976) demonstrated low pass filter noise mixed with monosyllabic words sharply diminished the word recognition scores for their sensori-neural hearing loss subjects as compared to the diminution in performance experienced by their normal hearing control subjects.

Generally, background noise is used because speech communication in every day listening situations most commonly takes place against a background competition. Secondly, noise is used because it tends to make the test more difficult. Many investigators content that the presentation of speech perception test materials against a background of noise enhances the sensitivity of the test in detecting and demonstrating communication difficulties experienced by individuals who are hearing-impaired (Cohen and Keith, 1976; Lovrinic, Bungi and Curry, 1968). These investigators report that a markedly greater decrease in scores is found for listeners who are hearing-impaired when a test is presented in some type of noise background. Other researchers have reported that it is not necessary that the addition of noise make a given test more diagnostically useful when compared to a quiet situation. Danhauer, Doyle and Lucks (1985, 1986) reported that often noise can add considerable confusion to results without solving the problem of test sensitivity. They recommended the consideration of materials such as nonsense syllable stimuli that may be sufficiently diagnostically sensitive even in quiet, without the need for additional noise to be added.

Several factors must be considered when using noise with speech tests. These variables include presentation levels; signal-to-noise ratios; presentation methods, such as ipsilateral versus contralateral, or earphone (supra-aural or insert) versus loudspeaker; and selection of noise type (Mendel and Danhauer, 1997).

Most testing procedures have not been standardized for use in noise, and therefore, the addition of noise places several uncontrollable variables on the test situation. Until some standardized masking procedures have been established, the clinical value of the results obtained should be questioned.

II. VARIABLES TO BE CONSIDERED WHILE RECORDING

(a) SPEAKER VARIABILITY

An important factor to be considered in relation to speech material is the speaker. In many ways, this is the most difficult to deal with, as it is unquantifiable. It is a serious impediment to standardization in that a listener may obtain different scores if the same list is read by two different speakers (Asher, 1958, cited in Martin, 1987). Probably the best-known example of this is the two different recordings of the PB-50 list by Rush-Hughes and Hirsh respectively. Not only do these two recordings give significantly different scores for normal listeners (difference of 10-20%), but also this difference is increased for listeners with sensori-neural hearing loss (Carhart, 1965).

Male versus female speaker:

Male and female voices are sufficiently different to cause differences in intelligibility scores for the same material and listener and as one might expect, such differences are aggravated if the speech signal is low-pass filtered before presentation (Hirsh, Reynolds and Joseph, 1954).

According to Joseph (1983), with the female talker, the speech identification scores are better than the male talkers. This difference on account of speakers should be considered while using the recorded stimuli.

Speaker familiarization:

It has been suggested that there is an element of familiarization on score differences due to different speakers; in other words, there is a 'tuning-in' period during which one may get accustomed to the peculiarities of a particular voice. A difference has been found where scores obtained with lists read by the same person throughout are compared with scores from lists where each word was read by a different speaker (Creelman, 1957).

Listeners recognize familiar voices well, but not perfectly (Ladefoged and Ladefoged, 1980, cited in Kreiman, 1997).

Effect of native language, accent and tone of voice:

There would be a difference in speech identification scores if the speaker and listener have vastly different dialects. There are ways of overcoming such difficulties. This is achieved by recording the material in a 'dialect' typical of broadcasting speakers.

Saslove and Yarmey (1980, cited in Kreiman, 1997) found that changing the emotional tone of utterance appears to have drastic effects on speaker recognizability. They found that when listeners heard a hostile voice but were asked to recognize it from a neutral sample, recognition was at chance.

Even a single speaker will not articulate words in precisely the same way on different occasions. Scores obtained by the same listeners, lists and speakers, but on different occasions, yield differences up to 10% (Brandy, 1966).

Hence, while recording the stimuli, the audiologist has to keep in mind the variables related to the speaker.

(b) QUALITY OF RECORDINGS

For tests that have adequate standardization information, these data are typically provided for a particular recording of the test. Many tests are now produced and commercially distributed by companies. In some cases, these companies may rerecord the test items for any particular test. Unless additional standardization of data are provided with these recordings, the tests may again be altered enough to make these rerecorded versions different from the original unless comparison data are provided to prove otherwise (Mendel and Danhauer, 1997).

In addition to the recording of test stimuli, caution also should be exerted regarding the quality of commercially produced tapes. Tn the past, many tapes have exhibited cross talk, echoing of the stimuli, and unacceptable levels of tape noise between stimulus presentations. Obviously high quality tape recordings are preferred. Today, many of the word lists are being rerecorded onto CDs to improve the quality of test tapes, and some audiometers and computer programs actually produce digitized versions of various speech signals that are stored in the system or generated on-line. These forms of stimuli are state-of-the-art and offer considerable variety and the flexibility over traditional disc and tape recordings. The fact that they can be digitized from almost any analog source, however, means that a different talker or type of background noise could be used for different presentations, and again, comparison data should be provided to show that no significant differences in test scores exist between these new recordings and the original analog tapes. Otherwise, similar comments made about monitored live voice testing also would be true for these stimuli produced using advanced technology (Mendel and Danhauer, 1997).

III. VARIABLES TO BE CONSIDERED DURING PRESENTATION

(a) ROOM ACOUSTICS

Speech intelligibility in rooms is influenced by i) the level of speech, ii) room reverberation and iii) background noise. The listener's task is to decode speech from such composite sounds. In order to maintain high intelligibility, the reverberation time in rooms with considerable noise levels should be shorter than the reverberation time in quiet places and should not exceed 0.8 seconds for normal hearing listeners (Nabelek and

Nabelek and Pickett (1974) studied the influence of noise and reverberation on binaural and monaural speech discrimination through hearing aids. They reported a binaural advantage of 3 dB for the normal listeners and L:5 dB for the hearing-impaired group, which was independent of reverberation time.

According to Rupp (1980), manufacturers and/or installers of new sound rooms should assure purchasers that the rooms meet the ambient noise restriction, both by specifications and by post-installation measurement. Rooms that have been in use for several years should undergo calibration review to ensure that the rooms meet 'Criteria for Permissible Ambient Noise during Audiometric Testing' by ANSI (1991, citedin abelek and Nabelek,1994)

Acoustical environment in classrooms can affect the achievement and performance of the hearing-impaired children. Speech recognition scores decreased in noise for both the normal hearing and hearing-impaired listeners, but there were two differences of practical importance between them. First, the impaired listeners' performance was adversely affected at signal to noise ratios and reverberation values, which did not alter the speech perception of normal hearing listeners. Second, since the hearing-impaired listeners performed more poorly than the normal hearing listeners, their scores became unacceptably low under more adverse listening conditions (Finitzo-Hieber and Tillman, 1978).

Gengel (1974) found that children having a moderate to severe sensori-neural hearing loss required a S/N ratio of at least +10 dB and preferably +20 dB to function effectively. Thus, the noise level should not be more than 40 dB on the C scale or 30 dBA, presuming that the average speech level at a distance of 3 feet to 15 feet would be 60 dB SPL. People with normal hearing require an S/N ratio of +60 dB for the reception of intelligible speech.

Room acoustics thus have a significant impact on speech communication. The listening conditions in both small and large rooms can be very good for normal listeners but might not be sufficiently good for special listeners (Nabelek and Pickett, 1974).

Testing should be done in acoustically treated rooms, which meet the standards of ambient noise level.

(b) INSTRUCTION

Researchers (Markides, 1979 and Eisenberg, Berlin, Dill and Frank, 1966) have reported that instruction given to listener made a difference on speech identification score. Markides (1979) used two modes of instructions. In the first mode, children were asked to listen carefully and to repeat each word. In the second mode, they were encouraged to speak whatever they heard. His results showed improvement in scores with instruction than without instructions.

In organizing the patient to the listening task, the ASHA "Guidelines" (1979, cited in Rupp, 1980) identify the following components in an instructional set:

1) Orient the client to the nature of the task
2) Specify the client's mode of response
3) Indicate that test material is speech material
4) Stress the need... to respond at faint listening levels and encourage the client to guess.

An efficient speech test must have appropriate verbal instruction for obtaining correct responses. The instruction should be simple and comprehendible.

(c) CARRIER PHRASE

The use or non-use of a carrier phrase preceding the test item is a variable in speech identification testing. The carrier phrases are used not only to alert the listener to the upcoming word but also to assist the talker in monitoring the presentation level of the stimulus (Carhart, 1952).

Nothern and *Hattler* (1974) found that when a carrier phrase was omitted, identification scores were worse. They found greater chances of better identification with a carrier phrase. The use of a carrier phrase especially improves the speech identification score in subjects with sloping audiometric contours.

Gladstone and Siegenthaler (1972) used three carrier phrases "say the word....", "you will say......", "point to the........" for CID W-22 word lists. It was found that there was an enhancement of identification score with the carrier phrase.

Gelfand (1975) used CID W-22 word list on twenty-two to sixty-six year old adults. He found the identification scores were five percentage points higher when a carrier phrase was included.

Martin, et al., (1962) and Gelfand (1975) reported that about half of the sensori-neural hearing loss subjects preferred that the carrier phrase precede the test word; most of them were normal subjects and those with conductive hearing loss did not.

Martin, Hawkins, and Bailey (1962) raised the question of whether a carrier phrase is essential for speech identification testing. They found that the test scores were the same with and without the carrier phrase.

Me Lennan and Knox (1975) too found no difference in word identification scores obtained with and without the carrier phrase. Their listeners controlled the word presentation for the latter condition. For the condition in which the subject controlled the word presentation, the tape transport mechanism automatically stopped after each word and was activated again by the listeners pushing a button when ready for the next stimulus. Mc Lennan and Knox (1975) noted that this procedure reduced the length of the time required for each list administration to about one-half that required for conventional presentation with the carrier phrase and a fixed time interval between items. They also reported that most of their listeners preferred the test conditions in which the time presentation of each item was controlled by the listener.

With the advent of digitized speech stimuli (Kamm, Carter ette, Morgan and Dirks, 1980) and the introduction of computers into audiometer technology, subject control of presentation of speech stimuli in a manner akin to that used by Mc Lennan and Knox should not be difficult. Thus the usage of a carrier phrase is viewed differently by different authors. Those favouring its use argue that a carrier phrase acts as an alerting signal and those not favouring its usage argue that it consumes greater time for testing.

(d) PRESENTATION MODE

Speech audiometry stimuli can be presented by monitored live voice (MLV) or recorded voice. Use of live voice is convenient and allows for flexibility and reduced administration time. Live voice presentation is typically used for determination of speech reception threshold, despite ASHA (1988) recommendation to use recorded materials (cited in Kruger & Mazor, 1987). Live voice may be more acceptable for threshold testing because the patient is primarily responding to intense vowel sounds that are generally equated by monitoring the peaks on v-u meter. However, for suprathreshold testing, performance depends more on receiving less consonant information that cannot be monitored by fast action of v-u meter (Thibodeau, 2000).

Taylor (1985) noted that recorded test materials are preferable over live voice materials for a number of reasons.

1. The acoustical characteristics of the recorded stimulus can be measured or analyzed.
2. There is less opportunity for bias introduced by the talker unintentionally slowing down or talking more clearly or loudly.
3. The same test conditions can be exactly repeated to the child at another time or to another child.
4. In monitored live voice, the talker is often familiar to the child and this may inflate performance.
5. The talker could mispronounce the word.

The use of recorded speech standardizes the composition and presentation of speech stimuli and controls for signal intensity. The disadvantages of recorded presentation include lack of flexibility which may be important for difficult-to-test population. Phonographic and tape recording may result in signal distortion and introduction of noise. These problems can be averted with digitalized recordings (ASHA, 1979, 1988, cited in Kruger and Mazor, 1987).

Kamm, Carterette, Morgan and Dirks (1980) discussed the feasibility of using digitized speech recordings (digital representation of a real-speech waveform) in clinical practice. They recommended the use of digitized recordings for (a) their high signal to noise ratio and dynamic range, (b) the presence of zero wow and flutter, (c) the absence of harmonic distortion near the upper signal intensity range and of modulation noise side-bands near the signal, (d) the absence of cross-talk between channels, (e) the presence of a full-band width, (f) the lack of amplitude variations resulting from regional changes in magnetization, (g) the absence of print-through or other interaction between adjacent tape players, and (h) the ability to randomly select speech items. Therefore, whenever possible digitized recordings should be used in speech testing.

The field of computer generation of speech stimuli has already grown beyond the realm of audiology and will only continue to do so in the future. Like most areas of computer development, audiology undoubtedly will have much to gain from this technology but clinicians and researchers will have to remember the requirements for standardized tests described when making those applications to the field of speech perception measurements (Ncwby and Popelka, 1992).

Early applications of computers in speech audiometry involved simple control over signal presentation level (Wittich, Wood and Mahaffey, 1971). Recently, the development of computer-based audiometry has progressed in two directions - the use of computer as a digital player, the use of computer for automating adaptive speech audiometric procedures (Stach, 1988).

The method of presentation of speech stimuli through computers is one modification of conventional speech audiometry. The use of recorded stimuli is very important for all speech audiometric procedures. In the conventional speech audiometric procedures, the words are pre-recorded on a medium such as an audio cassette tape that can be used to play the words back in the original recorded order and at a predetermined rate such as one word every three seconds. This method is not appropriate for use with young children. Because the stimuli may have to be varied drastically according to the child's linguistic ability, the particular word list is often unknown until just prior to giving the test. In addition, the fixed rate of stimulus presentation with an audio cassette tape also limits its use for many children. Thus, it may be impossible to use conventional audiotapes for many young children and the examiner may have to rely on monitored live voice (Moog and Geers, 1990). The peadiatric audiologist may desire to use recorded speech materials but, as it often occurs, a more subjective, customized approach using monitored live may be necessary for a particular child. Carhart (1946, cited in Penrod, 1972) indicated that 'phonographic presentation increases the stability of the condition but reduces the flexibility of the technique'.

One approach to this problem was developed at Central Institute for the Deaf. Speech stimuli were recorded onto the storage disc of a computer. A computer program was developed that allowed play-back of the recorded words. This satisfied the requirement for recorded stimuli. In fact, compared to conventional play back systems, degradation in the quality of the stimuli does not occur as the number of play-back system increases, because the stimuli are recorded digitally. This is true regardless of the number of times the words are played back. The computer program also allowed random access and random play-back of the words. Any word can be selected and played back instantly at the press of a button. This allows the audiologist to select at random the words to be played and then to play them in any order and at any rate (Newby and Popelka, 1992).

Thus, the procedure allows the use of pre-recorded stimuli for children who are too young to perform speech audiometric procedures when using conventional speech play back systems. It is very convenient to repeat a particular word for a child who may not have been listening during the initial presentation of a particular word. With this system, highly repeatable speech audiometric results have been possible.

By using a computer as a digital tape player, live voice testing can be mimicked and the procedural limitations inherent in conventionally recorded materials can be eliminated (Stach, 1988). For instance, the computer program can be set-up to produce an entire list of words with the time between words selectable for a particular child, or the time actually varied according to the amount of time it takes for the child to respond. The time between words could become shorter if the child begins to respond quickly, or alternatively become longer if the child takes a long time to respond. Other modifications may include the play-back of the word being initiated by the child, and the presentation of animated graphics on the screen as a method of usual reinforcement (Newby and Popelka, 1992).

The development of audio compact disc (CD) technology offers the following advantages.

1. High fidelity recording with enhanced signal to noise ratio
2. Virtually infinite channel separation and no point through
3. Identical recording from one disc to another
4. Recording medium that rarely deteriorates as a function of use and time, and therefore, seldom needs replacing
5. Almost instantaneous access to any one of 100 tracks (i.e., no winding or rewinding to access a particular word list)

6. 144 minutes of recorded materials per disc
7. Offers an extremely favourable quality ratio (Wilson, 1993, cited in Mendel and Danhauer, 1997).

However, there are certain problems. Occasionally a good CD goes bad manifesting one of the two problems - either noise develops on the quiet material or the CD player will not access the requested track.

Given below are some useful features of CD players used in auditory evaluation.

- random tract selection
- display of track and time remaining while playing
- channel segment define and play
- remote control facility
- variable output level.

In the future, the audio CD may be the focal point of audiological evaluations and rehabilitation as well as a rich source of information and demonstration material for educational purposes. All signals used in audiological evaluation can be stored on the disc including pure tones, narrow band noise at the required levels and speech materials (Clifford, 1978, cited in Mendel and Danhauer, 1997).

Currently, auditory research labs are able to generate any tonal or noise signals in any paradigm with available software. Digital speech signals can also be produced. The rudimentary audiology facility of the future might very well function with a retrieval system on the CD containing all required signals delivered to the patient through a single two-channel amplifier attenuator complex that is calibrated. Digital technology would simplify greatly the instruments used by audiologists in the future (Ghent, 1994, cited in Mendel and Danhauer, 1997).

(e) PRESENTATION LEVEL

One of the problems in speech perception testing lies in the dependence of listener's speech perception scores on the intensity of the signal (Boothroyd, 1968 and Carhart, 1965). Early in the development of word identification testing as a clinical tool, the choice of an intensity level to carry out testing was based on the performance of normal hearing listeners. Data from groups of subjects with normal hearing show that, by 24-40 dB above the speech recognition threshold, most subjects achieve 100% recognition of single syllable words on the clinical word list. As a result, the early clinical standard was to test patients at 40 dB sensation level (SL). Sensation level was referred to either the pure tone average or the speech recognition threshold (Stach, 1998).

Over the years, this notion of testing at 40 dB SL began to be questioned as clinicians realized that the audibility of speech signals varied with both degree and configuration of hearing loss. These strategies have been replaced with the practice of testing and comparing ears at equal SPL and in searching for the maximum word identification scores at high intensity levels (Stach, 1998).

Carhart (1965) pointed out that by making use of just one intensity level, one cannot be sure that he is determining the maximum identification score of the individual, unless he has got a score of 100% at that level. To obtain a maximum score, lists of words or sentences are presented at 3 to 5 different intensity levels, extending from just above the speech threshold to the upper level of comfortable listening. Moog and Geers (1990) reported that the test should be administered over high quality amplification initially, the clinician estimate both the child's detection threshold and preferred listening level for speech using a bracketing procedure.

Considering the appropriate sensation level for the presentation of test items in paediatric population, Sanderson-Leepa and Rintelmann (1976) suggest that a sensation level of 32 dB is appropriate for normal hearing children. Examination of a relatively large number of clinical records indicates that children having mild to moderate hearing losses attain relatively high speech recognition scores at SLs of 36 to 40 dB. One notable exception occurs which a child has a precipitous high frequency hearing loss. Often the maximum speech recognition score is not obtained unless the degree of impairment at 2000 Hz is considered when selecting the presentation level (Matkin, 1968). For those children with profound hearing loss, an average SL of 21.6 dB above speech detection threshold was sufficient. The severely hearing impaired children achieved their best scores at an average SL of 30.6 dB relative to speech detection threshold (Erber and Witt, 1977).

Researchers have stated various presentation levels at which the speech identification scores reaches the maximum. Giolas (1975) obtained a maximum score at 60 dB SPL (Tillman and Carhart, 1966) and at 32 dB SL (Katz and Elliott, 1980). Abrol (1971), Ghosh (1988) and Mathew (1996) observed maximum speech discrimination scores at 30 dB SL using Hindi PB list, Bengali word list and Malayalam word list respectively. Kapur (1971) obtained the same results with Tamil word list at 35 dB SL. Speech discrimination test in English for Indian population were conducted by Swarnalatha (1972), Mayadevi (1974) and Rout (1996). They obtained best scores at 30 dB SL (ref SRT), 33 dB SL (ref SRT) and 30 dB SL (ref FA) respectively.

(f) RATE OF PRESENTATION

Changes in speaking rate will alter the perception and categorization of signal (Millers, 1981). Johnson and Strange (1982) suggested that correct information about articulation rate is necessary to compensate for the incomplete acoustic specification which may occur at faster speaking rates.

Study carried out by Sommers, Nygaord and Pisoni (1994) reported that identification scores were better for single speaking rates than for mixed speaking rate. This was attributed to increased acoustic-phonetic variability, which resulted in poorer scores. Mullenix and Pisoni (1990, cited in Vandana, 1998) reported similar finding that is identification scores were better at single speaking rate condition.

The rate of presentation of stimuli will depend on the time taken by the subject to respond. The following factors determine the time taken for the subject to respond to each item, a) difficulty of the task - generally, the more unsure the individual is of the stimulus, the larger the response time, b) the more similar the stimulus is to its foils (as in a closed-set task), c) the greater the hearing loss, and d) competing background noise. The more difficult the decision process is for the subject, the greater the response time, which decreases the rate of presentation. Measuring response time can offer considerable reformation regarding the confidence of a subject's response and determines the rate of presentation (Mendel and Danhauer, 1997).

The control over stimulus presentation also depends upon the time available in clinical situations. In busy diagnostic settings, the clinicians tend to forego recorded versions of tests in lieu of monitored live voice presentation where the clinician modifies the stimulus speed by decreasing the interstimulus interval between items. However, by using a micro-computer as a digital tape player, live voice testing can be mimicked and the speech stimuli can be presented at the rate at which the subject responds (Stach, 1998).

Thus, the rate of presentation would depend on the subject's response time and the test administration time available. However, researchers have suggested a single speaking rate for better speech identification scores.

IV. VARIABLES TO BE CONSIDERED WITH RESPONSE STRATEGIES

(a) RESPONSE TASK

Two general types of response formats exist: open or closed set. For open set tasks, three response options exist: repeat the stimuli orally, write the stimuli on paper, or type the stimuli on a keyboard. In the closed set method, a multiple choice (forced-choice) task, the stimulus is provided among a limited number of response alternatives, or foils, and the listener is required to select one of the given response. The determination of which response format is employed in any given test is a function of several factors including the context in which the stimulus is presented and the uncertainty or lack of knowledge of the stimulus (Mendel and Danhauer, 1997).

Response formats also depend largely on the age of the patient. Younger children are more likely to respond in closed set formats as a result of limited vocabulary and oral or graphic skills, whereas older patients with normal speech production are likely to repeat the stimuli, which is the most time efficient format (Thibodeau, 2000).

A closed set task results in the greatest scoring accuracy because the response is clearly indicated. Interpretation of the verbal response may be influenced by the articulation of the patient and by the bandwidth and signal to noise ratio of the monitoring system. Furthermore, a tendency exists for the examiner to err in favour of accepting an incorrect verbal response (Merrell and Atkinson, 1965).

When testing young children whose articulation skills are developing, two examiners may be needed. One to deliver the stimuli and monitor responses through the talkback system and the other to manipulate responses from within the test room (Thibodeau, 2000).

The difficulty and sensitivity of closed set tests can be manipulated by changing the response-set used. That is, the response alternatives can be selected so that they offer a clear isolation of particular phonemes or other types of stimuli. The listener's ability to discriminate among initial consonants, interconsonantal vowel perception can be evaluated using closed set response format (Mendel and Danhauer, 1997).

In open set tests, scoring is more time consuming and the judgements are more subjective, sometimes requiring the experimenter to be sophisticated in the study of phonetics. Also, the administration and response times are generally shorter for closed set tests. Finally, closed set tests using a written answer form may be more suitable for some individuals (example: those with speech production problems or speakers of a foreign language) for whom the talk-back response is not appropriate.

There are many advantages and disadvantages to each response paradigm. The following are several advantages cited by proponents of closed set tests (Black, 1957; Jerger, Speaks and Trammell, 1968; Owens and Schubert, 1977).

- Difficulty and sensitivity of test items can be manipulated by changing the response set used
- An equal number of alternatives is provided for each stimulus item
- Results are easier to score because of their written format
- Closed set tasks have also been adopted for use with computers so that patients/subjects can record their own responses to stimuli

The disadvantage of closed set testing is that there is a chance factor or 'guessing floor' inherent in the closed set testing paradigm (Black, 1957).

In conclusion, for children, the closed set response format is the preferred procedure. This is also recommended in Indian studies by Rout (1996), Mathew (1996), Vandana (1998) and Prakash (1999).

(b) REINFORCEMENT

Researchers (Markides, 1979 and Eisenberg et al., 1966) have reported reinforcement and instruction given to the listener made a difference on speech identification score.

Children are usually distractive and have less attention when compared to adults. Smith and Hodgon (1970) reported the use of token reinforcement (candy, toy, money, etc) to maintain the interesting young children. Sanderson-Leepa and Rintelmann (1976) suggested the use of tangible reinforcement with NU-6 stimulus material. They also suggested that this would increase child's attention to the test. It is important that the client receive sufficient personal reward and encouragement to help him or her work through a possible demanding listening battery (Rupp, 1980).

Eisenberg, Berlin, Dill and Frank (1966) conducted the Wepman Auditory Discrimination Test (Wepman, 1958) on Negro and White children. Some of these children made higher number of errors. In the second test form, the children were cautioned to listen better and were verbally rewarded for the correct response. He reported improvement in scores with reinforcement(cited in Berlin and Dill, 1967).

The other authors who also have stressed the importance of social or tangible reinforcements are Mendel and Danhauer (1997), Martin (1975), Olsen and Matkin (1979, cited in Rentelmann, 1979) and Indian authors like Vandana (1998), and Prakash (1999).

Thus, reinforcement, either social or tangible, is important for children to sustain their attention and interest. This would enable them to obtain better scores.

(c) SCORING

Dillion and Ching (1955) gave two ways to represent the test scores. They are quantitative and qualitative scoring.

Quantitative scoring:

Here the scoring could be done in any of the following ways.

- Items can be scored as proportion of words or proportion of phonemes correct. Phoneme scoring will lead to higher score than word scoring because words cannot be correct unless all its phonemes are correct. The disadvantage of phoneme scoring is that it places additional demands on the concentration on the tester.

- Another scoring method is to count complete sentences as test items. This occurs when the response task . requires the subject to follow an instruction or answer a question and when the subject's actions are then judged as either right or wrong.
- Scoring can be done by considering items into units and distinctive features (Mc Phreson and Pang-Ching, 1979). This provides additional information about errors made.
- A variation to counting items occurs in connected discourse tracking (DeFilippo and Scott, 1978). In this, the talker presents and represents words and phrases until the listener is able to repeat them correctly. In this case, the number of words per minute, rather than the proportion of words correct is scored.

Boothyord (1968) reported phoneme scoring to be 20-30% higher than whole word scoring. According to him, phoneme scoring reduces the influence of language function and interlist difference.

Qualitative scoring:

Here the scores are represented either in percentage or threshold. The percentage of speech units correct is the most appropriate way to express the result. Whenever the purpose is to find maximum scores obtained under some specified condition, qualitative scoring can be used (Dillion and Ching, 1995).

Depending on the type of the speech test, the tester can either select qualitative or quantitative method of scoring. The variables, which affect the scoring of the responses, are the language background and the training given to the tester.

In summary, there are many factors in the selection of stimuli, in the administration and interpretation speech perception tests that must be considered. Clinicians and researchers must be aware of the limitations of such test procedures and the effect these limitations may have on conclusions made about an individual's speech perception abilities. The key is to be sure that the variables are controlled appropriately so that a true reflection of a listener's speech understanding abilities is obtained.

METHOD

The study has been undertaken to compare the speech identification scores in children when the signal is presented through a computer and a compact disc.

Subjects:

Thirty-two children comprising of 16 males and 16 females were taken. They were divided into four groups based on their age. Group I included children in the age range of 3.5 to 3.11 years; Group II in the age range of 4.0 to 4.11 years; Group III in the age range of 5.0 to 5.11 years and Group IV in the age range of 6.0 to 6.11 years.

The subjects met the following criteria

1) The language spoken at home was Kannada
2) Had normal hearing and vision
3) No history of chronic otological problem
4) Normal speech and motor milestones

Test Material:

Bisyllabic phonemically balanced picturable word test for children in Kannada, developed by Vandana (1998), was used. The test contains two lists with fifty words each. Each list has two equal half lists (twenty-five words). In the present study, each variable was tested using a half-list. The picture book, with four alternative choices for each test item was used to obtain the responses.

Instrumentation:

A computer with AudioLab software (16 Bit, Mono, 32000 Hz, 63 KB/S) was used to record the speech material. The material was then transferred to a digital tape recorder (Sony portable Mini Disc Recorder MZ-R70) from which the material was transferred to a compact disc (CD) using a CD writer.

The audioiogical testing was carried out using a two channel clinical audiometer (Madscn OB822) coupled to acoustically matched ear phones (TDH-39) with MX-41R ear cushions and a bone vibrator (Radio ear B-71). The audiometer was calibrated to confirm to ANSI (1992, cited in Frank, 2000) standards. The speech material from the computer or CD player (Philips CD) was routed through the audiometer to a compatible loudspeaker (Madsen).

Recording of test material:

The test material was recorded into a computer in a sound treated room by a female native Kannada speaker through a mic (AKG D-75). The computerized material was, scaled using the AudioLab software so that all the words were of similar intensity. Before each list, a 1 kHz calibration tone was recorded. A batch file was created with an inter-stimulus interval of four seconds. The material was then transferred to a digital tape recorder from which it was again transferred to a CD using a CD writer.

Procedure:

a) Pure Tone Testing:

To ensure that the subject had normal hearing, pure tone testing was done. Pure tone thresholds for air conduction and bone conduction were obtained for the frequencies from 250-8 kHz and 250-4 kHz respectively.

b) **Speech Identification Score Testing:**

The subjects were seated at a distance of one meter away from the loudspeaker. Due to constraints in the room dimension, the loudspeaker was placed at an azimuth of 135°. The calibration was done with the speaker in the above mentioned placement.

Instruction: Subjects were instructed in Kannada to point to the picture of the word that he/she heard.

Test administration:

Two examiners carried out the test. One examiner presented the stimuli either through the CD player or computer and the other examiner was seated beside the child to help him/her turn the pages of the picture book.

Initially three practice items were presented at a comfortable level i.e., 40 dB SL relative (the average of thresholds of speech frequencies - 500 Hz, 1 kHz and 2 kHz) (ASHA, 1977, cited in Rupp and Stockdell, 1980).

Each subject was tested at two intensity levels i.e., 30 dB SL and 40 dB SL. It was ensured that no list was repeated per subject. All subjects listened to both the intensities as well as both presentation modes (computer and CD). The variables were randomly presented. The correct responses were reinforced with a smile and a gesture of approval.

The testing was done after a month on eight subjects (two males and two females from each of the two groups) with the material being presented through the computer with an inter-stimulus interval of four seconds. This testing was done to check if any differences in speech identification scores were seen in manual versus automatic presentation and to rule out the variability due to the use of different instruments.

Scoring:

Responses were recorded in a score sheet. Each correct response was given a score of one and an incorrect response was given a score of zero. In addition, the time taken for the subjects to carry out the test, when the material was presented through the computer with variable inter-stimulus interval, was noted. The data collected was statistically analyzed.

RESULTS AND DISCUSSION

The present study was done to obtain the effect of two presentation modes (CD and computer) on speech identification scores in children. The analysis was done (using the t-test) to compare the speech identification scores:

(a) between two presentation modes at two intensity levels (30 dB SL and 40 dB SL)

  (i) for all the subjects, and

  (ii) age-wise sub-groups

(b) within two presentation modes across two intensity levels.

  (i) for all subjects, and

  (ii) age-wise sub-groups

(c) across age groups

(d) across fixed and variable interstimulus interval

  (i) for all subjects, and

  (ii) across age groups

(6) In addition, the time taken to respond for manual and automatic presentation was compared.

Effect of presentation modes (CD and computer) on speech identification scores (SIS)

The test material was presented through the CD and computer. The test was administered at two intensity levels i.e. 30 dB SL and 40 dB SL relative to the pure tone average. The thirty-two subjects were divided into four groups based on the age of the children. Group I was in the age range of 3.5 to 3.11 years, while group II, III and IV were in the age ranges of 4.0 to 4.11 years, 5.0 to 5.11 years and 6.0 and 6.11 years respectively.

(a) i) Effect on speech identification scores at 30 dB SL and 40 dB SL between CD and computer for all subjects

The scores of the subjects were compared at two intensity levels (30 dB SL and 40 dB SL). This was done between the two presentation modes (CD and computer). For this, the mean, standard deviation (SD) and paired 't' valued were calculated.

Table 1: Mean and standard deviation (SD) of speech identification scores across the different presentation modes at 30 dB SL and 40 dB SL

Variable	Number (N)	Mean	S.D.	t
30 CD	32	23.0625	1.8654	0.471*
30 C	32	22.8750	1.6412	
40 CD	32	23.3125	1.4906	1.285*
40 C	32	22.8438	1.5680	

*Not significant at 0.01 level and 0.05 level.

The results tabulated in table 1 show that there is no significant difference in mean speech identification scores, when the stimuli was presented through computer and compact disc (CD) at both 30 dB SL and 40 dBSL.

a) ii) Effect of speech identification scores at two intensity levels within the age group

Within the four age groups, the two presentation modes (CD and computer) were compared. This was done for both intensity levels (30 dB SL and 40 dB SL). The mean, standard deviation and paired 't' values were calculated for the above variables (table 2 and 3).

Table 2. Mean, standard deviation and paired 't' values of speech identification scores between CD and computer (C) at 30 dB SL within the age groups

Group	No. of Subjects	Variable	Mean	S.D.	T
I	8	30 C	22.75	1.7525	•0.574
		30 CD	23.125	1.3562	
II	8	30 C	22.75	1.3887	•0.351
		30 CD	23.125	2.1002	
III	8	30 C	22.625	1.9955	•1.109
		30 CD	21.75	2.1213	
IV	8	30 C	23.375	1.590	•1.433
		30 CD	24.25	1.0351	

* Not significant at 0.05 and 0.01 level of significance.

Table 3. Mean, standard deviation and paired 't' values of speech identification scores between CD and computer (C) at 40 dB SL within the age groups

Group	No. of Subjects	Variable	Mean	S.D.	T
I	8	40 C	22.375	2.0659	*0.957
		40 CD	23.00	1.3093	
II	8	40 C	23.25	0.8864	*0.723
		40 CD	22.625	1.8464	
HI	8	40 C	22.00	1.5119	•2.049
		40 CD	23.5	1.1952	
IV	8	40 C	23.75	1.1650	•0.667
		40 CD	24.125	1.3562	

* Not significant at 0.05 and 0.01 level

Table 2 and 3 show that there is no significant difference in speech identification scores within the age groups for the two presentation modes. This was evident at both 30 dB SL and 40 dB SL.

This could be because both computer and CD make use of digitized speech recordings. Hence, there is no difference in the quality of the speech signal that the subject heard. This is indicative of high fidelity, enhanced signal-to-noise ratio and low distortion in both CD and the computer. The above findings are supported by ASHA, 1979, 1988 (cited in Olsen & Matkin, 1979); Kamm, Carterette, Morgan, and Dicks (1980); Wilson, 1997 (cited in Mendel and Danhauer, 1997). These authors have highlighted the advantages of using digitized stimuli and recommend it use in speech testing.

Hence, it suggested that an audiologist could use either CD or computer for speech identification testing in children. Selection of the mode of presentation of stimuli i.e., either through computer or CD could depend on factors such as availability of instruments, age of the subject, i.e., children versus adults. There is a difference between the two presentation modes in adults at 30 dB SL (Chandni Jain, Personal Communication, 2002).

(b) i) Effect on speech identification scores across intensity levels with CD and computer (C) for all subjects

Within each presentation mode, i.e., computer or CD, the effect of the two intensity levels (30 dB SL and 40 dB SL) was analyzed. This was done using the paired 't' test for the thirty-two subjects.

Table 4. Mean, SD and paired 't' values of speech identification scores between two intensity levels

Variable	Number	Mean	Standard deviation	t values
30 C	32	22.8750	1.6412	0.098*
40 C	32	22.8438	0.5803	
30 CD	32	23.0625	1.8654	0.78*
30 CD	32	23.3125	1.4906	

* Not significant at 0.01 and 0.05 level

The results, tabulated in table 4, show that there is no significant difference in speech identification scores across the two intensity levels (30 dB SL and 40 dB SL). This occurred for both CD and computer modes of presentation.

(b) ii) Effect on speech identification scores across intensity levels with CD and computer within age-wise sub groups

Within the four age groups, the effects of two intensity levels were analyzed. This was done for each presentation mode. Analysis for it was done using the paired 't' test.

Table 5. Paired 't' values of speech identification scores across 30 dB SL and 40 dB SL

Groups	Number	30 CD vs. 40 CD	30 C vs. 40 C	
I	8	0.243	0.390	NS*
II	8	0.577	1.183	
III	8	2.13	1.049	
IV	8	0.552	0.814	

* Not significant at 0.01 and 0.05 level of significance

As seen with the grouped data in table 4, the age-wise groups also showed no significant difference in speech identification scores when the stimuli was presented at the two intensity levels. This finding was seen for both CD and computer mode of presentation.

Thus, clinicians could use either 30 dB SL or 40 dB SL and still obtain equivalent scores in children. This can be done either when the signal is being presented through the computer or the CD.

These findings are in good agreement with other studies in Western countries (Tillman, 1963 and Carhart, 1965) and also in India (Abrol (1971), Samuel (1976), Swarnalatha (1972), Rout (1996), Mathew (1996) and Vandana (1998). All these investigators obtained maximum scores at 30 dB SL.

The application of this finding in speech identification testing can be two fold - in patients with reduced uncomfortable loudness level and in patients with severe hearing loss where speech identification testing cannot be done at 40 dB SL due to audiometric limits. Hence, in these cases, speech identification testing can be done at 30 dB SL as there is no difference in scores between 30 dB SL and 40 dB SL.

(c) Effect of age on speech identification scores

The speech identification scores obtained when the stimuli was presented through computer and CD was compared between the age groups. This comparison was done at both 30 dB SL and 40 dB SL. This analysis was done using the independent't' test.

Table 6. Independent't' values of speech identification scores obtained from computerized and CD speech stimuli across age groups at two intensity levels

Group Comparison	Variables				
	30 CD	40 CD	30 C	40 C	
I Vs. II	0	0.469	0	1.01	
I Vs. Ill	1.545	0.798	0.133	0.414	
I Vs. IV	1.865	1.68	0.745	1.640	NS*
II Vs. Ill	1.303	1.125	0.145	2.017	
II Vs. IV	1.359	1.852	0.835	0.966	
III Vs. IV	2.06	0.978	0.830	2.04	

* Not significant at 0.01 and 0.05 level

The 't' values show that there is no significant difference in speech identification scores obtained when the stimuli was presented through CD and computer across age groups at both 30 dB SL and 40 dB SL. Thus children as young as 3.5 years of age can be tested either using computer recorded material or CD, without any detrimental effect on the speech identification scores.

(d) Effect of fixed and variable interstimulus interval on speech identification scores

A part of the subjects, representating of all the four age groups were reevaluated for their response time. The stimuli were presented through the computer at a fixed interstimulus interval of four seconds (automatic presentation) and at a variable interstimulus interval (manual presentation).

The speech identification scores obtained with fixed and variable interval were compared at two intensities (30 dB SL and 40 dB SL).

Table 7. Mean, S.D and paired 't' values of speech identification scores obtained with manual and automatic presentation of stimuli at 30 dB SL and 40 dB SL.

Variables	Number	Presentation	Mean	S.D.	t values
30 C	8	Manual	23.00	1.4142	3.326**
		Automatic	24.75	0.4629	
40 C	8	Manual	22.125	0.7440	5.227**
		Automatic	23.5	1.5119	

** Significant at 0.01 level.

The results show that there is a significant difference in manual (variable interstimulus interval) and automatic (fixed interstimulus interval) presentation at both 30 dB SL and 40 dB SL (table 7). As evidence from the 't' values, there was a significant difference in speech identification scores between automatic and manual presentation at both intensity levels. The subjects obtained higher scores when the interstimulus interval was kept constant. This occurred for both presentation levels.

(e) In addition, the time taken to respond by the children for manual and automatic presentation was compared.

The test administration time was compared with the signal being presented manually through the computer (i.e. at the pace at which the children responded) and automatic (i.e. at a fixed interstimulus interval). This was calculated for all the subjects and the age-wise sub-groups, at two intensity levels.

(e) i) Time taken to respond by all subjects

Table 8. Mean, SD and paired 't' values of test administration time for manual presentation at 30 dB SL and 40 dB SL.

Variables	Number	Presentation	Mean time (seconds)	S.D.	t values
30 C	8	Manual	75.31	12.3	11.3*
		Automatic	108	0	
40 C	8	Manual	76.87	13.7	9.53*
		Automatic	108	0	

* Significant at 0.05 and 0.01 level.

It is evident that there is significant difference in the time taken to respond by children at both 30 dB SL and 40 dB SL. At both intensity levels the children responded faster for the manual presentation at both intensity levels. This shows that even at the lower sensation level, children heard well enough and reacted as fast as they did for the louder signal. Had the signal been unclear to them at lower SL, they might have taken a longer time.

(e) ii) Time taken to respond by the age-wise sub-groups

Table 9. Mean and standard deviation and paired 't' values of the test administration time for manual presentation and automatic presentation at 30 dB SL and 40 dB SL for four age, groups.

Groups	Number	Variable		Mean	SD	't'
I	8	30 C	Auto	108	0	5.7*
			Manual	83.7	11.8	
		40 C	Auto	108	0	7.6*
			Manual	86.2	8.7	
II	8	30 C	Auto	108	0	5.4*
			Manual	86.8	10.9	
		40 C	Auto	108	0	8.3*
			Manual	76.8	10.6	
III	8	30 C	Auto	108	0	8.857*
			Manual	73.7	10.9	
		40 C	Auto	108	0	8.3*
			Manual	73.7	11.5	
IV	8	30 C	Auto	108	0	16.8*
			Manual	63.1	7.5	
		40 C	Auto	108	0	15.0*
			Manual	64.3	8.2	

* Significant at 0.01 level and 0.05 level.

From table 9, it can be seen that there is a significant difference in the time taken by children of all the age groups to respond, when the interstimulus interval is fixed and variable. All the children tend to respond faster when the interstimulus interval was variable (manual). However, from table 7, it was known that the scores are better in the fixed inter-stimulus (automatic) presentation at both 30 dB SL and 40 dB SL. Hence, it is advisable to do the testing using automatic presentation for better speech identification scores despite the children responding fast with manual presentation.

From the findings of the study, it can be concluded:

(1) there is no significant difference between computer and CD presentation on speech identification scores. Hence either can be used while testing children.

(2) Speech identification scores did not differ significantly between the two presentation levels (30 dB SL and 40 dB SL). Thus, children can be tested at either of the intensity levels with no detrimental effect on their scores.

(3) lnterstimulus interval plays a role while testing young children. Better scores are obtained with an interstimulus interval of four seconds, rather than when this interval varies at the pace of the response of the children. However, the children responded faster when the interstimulus interval varied.

(4) There is no significant difference in speech identification scores obtained when the material is presented through a computer or CD speech across the four age groups. This was true for both 30 dB SL and 40 dB SL.

SUMMARY AND CONCLUSION

Paediatric speech audiometry is an essential feature of a comprehensive audiologic evaluation (Martin, 1987). Speech identification provides an estimate of how well a person hears speech at suprathreshold levels. This testing can be done using recorded or monitored live voice presentation. Recorded material can be analoged or digitized (computer or CD) (Stack, 1998).

The present study was carried out with the objective of comparing speech identification scores through two presentation modes (CD and computer) in children. This was done to find if there was a difference in the speech identification scores through the two-presentation modes.

The subject included thirty-two children who spoke Kannada and were in the age range of 3.5 years to 6.11 years. All the children had normal speech motor milestones, normal hearing and vision and no chronic otological problems. The children were divided into four age groups based on their age. Group 1 was in the age range of 3.5-3.11 years. Group II, III & IV were in the age ranges of 4.0-4.11 years, 5.0-5.11 years and 6.0-6.11 years respectively.

Speech identification testing was done in a sound field. The stimuli were presented using a computer and CD player. This was done at two intensities (30 dB SL and 40 dB SL with reference to pure tone average).

The speech identification scores were compared

(a) between CD and computer at two intensity levels

(b) within CD and computer across two intensity levels

(c) across age groups

(d) across fixed and variable interstimulus interval at two intensity levels.

In addition, the test administration time was compared across the manual presentation (where the interstimulus using the interval was varied at the subjects pace of response) and automatic presentation (fixed interstimulus interval) using the computer.

The data obtained was analyzed using 't' test. Results are as shown below.

(1) The two presentation modes (CD and computer) did not have a significant difference in speech identification scores. Hence any mode can be used in clinical testing for speech identification in children.

(2) The two presentation levels (30 dB SL and 40 dB SL) also did not have a significant difference in speech identification scores. Hence, 30 dB SL could be used for speech identification testing in children instead of 40 dBSL, if required.

(3) Better speech identification scores were obtained with an interstimulus interval of four seconds. Hence, it is advisable to do the testing with an interstimulus interval of four seconds rather than using a variable interstimulus interval. Though the subjects performed faster with the variable interstimulus interval, they tended to get poorer scores.

(4) There is no difference in the speech identification scores obtained from CD and computer across age groups at both 30 dB SL and 40 dB SL.

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APPENDIX -1

TEST LISTS (Given by Vandana, 1998)

Familarization items:-

ಮಂಚ /mancha/
ಬೆಕ್ಕು /bekku/
ತುಟಿ /tuti/

Test items:-

List-A		List - B	
ಲೋಟ	/lo:ta/	ಕಣ್ಣು	/kaṇṇu/
ಏಣಿ	/e:ṇi/	ಹೂವು	/hu:vu/
ಚಾಕು	/cha:ku/	ಕಾಗೆ	/ka:ge/
ಬಸ್ಸು	/bassu/	ಕಪ್ಪೆ	/kappe/
ಗೂಬೆ	/gu:be/	ಮೊಲ	/mola/
ಕತ್ತು	/kat̪t̪u/	ಏಣಿ	/e:ṇi/
ಲಾರಿ	/la:ri/	ಮಳೆ	/maḷe/
ಮನೆ	/mane/	ಲೋಟ	/lo:ta/
ನಳ್ಳಿ	/naḷḷi/	ದಾರ	/da:ra
ಮೇಕೆ	/me:ke/	ಚಾಕು	/cha:ku/
ಮೊಲ	/mola/	ಮನೆ	/mane/
ಕಾಗೆ	/ka:ge/	ನಳ್ಳಿ	/naḷḷi/
ಸೇಬು	/se:bu/	ಓಲೆ	/o:le/
ಬೀಗ	/bi:ga/	ಬಸ್ಸು	/bassu/
ಕೋಳಿ	/ko:ḷi/	ಕತ್ತು	/kat̪t̪u/
ಹೂವು	/hu:vu/	ಗೂಬೆ	/gu:be/
ಮೂಗು	/mu:gu/	ಛತ್ರಿ	/chat̪ri/
ಹಸು	/hasu/	ಮೇಕೆ	/me:ke/
ಮಳೆ	/male/	ಸೇಬು	/se:bu/
ಕಪ್ಪೆ	/kappe/	ಬೀಗ	/bi:ga/
ಕಣ್ಣು	/kaṇṇu/	ಲಾರಿ	/la:ri/

ದಾರ /d̪a:ra/
ಛತ್ರಿ /chatri/
ಚೀಲ /chi:la/
ಮೀನು /mi:nu/
ಮೇಜು /me:ju/
ಇಲಿ /ili/
ಸೂಜಿ /su:ji/
ತಲೆ /t̪ale/
ಕಿವಿ /kivi/
ಪೆನ್ನು /pennu/
ಮರ /mara/
ಬಳೆ /baḷe/
ಕಾಲು /ka:lu/
ಗಂಟೆ /gante/
ಸರ /sara/
ಚೆಂಡು /chendu/
ರೈಲು /railu/
ಕಾರು /ka:ru/
ಓಲೆ /o:le/
ಆನೆ /a:ne/
ತಟ್ಟೆ /t̪atte/
ಗಿಣಿ /gini/
ಹಾವು /ha:vu/
ನಾಯಿ /na:yi/
ಹಲ್ಲು /hallu/
ಕಾಸು /ka:su/
ಸೂರ್ಯ /su:rya/
ನೀರು /ni:ru/
ಎಲೆ /ele/

ಮೂಗು /male/
ಕಾಗೆ /ka:ge/
ಗಿಣಿ /gini/
ತಟ್ಟೆ /t̪atte/
ಸರ /sara/
ಕಾರು /ka:ru/
ಪೆನ್ನು /pennu/
ನೀರು /ni:ru/
ಬಳೆ /baḷe/
ಆನೆ /a:ne/
ಚೆಂಡು /chendu/
ಹಲ್ಲು /hallu/
ಮರ /mara/
ಮೀನು /mi:nu/
ನಾಯಿ /na:yi/
ಕೋಳಿ /ko:ḷi/
ಕಿವಿ /kivi/
ಇಲಿ /ili/
ಸೂರ್ಯ /su:rya/
ಕಾಸು /ka:su/
ಕಾಲು /ka:lu/
ಎಲೆ /ele/
ಚೀಲ /chi:la/
ಮೇಜು /me:ju/
ಸೂಜಿ /su:ji/
ಗಂಟೆ /gante/
ರೈಲು /railu/
ತಲೆ /tale/
ಹಾವು /ha:vu/

NOTE; (Lists 'A' and 'B[1] are reverse orders of lists A & B)