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VIBROTACTILE AID-WITH & WITHOUT SPEECHREADING -A COMPARISION

REG.NO. M9321

AN INDEPENDENT PROJECT WORK SUBMITTED IN PART FULFILMENT FOR FIRST YEAR M.Sc. (SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.

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

1994

CERTIFICATE

This is to certify that the Independent Project entitled: **VIBROTACTILE AID-UITH & WITHOUT SPEECHREADING - A COMPARISON** is the bonafide work done in part fulfilment for first year M.Sc, (Speech and Hearing) of the student with REg. No.M9321.

Mysore
May 1994

Director
All India Institute of
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Mysore 570 006.

CERTIFICATE

This is to certify that this Independent Project entitled: **VIBROTACTILE AID-WITH & WITHOUT SPEECHREADING - A COMPARISION** has been prepared under my supervision and guidance.

Mysore
May 1994

Or.(Miss) S.Nikam,
GUIDE

DECLARATION

I hereby declare that this Independent Project entitled: **VIBROTACTILE AID-WITH & WITHOUT SPEECHREADING - A COMPARISION** is the result of my own study undertaken under the **guidance** of Dr.(Mise) S.Nikam, Director, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore
May 1994.

Reg. No.M9321

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INTRODUCTION

Sensory capability is the capacity of the organism to exhibit relatively simple behavioral or physiological response to a set of simple well controlled stimulus condition.

By nature man is a gregarious animal whose entire well being is closely related to his ability to communicate freely with his fellow beings. Out of this need evolved one of the most remarkable achievements of all times, the development of language to facilitate the interchange of ideas, feelings and desires and the like. Obviously, communication requires not only verbalization of language by the speaker but also its intelligent reception by the listener. A difficult situation arises when an impairment of hearing, vision, speech hinders the expression or reception of language.

The sensory apparatus of hearing is an indispensable tool for hearing and for the development of speech and language. Its functions are coordinated with other sensory modalities like vision, touch, taste and smell, the former two being the most important. Those individuals who have been deprived of their sense of hearing might have to depend on the visual and tactile sense of communication. They may also have to depend on speech reading information received through the visual and tactile senses.

In spite of the considerable advances in hearing aid technology that have occurred in the past decades there remains a population of hearing impaired individuals who cannot derive sufficient benefit from the use of a conventional hearing aid. For people who have suffered a profound loss of hearing either congenitally or adventiously in later life, the necessity for alternative pathways from the acoustic world to the brain is urgent. This realization has led to the development of alternative devices for use by people who cannot benefit from the hearing aid.

The deaf/blind do not miraculously acquire a supersense to compensate for their particular handicap. It is a shift of attention that enables them to work seeming miracles. For the profound hearing - impaired children vision is the main compensatory sense used for speech perception. Messages conveyed through speechreading constitute an optical language encoded in the muscular changes that accompany production of acoustic messages. The process is often difficult because numerous speech elements look alike even to a careful observer and the lipreader often must extract meaning from the situation and language context.

Communication through the skin also offers possibilities for adding to the ways of receiving information because the ability to perceive through the skin a variety of patterns of pressure and vibration has suggested itself as an exploitable talent that can be used as a functional channel to perceive the acoustic messages.

The frequency response of the ear is between 20 and 20,000 Hz with the optimal frequency response between 300 and 3000 Hz. However the response of the skin is limited to frequencies of 10 to 500 Hz. The optimal frequency response of the skin being only to low frequency stimulation is a major limiting factor when hearing aid amplification is used because hearing aids typically do not amplify frequencies below 400-500 Hz. This is most likely the primary reason why the majority of individuals with profound hearing loss obtain little benefit from hearing aid use and as many as 23% of the profound hearing impaired school aged population choose not to wear the hearing aid. Here comes into the scene the tactile aid. The goal of a tactile aid is to improve communication by changing acoustic signals into vibratory or electric signals and delivering them to the skin in the most efficient way possible, maximizing the physiological capabi1ities of the skin. But with the tactile sense alone it is difficult to understand spoken messages and this modality is more useful as a supplement to speechreading. For the profound hearing impaired individuals improvements in the speechreading performance is promised when speechreading is combined with tactile devices that are designed to efficiently and effectively transmit information bearing speech features. Hence both speechreading and tactile sense *are* complementary to each other and need to be described as a component of a bi-or multisensory process.

<u>The goals of tactile aids are</u>.

1. to provide the wearers with increased auditory contact with their environment including awareness of their own voice.
S. to improve their ability to speechread.
3. ultimately to provide the ability to discriminate connected discourse.

When a vibrotactile stimulus is presented to the skin, quickly adapting mechanoreceptors are stimulated. The primary afferent fibers transmit the information from the mechanoreceptors to the dorsal horn of the spinal cord where they ascend ipsilaterally in the dorsal column and terminate in the nuclei at the level of the medulla in the brainstem. At that point the fibres decussate and continue up the medial lemniscus to the thalamus. From the thalamus the vibrotactile information ascends to the somatosensory *area* of the cortex (Martin, 1985). Verillo (1980) reported a progressive decrease in sensitivity at frequencies between 80-700 Hz. The sharpest decrease occurs at 50-65 years. Since the cues utilized by deaf 'individuals for speech reception *are* not necessarily same as those used by the normal hearing population the ultimate goal of a tactile communication system is to extract the relevant acoustic information from the speech signal and to transpose it to the individual in a tactile mode as a means of supplementing or replacing the auditory reception of speech.

Touch may substitute one of the major senses. With tactile stimulation acoustic signals that have been transposed into vibratory patterns on the skin are used to augment or replace conventional air conduction amplification. Except for the fact that both hearing and touch respond to mechanical forms of energy they do not seem to be very closely related in the human anatomy. The inner *ear* is an insular organ with an intricate geometric design that accepts a flow of mechanical energy, performs rapid preliminary analysis of it. Then it is converted into a message that ultimately reaches the cortex. In contrast the skin is a diffuse system occupied by a vast number of entities other than mechano receptors and hence serves many other functions. At the receptor level the skin is less sensitive than the ear, the result of this is that it takes much more energy to inform the skin a message. This is a fact that transducer designers continue to lament. Another notable difference between the ear and skin is the nature of the message normally imparted through them. For the neonate the tactile message is warmth, caresses and support. The auditory message is also comforting but it soon takes on signalling aspects. It is the means by which the parent encourages the child to discriminate environmental events of all kinds through speech and language.

Tactile aids can use two types of stimulation -

1. Vibrotactile in which acoustic signals are presented as vibrations to the skin using mechanical transducers.
2. Electrotactile (electrocutaneons) in which acoustic signals are presented to the skin as electric currents.

Use of vibrotactile approach has been preferred over the electrotactile approach due to the availability of vibrators for experimental use and also the inherent difficulties experienced with applying an electric current to the skin.

There has been renewed interest in developing instrumentation for tactile stimulation that will adequately aid in both speech reception and production. Basically types of tactile devices are separated into single channel and multichannel aids. With single channel devices the available information is limited to simple awareness of environmental sounds and temporal cues (stress patterns and prosody). For speech the single channel device is severely limited and is capable of displaying only rudimentary fundamental frequency information. However, single channel devices, though limited, they have proven to be beneficial in supplementing speechreading. Multichannel devices are made up of individual vibrators that *are* perceived separately. Continuous multichannel devices differ from discrete, in that there *are* more vibrators, which are placed close together. Multichannel tactile devices can present information using a one dimensional (linear) or two dimensional display. A one dimensional linear array is like a piano keyboard with low frequencies at one end and high frequencies at the other. Two dimensional arrays code frequency along one spatial axis and intensity along the other. It is theorized that the two dimensional array would make it possible for the skin to extract both frequency and intensity cues from the complex speech signal in a more efficient manner than one dimensional array.

There is no question that tactile aids provide maximal benefit in face to face conversation where the signal to noise ratio is favorable and the use of visual cues is maximized.

With tactile aids the skin's limited ability to process sound is a major limiting factor. Sherrick (1984) argues that speech is a special code that only the auditory system can process and since the skin is limited in its ability to process sound it is probable that tactile aids will not function as a substitute for hearing but rather supplement to communication by facilitating speechreading. The purpose of vibraotactile stimulation is to provide additional sensory input to the information the hearing impaired child is able to receive auditorily and visually. As supported by Pickett (1963) the addition of a new sensory channel adds complementary and redundant information to that which the child is already receiving.

The vibratactile aid used in this study is the **TACTAID II +** .

It is a device that converts sound information into a pattern of vibration that can be used by the most profoundly hearing impaired children to improve their understanding of the world of sound. The Tactaid 11**+** employs a processing scheme whereby the incoming acoustic signal is divided into two - channels, the lower channel covers the range of 100 Hz to 1.8 KHz and the upper channel covers the range of 1.5 KHz to 10 KHz. All sounds *are* transposed to frequencies centered around £50 Hz which are then transmitted to the two vibrators. The unit employs automatic noise suppresser (ANS) circuit to reduce the steady state background noise. The Tactaid **11+** is an updated version of **Tactaid II.**

Usefulness of the **Tactaid 11+** is in the following areas!

(1) it facilitates the development of awareness of sounds in the environment.

(2) it is useful for conveying and recognizing many suprasegmental characteristics of speech such as rhythm, phrasing, syllabic pattern, stress, and loudness. Also in determining the presence or absence of sibilants.

(3) it will provide helpful feedback information about the user's own speech production.

(4) with sufficient training it will be found to be a useful aid to speechreading.

NEED FOR STUDY:

It is a well known fact that when the hearing loss enters the profound range of impairment difficulty is apparent in the perception of all types of phonetic contrasts. The performance of children with losses greater than 100 dB HL might reflect vibratactile responses to auditory stimuli, that is, they do not hear at all but rather they respond to auditory stimuli, on the basis of vibratactile stimulation to their ears. These children *are* able to perceive cues of place of articulation relying on speechreading. But the performance of children with profound losses with combined visual and auditory cues is only slightly better than their performance when only visual cues are available. Hence the effects need to be determined combining tactile and visual cues. It is stated that with sufficient training and assistance of the TACTAID II+, one is able to see significant improvements in the child's sound awareness, language and speechreading ability. Hence this study evaluates the contribution of both tactile and visual cues in the perception of speech in profoundly hear ing-impaired children.

The current study was undertaken to find out if there is any significant variation in the performance of the subjects when they-

(a) rely only on tactile cues

(b) rely only on visual cues (their speechreading ability)

(c) rely on both tactile and visual cues.

REVIEW OF LITERATURE

The idea of using the tactile sense as a substitute for or supplement to the hearing impaired is not new. For several centuries teachers have attempted to convey information by encouraging their pupils to use the sense of touch. As early as the mid 18th century the great French teacher Jacobo Rodriguez Periera used the sense of touch for noting the vibrations of the voice with many of his pupils Greene (1783), Abbe del Epee (1784) Arrowsmith (1879) all report using the tactile sensation for input of stimulation. Thus it is clear that use of tactile input has developed well before and been in use for over a century.

Simultaneously attempts to develop electrical devices to transmit acoustic messages to the sense of touch were being worked upon. Dupont (1907) early in this century worked on this concept.

Though use of tactile sensations had been in use, it was Stony in 1917 who advocated the use of tactile sensations strongly. He felt that the child should be allowed to touch the teacher's face and larynx but warned against the teacher touching the child's face and larynx. Perhaps the idea behind this warning was that the drive to speak should come from the child and not imposed by the teacher.

It was the pioneering work of Robert H Gault and his colleagues in the 1920s that brought forward formal efforts and research in studying tactile stimulation and use of tactile aids. Gault's original aim was to use touch as a substitute for hearing in interpreting and controlling speech. Gault's primary hypothetical construct was "to graft an *ear* to the skin". Thus, it was evident that Gault was attempting to develop a sensory substitute for the impaired *ear* rather than a sensory aid to assist the hearing impaired individual. Gault (1924, 1926a, 1926b), Gault and Goodfellow (1937) conducted a series of experiments, using devices like crude 14 foot "speaking tube". Here the subject places his or her hand over the end to a single hand held vibrator. Gault found that one subject after 35-40 hours of practice could recognize 34 words through tactile stimulation only and a greater number of sentences made up by combining these words. Also the subject attained an accuracy of 88-95% when familiar words were used. Gault in 1930 reported that aided speech reading scores to be 11% better for words and 15% better for sentences than those obtained when the same materials were presented through speechreading alone. In the studies quoted, it is found that the scores for the sentences is better than the scores for words. This could be attributed to the fact that the sentences themselves provide more clues.

Using Gault's aid with congenitally hearing impaired children Goodfellow (1934) reported that aided speechreading was improved by 20%. Thus it can be stated that the tactile aid enables the child to locate emphasized words and phrases in speech more successfully, perceive inflection, natural phrasing of spoken language and also identify homophenous words.

In 1963 Pickett conducted a study wherein the tactile communication of speech sounds to the hearing impaired was compared with lip-reading. Tasks of discrimination and identification were used in both conditions individually. The vocoder provided new information for discriminating /m, b/ and number of syllables and also provided redundant information for identifying some of the vowels. Thus a larger number of speech sounds could be discriminated and also the redundant vowel information will tend to support transmission of vowels when the receiver's eyes leave the talker's face or he is too far from the speaker to receive lip-reading cues.

The results of this study certainly proved that some of the features of speech were better received tactually than by lip-reading. But the question that can be risen is that how a definitive comparison can be made between tactual communication and lip-reading. The reason is the large amount of lip-reading experience that preceded the test when compared with the small amount of practice on the tactual vocoder. Inspite of this factor it was reported that consonant and vowel durational patterns and the number of syllables in a word were better perceived tactually than by lip-reading. Also tactual reception was superior for perceiving /m/ vs */to/* and number of syllables.

Suzuki, Kagami and Takahashi (1968) trained children with 10 vibratory outputs. Their observation was that certain homophonous words were discriminated significantly when vision was aided by touch. Better additional information enhanced speechreading. The tactile sensation thus can supply gross features of spectrum, time and amplitude.

Kringlebotn (1968) used a vibratory system to teach the articulation of the /s/ sound. Ten profoundly hearing impaired boys were tested under two conditions!

(1) audition supplemented by speechreading

(E) audition and lip–reading supplemented by a vibrotactile cue.

Here again results showed that the tactile cue enhanced the performance. The tactile aid supplies those cues that *are* not visible overtly and hence contributes largely to better performance.

Despite these promising results the use of tactile aids was largely discontinued during the period when there was wide spread availability of wearable hearing aids. It soon dawned on them that many congenitally profoundly hearing-impaired individuals received little benefit from a hearing aid, thus this contributed to the revival of tactile aids.

The first tactile aids fitted in the 1970s were simply devices that consisted of bone conduction vibrators driven by high power hearing aid. In these aids the limited frequency response of the skin considerably restricted the information available to just the frequencies below 1000 Hz. Also above 1000 Hz there were reports of poor frequency discrimination. Thus at that time the users of tactile aids basically received only time and intensity information.

1973 to 1977 saw the development of a variety of tactile aids. Berguesse (1976) modified the single channel aid to generate a single frequency to which the skin was most sensitive. Thus, here it is seen that the amplitude of the speech signal is modulated so as to yield the prosodic sequence that mirrored the speech.

The year 1976 saw the advent of spectrally oriented aids. Goldstein and Stark (1970) evaluated this spatio temporal vocoder type aid. Such aids can be useful for training profoundly hearing impaired individuals in the reception and production of speech segments.

Evaluation of a tactile vocoder for word recognition was done by Erber (1974). The vocoder was designed so as to combine many features. Words were used as stimuli. Results showed that majority of the phonemes can be identified. The confusions that are formed through cutaneous sense are similar to those that occur in addition or in visual representation of the speech signal.

Rosenberg (1973), Decker and Foleon (1978) Plant (1982) all reported that using simple tactile devices resulted in significant improvement in speechreading performance.

Another study that tested the discrimination of fricatives by hearing impaired children using a vibrotactile cue was conducted by Ling and Sofin (1975). The children were tested under two conditions.

<1) audition supplemented by lip-reading

(2) audition and reading supplemented by a vibrotactile cue.

Here again, results showed that the subjects had a superior performance, speech reception was improved and errors were reduced when the tactile cue was given. This study was the first in the series of experiments planned to determine whether information on manner of articulation could be transmitted tactually in parallel with visual and auditory information. It is evident the subjects do learn to process the tactile cue in parallel with visual and auditory information.

Hence, work on tactile cueing of speech need not be limited to fricatives as in the above study. Other features such as nasality, voicing and plosion can be automatically extracted from the speech signals and tactile cues such as differences in intensity, frequency, duration or all three can be incorporated.

Zeiser and Erber (1977) studied the auditory vibratory perception of syllabic structure in words by profound hearing impaired children.- Sixty monosyllabic, disyllabic and trisyllabic words were used. Besides the 20 hearing impaired children 20 normal hearing adults were also tested. They observed that the performance of the profound hearing impaired children while listening to the stimulus was very similar to their performance while feeling them. An analysis of the responses that were not anticipated suggests that previous linguistic experience may play a role in perception of number of syllables. Another important observation made was that tactual perception of syllabic patterns in words is very similar to vibrotactile perception by normal hearing adults.

This study highlightens the fact that profound hearing impaired children may not have true hearing and would rather perceive the amplified sounds through tactile receptors than through the auditory channel.

Erber in 1979 discussed speech perception by profoundly hearing impaired children. He enlightened the role of visual and tactile sense. Profound hearing impaired children can categorize spoken consonants on the basis of the points of articulation (although consonant recognition is affected to an extent by vowel context). Perception of speech through the visual mode improves under good optical conditions and familiarity of words/sentences presented, length of the utterance spoken. Also recognition of words by profound hearing impaired children through vision alone and vision and another sensory system (ie.tactile) resulted in a 1 to 15%. mean improvement over lip-reading alone. Gross time and intensity patterns can be detected and also nasality, voicing identification difficulty will be reduced with the use of tactile aids.

The tactile perception by profoundly hearing impaired (for environmental and speech sounds) was studied by Plant (1983). Four subjects were fitted with single channel vibrotactile aids and provided with training in their use. Testing aimead At assessing their aided and unaided lip-reading performanca, their ability to detect segmentals and suprasegmental features of speech and discrimination of environmental sounds. Results showed that useful information was provided by the vibrotactile aid to speech and non-speech tasks, time and intensity cues were well presented. This study is another one that confirms that the lip-reading performance for both sentence materials and individual consonants is enhanced considerably by the use of the vibrotactile aid. Further analysis of the results show that recognition of the features of voicing, nasality and manner were enhanced by the vibrotactile aid. This finding was is of relevance in the sense it could be stated that the vibrotactile aid may provide important information that will enhance both speech perception and production (due to excellent feedback and self-monitoring).

Plant and Spens <19S3) described the development of a new wearable tactile aid for the profoundly hearing impaired. The aid's potential lies in 3 areas (a) awareness of sounds (b) supplement to lip-reading (c) provides information enabling the person to monitor his/her own voice. The subjects who used this aid stated that it is beneficial in perception of environmental sounds and in lip-reading.

A study was conducted to evaluate the usefulness of a tactile vocoder by Brooks and Frost (1983). Normal subjects were taken up to identify words presented through the tactile vocoder. Words that were poorly identified before were readily identified with the additional cues provided by the tactual vocoder. Phonetic identification tests showed that features of voicing, nasality and frication were reliably recognized. Thus here is another study indicative of the fact that the tactile vocoder will be useful in providing information to the component of lip-reading.

Oiler and Payne (1983) report that with a brief training period deaf adolescents can attain a high level of perceptual performance with a tactual speech system in discriminating certain hard to lip-read word pairs. Some contrasts are learned quickly while others require extensive training. Some important speech cues which cannot be easily perceived through lip-reading were transmitted effectively within few hours of training.

Kaplan (1983) reported an interesting single case study of a client post1ingually profound hearing impaired fitted with a vibrotactile aid. Prior to use of this aid ha was unable to distinguish between speech and non-speech sounds and speechreading skills were poor. But using the aid the client showed significant improvement in discrimination of speech and non-speech sounds. Also speechreading of connected material improved along with perception of stress and intonation.

Plant and Spens (1986) reported on a single case of a 48 year old Swedish male deafened at the age of 8 years by meningitis who developed a unique method whereby he could perceive a speaker's laryngeal vibration and use this information as a supplement to lip-reading. Improvements in his lip-reading ability were seen with materials ranging in complexity from nonsense syllables to connected discourse. Testing Via the tactile mode alone showed that the subject was able to perceive consonant voicing almost perfectly (99.3%. correctly) and consonant manner of articulation at high level of proficiency. Here the subjects overall performance certainly gives a striking example of the great potential value of tactile information to lip-reading performance. Another important factor that needs to be stated contributing to the subject's success is the long period of time he has been using this method.

The vibrotactile perception of suprasegmental features of speech comparing the single channel and multichannel instruments was done by Carney and Beacheler (1986). Results showed that the subjects tended to have higher scores on syllable number and syllable stress using the single channel devices. Thus, it could indicate that the single channel device provided better cues for identification of certain suprasegmental features of speech. This finding does support the contention that single channel devices provide temporal cues (stress patterns and prosody).

A paper on a single channel transducer vibrotactile aid to lip-reading was presented by Plant (1986). This aid presented Fo cues and information as to the presence\absence of high frequency energy. Testing the consonant perception at the level of lip-reading alone and lip-reading supplemented by the aid, improvement in the perception of consonants voicing and manner of articulation was seen in the aided consonant. Thus, here was yet another tactile aid that offers much information that can serve as a supplement to lip-reading.

Many of the confusions confronted to the lipreader can be overcome by an aid presenting Fo information. Visually unperceivable features such as nasality, voicing could be detected with the tactile aid.

Eilers et al. (1988) brought to light the similarities between tactual and auditory speech perception. Their research considered the possibility that fundamental properties of speech perception is independent of audition. Both labeling and discrimination function of one consonantal and one vocalic were similar but not identical. The clearest difference between them is discriminatory precision. Auditory discrimination is superior to tactual but rates higher false positive. Perhaps this difference could be attributed to superior auditory sensitivity, experience in speech perception through this mode and the due limitations of the tactile device.

Plant (1988) reviewed studies on speechreading with tactile supplements. He emphasized the fact that tactile displays were designed to complement visual cues and aimed at providing information not available from speechreading. Using the vibrotactile aid TACTAID II he conducted a study in 1987, where extensive training and testing was carried out using this device with one profoundly hearing impaired subject. 20 hours of training was given. Testing was conducted before, during and after training to evaluate the subject's speechreading performance (in aided and unaided condition). Results, showed superior performance in aided condition. Plant stressed that limited experience and training made it impossible to know what the ultimate limits of performance were for these devices. He also stated that even with little training patients are helped significantly at the syllable level and in recognizing a number of suprasegmental features such as rhythm, syllable number and dynamic speech flow. These devices are also useful as speech training devices, help in contrasting voiced \unvoiced, nasal \oral and stop\continuants.

An extensive report on recent technological advances made in portable tactile aids for speech perception was given by Michael, Kimbrough and Rebecca (1989). They grouped studies on them into 3 categories:

(1) those emphasizing training subjects to perceive speech through touch.
(2) those emphasizing the additive benefit of tactile aid when combined with speechreading, aided hearing, both speechreading and aided hearing.
(3) comparison of subjects performance using different tactile aids on the same tasks.

It is indicated that regardless of differences in device characteristics (ie. number of channels or type of information conveyed) portable tactile aids did serve as a supplement to speechreading.

Cowen et al. (1989) reported 3 studies on speech perception of normally hearing and hearing-impaired adults using combinations of visual, tactile and auditory input. The first study examined the contribution of tactile information to speech recognition in the combined tactile plus auditory mode and combined tactile plus auditory plus lip-reading mode. The addition of tactile information to both conditions resulted in significant improvement in phoneme and word discrimination scores. The tactile aid proved to be effective in providing cues to duration, Fl and F2 features for vowels and manner of articulation features for consonants. The second study assesses the contribution of tactile information to both the conditions (T+A, T+A+V) using different frequency ranges. Here again tactile input improved the scores. The final study measured the

contribution of the tactile mode contribution to speech recognition in the same two conditions for 3 hearing-impaired adults. Results showed that additional information available through the tactile aid was shown to improve speech discrimination scores. However, degree was inversely related to the level of residual hearing. Results indicated that the electrotactile aid may be useful for patients with little residual hearing and for severe profound hearing - impaired individuals.

Weisenberger and Russel (1789) compared two commercially available single channel vibrotactile aids, using the same subjects, performing a variety of tasks including sound detection, environmental sound identification, syllable rhythm, stress categorization and speech sound recognition. Results indicated that the subject performed comparably with both devices on all tasks suggesting they did not make use of the spectral information available in the more complex signal.

Kimborough et al. (1989) evaluated the effect of a model training program using tactual vocoders. A comparison was made between speech production gains made by the hearing impaired children in the tactual speech project (TSP) and those made by a group of similar hearing impaired children from traditional public school programs. In the course of about a year, the TSP children showed gains in syllable inventories and pronunciation of vocabulary items. The TSP children progress at a rate that makes real speech communication possible for them in classroom settings.

Lynch et al. (1989) studied multisensory speech perception by profoundly hearing impaired children. Four children in study 1 (5-7 years), four children in study S (8-11 years) received unimodal (tactual) word recognition training with tactual speech perception aids. Fallowing training the subjects were tested on a list containing equal numbers of trained words of tactually new words in 3 conditions (a) aided hearing only (b) tactual aid alone (c) combined mode. Results indicated that subjects performed better in the combined condition on both trained and tactually new words providing evidence for significant sensory integration following unimodal training.

Reed and Grant et al. (1989) reviewed research on tactual communication of speech-the ideas, issues and findings. They put forward four major points.

1. the tactual sense is capable of receiving continuous speech at nearly normal speaking rates with nearly zero error rates.

2. subjects are capable of integrating a relatively impoverished tactual signal with visual speechreading to achieve essentially normal speech reception and performance.
3. limitations on the speech reception performance obtained with current tactual aids are due primarily to inadequacies in the design of the aid and or in the training received with the aids.
4. there are no fundamental scientific obstacles to eliminate these inadequacies and achieving much improved speech reception for individuals with profound hearing-impairment.

Broadstone et al. (1989) conducted a study wherein they compared one versus two channel aids - Minivib 3 versus Tactaid II. To determine whether situations existed in which adding a second channel either improved or hindered performance with tactile aid, the tasks used were those requiring both envelope information and fine structure information in comparison. The two devices differed in their transmission of envelope information. Results indicated that when using the Tactaid II, subjects performed slightly more accurately on the word identification task (a task in which fine structure information would be beneficial) Minivib 3 subjects were better at judging syllable rhythm a task requiring envelope perception.

Hesketch and Osberger (1990) listed the training strategies for profound hearing impaired children using the tactaid II+ This study highlighted the many aspects of functioning.

monitoring of the aid as well as a training model with suggested activities and strategies. They also stated the unrealistic and realistic performance goals associated with it. Problems and limitations found to affect the performance include:

(1) feedback when vibrators are oriented towards hard surfaces such as the desk (S) inconsistent vibrator placement on the child and (3) difficulty in identifying syllable number when boundaries are marked by continuant sounds. Performance data were collected from the child at 3 intervals. First set when the child received the tactaid II+. The second and third set obtained six and eleven months post device fitting. The subject received 5 subtests - syllable length, fundamental frequency (steady versus changing contour) vowel height, vowel place and consonant manner. Data showed that on nearly every subset, scores were substantially higher maintaining the level of performance.

Speech perception with a single channel cochlear implant was studied in comparison with a single channel tactile device by Carney, Miyamoto (1990). Results suggested that single channel sensory devices whether cochlear implants or vibrotactile devices produce similar patterns of speech perception (a) Intonation is more readily perceived than either the number of syllables or syllabic stress in a word (b) the phonetic feature of voicing is perceived best followed by manner and place of articulation.

Small (1991) conducted a study in which 45 normal hearing individuals participated to determine whether training in both lip-reading and vibrotactile usage (Tactaid 11+) would influence the subject's lip-reading performance at increasing distances. The subjects were randomly assigned into 3 groups (1) those who lip-read only (2) those who used the Tactaid 11+ with no training (3) those who received four hours of combined lip-reading and tactile aid training. Three distances were tested 6 feet, 12 feet and 18 feet. Subjects showed an overall decrease in lip-reading performance with increasing distance. Group 3 subjects who received training performed better than the other subjects across all distances the combined training apparently enabled subjects to improve their lip-reading of sentences at increasing distances. ,

Beers and Tobey (1998) discussed the effects of tactile aids and cochlear implants in the development of speech production skills in children with profound hearing impairment. They concluded that tactile aid users significantly increased their ability to imitate back vowels. Significant increases occurred in their ability to imitate initial/final consonant stops fricatives, affricates, glides and laterals, bilabials and dentals. These findings suggested that visibility is an important variable in the initiation of initial consonants in tactile aid users and certainly assist children in acquiring several features of speech.

Ohngren, Ronnberg, Lyxell (1992) discussed - tactiling as a usable support for speech reading. The purpose of this study was to find out whether deafened adults can take advantage of the extra information in speech reading given by vibrotactional and motional patterns picked up by placing a hand on the speaker's throat and shoulder. And also to determine how valuable this tactile system is as a support system for speechreading. (Tactiling being speechreading with tactile supplement.) Results indicated that tactiling is better than speechreading alone and also that this method is worth pursuing as a communication system for the severe profoundly hearing impaired.

Despite the availability of tactile devices they have not been widely accepted by hearing-impaired people or their educators. These aids have not been favoured because of the nature of the devices, their usage and not because of inherent limitation of the skin as a communication channel. Because of their high cost, very few devices have been purchased by schools for the hearing impaired.

To understand how combined modality perception produces improved performance it is necessary to consider the kinds of acoustic information that are effectively transmitted by amplified audition, visual and tactile modes. Complementarity of information provided by aiding multiple sensory modalities provides a basis for enhanced performance in perception.

Further research is needed however on the use of tactile aids by the profoundly hearing impaired in conjunction with speechreading and aided hearing. Research would provide an indication of how well profound hearing impaired children could use speech information from touch with all of the speech perception avenues available to them in everyday communication. Research is needed to also determine relative amounts of unimodal and multimodal training that are optimal to achieve rapid learning and successful integration of multisensory information.

METHODOLOGY

1. Sub jects
S. Instrumentation
3. Test environment
4. Electroacoustic measurements
5. Test materials
6. Procedure

Currently much of the work in the field of tactual communication with speechreading is addressed to tactile input as a supplement to visual speechreading and its relevance to face-to—face communication by sighted individuals with profound hearing-impairment. This study was undertaken to compare the subjects performance under 3 conditions.

(a) relying on using tactile cues alone
(b) relying on visual cues alone
(c) relying on tactile plus visual cues.

SUBJECTS:

A total of S subjects (4 males and 1 female) in the age range of 8-11 years who had profound hearing loss were chosen. All of them were using a strong class hearing aid. Each subject underwent a training period of 10 hours approximately with the vibrotactile aid.

Criteria for selection of **subjects**::

(1) The subject had congenital hearing loss, preselected on the basis of their hearing loss being in the profound (91 dB+) range. Each subject had a vocabulary of 200 + words and conversed using simple sentences in Kannada.

(S) All of the subjects had normal intellectual functioning as measured by standard intelligence tests.

(3) None of the subjects had any other known or suspected physical or neurological impairment.

(4) All the subjects had normal vision acuity.

(5) The parents of the subjects had normal hearing and no other member in their immediate family had hearing-impairment.

(6) Kannada was the language primarily spoken at home.

INSTRUMENTATION:

The vibrotactile aid TACTAID 11+ was ueed to train and assess the performance of the subjects. TACTAID 11+ is a two channel wearable vibrotactile aid. It consists of 3 main parts -

1) the processor which contains the processing electronics, the system controls, rechargeable batteries microphone and telecoi1.

2) the vibrators - there are 2 light weight skin vibrators, one responds to high frequency sounds the other to low frequency sounds.

3) the cord which connects the vibrators to the processor.

TEST ENVIRONMENT:

The testing was carried out in a natural setting, the conditions being the same as those during the training of the subjects.

ELECTROACOUSTIC MEASUREMENTS:

Electroacoustic measurements of the vibrotactile aid TACTAID 11+ was carried out using FONIX 6500 system.

TEST MATERIALS:

A total of 50 picturised common words and 10 picturised spondee words, all within the vocabulary of the subjects were chosen. The chosen stimuli entailed all speech frequencies and different place and manner of articulation. The list of picturised common words and spondee words are listed in Appendix.

PROCEDURE:

The order of presentation of the stimulus was preselected using a random table (Black and Champion). For both the picturised words and spondee stimuli, 3 individual lists were constructed on random basis using the random table. Each list for each of the 3 conditions (a) relying on tactile cues only (b) relying on visual cues only (c) relying on both tactile and visual cues at a distance of 3 feet from the tester (in all the 3 conditions). At the time of testing each subject was asked to be relaxed, alert and pay maximum attention to the stimulus presented. The vibrators of the tactile aid were strapped onto the wrist of the child such that the low frequency vibrators was placed always to the left side of the body.

The stimuli (which were in the form of picture cards) ware neatly displayed on the table placed in front of the subject.

In the first condition the subjects had to rely on cues presented through the tactile mode only. In the second condition they had to rely on their speechreading ability only. In the third condition they obtained cues from the tactile modality and their speechreading ability (the visual cues). Each subject was instructed to convey his response by pointing at the specific picture when the stimulus was given .

Recording the response for each subject, their responses in each of the 3 conditions for both picturised common words and spondee words were recorded. A positive score was given if the subject identified the correct picture for the stimulus presented. The total positive scores were summed individually for the 3 conditions.

RESULTS AND DISCUSSION

The aim of the study was to determine if there was any significant difference in the subjects' performance in the following three conditions:

(1> subject relying only on tactile cues

(2) subject relying only on visual cues (speechreading ability)

(3) subject relying on tactile plus visual cues.

Data was collected based on the methodology given in the previous chapter. The scores were obtained for each subject under the three conditions stated above using two test materials namely picturised common words and pictured spondee words (given in Appendix).

Statistical analysis was carried out using the paired t-test to check for any significant differences among the 3 conditions mentioned earlier, the level of significance being .0.05. The results obtained using the paired t-test revealed the following:

Conditions using common words	Mean	SD	't'score	Significance at 0.05 level
(a) vs (b)	3.8	2.96	1.2B	Not significant
(a) vs <c>	6.83	2.83	2 .12	Not significant
(b) ve (c)	1.8	3.28	0 .54	Not significant

Spondee	Mean	SD	't'score	Significance at 0.05 level
(a) vs (b)	0.4	9.2	0.04	Not significant
(a) vs (c)	2.4	9.2	0.26	Not significant
(b) vs (c)	2.8	4.6	0.478	Not significant

Tactile devices certainly are known to supplement speechreading (Boothroyd, 1985, 1986; Sparks et al. 1986). Features such as nasality, voicing frication and position can be automatically extracted from the speech signals and presented be cues by the tactile aid. Currently much of the research in this field is addressed to tactile input as a supplement to visual speechreading. Devices have been designed to display acoustic/ articulatory aspects of speech and shown to supplement speechreading (Boothroyd, 1985; Sparks et al. 1986). Studies show that improving the reception of continuous speech using tactual supplements to speechreading is clearly a less difficult problem than achieving good speech reception using tactual sense only (Grant et al. 1986).

Osberger et al (1990) based on their studies concluded that the TACTAID 11+ cannot be used to perform open set speech recognition tasks and that children fail to identify familiar environmental sounds in everyday situation and face difficulty in spontaneous identification of speech sounds, words or phrases.

Lynch et al. (1989) have found that the information perceived via the TACTAID 11+ can be used by children to enhance their speechreading performance.

Despite these results, a few negative results have also been obtained. Blarney et al (1989) and Sparks et al. (1979) have shown that using multichannel tactile aids very little improvement was observed in the aided speechreading scores. Miyamoto et al. (1989) stated that irrespective of the amount of training or length of device, use of a two channel sensory aid such as the TACTAID 11+ does not provide sufficient spectral information for understanding speech on the basis of segmental cues.

In the present study, although the actual scores of the subjects showed a difference in the different conditions the scores in the combined condition being better than the scores in the unimodal conditions, they were not found to be significant statistically. Failure to obtain significant results could be attributed to various factors. The use of the vibrotactile aid is a relatively new experience to the children when compared to the long intensive training they have been having in speechreading. Thus a training period of just 10 hours might have proved to be insufficient to enable the subjects supplement speechreading through the tactile mode. Perhaps the backing up of a more intensive training programme would prove to be more beneficial.

SUMMARY AND CONCLUSION

The current study was undertaken to investigate the subjects' performance using a vibrotactile aid in the following three conditions:

(a) subject relying only on tactile cues
(b) subject relying only on his speechreading ability (the visual cues)
(c) subject relying on both tactile and visual cues.

A total of S subjects, 4 males and 1 female, were chosen. Each subject underwent a brief training period of 10 hours approximately with the vibrotactile aid (TACTAID 11+). Each subject had profound hearing-impairment. Stimuli used for training and testing were picturised common words and spondee words. For testing purposes 80 common words and 10 spondee words were selected. Testing was carried out immediately following the cessation of the training period.

Statistical analysis of the data obtained after testing was carried out using the paired t-test, level of significance being 0.05. Results showed that there was no significant variation statistically in the performance of the subjects in the following conditions:

(a) tactile cues versus visual cues
(b) tactile cues versus tactile plus visual cues
(c) visual cues versus tactile cues plus visual cues.

It could be stated that before a tactile aid is recommended for a child it is important to assess the child's perceptual skills via the hearing aid. Learning to decode the tactile pattern rarely occurs spontaneously but requires intensive training in highly structured setting.

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APPENDIX

List of common words

) pɛnnu

) kudure

) bəssu

) tɛlifon

) huvu

6) watʃu

7) a:ne

8) baɭehaɳu

9) kəp

10) tutbrəʃ

11) pɛnsɪl

12) pa:pa

13) ʃuzu

14) topɪ

15) vɪmana

16) fæn

17) məra

18) batʃəŋɪge

19) saɪkəl

20) ətʃɪ

List of spondees

1) kət̪ru - tʃət̪ri

2) hu:vu - ha:vu

3) ga:dɪ - dʒa:dɪ

4) dʒəna - d̪ana

5) bʰavi - ba:ɪ

6) pɛnnu - bɛnnu

7) maɭɛ - baɭɛ

8) kət̪t̪u - kət̪t̪ɛ

9) ka:ru - ka:lu

10) kat̪t̪ɛ - kappɛ