COMPARISON OF SPEECH IDENTIFICATION SCORES (IN THE PRESENCE OF NOISE) USING BINAURAL BTE AND BINAURAL BODY LEVEL HEARING AIDS

(Register No. 02SH0019)

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
MANASAGANGOTRI, MYSORE

MAY 2003

CERTIFICATE

This is to certify that this Independent Project entitled **"COMPARISON OF SPEECH IDENTIFICATION SCORES (IN THE PRESENCE OF NOISE) USING BINAURAL BTE AND BINAURAL BODY LEVEL HEARING AIDS"** is a bonafide work in part of fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No. 02SH0019).

Mysore

May, 2003

Dr. M. Jayaram
Director
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CERTIFICATE

This is to certify that this Independent Project entitled **"COMPARISON OF SPEECH IDENTIFICATION SCORES (IN THE PRESENCE OF NOISE) USING BINAURAL BTE AND BINAURAL BODY LEVEL HEARING AIDS"** has been prepared under my supervision and guidance. It is also certified that this project has not been submitted earlier in any other University for the award of any Diploma or Degree.

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May, 2003

DECLARATION

This Independent Project entitled **"COMPARISON OF SPEECH IDENTIFICATION SCORES (IN THE PRESENCE OF NOISE) USING BINAURAL BTE AND BINAURAL BODY LEVEL HEARING AIDS"** is the result of my own study under the guidance of **Dr. K. Rajalakshmi** Lecturer, Department of Audiology, All India Institute of Speech and Hearing, Mysore and not been submitted earlier in any other University for the award of any Diploma or Degree.

Mysore,

May, 2003 Reg. No. 02SH0019

Dedicated to
papa & mummy

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INTRODUCTION

Hearing is based on the processing of information received through two ears. Binaural hearing is based on the ability of the total human system to detect two different signals, analyze their differences and perceive a single auditory image .In normal binaural (pertaining to two ears) hearing, one utilizes the dimensions of intensity, frequency and time to assist oneself in localization and identifying a signal. The ability of an individual to spatially place signals, as well as separate signals from noise, results from binaural hearing function.

Binaural hearing occurs when there is a balance between the two ears, as in normally hearing individuals. In individuals with hearing loss, this balance between the ears is disturbed and hence binaural hearing is precluded.

The amplification system generally advocated for a bilaterally hearing impaired individual include one hearing aid delivering sound to one ear (monaural), one hearing aid delivering sound to both ears (pseudobinaural or Y-cord), or two hearing aids delivering sound separately to both ears (binaural). But there is a general disagreement regarding which system provides optimum amplification.

Historically, manufacturers and dispensers of hearing aids have strongly advocated binaural fittings, while audiologists have been more reluctant to do so. A great deal of formal and informal research has been performed in an attempt to demonstrate the advantage of binaural amplification.

Binaural amplification has been defined by Konkle and Schwartz (1981) as "True dichotic or stereophonic stimulation of each ear independently is binaural amplification".

Wright (1959) (as cited in Pollack, 1975) states that the purpose of binaural amplification is to create a sound environment for the listener that is a faithful reproduction of the original acoustic event so that he can take advantage of the intensity, time and spectrum differences of the auditory signal at each ear.

These differences, theoretically, provide the additional cues necessary for a more reasonable approximation of the hearing experiences of the normal hearing population. While binaural ear level aids provide these signal differences, two body aids do not. Two microphones on the chest, especially with a child, are separated by no more than two or three inches, while the ears are separated by seven or eight inches. Additionally, the head exerts a sound shadow between the ears. It is the presence of the head between the microphones that is primarily responsible for the intensity, time and spectrum differences. Two body aids do not achieve the purpose of restoring a semblance of normal binaural auditory functioning as ear level aids do.

Poulos (1950), Bender and Wiig (1961), Lewis and Green (1962) and Whetnall (1964) (as cited in Markides, 1977), working with children over a prolonged period, observed that such children were able to monitor their speech better, were more alert to sound and showed rapid development in speech and language when fitted with binaural hearing aids.

Bentzen, Frost and Skaftason (1970) (as cited in Markides, 1977) recommended that binaural hearing aids should be considered standard treatment with all patients suffering from bilateral hearing loss.

Langford (1970) (as cited in Pollack, 1975) has summarized the clinical and research observations and proposed five potential advantages of binaural amplification:

- Better sound localization
- Increased speech discrimination in noise
- Greater ease of listening
- Better spatial balance
- Improved sound quality

- Localisation

Man needs two ears for satisfactory auditory localization (Bergman, 1957; Carhart, 1958; Wright, 1959) (as cited in Pollack, 1975). The rationaleis that it takes analysis of input to two ears to determine effectively the distances and position in both azimuth and elevation of the sound sources. Studies done by Ross (1980) (as cited in Pollack, 1975), evaluating localization ability showed binaural hearing aid superiority.

- Speech discrimination

One of the most important advantages of binaural hearing is the improvement in auditory figure-ground relationships. The listener is better able to interpret speech in a background noise. Koenig (1950) (as cited in Pollack, 1975) reported that binaural hearing improved "directionality", "squelched" reverberation and markedly increased speech intelligibility. Gelfand and Hochberg (1973) (as cited in Pollack, 1975) hypothesized that "squelch effect" was responsible for their finding of better speech discrimination under reverberant conditions for binaural amplification. This case was observed in normals and sensori-neural hearing impaired subjects.

Tillman, Kasten and Horner (1963) (as cited in Pollack, 1975) reported on the head shadow effect where they found that the sound field thresholds for speech to be almost 7dB better at the ear nearer the sound source than at the farther ear.

Bergman (1957), Marlke and Aber (1958), Belzde and Marlke (1959), Black and Hast (1962), Decroiz and Dehaussy (1964) and Harris (1965) (as cited in Pollack, 1975) and Heffler and Schultz (1964) and Zelnick (1970 b) demonstrated significantly better speech discrimination scores with binaural than with monaural aids.

- **Ease of listening**

Carhart (1958) (as cited in Pollack, 1975) indicated, "Less effort is required for comfortable listening when binaural system is used". Langford (1970) (as cited in Pollack, 1975) reported that a binaural arrangement provides greater intensity to the auditory system than does a monaural aid. This allows the user to hear faint sounds with greater ease. Kodman (1961) (as cited in Pollack, 1975) suggested that binaural hearing promotes an interaural effect, which is reflected in better sound balance and ease of perception.

- **Spatial balance**

There appears to be an increased precision in auditory orientation when some binaural listeners are confronted with a complex acoustic environment. Huizing and Taselaar (1961) (as cited in Pollack, 1975) reported that under certain circumstances distorted signals are integrated more effectively binaurally than monaurally.

Dirks and Wilson (1969) (as cited in Pollack, 1975) demonstrated a binaural advantage in subjects with sensori-neural hearing loss when sound sources were spatially separated so that the individual could make use of interaural time differences.

Better "acoustic balance" results as a benefit of binaural hearing aid (Carhart, 1958 and Langford, 1970) (as cited in Pollack, 1975). Wright (1959) indicated, however, that differences in threshold balances between ears, particularly in the presence of sensori-neural hearing loss, may preclude "balanced hearing" for many hearing aid patients.

- **Sound quality**

Binaural amplification appears to provide greater "fullness" to sound. Numerous case studies have yielded subjective reports from users of binaural hearing aids that sound quality is considerably better than that obtained with monaural instrumentation (Haskins and Hardy, 1960; Kodman, 1961 and Heffler and Schultz, 1964) (as cited in Pollack, 1975). Other advantages of binaural amplification are due to binaural gain, head shadow effect and binaural summation.

Apart from this some other advantages are :

Mean binaural advantage

Hawkins and Yacculo's (1984) study demonstrate a mean binaural advantage of approximately 2-3 dB, which is in good agreement with other studies (Carhart, 1965; Olsen & Carhart, 1967; Mackeith and Coles, 1971; Nabelek & Pickett, 1974a and Markides, 1977).

Nabelek and Pickett (1974) concluded that the average binaural gain for normal subjects is 3 dB and 1.5dB for hearing impaired subjects.

Olsen and Carhart (1967) found a similar binaural advantage with subjects having bilateral symmetrical hearing loss and also with normal hearing subjects.

Zelnick (1970) found a binaural advantage of about 15% with subjects having bilaterally symmetrical hearing loss and using commercial ear level hearing aid.

Head shadow effect

Markides (1977) explains what the head shadow effect is. A signal coming from the right side of a person will be louder in his right ear than when compared in his left ear and vice versa. The reduction in loudness that occurs in the far ear (that is, the ear on the far side of the head in relation to the signal source) is obviously due to the head intervening. This reduction in intensity is termed as the head shadow effect.

When listening in noise, a reduction in signal-to-noise ratio of up to 13 dB can be observed due to head shadow effects (Mackeith and Coles, 1971).

One major advantage of wearing two aids is the elimination of head shadow effect. Because of the head shadow, the sounds to the ear opposite to **the sound** source are significantly reduced in amplitude (Olsen and Carhart, 1967).

Loudness summation

The term "binaural loudness summation "refers to the fact that when a sound is presented binaurally to normal hearing persons it is perceived as louder than when the same sound is presented monaurally.

Binaural summation yields a binaural threshold advantage of about 3dB (Bender & Wiig, 1960). Hearing-impaired people, often find themselves listening to speech at threshold level. It is obvious, therefore, that for such people a few dB gain at threshold can be a very real advantage (Markides, 1977).

At low levels of detectability binaural summation has been shown to be about 3dB both for pure tones (Hirsh, 1948) and for speech (Licklider, 1948) (as cited in Dermody and Byrne, 1975). For normal hearing persons, binaural summation is greater at suprathreshold levels than at threshold. Causse and Chavasse (1942) (as cited in Dermody and Byrne, 1975) reported that the 3dB summation effect at threshold increased to about 6dB at 35 dB above threshold. Reynolds and Stevens (1960) (as cited in Dermody and Byrne, 1975) found that binaural summation increase from 3dB at threshold to 10dB at 90dB SPL.

An advantage of fitting binaural hearing aid is that individuals tend to set the volume control lower than when they are fit with monaural hearing aid.

All these advantages assist the binaural hearing and thus helps the bilaterally hearing impaired individual to improve their speech identification ability.

Speech identification is important for atleast two reasons. The first reason being that it provides an estimate of how well a person will hear speech at suprathreshold 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 tool for screening retro cochlear disorders (Stach, 1998).

NEED FOR THE STUDY

Binaural hearing has a lot of advantages but the difference in speech identification scores when using a binaural behind the ear (BTE) and binaural body level (BL) hearing aids are not conclusive.

So the present study is an effort to find the differences in speech identification scores (in the presence of noise) in two binaural listening conditions.

AIM OF THE STUDY

To find out the differences in speech identification scores (in the presence of noise) using a binaural behind the ear (BTE) and binaural body level (BL) hearing aids.

REVIEW OF LITERATURE

Paediatric speech audiometry is an essential feature of a comprehensive audiological evaluation (Martin, 1987). With children we generally use the speech identification testing which provides an estimate of how well the child hears at suprathreshold levels.

Before embarking on a review of the pertinent literature with regard to the effect of binaural hearing aids on speech intelligibility we need to know the variables that affect the speech identification testing.

There are a lot of variables which affect the speech identification scores and these need to be particularly considered while testing the paediatric population.

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

I.VARIABILITY OF SPEECH STIMULI

a) Types of speech stimuli
b) Calibration of speech stimuli
c) Word familiarity
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I. VARIABILITY OF SPEECH STIMULI

a) Types of speech stimuli

Various kinds of speech stimuli have been used for speech identification testing. They include nonsense syllables, phonemically balanced monosyllable words, bisyllabic words, sentences and continued discourse (Fletcher and Steinberg, 1929, cited in Jamielson, 1972)

Nonsense syllable

Nonsense syllable can be used to test speech identification ability. The advantage of nonsense syllable over other test materials is that when the former is used the linguistic cues that contaminate the test performance are eliminated. Their intelligibility is not dependent on the listener's vocabulary (Berger, 1971). They are non redundant (Carhart, 1965).

Nonsense syllables have the disadvantage of being unfamiliar to children and confusing to the listener (Carhart, 1965). He originally suggested that nonsense words are too abstract and difficult to discriminate. Hence, the use of meaningful stimuli was recommended.

Monosyllable words

Monosyllabic words are less analytic units of speech and are more easily repeated than nonsense syllables (Egan, 1948). They are not as confusing as nonsense syllables. They are preferred because they are non redundant and are meaningful (Carhart, 1965).

A number of monosyllabic word lists have been developed for the paediatric population. The popular ones are: the phonetically balanced kindergarten 50 (PBK50) (Haskins, 1949), word intelligibility picture identification test (W1PI) (Ross and Lerman, 1970), the Northwestern 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 (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

Bisyllabic list for speech identification was mainly developed because of language restriction i.e. some languages do not have concrete monosyllabic words. They can be identified not only on the basis of phonetic elements but also on the basis of stress pattern (Hirsh, 1952). They are less analytic than monosyllables and provide additional cues for intelligibility.

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 (Mathews, 1996); Speech Identification Test for Kannada speaking children (Vandana,1998).

Sentences

Sentences are considered to be more valid indicators of intelligibility. But they are not typically used to 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 (PSI) (Jerger and Jerger, 1980); The Bench Kowal and Bamford, 1979); A Sentence Test for measuring Speech Discrimination in children (Weber and Redell, 1976); Synthetic Speech Identification test in Kannada

(Nagaraja, 1977); The Common Objects Token test: A sentence test for profoundly hearing-impaired children (Plant and Moore, 1992).

Thus while testing the paediatric population, the age, language level and the purpose of testing should be considered while selecting the speech stimuli.

b) Calibration of speech stimuli

Calibration of complex signals requires a different calibration procedure than that used for pure tone testing.

When calibrating the sound field-testing, many factors must be accounted for. These include distance from the speaker, azimuth, ear canal resonance, head shadow, and standing waves (ASHA, 1992, 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**

Many researchers have suggested that word familiarity is an important variable in speech identification testing (Hutton and Weaver, 1959; Owens, 1961; Carhart, 1965).

Words that are encountered more frequently in real life tend to be recognized better in speech tests than words that are not. The familiarity of a word obviously needs to be viewed in the context of the people on whom the test is to be administered. Children who have a profound hearing loss since birth will usually have a much narrower vocabulary than normal hearing children of their own age.

Owens's (1961) study on the intelligibility of words varying in familiarity shows that tests characterized by greater familiarity even to a slightest degree were significantly more intelligible. The less familiar the stimulus, more likely it is to be misidentified (Schultz, 1964). Devaraj's (1983) study on the effect of word familiarity on speech identification scores carried out on Indian English speakers is also in consonance with the above studies.

In general, it is recommended that the test items should be familiar to the target population. Unfamiliarity can adversely affect the responses obtained from the subjects.

d) Number of items per list / half vs. full list

Resnick (1962) has suggested that time can be saved in speech identification testing by limiting the test list to twenty-five words; using one half list with a weight of 4% per word. The half list selected should produce reliable and valid test results. If twenty-five items are given and speech identification scores is high, there is a reasonable expectation that there is no significant artifact adversely affecting performance.

Runge and Hosford-Dunn (1985) reported that if a listener responds correctly to the first ten items, there is little need to administer the remaining stimuli because the listener has already correctly perceived the most difficult items.

Runge and Hosford-Dunn (1985) also recommended terminating the test after ten words if no error occurs on their reordered lists and after twenty-five words if there are no more than four errors. Otherwise a full, fifty word list should be administered.

From the review of literature, it can be concluded that either of the list (half or full) can be used depending on the availability of time and purpose of the test.

e) Number of lists

In clinical practice, the use of several number of lists is rare. The need arises only when one has to determine the articulation function of an individual.

It is important that the same list should not be used more than once, because the scores may be contaminated with memory and practice effects (Tillman and Carhart, 1963). To overcome this problem, Dillon and Ching (1995) have suggested the use of equivalent lists so that any item will be presented only once. It is also important that each list should be comparable with the other. The items in each list should be identical with respect to difficulty (Hood and Poole, 1977). If the two lists do not meet these criteria, then the scores obtained by each of them will not be comparable.

f) 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 babble of a number of talkers, or background competition of a single talker.

Generally, background noise is used because speech communications in everyday listening situations most commonly takes place against a background competition noise. Secondly, noise is used because it tends to make the test more difficult. Many investigators contend 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 (Lovrinic et al., 1968; Cohen & Keith, 1976). 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 stated that although speech perception test scores usually become worse in the presence of noise, it is not clear that the addition of noise makes a given test more diagnostically useful than in quiet situations.

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.

II. 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.

According to Nabelek and Nabelek (1994), reverberation is the persistence of sound in an enclosed space resulting from sound reflection within that space.

Reverberation in rooms with moderate reverberation time, T, up to 0.5 sec. does not impair speech understanding for normal hearing listeners (Crum & Tillman, 1973) but recedes speech understanding for hearing impaired subjects (Finitzo-Hieber & Tillman, 1978).

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 sec. for normal hearing listeners (Nabelek and Nabelek, 1994). 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 listener and 1.5 dB for the hearing impaired group, which was independent of reverberation time.

Nabelek and Pickett (1974) found that the speech perception was poorer and performance decreased more rapidly with prolongation of reverberation time. The hearing impaired subjects performed an average of 7% poorer under the longer reverberation in the presence of noise and also in quiet. The normal subjects performed 15% poorer, at longer reverberation only in the presence of masking noise. Sensorineural hearing-impaired listeners are more sensitive to increased reverberation than are normal listeners (Nabelek and Pickett, 1974).

Gelfand and Hochberg (1976) reported that binaural hearing resulted in superior speech discrimination performance under reverberation for both normal and hearing-impaired subjects, compared to monaural hearing. As reverberation time increased, the monaural scores of both groups dropped substantially compared to the binaural scores.

Moncur and Dirks (1967) found a small increase in the binaural advantage as measured in an anechoic room compared with a reverberation condition where T= 0.9 sec. Mackeith and Coles (1971) found a large increase in the binaural advantage at T= 0.10 sec, compared with T=0.35sec.

A combination of noise and reverberation has a substantial effect on speech perception for both normal-hearing and hearing -impaired subjects (Nabelek and Pickett, 1974a, 1974b). The combined effects are greater than the effect of reverberation and noise measured separately (Finitzo-Hieber & Tillman, 1978).

According to Rupp and Stockdell (1980) (as cited in Rupp & Stockdell, 1980), manufacturers and/or installers of new sound rooms should assure purchases 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, cited** in **Nabelek** and Nabelek, **1994).**

Acoustical environment in classrooms can effect the achievement and performance of the hearing-impaired children. Gengel (1974) found that children having a moderate to severe sensori-neural hearing loss required a S/N ratio of atleast +10dB and preferably +20dB to function effectively.

Erber (1971) found that the hearing-impaired children required about 10 to 15dB greater S/N ratio than the normal hearing children needed for maximum speech intelligibility.

Thus room acoustics has a significant effect on the speech communication. Testing should be done in acoustically treated rooms, which meet the standards of ambient noise level.

b) Presentation Mode

Controversy exists as to whether recorded or monitored live voice (MLV) test materials should be used. The advantage of live voice presentation is that it provides the examiner greater flexibility over the test environment and requires shorter time of test administration because the tester can control the rate of stimulus presentations (Resnick, 1962; Creston, Gillespie, & Krolm, 1966). Monitored live voice may be preferred with the difficult to test population for example children who may require restriction of the test items and consideration of vocabulary. However, there are certain disadvantages like difficulty in monitoring the test words to a consistent intensity level and it may not be possible to present each speech material in the same manner to every subject (ASHA, 1979) (as cited in Kruger and Mazor, 1987).

Those who urge the use of recorded test material argue that only through recordings can consistency in presentation be maintained (Carhart, 1965). Recorded test can be edited to ensure uniformity of presentation level, can be standardized with normal listeners to ensure that the talker has correctly produced all items and their acoustic characteristics can be analyzed. But the problem with the recorded tests is that the signals cannot be presented at a pace that is consistent with the subject's response time and it can't be repeated. These pose major hindrance when evaluating children and difficult to test population. The use of interactive video laser discs coupled with adaptive presentations can make recorded stimuli suitable even for small children (Dillion and Ching, 1995). Computerized speech audiometry overcomes the disadvantages of both the recorded and MLV speech tests.

It can be concluded that the presentation mode depends on the availability of instruments.

c) **Instruction**

Researchers (Eisenberg, Berlin, Dill and Frank, 1966; Markides, 1979) have reported that instruction given to listener made a difference on speech identification score. Markides (1979) used two modes of instruction. 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. These results showed improvement in scores with instruction than without instruction.

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.

A good speech test must have appropriate verbal instruction for obtaining correct responses.

d) Carrier phrase

Another variable, which may affect the speech identification scores, is the use or omission of a carrier phrase. Typically, during speech identification testing, a carrier phrase precedes the stimulus word. The main purpose of using carrier phrase in speech audiometry is alert the listener for the test word and allowing the announcer to monitor his voice.

The most commonly employed carrier phrases are " say the word_____," "You will say________," "Write the word_________" and " Show me_______." There have been equivocal results reported in literature regarding the effects of scores on monosyllabic word tests with and without the use of a carrier phrase. Martin, Hawkins, and Bailey (1962) reported no significant differences in discrimination (recognition) of words recorded with a carrier phrase for PB word lists. On the other hand, Gladstone and Siegenthaler (1972) found that words from the CID-W22 test presented in isolation were more difficult to identify than were words spoken with a carrier phrase.

The issue of whether to use a carrier phrase is presently unresolved. One factor in determining when to use a carrier phrase may be determined by whether recordings or MLV presents the test.

e) Presentation level

The effects of presentation level on understanding of different stimulus materials can easily be visualized by employing the performance intensity (PI) function. Easier materials (e.g. Sentences and spondees) can be perceived at lower intensity levels, whereas more difficult stimuli (e.g. Nonsense syllables) may require higher presentation levels to obtain the same score. Maximum for sentence stimuli occurs generally around 25dB HL whereas maximum for nonsense stimuli occurs around 40 dBHL (Mendel and Danhauer, 1997).

Giolas (1975) obtained maximum speech intelligibility scores at 60dB SPL for CID-W22 word list.

Various researchers have developed materials for speech identification tests for the Indian population and obtained maximum speech discrimination score at 30dB - 40 dB SL either with respect to pure tone average (PTA), speech reception threshold (SRT) or Fletcher's average (FA).

Abrol (1971), Ghosh (1988) and Mathew (1996) observed maximum speech discrimination scores at 30dBSL using Hindi **PB** list, **Bengali word** list **and** Malayalam word list respectively. Kapur (1971) obtained **the** same **results with Tamil** word list at 35dBSL. 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), 33dB SL (ref. SRT), and 30dB SL (ref FA) respectively.

Clinically, most of the speech tests use 25 to 40 dB SL. 25dB SL correspond to the beginning of the plateau where normal subjects obtain 90% scores and 40dB SL represents reasonable comfortable listening level for normal hearing individuals. So it is always preferable to do the testing at 30-40dB SL to obtain better speech identification score.

f) Rate of presentation

This is another important variable which affects the test administration time and inturn speech identification scores. Changes in speaking rate will alter the perception and categorization of signal (Millers, 1981).

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

III. VARIABLES TO BE CONSIDERED WITH RESPONSE STRATEGIES

a) Response mode

Subject can indicate the presence of the test items either by pointing, selecting, repeating or by writing. There are two response modes. One is an open set response and the other is a closed set response.

Open set response

In this response mode, an individual can either repeat the test stimuli or can write down the test word. Studies done by Merell & Atkinson (1965), showed that the oral discrimination scores were always higher than written down discrimination scores. Devaraj (1983) compared the oral and written response modalities and reported that written responses should be preferred whenever possible. Similar findings are found by Northern and Hattler (1974).

Closed set response

Here the subject is required to point to the test item. In some cases, the test items are represented as picture to which the subject has to point. The pointing can be via a touch sensitive screen or mouse or a key board (Dillion & Ching, 1995). Response biases in the closed set response can be controlled by using randomized arrangement of pictures.

Response formats also largely depend on the age of the patient. Younger children are more likely to respond in closed set formats because of the 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).

When testing younger 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 the responses from within the test room (Thibodeau, 2000).

It can be concluded that the closed set response format is the preferred procedure for children. This is also recommended by Indian studies by Rout (1996), Mathew (1996), Vandana (1998) and Prakash (1999).

b) Reinforcement

Researchers (Markides, 1979 and Eisenberg et al., 1966) have suggested that 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 Hodgson (1970) reported the use of token reinforcement (candy, toy, money etc) to maintain the interest in 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.

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).

Other authors who have stressed the importance of social and tangible reinforcements are Mendel and Danhauer (1997), Olsen and Martin (1979), and Indian authors like Vandana (1998) and Prakash (1999).

Hence reinforcement is an important aspect, which needs to be considered in the speech identification testing to sustain the attention and interest.

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 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 of 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 some connected discourse tracking (De Fillipo 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 interest 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 the 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.

On the whole, there are a lot of variables, which need to be considered while doing the speech identification testing. Clinicians and researchers should be aware of the limitations of these test procedures and the effect these limitations may have on the results of speech identification tests.

SPEECH IDENTIFICATION IN BINAURAL AMPLIFCATION

One of the advantages of binaural hearing is improved speech identification in the presence of noise. Numerous studies involving experimental study and subjective reports have been performed to realize this binaural advantage in the hearing impaired with binaural amplification.

Dot, Hickson and Connell (1992) evaluated the speech perception abilities in noise of 14 asymmetrical hearing-impaired subjects who had been fitted with bilateral contralateral routing of signal (BICROS) hearing aids wearing both conventional monaural amplification and their own BICROS aids. Sentence lists from Speech Perception in Noise (SPIN) test and the Synthetic Sentence Identification (SSI) test were presented in a background of recorded form-talker babble. The results showed that there was substantial improvement in speech discrimination with BICROS microphone in the two noise conditions (40 dB and 60 dB SPL) as compared to monaural amplification only.

Binaural hearing is reportedly advantageous for speech identification and intelligibility in noise (Bergman, 1957; Markle and Aber, 1958; Harris, 1965; cited in Dot, Hickson and Connel, 1992).

Binaural fusion may enhance perception of sounds from noise or speech backgrounds by the fusion of distorted signals at one ear or the other, particularly in the presence of hearing loss and low fidelity amplification (Hodgson and Skinner, 1977).

Cooper and Cutts (1971) investigated the speech discrimination in noise using sixteen normal hearing and fifteen sensori-neural impaired subjects at four different S/N ratios i.e., (0,4, 8, 12 dB). The results indicated that the range of impaired scores were approximately twice that of normals at 8, 12dB S/N ratios. At 4 dB S/N ratio, the values were closer although the hearing impaired group still demonstrates a greater degree of intersubject variation.

In a study conducted by Day, Browning and Gatehouse (1988), the benefit from binaural hearing aids in individuals with bilateral severe hearing-impaired was studied against monaural aids. Free-field audiovisual sentence-in-noise test (FASIN) was carried out at S/N ratio of +5dB. The mean benefit of binaural over monaural aids was 8.7% on the FASIN test. It was concluded that binaural hearing aids are generally more effective than a single aid in enabling an individual with a bilateral severe hearing impairment to speech-read in noise.

Other researchers like Wright and Carhart (1960), Nordlund and Fritzell (1963) and Dermody and Byrne (1975) have also reported improvement in speech identification in noise with binaural hearing aids.

Hawkins & Yacullo (1984) performed a study on twelve normal hearing adults and eleven subjects with bilateral symmetrical mild-to-moderate sloping sensori-neural hearing loss to determine the S/N ratio required for a constant performance level of word recognition under three levels of reverberation using monaural and binaural hearing aids having both directional and omnidirectional microphones. The results indicated that,

a) a significant binaural advantage (2-3dB) was independent of hearing and arrangement (monaural or binaural) but depended upon the level of reverberation.

b) a significant reverberation effect which was larger than either binaural or directional microphone effect and

c) additive binaural and directional microphone advantages. The results obtained suggested the S/N is optimized when binaural hearing aid with directional microphone are used in rooms with short reverberation time.

Nabelek and Pickett (1974) studied the speech perception with normal and hearing impaired subjects in a single sound treated room at S/N ratios of +10, +5, 0 and -5 dB and at reverberation time T = 0.3 and T = 0.6 sec. Binaural and monaural perception through hearing aids was compared in quiet and in the presence of babble of eight voices. Binaural listening yielded higher word recognition scores. In quiet and at S/N ratio of +10dB the impaired subjects obtained binaural scores that averaged 4.5% points better than monaural scores at T = 0.3 sec and at T = 0.6 sec. Binaural scores were 3.6% better than monaural.

Markle and Aber (1958) (as cited in Markides, 1977) clinically evaluated monaural and binaural hearing aids with respect to speech identification abilities of the subject and they showed significant difference in favour of binaural hearing aid in the order of 11 and 29% at S/N ratio of 0 and 10 dB respectively.

Markides (1977) indicated that individuals with symmetrical hearing impairment showed significant binaural advantage for speech perception.

But there is little concrete evidence that binaural amplification actually provides any significant improvement in the ability to understand speech.

Pollack (1975) indicates that binaural hearing rarely improves SRT but in almost every case, brings about a significant change in the discrimination/identification score.

Ross (1977) (as cited in Chermak, 1981) reviewing the earlier studies point out that majority of studies comparing speech discrimination scores obtained with binaural and monaural hearing aids with hearing impaired subjects revealed binaural superiority.

Zelnick (1970) (as cited in Zelnick, 1985; cited in Yamini, 1988) reported the results of his research with hearing impaired listeners suffering from approximately bilateral symmetrical sensori-neural hearing disorders. He found that on scoring speech discrimination with phonemic method suggested by Duffy (1967) the binaural system proved significantly superior for speech intelligibility to the monaural mode.

Nabelek and Pickett (1974) demonstrated that aided hearing impaired individuals showed a binaural advantage for speech identification in quiet and with background noise in both low and moderately reverberant environments.

Kuyper (1972) (as cited in Yamini, 1988) indicated significant improvement of speech identification both in noise and in babble in ninteen out of twenty five patients (8-16 years of age) fitted with a stereophonic hearing aid in a normal environment.

On the contrary, another study reported that speech identification in noise with a S/N ratio of 10 dB was reduced only for a sensori-neural group (Palva, 1955; as , cited in Copper and Cutts, 1971).

Markides (1977) found that there were only slight differences in speech identification between the performances of the subjects when using two pairs of ear level hearing aids. Similarly the speech identification performance using three pairs of body worn hearing aids were virtually identical.

Though studies were carried out comparing pairs of ear level and body level hearing aids separately but there has been no empirical study comparing the binaural ear level to the binaural body level hearing aids basically with reference to speech identification testing. So the present study focusses on this aspect.

METHOD

This study has been taken up to compare the speech identification scores (with and without noise) using binaural behind the ear (BTE) and binaural body level (BL) hearing aids.

SUBJECTS

Twenty-four children (twelve having severe sensori-neural hearing loss and twelve having profound hearing loss) were selected for the present study. The subjects fulfilled the following criteria:

i) The subjects had bilateral symmetrical sensori-neural hearing loss with the degree varying from severe to profound

ii) All the subjects were binaural behind the ear hearing aid users

iii) The subjects were in the age range of 3.5-6.11 years,

iv) They had no history of middle ear pathology

v) They had no history of any neurological problem

vi) They had normal I.Q.

vii)The subjects had attended speech and language therapy for atleast one year.

TEST MATERIAL

Bisyllabic phonemically balanced word list in Kannada, developed by Vandana (1998) was used. The test contains two lists with fifty words each. Each list has equal half list (twenty-five words). In the present study, both binaural body level (BL) and binaural behind-the-ear (BTE) hearing aid was tested using a half list. The picture book with four alternative choices for each item was used to obtain the responses.

INSTRUMENTATION

A two-channel, clinical audiometer, MAICO MA-53 with MAICO AL5 loudspeaker (single unit) was used for testing. The calibration of frequency and intensity for pure tone and speech was done to confirm to ANSI (1996) specifications.

TEST ENVIRONMENT

Testing was carried out in a sound treated two-room situation. The ambient noise was within permissible limits as recommended by ANSI (1991).

PROCEDURE

All the subjects were tested for

Two parameters

- Speech identification in quiet
- Speech identification in noise

This was done under two different conditions of amplification

(i) Own binaural behind the ear (BTE)

(ii) Binaural body level hearing aid (BL)

Then a comparison was made between the speech identification scores in these 2 different listening conditions.

CALIBRATION

The loud speakers were calibrated by placing it at 45° azimuth.

INSTRUCTION

The subjects were given instruction in Kannada in the following way:

" You will hear some words through the speaker. Listen carefully to each word and look at all the pictures on the page. Point to the picture of the word that you hear. If you listen carefully and point correctly you will be given sweets".

ADMINISTRATION OF THE SPEECH IDENTIFICATION TEST

The subject was seated at a distance of one meter away from the loudspeaker placed at 45° azimuth. Two examiners carried out the speech test. One examiner presented the stimuli using monitored live-voice. A distance of 6-9 inches was maintained between the microphone and mouth of the speaker as recommended by Penrod (1994). The other examiner was seated beside the child to help him/her turn to the appropriate page of the picture response book.

Initially three practice items were presented at a comfortable level i.e. 40dBSL relative to Fletcher's average (the average of 500Hz, 1 KHz, 2KHz) (Rupp and Stockdell, 1980).

Initially the unaided speech identification testing was carried out followed by the aided speech identification testing in the binaural body level and binaural behind the ear amplification conditions. The bisyllabic phonemically balanced word list was presented at +10dB S/N ratio through the loud speakers placed at 45° azimuth. The order of the test forms was randomized using a random table for each subject. No subject heard the test items in the same order more than once.

SCORING

The responses were recorded on a score sheet. Every correct response was given a score of 4% and an incorrect response was scored as 0%. The child was reinforced after every correct response. The percentages of correct responses were calculated for each subject. The data collected was statistically analyzed.

RESULTS

The aim of the present study was to find out the differences in speech identification scores (in the presence of noise) using a binaural behind-the-ear (BTE) and binaural body level (BL) hearing aids.

The twenty-four children (twelve having bilateral symmetrical sensori-neural hearing loss and twelve having bilateral symmetrical profound hearing loss) were subjected to speech identification testing at an S/N ratio of +10dB under the above mentioned amplification conditions. The data was analyzed using t-test to compare the speech identification scores between

1. unaided and body level
2. unaided and behind-the-ear
3. body level and behind-the-ear

The mean, standard deviation and 't' values were calculated for both severe sensori-neural hearing loss and profound sensori-neural hearing loss groups.

Table 1 shows the mean, SD & 't' values of speech identification scores across different conditions for severe sensori-neural hearing loss individuals.

VARIABLE	N	M	SD	t
Unaided	12	9	2.23	3.92**
Body level	12	13.75	2.37	
Unaided	12	9	2.23	7.56**
Behind-the-ear	12	15.66	2.32	
Body level	12	13.75	2.37	2.09*
Behind-the-ear	12	15.66	2.32	

df=22 *p<0.05 **p<0.01

The results tabulated in table 1 shows that

i. **there is a significant difference between the unaided speech identification** scores **and speech** identification scores **obtained in the body** level listening condition at 0.01 level of confidence.

ii. There is a significant difference between unaided speech identification scores and speech identification scores obtained in the behind-the-ear condition at 0.01 level of significance.

iii. There is a significant difference between speech identification scores obtained in the body level and behind-the-ear conditions at 0.05 level of significance.

iv. The mean speech identification scores obtained in the behind-the-ear condition was higher as compared to the other two conditions(unaided and body level).

Table 2 shows Mean, SD and 't' values of speech identification scores across different conditions for profound hearing loss individuals.

VARIABLE	N	M	SD	t
Unaided	12	8.25	1.83	5.14**
Body level	12	11.08	0.87	
Unaided	12	8.25	1.83	6.85**
Behind-the-ear	12	12.5	1.32	
Body level	12	11.08	0.87	3.30**
Behind-the-ear	12	12.5	1.32	

df=22 **p<0.01

Table 2 summarizes the results of t-test .It indicated that there is statistically significant difference in speech identification scores between the three conditions:

i. Unaided vs body level
ii. Unaided vs behind-the-ear
iii. Behind-the-ear vs Body level

at 0.01 level of significance.

The mean speech identification scores obtained in the behind-the-ear condition was higher as compared to the other two conditions (unaided and body level).

DISCUSSION

Evidences from literature have reported the comparison of performances across different types of body level and ear level hearing aids. There is a dearth of studies were done comparing the performance of speech identification scores (SlS)between behind-the-ear(BTE) and body level (BL)hearing aids. Hence the present study was an attempt to compare the binaural performances across subjects using BTE and BL hearing aids.

The test results indicate that there has been significant improvement in the two binaural listening conditions as compared to the unaided condition with reference to SIS in quiet and in noise (i.e. at S/N ratio of +10dB). This can be attributed to the benefits of amplification.

Apart from this a significant improvement was also noted for behind-the-ear (BTE) as compared to the body level (BL) speech identification scores in the presence of noise. This could probably be due to the head shadow effect. Because of the head shadow, the sounds to the ear opposite to the sound source are significantly reduced in amplitude (Olsen & Carhart, 1967). Mackeith and Coles (1971) report that this reduction could be upto 13 dB due to head shadow effect. Markides (1977) also reported that binaural hearing aids of the ear level types provided significant advantages in terms of squelch effect varying from 1.44 dB to 2.67 dB. The head shadow effects achieved with these aids were consistently with in 6-7dB. The advantageous squelching effect of binaural hearing aid over monaural hearing aid use was also observed when the subjects were using the body worn types. With such aids the subjects exhibited binaural squelch effects varying in magnitude from 1.78 dB to 4dB. The head shadow type of advantage was not obtained in this case.

The difference could also be due to the increased speech discrimination in noise. Researchers like Bergman (1957), Marlke and Aber (1958), Harris (1965) report that binaural hearing is advantageous for speech identification and intelligibility in noise. Similar findings have been reported by Wright and Carhart (1960), Nordlund and Fritzell (1963) and Dermody and Byrne (1975) for binaural hearing aids.

Another study by Pollack (1975) reveals that binaural hearing rarely improves speech recognition threshold (SRT) but in almost every case brings about a change in speech identification scores.

In the present study SIS testing was done in the presence of noise to increase the diagnostic value of the test and to make it more sensitive. This was also reported by Cohen & Keith (l976)and Lovrinic et al..(1968).

Dot, Hickson and Connell (1992) reported that there was substantial improvement in speech discrimination with BICROS microphone in noise conditions as compared to monaural amplification only.

Investigators like Nabelek & Pickett (1974) have found a binaural advantage for SIS in quiet and with background noise in both low and moderately reverberant environments in aided hearing-impaired individuals.

Different researchers have used different levels of S/N ratio to find the speech discrimination/identification. One study by Marlke and Aber (1988) demonstrated significant improvement in speech identification ability of around 29% at S/N ratio of +10dB by using binaural hearing aids. So in the present study an S/N ratio of+10dB was employed. A qualitative scoring of the results indicated a significant improvement in the speech identification ability at + lOdB S/N ratio. This was more significant in the severe sensori-neural hearing loss group as compared to the profound hearing loss group.

Another factor which led to the improvement in SIS in noise was because of symmetrical hearing impairment. Similar findings have been suggested by Markides (1977). Zelnick (1970) also found a binaural advantage of about 15% with subjects having bilateral symmetrical hearing loss and using commercial ear level hearing aids.

As evidenced by many researchers there is a better speech perception in binaural aided conditions. The present study was aimed at finding out the differences in binaural body level hearing aid listening vs binaural ear level hearing aid listening conditions. The parameter studied was speech perception in noise. It was found that the results are in agreement with the earlier investigators.

Recommendations for further research

Due to time constraints the other advantages of binaural hearing could not be taken up for the study. Hence, further research could be carried out for testing other advantages of binaural listening.

SUMMARY AND CONCLUSION

Binaural hearing is based on the ability of the total human system to detect two different signals, analyze their differences and perceive a single auditory image. Binaural hearing has a lot of advantages like better sound localisation, increased speech discrimination in noise, greater case of listening, better spatial balance and improved sound quality.

The present study was carried out with an objective to find out the differences in speech identification scores (in the presence of noise) using a binaural behind-the-ear (BTE) and binaural body level (BL) hearing aid.

The twenty-four subjects were divided into two groups - (twelve having severe sensori-neural hearing loss and another twelve having profound sensori-neural hearing loss) who were subjected to speech identification testing. The subjects were in the age range of 3.5-6.11 years and had bilateral symmetrical hearing loss and were binaural BTE users. There was no history of middle ear pathology or any neurological problems.

Speech identification testing was done in a sound treated two-room situation. The subjects were tested for two parameters.

Speech identification in quiet

Speech identification in noise

Under two conditions of amplification i.e.,

- own binaural BTE
- binaural body level hearing aid.

A comparison was made between the speech identification scores in these two different listening conditions.

The results of t-test for severe hearing loss group indicated that

i) There is significant difference between the unaided SIS and SIS obtained in the body level condition at 0.01 level of significance.

ii) There is significant difference between unaided SIS and SIS obtained in the BTE condition at 0.01 level of significance.

iii) There is significant difference between SIS obtained in the body level and BTE condition at 0.05 level of significance.

iv) The mean SIS obtained in the BTE condition was higher as compared to the other two conditions (unaided and body level).

The results of t-test for profound hearing loss group suggested that there is statistically significant difference in SIS between the 3 conditions

(i) Unaided vs body level

(ii) Unaided Vs behind the ear

(iii) Behind the ear vs body level

at 0.01 level of significance

The mean SIS obtained in the BTE condition was higher as compared to the other two conditions (unaided and body level).

From the results of the present study it can be concluded that binaural behind-the-ear hearing aid is considered to be better than binaural body level particularly with reference to speech identification scores.

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APPENDIX-I
TEST LISTS (Given by Vandana, 1998)
Familarization items:

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

Test items

List - A		List - B	
ಲೋಟ	/lo:ta/	ಕಣ್ಣು	/kannu/
ಏಣಿ	/e:ni/	ಹೂವು	/hu:vu/
ಚಾಕು	/cha:ku/	ಕಾಗೆ	ka:ge/
ಬಸ್ಸು	/bassu/	ಕಪ್ಪೆ	/kappe/
ಗೂಬೆ	/gu:be/	ಮೊಲ	/mola/
ಕತ್ತು	/kattu/	ಏಣಿ	/e:ni/
ಲಾರಿ	/la:ri/	ಮಳೆ	/male/
ಮನೆ	/mane/	ಲೋಟ	/lo:ta/
ನಳ್ಳಿ	/nalli/	ದಾರ	/da:ra/
ಮೇಕೆ	/me:ke/	ಚಾಕು	/cha:ku/
ಮೊಲ	mola/	ಮನೆ	/mane/
ಕಾಗೆ	/ka:ge/	ನಳ್ಳಿ	/nalli/
ಸೇಬು	/se:bu/	ಓಲೆ	o:le/
ಬೀಗ	/bi:ga/	ಬಸ್ಸು	/bassu/
ಕೋಳಿ	/ko:li/	ಕತ್ತು	/kattu/
ಹೂವು	/hu:vu/	ಗೂಬೆ	/gu:be/
ಮೂಗು	/mu:gu/	ಛತ್ರಿ	/chatri/
ಹಸು	/hasu/	ಮೇಕೆ	/me:ke/
ಮಳೆ	male/	ಸೇಬು	/se:bu/
ಕಪ್ಪೆ	/kappe/	ಬೀಗ	/bi:ga/
ಕಣ್ಣು	/kannu/	ಲಾರಿ	la:ri/
ದಾರ	/da:ra/	ಮಳೆ	/male/
ಛತ್ರಿ	/chatri/	ಕಾಗೆ	/ka:ge/
ಚೀಲ	/chi:la/	ಗಿಣಿ	/gini/
ಮೀನು	mi:nu/	ತಟ್ಟೆ	/tatte/
ಮೇಜು	/me:ju/	ಸರ	/sara/
ಇಲಿ	/illi/	ಕಾರು	/ka:ru/
ಸೂಜಿ	su:ji/	ಪೆನ್ನು	/pennu/

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

Note : (lists 'A' and 'B' are reverse orders of lists A & B).