A COMPARISON OF SUBJECT PERFORMANCE USING HEARING AID AND TACTILE AID (1993-1994)

REG.NO.M9316

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

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

MAY 1994

DEDICATED TO

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CERTIFICATE

This is to certify that the Independent Project entitled: A COMPARISON OP SUBJECT PERFORMANCE USING HEARING AID TACTILE AID (1993-1994) is a bonafied work, done in part fulfillment for the first year Master Degree of Science (Speech and Hearing), of the student Reg.No. M9316.

Mysore
May 1994

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CERTIFICATE

This is to certify that the Independent Project entitled A COMPARISON OF SUBJECT PERFORMANCE USING HEARING AID AND TACTILE AID (1993-1994) has been prepared under my supervision and guidance.

Mysore
May 1994

Dr.(Miss) S.Nikam
GUIDE

DECLARATION

This is to certify that the Independent Project entitled A COMPARISON OF SUBJECT PERFORMANCE USING HEARING AID AND TACTILE AID (1993-1994) is the result of my own study under the guidance of Dr. (Miss) S.Nikam, Director, and HOD-Audiology Department, 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.M9316

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INTRODUCTION

(A quick glance at tactile aids)

My name is Sam, Sometimes I am called silent Sam, a tag X loathe out of prejudice, both mine and the bestowers Besides it is misleading since I make more noise sipping my soup than the guy at the next table, who is not hearing impaired, but wishes he were every time I take a particularly enthusiastic spoonful.

This is my story, of how I live through a day and the problems I face as a hearing impaired human being says silent Sam. Sam is one among the many who are born hearing impaired or have acquired a hearing loss. These many I am refering to may be ministers, owners of clothing stores, physicians, teachers, a preschool child, an infant affected by meningitis, or for that matter it could even be you. Hearing impairment is one of the most handicapped conditions in this country, yet goes unnoticed,if hearing aids are unseen,on the individual, or one does not hear the speech production of a congenitally deaf youngster. Very little interaction can take place among people without the ability to speak and to hear. As Toubbeh (1973) has said "Human communication is action, it is culture, it is the history of man, it is the fabric of all societies, it's absence negates man's existence".

The sensory apparatus of hearing is an indispensible tool for hearing and for the development of speech and language. Its functions are co-ordinated with other sensory modalities like vision, touch, taste and smell, the former two being the most important. Non-auditory sensory cues provide information to the listener applicable to the process of speech perception. For the normal listener, these clues are generally redundant and are used only to confirm the auditory message. However, for the hearing impaired individual, these cues provide essential information and supplement the information obtained by means of the listener* s residual hearing.

The non-auditory cues can be used to monitor (or improve) the hearing impaired individual's speech production as well as aid the listener in the process of speech perception. Tactile information generated during speech production can be obtained by touching parts of the speech apparatus (such as lips, teeth, cheeks, nose, throat, jaw etc).

Gault was the earliest to pioneer the use of tactual aids for speech reception. Gault's era was one of great productivity and excitement about the possible use of tactual aids for the hearing impaired.

Today, with conventional hearing aids, acoustic signals are amplified to an intensity great enough to make them audible to the impaired ear. In the preschool and school age child, the added acoustic stimulation should help to improve the reception of speech and as a consequence foster the development of speech and language skills. Although the vast majority of hearing impaired children and adults benefit significantly from conventional amplification, it is quite clear that there are those Who don't. Specifically, those with severe to profound deafness typically receive so little additional information from the amplified signal that they will not wear a hearing aid when given a choice. Two methods are available to such individuals - Cochlear implants and tactile aids. The costs of cochlear implants severity limit their availability to most profoundly deaf persons.

NEED FOR TACTILE AIDS:

The need for tactile aids depend entirely on the incidence of severe-profound deafness and an estimate of those among this population who might benefit from their use with regard to tactile aids. Except for rare sensory disorders of skin, there are no clear physiologic contraindications. Also a favourable aspect of tactile aids use is that a trial period can be carried out with little difficulty, because the instruments are not permanently implanted in the body through surgery. Thus tactile aids have a potentially wider application and can be used with less trauma than cochlear implants.

TYPES OF STIMULATION:

Tactile aids can use 2 types of stimulation.

1) Vibrotactile in which acoustic signals are presented as vibrations to the skin using mechanical transducers.

2) Electrotactile in which acoustic signals are presented to the skin as electric currents.

The 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. A combined approach has also been tried. De Fileppo compared the performance of a single channel vibrotactile and electrotactile aid on the hand and found that the combined system produced superior scores.

LOCATION OF STIMULATION; Unlike cochlear implants, which are designed to stimulate only structures within the cochlea, a decision has to be made with tactile stimulation as to where on the body to provide stimulation. The majority of studies have used parts of the hands, arms, abdomen, jaw, thorax, forehead or thighs as locations of stimulation. As a sensor for vibrators, the fingers of the hands have structural and functional characteristics indicating that they are among the more sensitive body parts. One problem with using the fingertips is their accessibility. Using them for tactile stimulation would affect manual dexterity and perhaps be a serious drawback. Another intriguing clinical approach would be to stimulate the skin close to the ear perhaps the pinna, or outer ear canal itself. This may have the psychological advantage of associating tactile stimulation with hearing sensation.

SINGLE Vs. MULTICHANNEL TACTILE 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 rudimentary fundamental frequency information. However single channel devices as limited as they are have proven to be beneficial in supplementing speechreading.

Multichannel aids can present tactile information using a one-dimentional display. A one dimentional display is like a piano keyboard with low frequencies at one end and high frequencies at the other. In this type of display, spectral cues are presented in a manner similar to that in the cochlea. Frequency is coded by place stimulation as on the piano keyboard and intensity is coded by the vibratory amplitude.

Primary differences between hearing aids, cochlear implants and tactile aids.

Factor	Hearing aid(s)	Cochlear Implant	Tactile aids
Daily use	Yes	Probably	?
Trial period	Yes	No	Yes
Initial cost	US $550 or $200	US $10,000 $20,000	US $480 - $3000
Risk	None	Yes	None
Safety	Safe	?	Safe
Long-term sequele	Minimal	?	Minimal
Effectiveness	Depends on type of loss, and amount of residual hearing.	Depends on residual neural population and coding processing techniques.	Depends on speaker's ability to process sound and processing technique

While the use of tactile information, by the hearing impaired is not a new concept, recent technological advancements have resulted in the development of wearable tactile aids. The availability of these devices offers the profoundly hearing impaired new opportunities for the development of effective and meaningful communication skills as well as an increased awareness of their environment. Numerous research projects and studies are underway exploring various aspects of benefits, function and application of tactile aids. Some of the more important issues being investigated are -

1. No.of tactile channels for optimal enhancement of tactile communication.
2. Mode of delivery of the tactile information.
3. Location of the vibrators from both a functional and cosmetic standpoint.
4. Finally, it's important to call upon the electrophysiological data as regards vibrotactile sensation in planning rehabilitation program.

NEED FOR THE STUDY?

Keeping in mind the advantages of vibrotactile aids, and it's nature and also the results of various studies on tactile aids in the past, this present study is aimed at corroborating past research which demonstrates the effectiveness of the tactile aid with a newly purchased device TACTAID II+. The aim of the study was to compare the subject's performance under the 3 conditions of (l) hearing aid alone (2) Tactaid alone and (3) Tactile aid + hearing aid.

APPLICATIONS OF TACTILE AIDS (TACTAID II +):

Tactile aids are devices that use the sense of touch to enable a profoundly deaf person to feel sounds that they cannot hear. The Tactile aids are state-of-art devices that convert sound information into patterns of vibration that can be used by most profoundly deaf children to improve their understanding of the world of sound. With appropriate training, they will be able to produce more accurate speech sounds with less effort, they will be able to distinguish among these sounds. With the assistance of the aid, improvement can be seen in the child's language, lipreading, general sound awareness and equally important better social and emotional development. The following areas of usefulness might be observed,

1. Tactile aids tend to facilitate the development of an awareness of sounds in the environment such as doorbells, traffic noises, and telephones with sufficient practise tactaid users will be able to distinguish and identify most of the sounds,

2. The aids may be useful for conveying and recognizing many segmentals and suprasegmental characteristics of speech such as rhythm, phrasing, duration, syllabic pattern, stress, presence or absence of sibilants and loudness (considerable variation may be observed in effectiveness depending on material used, context of presentation and degree of training).

3. The aids might provide helpful feedback information about the user's own speech production. This is most evident through the quality of sound production and willingness to utilize expressive language,

4. With sufficient training, the aid will be a useful one to speechreading.

REVIEW OF LITERATURE

Sherriek (1985) proclaimed that touch may substitute one of the major senses in a thought that had a long past.

In the process of arriving at the final cochlear model, von Bekesy, set out states in much of what was unknown territory in the skin's sensory system. Except for the fact that both hearing and touch responded to the same 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 special flux of mechanical energy, performs a rapid preliminary analysis of it, then converts it to a nervous message. The skin is a diffuse system occupied by myriad entities other than mechanoreceptors and hence serving other functions, not the least of which is to keep the environment where it belongs. At the receptor level, the skin is less sensitive than the ear by perhaps 14 orders of magnitude. In part, they presume that this is to lessen the effects of shocks the flesh is here to, but the result is that it takes much more energy to inform the skin. Another notable difference between the ear and skin is the nature of the message, normally imparted through them. The skin, except for its role in prevention, as the non-intellectual sense is better adapted to some emotional needs.

Oiler, Rayne and Garino (1980) suggested that deaf perceivers may also be able to discriminate some hard to lipread word pairs after a short training period. The transmission of certain speech information not available through the traditional method of lipreading and the provision of employing tactual vocoders in speech perception for the deaf person after a brief training period. Eight deaf adolescents assisted as subjects in this study, whose loss was profound. A tactual vocoder was used and each subject was required to discriminate between the members of hard to lipread word pairs, based on tactual information. The stimuli employed were pairs of words contrasting in manner of articulation.

The results convey that with a brief training period of one hour, the subjects can attain a high level of perceptual performance with a tactual system in discrimination of certain hard to lipread word pairs pronounced by both a male and a female speaker. Some speech sounds, previously, indistinguishable, can immediately be available for speech comprehension through the tactual vocoder and other speech sounds will be recognizeable with further training. It was found that word patterns that result in stimulation across a greater area of skin, tend to be more discriminable than word patterns which stimulate only small areas of skin. It is reasonable to expect from this study that the speech perception offered by the tactual vocoder, may be of substantial general importance even with a limited training experience. The progress made by the subject is worth noting, even when systematic speech stimuli which was not present in this study. However, the study predicts substantial skills when perception becomes well established in case of deaf subjects.

Weisenberg et al (1987) studied the role of tactile aids in providing information about acoustic stimuli. The authors, in the present article have presented a framework which is outlined for describing normal listening situations as a hierrachy of tasks requiring increasingly complex analysis of the acoustic waveform, including sound detection, environmental sounds, identification, syllable rhythm and stress categorization, phoneme and word identification and comprehension of connected speech. The types of benefits provided by the tactite aids in each of the tasks are exemplified using data from studies of single channel commercially available devices and multichannel tactile vocoders in the laboratories.

Levels of processing	Waveform analysis
Localization	Interaural intensity differences.
Detection	Presence of energy.
Identification	
- Environmental sounds	Amplitude envelope

- Words

(i) Syllable rhythm and she is	Amplitude envelope.
(ii) Whole word identification	Pine spectral/temporal features.
(iii) Connected speech	Pine spectral/temporal features.

In summary, all these results suggested that the tactile aids can provide helpful information in a variety of listening tasks, including detection, localization, environmental sounds identification etc. Finally, an examination of the different levels of information, extracted from an acoustic waveform by a listener, including that necessary for detection, environmental sounds identification etc, is of interest not only for the evaluation of tactile aids, but also for the assessment of any type of device, designed to provide acoustic information to the hearing impaired patient.

Derchi (1987) studied the utility of tactile aids. The author stated that the needs of profoundly hearing impaired have received considerable attention with the advent of cochlear implant and recent introduction of wearable tactile aids. The availability of these devices, as well as other assistive devices is changing the role of the dispenser with regard to vibrotactile aids and offer some guidelines for -

1) Identification of the client as a vibrotactile candidate.
2) Recommendation and fitting of a vibrotactile aids.
3) Provision for aural rehabilitation with a tactile device.

The role of a dispenser: At very least, the dispenser has a responsibility to his clients to become knowledgeable regarding tactile devices and to inform his clients of availability of these devices when appropriate full service facilities will be in a position to offer a broad spectrum of evaluating and consultation services and may even provide the aural rehabilitation services necessary for the successful use of the tactile aid.

The vibrotactile candidate: Frequently a support network is a key factor in determining the motivational level of the candidate. The success of becoming tactually competent will depend greatly on the existence of a strong net work of support through family and friends who provide encouragement and reinforcement in mastering the use of the tactile aid.

In addition, the client must be willing to wear the device on a daily basis or as needed to be of maximum benefit. Finally, the client must be willing to commit to an extensive program of rehabilitation aimed at enhancing his interpretation of vibrotactile information and improving his communication skills.

<u>Recommending/fitting a vibr</u>otactile aids In evaluating a device for the client, it *in* recommended to begin with an overall appearance of the device. To consider size, weight and cosmetics as these would be important factors in the client's acceptance of the aid. The ease of use and simplicity of operation of the device, relative to the age of the client and his ability to operate the device must also be considered. A unit that has sufficient daily operating time should be selected to meet the needs of the client without recharging, or replacing batteries. The unit should incorporate processing that differentiates speech from noise and ensures consistent reproduction of speech signals via the vibrators. Finally, the availability of a structured training program should be considered, which is aimed at assisting both the therapist and the client in the successful use of the particular device.

With the selection of the proper device it is reasonable for the client to expect to achieve the following with the use of a vibrotactile aid.

1) He will be able to discriminate between silences and noise and develop an awareness of environmental sounds.
2) Identification of speech sounds will improve and depending on the vibrotactile device selected, the user will be able to discriminate between voiced and voiceless phonemes.

Tactile training and aural rehabilitationt

It is imperative that professional therapy services be available to direct the client in the use of the device and the development of vibrotactile communication skills. The length of individual therapy sessions and extent of the overall program well depend for the most part on the rate of progress of the individual client,

Charlotte et al conducted research in tactual communication of speech. The authors present an overview of current research findings in the field of tactual communication of speech. They consider seme implications for future research trends in the development of tactual aids.

The summary of the current state of research in tactual communication of speech leads the authors to conclude that there are no fundamental scientific obstacles to achieving much important speech reception for individuals with profound hearing losses*

Recent discussions of the role of tactile aids in the clinical treatment of individuals with profound auditory impairment have focussed on comparing relative performance, clinical effectiveness, cost etc.

A second issue involves the population of individuals for whom treatment by cochlear implant is not a reasonable possibility because of funds etc. In such cases, tactile aids may play an important role in world wide treatment of profound hearing impairment,

Sherrick (1984) in his report summarized the consequences of a group of American investigators who analyzed the capabi-lities of touch and allied bodily senses for processing of information, that is normally handled by the sense of hearing The authors briefly introduce the sense of hearing, including the educational procedures of sign language, and lipreading the medical procedures of cochlear implants and the sensory substitution procedures of visual or tactual displays, which are most commonly electronically activated, desirable objectives are givenn. Among these are a better understanding of the processing of capabilities of the skin, the form an effi-cient transducer may take and what features of the speech stream may most profitably be extracted for processing and display to the sense of touch. Because the technology for device design and production in this area is seriously retarded, a great amount of space is devoted to the precise specification of the transducer for the tactile display.
A multi-channel display exists, and several of these may be movable systems if their transducer elements can be kept small and use little energy. What is of current even urgent

importance is the early and widespread deployment of a single-channel tactile aid to permit the general assessment of the effectiveness of simple sensory adjurant for a deaf person who has lipreadlng skills.

There are a number of reasons for recommending what might seem to be a precipitous move to those who know that our understanding of speech perception and of processing capabilities of the skin, as well as of the technology of transducer structure is unsatisfactory. First, some deaf persons can make use of even a simple aid. Second, the results of such a study should put tactile aids into a better position for comparison with cochlear implants for which the subjects population is growing rapidly. Third, research and development efforts on tactile aids have often ended in the laboratory. Yet such trials are the very situations in which individuals will test in limits of their aids, and sometimes develop ingeneous uses for them or use then in unforseen conditions*

Oliva et al. (1932) reported the results of a study on the vibrotactile perception of profoundly deaf children using a prosthetic device. He reported that vibrotactile perceptual mode affords adequate information about duration and intensity and have rhythm and accent, but is severely limited as far as frequency is concerned, the upper limit being around 1K. Differential perception of frequency is rather crude, but nevertheless sufficient to provide information about large variations in fundamentals of speech.

In order to afford a means for deaf children to benefit from vibrotactile perception in free field condition, a vibratory stimulation prosthetic device (VSPD) as described by Boorsina (1975) has been utilized for the past 4 years. This consisted of a small vibrator clipped to an earmold and connected to a standard body worn hearing aid. VSPD stimulates speech production when worn continuously. It also facilitates language acquisition through better contact with educators and with acoustic environment. It is an efficient means of voice-pitch correction. It is of greater use if subjects already know the verbo tonal method. The number and selection of subjects taken have not been specified.

Brooks and Frost (1933) evaluated the performance of a tactile vocoder for word recognition. The purpose of this study was to evaluate the usefulness of a tactile vocoder in a study that was designed to combine many features considered by the authors. Some of these features were one-third octave filtering, a linear array- using solenoids as the transducers and a cancer frequency for the solenoids of 100 Hz. Normal subjects were taken up for the study who learned to identify words through a tactile vocoder, with 16 filter channels and output of each filter was detected which was transmitted to a solenoid array placed on the subject's ventromedial forearm live voice was used as stimulus. In 40-45 hours the subjects learned 70 words and the second set of subjects learned 150 words in 55 hours. It was found that words that were poorly identified initially were identified more readily with increased experience. Phonetic identification lists showed that features of voicing, nasality and frication were easily recognized indicating that the tactile vocoder was useful in providing information to compound lip reading. Finally subjects learned to rapidly generalize to unfamiliar readers, words which had lower/higher probability of being identified correctly were similar across subjects. Both groups found some words easier to learn than others.

In this study, nasality appeared to be transmitted very reliably, but identification of particular nasal sounds was a more difficult task. Frication was also identified well, but errors for unvoiced fricative /f/ and /o/ were due to the fact that this information was not being transmitted through the system due to the amplitude of these fricatives.

It was difficult to compare the learning rates (in this study) with those found, using other communication systems because methodologies, stimuli and subjects vary greatly. Evaluation of error patterns was done, in this study for future modifications of the vocoder.

Risberg (1987) studied speech coding in a single channel implant and a comparison of results for auditory, tactile and electrical stimulation. This aim of speech coding in a sensory aid for the deaf was to adapt the natural acoustic signal to the capacity of the sensory channel used. The authors experience with deaf persons, using a simple tactile aid or an electrocochlear implant indicates however that speech understanding without lip reading can be obtained in simple, single channel systems. Results of the coding evaluation revealed that -

1) Intensity variation of 20-30 dB must be transmitted.
2) Fundamental frequency variations in speech are important and hence the systems should be based on the extraction of fundamental frequency.
3) Gross spectral information can be transmitted by means of single frequency, gives good during lip reading and will be useful for everyday sounds.

Rebecca E Eilers, Kimborough and Kathleen (1989) studied the speech and language progress of hearing impaired children in a systematic training program using tactual vocoder to evaluate the effect of a model training program using a tactual vocoder, a comparison was made between gains made by hearing impaired children in the tactual speech project (TSP) and those made by a group of hearing impaired children from traditional problem school programs. In the course of about a year, 11 children in the TSP showed gains in syllable inventories, pronounciation of vocalizations. Comparable gains were not made by a group of 15 children similar to the *TSP* group in hearing loss, intelligence, socio-economic status and language background. Another group of TSP was evaluated for grammatical development (in speech) with the GAELP (Grammatical analysis of elicited language-presentence level). As predicted, based on the severity of hearing loss, secondary handicaps, ethnicity, and socio-economic status, the TSP children started the year with low percentlie rankings on the list when compared to the normal group. However in 5 months, the group had gained dramatically against the norma. It was concluded that a systematic training program incorporating artificial hearing devices can provide practical and extensive support for speech production and language development in young hearing impaired children. While tactual vocoders may play an important role in the TSP, and that other program factors contributed to the relative performance of children in TSP and elsewhere.

Spens (1980) compared some of the different speech conveying tactile systems for the deaf. The systems used in this study were (1) single vibrator system applied to the fingers (2) single vibrator system stimulating other body loci (3) stimulator arrays (spatial dimensions) (4) matrix mapped on the fingers (2 spatial dimensions) (5) matrix system stimulating the abdomen (2 spatial dimensions).

Materials included Swedish numerals in the vocabulary, which had small variations in timing, level, and pronounciation. Only one subject was tested, who was unfamiliar with different types of tactile systems except for optacon one control subject was blind, but a well trained optacon reader No auditory or visual information was presented. Masking was done under necessary conditions.

All systems conveyed information on a phonetic level about the spoken words. The correct responses ranged from 50% - 70% in all the systems. However, the conveyed information included 3 main types of confusion matrices.

1) Spectral changes, which involves large intensity changes, as in initial and final part of a word.
2) Large spectral changes with minor intensity changes such as from fricatives to vowels.
3) Small spectral changes, the those from vowel - vowel like consonants.

The more the processing of the speech signal the better the results. Furthermore the study provided some useful conclusions, regarding the capacity of a tactile system in conveying information.

1) Choice of stimulation area. In this study fingers were found to be the best choice of placement.
2) Amount of processing of speech signal including the number of spatial dimensions in the tactile display.
3) The information carried by large spectral changes were easier to learn.
4) There was no significant difference in performance which can be attributed to vibrotactile or electrotactile stimulation. The study did not attempt to make an absolute evaluation of the tactile information and conveying capacity of the aid.

Plant Risberg (1983) reported preliminary results obtained with a single channel vibrotactile and which extracts a speaker's fundamental frequency and represents it in a range, where the skin is maximally sensitive to frequency change. The aids ability to convey emphatic stress in sentences and word syllable number and type was tested, using both English and Swedish materials.

The 1st experiment was aimed at assessing the ability of untrained observers to detect the stress word in 3-4 word English sentences. The results indicated that the aid provides useful information as to improve emphatic stress in English sentence.

The 2nd experiment, was aimed at evaluating the aid' s ability to transmit word syllable number and type and the test items consisted of English monosyllables, trochers, spondees, and bisyllables.

Results indicated that the scores were above chance level performance and the subject's errors occured in a relatively systematic fashion. However, it was a relatively systematic fashion. However, it was a difficult task for both groups.

Experiment 3 used Swedish rhyme test materials and identification of syllabic contrasts were tested. Results indicated that better the familiarity, better the word syllable identification.

The experiment 4 involved the perception of emphatic stress in Swedish sentences. It was found that the primary cue to emphatic stress was frequency change with relatively weak intensity, and durational cues.

The overall results indicated that the aid transmits such information at a high level although it appears that extensive training would be needed with some tasks before optimal performance is attained.

It can be speculated that the subject,s performance would improve if the speaker used a rate of articulation that is slower than normal. It can also be investigated whether the temporal resolution of the skin can be improved with training before deciding to introduce a speaking strategy which leads to a decline in speech production Consideration also needs to be given to the provision of informations other than fundamental frequency, which will serve to improve the signal already available.

Barry and Craig et al. (1983) explored the effectiveness of the optacon transducer, using number of different coding schemes. Initially the amount of information contained in a two-dimensional spectral display was varied by a number of different spectral channels, presented to the skin, while simultaneously comparing two modes of presenting the information.

Later on, the size of tactile pattern was manipulated, and finally, performance with the spectral display was compared to performance with a vocal tract display. A spectral display consisted of frequency versus intensity function, and a vocal tract location by cross-sectional area. Both displays were presented to the finger tip via the tactile display of the optacon transducers. Normal hearing subjects participated in the study. In the 1st experiment, the spectral display was effective for identifying vowels where 24 spectral channels were presented as a solid histogram (filled patterns) than when it was represented as a simple spectral contour (unfilled patterns). Spatial masking within the filled pattern was postulated as the cause for decline in performance. Another experiment measured the utility of the spectral display when the syllables were produced by multiple speakers. The resulting increase in response confusions was primarily attributable to variations in the tactile patterns, caused by differences in vocal tract resonances among the speakers. The final experiment found an area function display for identification of vowels. The results demonstrated that a two dimensional spectral display is worthy of further development as a basic vibrotactile display for speech.

A vocal tract display was found to be inferior to the spectral display inverting the representation of the vocal tract on the fingertip showed that the finger is not uniformly sensitive to patterns produced along it's length. In summary, these experiments indicated that a 2-dimensional spectral display (with as few as eight channels) provides sufficient speech information for identification of vowels in CV syllables, and is therefore a good prospect for continued development.

Adele, Moise and Goldstein (198 3), conducted a longitudinal study of a profoundly deaf young child, with the aid of a vibro tactile communication device. The training started when the child was 33 months old, and it continued till she was 44 months. After 10 months of training with the device, and traditional aural/oral teaching techniques, the child acquired an understanding of 469 words. The subject's patterns of lexical comprehension was like that of younger hearing subjects.

The study highlighted that the rapid rate of lexical acquisition appeared to have been strongly influenced by the use of vibrotactile communication aids. However, this study should have used control groups consisting of normal hearing children and profoundly deaf children, who were not trained with the tactile device.

Collins and Richard (1985) conducted a study to determine whether or not tactually delivered analog speech sounds could be categorically perceived and if so, to compare tactile to auditory boundaries along a VOT continuant, using a classical discrimination paradigm. In designing the study, they assumed that a peak in a discrimination function would provide evidence of categorical perception via the tactile mode and the absence of peak would be indicative of non-categorical perception. VOT was selected as the dimension for physical continuam for a variety of reasons.

1) VOT information is easily extracted from tactile devices.
2) It was assumed that the temporal information earned by a low frequency voicing cue is transmitted by the tactile aid.

Pour normal hearing adults were taken as subjects. Stimulus was synthetic syllables along a /ga-ka/ continuam. The entire continuam was presented with VOT varying from 10-15 minutes and the subjects were asked to identify the point at which perception changed from /ga-ka/ or vice-versa VOT differences were found to be 15-20 minutes on tactile discrimination tasks. Non-continuous discrimination along a continuous physical dimension was indicative of categorical perception.

The results indicated that speech signals delivered by tactile stimulation could be categorically perceived as on a VOT continuum. The boundaries for the voiced-voiceless distinction fell at longer VOTs for tactile than for auditory system alone. This study's clinical implication was that children having longer than normal VOT boundaries tended to be the ones with profound hearing loss. It may be possible to apply the results of the present study to clinical diffe-rentiation of children who can and cannot utilize the audi-tory mode for communication. However, one limitation of this study was that it did not account for the perceptual distor-tion which is one of the limitations of tactile system.

Eberhardt, Benstein and Remorest et al. studied the ability to speech read sentences with a single channel vibro-tactile presentation of voice fundamental frequency. The aim of the study was to investigate the efficacy 6f four vibrotactile speech reading supplements. Three supplements provided single channel encoding of fundamental frequency. Two encodings involved scaling shifting glottal pulses to pulse rate ranges suited to tactual sensing capabilities. The third transformed fundamental frequency to differential amplitude of two fixed frequency sinewaves. The fourth supplement added to one of the fundamental frequency encodings of vibrator indicator indicated high frequency speech energy. Another goal was to develop methods for experimental control. A sentence corpus was recorded by video, microphone and elicited glattograph. After seventeen hours of treatment and five hours of visual alone baselining, each subject performed open set sentence identification. All subjects improved on visual alone, speech reading and maintained individual differences across the experiment. Vibrotactile benefit hence has not depend on speech reading.

Weisberg (1936) presented three experiments to measure the temporal sensitivity of the tactile system by obtaining the resulting modulating transfer functions for a number of amplitude modulated carrier waveforms. The modulating transfer function as used in linear system analysis described the output response of a system to a given input signal. In this case, the response by a tactile system was measured for a range of temporally varying (amplitude modulated) vibratory stimuli. The resulting transfer function plotted modulation depth required for the threshold detection of modulation as a function of the rate of modulation.

In the first experiment, the response of the tactile system to sinusoidal vibrotactile carrier modulation were measured, in an attempt to outline the basic features of the temporal modulation transfer for the system. Sinusoidal carriers were chosen because of their frequent employment sensitivity. Three normal hearing subjects were chosen and they were asked to indicate the interval that contained the modulated signal. The results indicated that the subjects could indeed perceive amplitude modulation with a fair degree of sensitivity, with peak sensitivity occurring at frequencies in the middle of the range listed (40-250 Hz).

The second experiment was done to investigate the possibility of side band resolution, and to determine whether overall modulation sensitivity was worse when non-sinusoidal carrier waveforms were used, sensitivity to amplitude modulation of broad band carriers was measured. Three normal hearing subjects were taken and ten samples of pseudorandom shift register were asked to choose the interval containing the modulated signal. Modulation depths varied with the frequencies ranging from 5-200 Hz.

Results indicated that sensitivity was best at 200 Hz and declined above and below this value. A more notable finding was the poor overall level of performance for the broad band noise carriers as compared to the sinusoidal carriers.

The aim of the third experiment was to compare vibrotactile performance with broad band and narrow band noise carrier waveforms. The results showed that modulation sensitivity was better with narrow band carriers or modulation frequencies between 20 and 50 Hz, but at very high frequencies, performance was better with the broad band carriers,

Infact, the overall levels of tactile performance with overall broad band and narrow band noise carriers were quite poor, suggesting that the use of amplitude modulation as a signal in tactile device for the deaf or blind would have been optimized by using 'smoother' sinusoidal carriers. This study could have used more numbers, of subjects than just three,

Bernstein et al, (1985) studied child and adult vibrotactile thresholds for stimulation and pulsatile stimuli.

Three experiments were performed to obtain vibrotactile sensitivity thresholds from hearing children and adults and from deaf children. An adaptive two interval forced choice procedure was used to obtain estimates for 70,7% point on a psychometric sensitivity curve. When hearing children of 5-6 years and 9-10 years of age and adults were tested with sinusoids and haversine pulse stimuli at 100, 10 Hz, 160 Hz and 250 Hz stimuli pulses/second respectively. Only the 10 Hz pulses resulted in an age effect. Through this stimulus young children were significantly less sensitive than adults. When sinusoids were again tested at 80, 20, 40 and 160 Hz, a small overall effect of age was observed with a significant effect only at 20 Hz. Two preliminary profound deaf children were tested with haversine pulses/second. Both children were at least sensitive to the tactile stimulation as were the hearing children and adults. Pulsatile stimulation as compared to sinusoidal stimulation exhibited relatively flat threshold versus frequency function. The results demonstrated no age effects for pulsatile stimulation and similar performance for deaf and hearing children suggest pulsatile stimulation approximately for vibratory speech communication aids for the deaf.

The results showed that the threshold curves for adults and children are the same, when stimulation was haversine pulses. Further, the shape of the curve was quite flat in comparison with curves resulting from sinusoidal stimulation. These results were in agreement with results published earlier.

In the area of audition, it had been found that young children have poorer pure tone sensitivity than older children or adults. Information about synchrories and asynchnories in development across sensory perceptual systems could help to resolve questions about the relative continuation of physiologic and perceptual or cognitive factors to developmental effects. Results of the study suggested the following:

1. Pulsatile stimulation does not in age effects nor large threshold shifts as a function of pulse rate and therefore preferable for implantation of a vibrotactile communicaion aid.
2. Young children are less sensitive than older children or adults at low sinusoidal stimuli (ie. in the vicinity of 10 and 20 Hz).
3. Deaf subjects, without additional handicapping conditions/ do not differ from hearing adults or children tested with haversine stimuli.

Hurley (1980) studied the effect of training on discrimination of vibrotactile speech stimuli. He selected 3 normal hearing undergraduates, none of whom had previous experience with vobrotactile speech perception. CV stimuli consisting of voicing contrasts were used. Each stimulus contrast was recorded 6 times in a randomized order for a total of 228 CV items. Of the 30 subjects, 5 received 10 training hours in 3 phases.

1) A minimum course in distinctive features and acoustic phonetics in order to maximize knowledge of the stimulus parameters to be discriminated.
2) Training in discriminating amplitude and duration using both tonal and speech stimuli,
3) Training in using the actual contrasts on which subjects were retested.

Results showed that short-term training did not produce a significant increase in vibrotactile discrimination. Either gross vibrotactile discrimination of speech contrasts was not amenable to training effects or the training program was inadequate.

While this vibrator was ineffective in contributing to the speech perception of connected discourse the results indicated that the use of such a vibrator might have clinical utility in teaching speech to the severe or profoundly hearing-impaired person. Specifically a vibrator specifically, a vibrator could be used to supplement work in articulation acquisition by providing an additional sensory input capable of transmitting differences in consonant phonemes.

Normal hearing young adults (N-30) discriminated CV s and vowels vibrotactually presented by a vibrator of the hearing aid type.Features of voicing, place and manner could be discriminated above chance levels when contrasted with the same phoneme class. Discrimination of vowels, however was at a chance level. Although a brief (10 hours) training curriculum did not significantly increase vibrotactile discrimination of either CV s or vowels, such a vibrator could be used to supplement the acquisition of articulation in the severely and profoundly hearing impaired persons.

Patti and Suzan in 1983 aimed at finding out the children's response to the use of vibrotactile apparatus. The purpose of vibrotactile stimulation was to provide additional sensory input to receive auditori all and visually. The authors had chosen three students for a 6 month period, of structured observation. The subjects had bilateral, profound SN loss. All three were four and a half years old wearable vibrotactile aids were used. Non-segmental aspects of speech and vowels, were introduced first for discrimination, then imitation and finally production. Presentation was often tactile and auditory only as lipreading cues were frequently not sufficient. Materials included pictures are cards for duration, pitch, rhythm patterns and intensity, puppets, manipulative objects, and motor responses. A subjective evaluation of a number of factors related to the vibrotactile output was conducted through the use of parent and teachers questionnaires. In looking at the advantages and disadvantages of the daily use of these aids, all parents and teachers felt the children's increased awareness of sound was the main advantage along with better awareness of the non-segmental aspects of speech. The disadvantage of these aids centered on the durability of these aids, feedback problems, wearing arrangements and usage of these aids in a noisy environment, where the influx of sound made the unit vibrate continuously. Since the consonants contained more feature information than vowels, it was anticipated that the use of vibrotactile stimulation would be of greater benefit to those in the future.

Pickett and McFarland (1985)'s paper reviewed data on speech perception via implanted electrodes and via tactile aids. The two approaches were compared in terras of amount and types of aid provided for communication. The authors discussed the performance levels with multi vs.single channel implants, promontary electrical stimulation versus implants for children and the possible design of complementary systems combining auditory implants and tactile information.

The authors had dealt with 2 main issues -

1) Implant vs. tactile stimulation, that is, how does speech reception result with the best implant system compared with those for the best tactile system. They dealt with the best or potential performance rather than the simpler, more limited aids.

2) Multichannel implants vs. single-channel implants (ie) whether multi channel systems are significantly better compared to a single channel type. This issue was motivated by the concerns bf clinical and system complexity.

However, it appeared from the data that neither approach can provide more than a modest aid to lip reading. Speech perception test results from multi channel implanted subjects are better, on the average, than for single channel implanted subjects. However the best single channel results were comparable to the best multi channel in test using simple sentences. There was great variation among subjects, with the same implant. Tactile aids performance by highly practised subjects seemed comparable to that of better implanted subjects. The authors drew some important conclusions about implants and tactile aids:

1) Speech perception of single words with multi channel implants is better than single channel implants.
2) Most implants could be characterized as highly dependant, for everyday speech communication in lipreading together with using their implant. However, these was a wide range of performance even among subjects with the same implant.
3) Test results on the best single channel implant suggested that the temporal information in the speech wave could be the main source of cues supporting aid performance.

4) The best implant performance was not substantially better, at this time, than for practised subjects with multi channel tactile speech systems.

5) Testing with open word or sentence materials had the inherent problems that the factor of the subject's knowledge of the language could overbear factors of the design of the aid.

6) In view of the difficulty of accurately establishing the degree of residual hearing in young deaf children and the limited benefits of present implants they favour the easy fitting of hearing aids and tactile aids, rather than implants*

Eiler and Oztanar et al. (1988) studied similarities between tactile and auditory speech perception. Perception of synthetic speech continua through the sense of touch and audition was compared utilizing a 32 channel spectrally oriented electrocutaneous display and standard auditory psychophysical procedures.

Experiment-1: Labelling according to continua four healthy adults who had more than forty hours of experience with an electrocutaneous tactile vocoder participated as subjects. Both consonantal and vocalic stimuli were of interest due to significant differences in associated patterns of auditory perception. Two vowels / / and /i/ were originally chosen for the study. The consonantal continum /sta/ - /sta/ was chosen because it is used frequently in a variety of languages and because there is a large body of background research in its auditory perception.

Auditory approach: The digitized auditory stimuli were presented to subjects in a sound treated booth through a high quality speaker stimuli at 80 dB SPL.

Tactual approach; Following synthesis, the speech stimuli were filtered digitally in non-real time by employing a cascade implementation of 32 infrared filters. Tactual and auditory identification were tested in separate sessions. Order of presentation of modality (auditory and tactual) and continum (vowel and consonant) was counter balanced across subjects. At the beginning of each identification test, a trial was initiated by presenting two representation of either end part stimulus.

Striking similarities between tactual and auditory functions were apparent. The similarities in labelling functions could not be accounted for, solely by general response strategies because the two continua differ with respect to symetry of labelling their end points. Instead subjects have responded to the acoustic and tactual properties of the speech signal in the labelling task characteristic of speech stimulus, typically was based not only on labelling functions but also on measures of discrimination.

<u>Experiment-2:</u> Discriminating acoustic continua in experiment 2, equal numbers of same different trials were presented. Each subject received 40 trials/stimulus pair. No feedback was provided. Results showed that both the vocalic and consonantal continua are perceived similarly in auditory and tactual modalities.

The clearest difference between auditory and tactual perception is discriminatory perception. Auditory discrimination was superior to tactual. Rates were higher false positives were higher, and smaller slip sizes could be discriminated. Factors that might have contributed to the differences included superior auditory sensitivity, extensive auditory experience, in speech perception and limitations in current tactual devices.

Skinner and Binger et al. (1983) compared the benefits from vibrotactile aid and cochlear implant for post lingually deaf adults. The goal of the study was to compare the benefits provided by a one or two channel vibrotactile aid to the benefit provided by a multichannel multi electrode vibrotactile implant for the same post lingually deaf adults. Pour post lingually deaf adults were evaluated presurgically with a one or two channel vibrotactile aid and post surgically with multi electrode multi channel intra cochlear implant. Although the vibrotactile aid provides awareness of sound and enhanced flow of conversation.

benefit to the **lip** reading was small on video taped tests and speech tracking. Scores on recorded, sound only speech tests were not significantly above chance except in discrimination of noise from voice with cochlear implant, benefit to lip reading was significantly greater than with the vibrotactile aid.

By focussing on the mean difference scores between lip reading done and lip reading with a prosthesis the variability, contributed by changes in the physical and mental states of the latter and patient across daya and differences in passage difficulty is minimized. For post lingually deaf adults who met the criteria for implantation, the multi channel, multi-electrode intra cochlear implant provides the possibility of much greater benefit, compared to a one or two channel vibro-tactile aid.

Thorton (1983) studied the acceptability of cochlear implants and vibrotactile aids. To obtain data on the likely acceptability of cochlear implants and vibrotactile aids, a questionnaire was sent to profoundly or totally hearing impaired patients. The questionnaire was designed to elicit patients attitudes towards a cochlear implant and to obtain information about their communication problems. A final questions briefly described a vibrotactile aid and asked if the patient would accept one. The data from this questionnaire were combined with data previously obtained from the patients which included information on how long they had been deaf, a ranking of the degree of their impairment and as to whether they used a hearing aid.

There were 15 3 replies 5856 of the sample said 'yes' or 'may be' they would accept an implant, and 73% said that 'yes' or 'may be' they would accept a vibrotactile aid. For tactile aid acceptability only one factor was significant and this was whether the patient had attended the clinic. This implies perhaps that a major factor in vibrotactile aid non-acceptability was the poor information which the patients had about the device. The only other factor of marginal significance, was the number of years since the patient went deaf, the acceptability increasing slightly as the time since onset descreased.

The acceptability of vibrotactile aids, as might be expected of a device that requires no surgical intervention and might well be as the devices receive more publicity. It should be noted here that the data presented here reflected patients attitudes towards a real comparison of the benefits obtained from these 2 devices.

METHODOLOGY

In this chapter, the subjects selected, the instruments used, and the procedure employed in the study is reported in detail.

a) SUBJECTS:

A total of 6 children were selected for the study (5 male and 1 female)with their ages ranging from 7-12 years having a mean age of 8 years. Pure tone audiometry revealed the hearing loss to be in the severe profound degree. All children used hearing aids of the strong category. All subjects had a good vocabulary of 200+ words and conversed well in long sentences. Standard intelligence tests revealed normal intellectual functioning and there was no known or suspected abnormalities accompanying the hearing-impairment. There was also no reported history of deafness in the family. All children were attenders of special schools for the deaf and also speech-language therapy Kannada was the primary language used for communication at home.

b) INSTRUMENTATION:

1) Audiometer - 0B-822 was used which is a dual channel audiometer fitted with earphones and a loudspeaker, to provide facilities for earphone as well as free field testing. The audiometer was calibrated according to IS standards before audiometric evaluations were done.

ii) Microphone - MD 402-K.

ill) Amplifier - Cosmic CD 100 Delux MK II.

iv) Loudspeaker - Cosmic Covox 4500.

v) Tactaid II+ - The tactaid II+ employed was a vibro-tactile aid that uses the sense of touch to enable the profoundly deaf persons to feel sounds that they cannot hear.

vi) Hearing aids: The subjects had their own body level hearing aids in the strong category.

c) <u>TEST ENVIRONMENT:</u>

Testing was carried out in a 2 room situation, the ambient noise which was determined to be within permissible limits.

d) <u>CALIBRATION:</u>

The loudspeakers were calibrated for warble tones and speech using sound level meter (B&K 2203) and microphone (B&K 4145). The procedure is given below:

(1) The loudspeaker was switched on.

(2) Reverse and ldB were selected.

(3) Hearing level was set to correct value for calibration (70 dB).

(4) The calibration key on display board was activated.

(5) The output level for each frequency was adjusted by turning the hearing level controls.

(6) When the calibration was complete, the calibration key was released.

For speech calibration, the same procedure was carried out, but instead of the loudspeaker, the microphone was switched on and the stimulus used was phonation of the vowel /a/.

e) ELECTROACOUSTIC .MEASUREMENTS:

Electroacoustic measurements of the Tactaid 11+ were done using FONIX 6500 system.

f) TEST MATERIALS:

The test materials consisted of -

a) Picturized paired words.

b) Picturized common words.

Lists are included in Appendix-I.& II

g) PROCEDURE:

(i) Pure tone testing: children were required to raise their finger in response to even the faintest sound heard and lower the same under non-tone conditions. Their thresholds were hence established.

(11) Speech testing: The subjects were given prior training using the vibrotactile aid, using a large vocabulary list, for an average of 1 hour/day. The training was carried out in a simple 1 room situation. Training required the subject to respond differentially to high and low frequency sounds, answer questions and participate in general conversation.

For the training session, the subjects were seated in the test room in a comfortable chair at a distance of 1 meter from the loudspeaker. One loudspeaker was made use of for the presentation of signal. The azimuth of the sound source was 45°.

The paired words and the common words were then presented. For the common word list presentation, 5 pictures were placed in front of the child, and the child was required to point to the word named.For the paired wordlist presentation, a set of 2 pairs of pictures were placed before the child and the child had to point to the right pair following the right sequence (hoovu-haavu to show hoovu and their haavu, failing which, it was scored as an error). A total of 3 word lists were prepared for the 3 conditions of (1) hearing aid (2) tactile aid (3) a combination of hearing aid + tactile aid. The order of occurrence of words in the 6 lists (3 paired words and 3 common words) with reference to the lable of random numbers (Black and Champion).

Depending on the task the instructions were given. The number of correct responses given under each condition was calculated and the raw scores were statistically tested. When subjects were tested with the hearing aid, batteries with correct voltage provided to ensure proper transmission of signals. An informal check of the subjects hearing aid was done before testing. In case of any distortion it was referred for repair.

The tactaid II+ was kept charged for a minimum of 8 hours every alternate day. During testing the 2 vibrators were strapped onto the wrist of the child, the low frequency vibrator was always oh the left side of the body. It was then switched on and used in the same manner as a regular hearing aid. Care was taken such that every subject was seated in the same place at the same distance from the loud-speakers.

ANALYSIS, RESULTS AND DISCUSSION

The aim of the study was to determine if there was any significant difference in the subject' s performance under the following 3 conditions.

a) Subject wearing only the hearing aid.

b) Subject wearing only the tactile aid*

c) Subject wearing both the hearing aid + tactile aid.

The data was collected based on the methodology given in the earlier chapter. The scores were obtained for each subject under 3 different conditions described above, using the 2 test materials namely picturized common words and picturized paired.words.

The paired 't' test used as the statistic revealed the following.

COMMON WORDS

Condition	SD	Mean	t value	(0.05 level) Significance
a&b	8.2	3.1	0.439	Not significant
b&c	1.41	1.0	0.7092	Not significant
a&c	7.95	3.3	0.415	Not significant

PAIRED WORDS

Condition	SD	Mean	t value	(0.05 level) Significance
a&b	3.3	0.666	.368	Not significant
b&c	5.3	1.33	0.251	Not significant
a&c	2.0	1.0	.5	Not significant

The results showed practically no significant difference between the 3 groups of conditions with respect to the paired word list as well as the common word list. Earlier literature has however reported a significant improvement in subject performance using the vibrotactile aid in the categories of

a) basic perception of acoustic stimuli (Welsenberger J.Metal 1933).
b) word recognition (Brooks and Frost, 1903).
c) fundamental frequency (Plant and Risberg, 1983).
d) vowel identification (Green, Craig, Wilson, Risoni and Rhodes, 1983),
e) categorical perception of speech (Collins and Richard, 1985).

Some inconsistencies between the results obtained in literature and the present study might be attributed to the following:

1) Children selected for our study of the age range 7-12 years have always been exposed to the aural oral mode of training ever since the time they began speech-language training which was fairly early and hence it was difficult to obtain a good estimate of mere perception of tactual stimuli.

2) The subjects selected earlier in literature were subjected to long hours of training (around 30). The children in this study were given only a maximum of 10 hours of training. This could be a potent cause for the descrepancies with the earlier studies.

3) Studies uptilnow reported in literature have all dealt with English as the medium of training and testing. English and Kannada have basic differences in that Kannada is a syllabic language and that what we speak is not actually what we write. Findings in the English language hence cannot be generalized onto Kannada. Error analysis could hence be done to determine whether this generalization is possible.

Miyamoto et al. (198$) and Osberger et al. Press, Volta Review (1992) formulated what performance expectations with the device are unrealistic after working with the TACTAID II+ with a large number of children over the past years.

First, it is unrealistic to expect the child to identify or detect warning signals in the environment. In most cases, responding to warning signals requires localizing the sound source. Given that the microphone is located in the front of the child, localization is almost impossible. Background noise also can mask the warning signal of interest. Research has shown that many children fail to identify familiar environmental sounds in everyday situation with TACTAID II+ (Robbins Renshow and Barry in Press). This occurs because of competing signals picked up by the device which make it difficult for the child to distinguish familiar environmental sounds from other noise in the environment.

Second, the Tactaid II+ cannot be used to perform open set speech recognition tasks. Irrespective of the amount of training or length of use, a 2 channel sensory aid such as TACTAID II+ does not provide sufficient spectral information for understanding speech on the basis of segmental cues (Miyanmoto et al. 1989; Osberger et al. in 1989 in press). Other investigators however have found that the information perceived via the tactaid II+ can be used by children to enhance SR performance.

A third unrealistic expectation is that the child will evidence spontaneous identification of spoken language in unstructured situations. Few if any of the children with whom they have worked during the past 3 years have shown spontaneous identification of speech sounds, words or phrases in unstructured situations.

SUMMARY AND CONCLUSION

Review of literature indicated a significant improvement in subject performance using Tactile aid compared to the conventional hearing aid, in the categories of word recognition, fundamental frequency vowel identification, basic perception of acoustic stimuli, categorical perception of speech etc. The present study was undertaken to verify and test a few of these utilities of the tactile aid as opposed to the hearing aid.

A study was hence conducted using a prototype developed indigenously,6 subjects were selected, and after a 10 hour training using the vibrotactile aid were tested under the following conditions:

a) Hearing aid alone

b) Tactile aid alone

c) Hearing aid + Tactile aid in a free field testing condition.

Results indicated that there was no significant difference between the subjects under the 3 conditions described above using either the paired words or the common words, some of the possible explanations for which have already been discussed.

SUGGESTIONS FOR FURTHER STUDY:

1. The aids performance can be tested to on subject's Who have not been exposed to such extensive aural oral method of speech language training, so that the effects of mere perception of tactile vibrations can be precisely evaluated.

2. The study could be carried out on a larger number of subjects, with more extensive period of training.

3. The effects of vibrotactile aids on perception could be tested in other languages besides English and can be seen whether the findings in English can be generalized to the other non-English (Indian) languages.

4. The same study could be carried out on adults to determine whether performance with the vibrotactile aid is compatible with children's performance.

BIBLIOGRAPHY

Adele, P., and Moise, H., Goldstein, Jr, (1983) x Development of lexical comprehension in aprofoundly deaf child, using a wearable, vibrotactile communication aid. LSHSS, 14, 138-149.

Bernstein, L.E., Schechler, M.B., Goldstein, M.H. Jr. (1986): Child and adult vibrotactile thresholds for stimulation and pulsatile stimuli. JASA. 80, 118-123.

Brooks, P.L., Frost, B.J. (1983): Evaluation of a tctile vocoder for word recognition. JASA, 74, 34-39.

Carl E. Sherrick (1985): Touch as a communicative sense: An Introduction. JASA, 77, 218-219.

Charletti, M.R., Nathaniel, I.D., Larrane, A., Delhorne, William, M.R., Ken, W.G. (1989): Research on tactual communication of speech: Ideas, issues and findings. The Volta Review, 91, 65-78.

Derchi, I. (1987): Tactile aids, where do they fit in? Hearing Instruments, 38, 38-41.

Gail, D. Chermak (1981): Handbook of Audiological rehabilitation, 10-14, Charles C Thomas, Illinois.

Graeme, M. Clark, Yet, C.T., James, P.P. (1990): Cochlear prosthesis. 14-17, Churchill, Livingstone, New York.

Green, B., Craig, Wilson, J.C., Pisoni, D.B., Rhodes, R.P. (1983): Vibrotactile identification of vowels. JASA, 73, 1766.

Jane Collins, M., Richard, R.H. (1985): Categorical perception of speech via the tactile mode. JSHR, 28, 594-598.

Lynch, M., Eilers, R., Oytanai, S., Oiler, P., Miskiel, Urbano (1988): Similarities between tactual and auditory speech perception, JSHR, 31, 124-131.

Oliver, P., Arjen, B. (1982): A prosthetic device utilizing vibrotactile perception of profoundly deaf children. BJA, 16, 277-279.

Oiler, D.K., Payne, S.L., Gavin (1980): Tactual speech perception by minimally trained deaf subjects. JSHR, 23, 769-778.

Patti,S., Suyan, A., Hansen (1983): The use of vibrotactile aid with preschool hearing impaired children: Case studies. Volta Review, 85, 14-26.

Pickett, J.M., McParland, W. (1985): Auditory implants and tactile aids for the profoundly deaf.

Plant, G. (1983): The use of vibrotactile aids with profoundly deaf children. STL-QPSR, No.l,36-51.

Plant, G., Risberg, A. (1983): The transmission of fundamental frequency variations via single channel vibrotactile aid. STL-QPSR, No.2-3, 16, 233-245.

Plant, G.L. (1982): Tactile perception by the profoundly deaf Speech and environmental sounds. BJA, 16, 233-245.

Raymond, M.H. (1982): Effect of training on discrimination of vibrotactile speech stimuli. JAR, 22, 43.

Rebecea, E., Kimbough, D.O., Kathleen, V. (1989): Speech and language progress of hearing impaired children in a systematic speech training program using tactile vocoder. The Volta Review, 91, 127-138.

Risberg, A. (1987): Speech coding in a single channel implant and a comparison of results for auditory tactile and electrical stimulation. Annals of Oto Rhino and Laryngology, 96, 65-66.

Ross, J.R., Marion, P.D. (1981): Auditory disorders in school children. 260-280, Thieme Stration Inc. New York.

Sherrick, C.E. (1984): Basic and applied research on tactile aids for the deaf: Progress and **Prospects.** JASA, 75, 1325-1342.

Silvio, P.E., Lynne, Berstein, E. (1990): Speech reading sentences with single channel vibrotactile presentation of voice fundamental frequency. JASA, 86, 1274-1285.

Skinner, M.w., Binyer, S., Fredrickson, J., Smith, P.G., Holden, T.H., Holden, L.K., Judich, M.J., Turner, B.A. (1988): Comparison of benefit from vibrotactile aids and cochlear implant for post-lingually deaf adults. Laryngoscope, 98, 1092-1099.

Spens, K.E. (1980): Tactile speech communication aids for the deaf: A comparison. STL-QPSR, 4, 23-39.

Thorton, A.R.D. (1988): The acceptability of cochlear implants and vibrotactile aids. BJA, 22, 105-112.

Weisenberg, J.M. (1986): Sensitivity to amplitude modulated vibrotactile signals. JASA, 80, 1707-1715.

Weisenberger, J.M., Miller, J.D. (1987): The role of tactile aids in providing information about acoustic stimuli. JASA, 82, 906-916.

APPENDIX - I
[COMMON WORDS]

pennu
kuɖure
bəssu
telifon
huvu
watʃ
a:ne
balehaɳu
kəp
tuʈʰbrəʃ
məra
pensɪl
papa
ʃuzu
topi
vɪmana
kurətʃɪ
fɛn
batʃənɪge
saɪkəl

APPENDIX-II
[PAIRED WORDS]

kət̪ri - tʃət̪ri

hu:vu - ha:vu

ga:ḍɪ - dʒa:ḍɪ

dʒəna - d̪ana

bʰavɪ - ba:ɪ

pɛnnu - bɛnnu

male - bale

kət̪t̪u - kat̪t̪e

ka:ru - ka:ḷu

kət̪t̪e - kappe