EFFECTIVENESS OF ENVIRONMENTAL SOUND TEST IN HEARING AID SELECTION FOR PAEDIATRIC POPULATION

Register No. 02SH0005

An Independent Project submitted in part fulfillment for the first year
M.Sc, (Speech and Hearing)
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All India Institute of Speech and Hearing
Manasagangotri
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Dedicated to

My

"Beloved' Parents and my loving (Mathy) Sisters"

to all my teachers,

who had been my breath & strength to over ride all the barriers and succeed in each & every attempt of mine

... Thank you my Lord

CERTIFICATE

This is to certify that the independent project entitled **"EFFECTIVENESS OF ENVIRONMENTAL SOUND TEST IN HEARING AID SELECTION FOR PAEDIATRIC POPULATION"** is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register No. **02SH0005.**

D. Jayaram

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Director
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Mysore
***June** 2003*

CERTIFICATE

This is to certify that the independent project entitled: **"EFFECTIVENESS OF ENVIRONMENTAL SOUND TEST IN HEARING AID SELECTION FOR PAEDIATRIC POPULATION"** has been prepared under my supervision and **guidance.** It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

Manjula. P 20.5.03

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Mysore
June *2003.*

DECLARATION

I hereby declare that this independent project entitled: **"EFFECTIVENESS OF ENVIRONMENTAL SOUND TEST IN HEARING AID SELECTION FOR PEADIATRIC POPULATION"** is the result of my own study under the guidance of **Ms. Manjula, P.** Lecturer, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any other University for the award of any Diploma or Degree.

Mysore
June 2003 **Reg.No. 02SH0005**

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"Pen is mightier than sword" - Still hands can't express the mind...

CONTENTS

LIST OF TABLES

INTRODUCTION

"Everywhere we are, we are surrounded by noise. When we ignore it, it annoys us. When we listen to it, we find it fascinating" - John Cage (as cited in Gygi, 2001).

Cage referred to as "noise" - the collection of background sounds in our environment, such as dogs barking, cars starting, sneezes, and electric saws. He has been investigating the perception of complex, familiar, naturally occurring non - speech sounds which, as a class, have been variously labeled 'common sounds', 'familiar sounds', 'everyday sounds', 'naturalistic sounds', but most often 'environmental sounds'. This class of sounds has been little studied for reasons discussed below. However, these sounds are fascinating because they can reveal much about how we hear in the world and there is still so much to be learned about them.

Development of listening skills is an on-going process. The basic factors contributing to the development of sophisticated listening skills are sound awareness, discrimination, localization, intonational patterns and memory (Grammatico, 1975). For the development of listening skills in a young child, the environment should be enriched with both verbal and non-verbal sounds. Horn sound, barking of a dog, etc. are the kind of stimuli for which the child responds even before he can actually imitate the sounds. Animal sounds are excellent stimuli to be used in the development of intonation and localization skills (Grammatico, 1975).

Besides being aware of environmental sounds, the child associates the meaning of the nonverbal environmental sounds. For a young child, the learning of the auditory skill takes the form of labeling the things and people, he can identify in his environment, (prammatico, 1975). That is to say, he starts to not only differentiate between the environmental sounds but also identify them. He starts discovering how tilings work which help in the development of cognitive skills.

According to Ruben and Rapin (1980), environmental sounds may be influential in lie development of central auditory nervous system. The effects of environmental sounds in shaping the organisms ability to hear appear to occur before central auditory system matures. These sounds would appear to have its greatest effect in shaping auditory ability from the time the inner ear and eighth nerve first becomes functional till the maturation of central nervous system.

According to the studies on auditory deprivation, the physiology of the auditory system is modified by environmental sounds. Clopton and Winfield (as cited in Ruben & Rapin, 1980)have reported that the firing rate of single units in the inferior colliculus increased selectively when stimulated with familiar sound pattern compared to the firing rate with a novel sound pattern. This evidence indicates that the level of the inferior colliculus can be modified by auditory experience.

. Wallace, Gravel, Me Carton, and Ruben (1988a); Wallace, Gravel, McCarton, Stapells, Bernstein, and Rubin (1988b), Jerger, Jerger, Alford and Abrams (1983), Gravel and Wallace (1992) - have highlighted the impact of auditory deprivation and its behavioral consequences. These studies have been done on human subjects to highlight the importance of normal hearing for the emergence of oral communication. The intelligibility of spoken language is considerably enhanced in children who experience a period of normal hearing before the onset of deafness (Boothroyd, as cited in Gravel & Ruben, 1996). Speech quality is usually markedly affected by the lack of both a normal input model and an auditory feedback loop (Boothroyd, 1982). So, the hearing impaired individual should be enabled to make maximum use of their residual hearing effectively for which amplification plays a vital role.

According to Ross and Tomassetti (1980), "the early and appropriate selection and use of amplification is the single most important habilitation tool available". The goals for pediatric hearing aid fitting are for comfort and audibility of speech and environmental sounds. The selection of a specific hearing aid for a hearing-impaired child challenges the skill of even the most experienced audiologists. When a child has both receptive and expressive language, the selection of a hearing aid is certainly easier. It is the non-verbal child who poses problems, because this youngster is not capable of communicating with the audiologist about the quality of various hearing aids. Appropriate selection of the frequency response and output characteristics must be carefully considered in fitting amplification to children. The aim will normally be to provide amplified speech that is as clear and intelligible as possible, with the provision also of important background sounds, such as ringing doorbell, or the sound of an approaching car. According to Eisenberg (1985), environmental sounds, in particular, may play an important role in the early stages of auditory stimulation.

A number of techniques, both behavioral and electro acoustic, have evolved as a measure to select the optimal hearing aid for each individual. None of them provide exact and precise information that is valid for every hearing aid fitting, but each one provides direction about the appropriate range of performance that the hearing aid must encompass.

The sounds that occur around us are almost all inharmonic vibrations occurring in an unpatterned manner. Yet we can identify most environmental sounds because they do have discernible characteristics, even though they lack pattern. The energy in these sounds is distributed differently by different vibrating sources. The physical characteristic of environmental sounds differs in ways that permit them to be coded to their sources. Hearing impairment removes or distorts some of this information, sometimes to the point of making coding impossible. Part of the assessment of useful residual hearing in children with severe to profound losses includes determining how much potential remains and to what extent the child can be trained to use amplified environmental sounds for functional purposes - that means to be able to respond appropriately (Boothroyd, 1982).

These environmental sounds are important not only as warnings, but also as providers of general information about our environment, which is important psychologically (Sanders, 1993). Unfortunately, background noise can, and does interfere with speech signal, and it can be difficult, or even impossible, for hearing impaired people to separate the sounds, they want to hear from those they do not. This is partly due to defective hearing mechanism, which is especially notable when cochlear damage has been sustained, and partly to the restrictions inherent in a hearing aid (Tate, 1994).

The timely fitting of appropriate amplification to infants, and children with hearing loss, is one of the more important responsibilities of a paediatric audiologist. Although the importance of providing an audible signal for developing and maintaining aural / oral communication for formal and informal learning is undisputed, the methods used to select and evaluate personal amplification for infants and children with hearing loss vary widely among facilities. A few audiologists use systematic approach for selecting and fitting amplification for young children and many do not use current technologies in the fitting process (Hedley-Williams, Tharpe & Bess, 1996). Because of the improvement in early identification of hearing loss in children , continued changes in technology, and a new array of amplification options available for infants and children, there is a critical need for a systematic, quantifiable and evidence based approach to providing amplification for the paediatric population. The goal is to ensure that children receive full-time and consistent audibility of the speech signal at safe and comfortable listening levels.

The age of the child and his / her language competence will determine what information can be obtained and when the child can co-operate. One can screen the standard children's test items to eliminate those with which the child is unfamiliar and when necessary generate individual lists from the child's vocabulary. Tests that allow the child to point to the test item named facilitate assessment of young children. These are for children who have some verbal language. Hearing impaired children who have limited vocabulary cannot be tested with such tests. In that case the environmental sound test can be used.

Sound events, including speech, need to be paid attention in order to be processed properly. Great interest should be shown in the sound source, which the child should be encouraged to handle if possible and to explore by other senses. We must be alert to the sounds made by the child's own activities, such as banging a spoon or spinning the wheels on a toy. One should not isolate those sounds from the activity as a whole and listen to them attentively.

Since early language acquisition arises from events observed, objects that make noise in the home provide a natural basis for the child's early experiences with amplified sound. The child needs to become aware of the world of sound, limited or distorted, though it may be. The goal of all the activities is to attempt to develop auditory behaviour in a child, which reflects a way of a relating to the environment .It is predicted upon the usefulness of sound.

Boothroyd (1982) reported that every activity must ensure that the auditory behaviour is productive, useful and rewarding to the child. Listening to sounds that serve no purpose encourages the ignoring of sound. The assessment of the ability to perceive environmental sounds will help in determining the auditory identification abilities of a child and will help in making estimation of his performance on speech identification task. The reality of sound, its referential functions and it's meaning, rather than being learnt naturally, must be taught. Also, the speech sound stimuli used in various therapeutic programs include speech, environmental sounds and musical instruments. Speech is a weak and distorted sound pattern decipherable only with in tight situational constraints and with rich supplementary visual cues. Consequently, acquisition of language through speech perception is slow and laborious.

In view of all the above, it can be postulated that environmental sounds sustain the children's attention in an evaluation procedure / in selection of hearing aids effectively than that of noise / warble tones which are also used as stimuli in hearing aid selection.

Need for the study

Environmental sounds can be justified to be better than Narrow Band Noise in selection of hearing aids, for pediatric population for the following reasons:

- The environmental sounds are always meaningful and more familiar, for a hearing impaired child, than Narrow Band Noise.
- It sustains the attention of the child better than Narrow Band Noise.

Environmental Sound Test (Rawat, 2001).

- Also, in the Indian context, since ours is a multi-lingual country, testing hearing impaired population (children) belonging to different languages, becomes difficult, as it requires speech identification tests in different languages. So, to overcome this inconvenience in testing pre-verbal hearing impaired children, Environmental Sound Test can be effectively used, as the test with environmental sounds can be administered for any paediatric population, irrespective of the language background.
- The Environmental Sound Test involves a picture identification task, so the training and instructions becomes easier and more comprehensible.
- As the Environmental Sound Test involves all frequency sounds, we can also infer if a child has a problem in hearing high frequency speech sounds or low frequency speech sounds or mid frequency words. Based on this, the hearing aid or the setting can be modified, according to the needs of the child. Also, a qualitative analysis can be done along with quantitative analysis, in this regard.

Tests developed in Western countries cannot be directly adopted for hearing aid selection in Indian population, as the type of environmental sounds varies. Hence, an Environmental Sound Test was developed for Indian population. This needs to be evaluated for its effectiveness in hearing aid selection.

The Environmental Sound Test used in hearing aid selection will enable to make rehabilitative suggestions for children who have not yet developed speech, i.e., it is not only of diagnostic use but also of rehabilitative use.

Since, there are limited number of tests developed using environmental sounds as stimuli during hearing aid selection, in Indian context, for preverbal children, the Environmental sound test (Rawat, 2001) might prove effective in hearing aid selection.

Aim of the study

The aim of the present study was to investigate the effectiveness of **Environmental Sound Test, developed by Rawat, 2001, for assessing listening skills in children,** in hearing aid selection for children in the age range from 3 to 5 years. The study aimed at comparison of the stimuli, Narrow Band Noise and Environmental Sounds, in hearing aid selection. To substantiate the aims, the following aspects were investigated:

- the performance scores of each child on Narrow Band Noise with different hearing aids.
- the performance scores of each child on Environmental Sound Test with different hearing aids.
- the performance between Environmental Sound Test and Narrow Band Noise.

REVIEW OF LITERATURE

The presentation of everyday sounds is a part of normal hearing experience The nature of environmental sounds to which developing organism is exposed seems to determine in part, its eventual auditory capabilities. The effects of environmental sounds in shaping the organism's ability to hear appear to occur before the central auditory nervous system matures (Ruben & Rapin, 1980).

A child is exposed to both verbal and nonverbal sounds such as mother's call, cycle bell and bird's chirp. As the child grows, he / she starts discriminating between the sounds and later identifies the sounds. This helps in cognitive development. It is essential to assess the auditory identification abilities of children in order to determine whether they have normal auditory perceptual abilities or not (Finitzo - Hieber, Gerling, Matkin & Cherow-Skalka, as cited in Flexer & Richards, 1994).

A child who is bom with hearing impairment will be deprived of communication unless remediated through amplification and specific auditory / speech language training is provided (Gravel & Ruben, 1996). Those children, who have deviant auditory abilities, would have to be rehabilitated, using appropriate approaches. Auditory identification tests could be used to select devices that would result in the child making maximum use of his / her residual hearing or benefiting maximum from cochlear implants.

Test results for children are often difficult to obtain. The younger the child, the harder it is to generate an audiometric profile and the more tentative must be the acceptance of the results that are obtained. Early audiograms often are little more than approximations of thresholds. These may have been obtained binaurally in a free field using a loudspeaker, and they are often confined to the critical speech frequencies. Even with older children, one requires repeated audiometric findings / testing before reliability and validity can be assured. Results obtained from speech reception and discrimination tests should be treated with great caution since many variables must be controlled.

The selection of amplification characteristics for preverbal children who are hearing impaired, is one of the most challenging problems confronting clinical audiologists. First, preverbal children do not have the ability to adjust the gain control of their hearing aids to a comfortable setting depending upon the acoustic conditions they encounter. Additionally, they are unable to express preference for a particular frequency response on the basis of the intelligibility or quality of their auditory experience. Finally, other than by skillful removing them from their ears, preverbal children have no other means of communicating their displeasure with the selection of output characteristics of their hearing aids. The real challenge lies in the fact that this very precise selection is based on extremely limited information regarding the child's unique auditory characteristics only. In these cases, the hearing aid selection is modified. In an attempt to find a hearing aid and a volume setting, that will presumably deliver the widest spectrum of sound, at least 10 - 20 dB above threshold, several hearing aids are tested with the noise bands at the average speech levels. The hearing aid and volume setting which best approximates the ideal is selected. When feasible, this is followed by tolerance tests to ensure that the child does not react adversely to these inputs. While this procedure is not ideal, it at least ensures that: (1) the child will receive speech above his threshold, and (2) the input levels are not so high as to cause discomfort.

In literature, it is given that there are ample clinical experiences and experimental evidences to validate the use of tools like PB lists in hearing aid selection. But the current dissatisfaction with hearing aid selection procedures stems from the time consuming nature of the task (Jeffers & Smith, 1964).

An aided audiogram will allow one to see how much of the speech signal spectrum is brought with in the range of residual audibility by the hearing aid (s) and which frequency components of speech sound is recognizable in some phonetic contexts but not in others. Stressing too strongly that amplification does nothing to change a person's hearing deficiency, regardless of improvements in test results, cannot be done. The actual sensory capabilities of the cochlea remain unchanged. What a hearing aid aims to do is to amplify speech so that the signal is intense enough to stimulate those remaining hair cells that are not activated by speech at normal intensity levels. Thus, a severe hearing impairment remains a severe hearing impairment regardless of the improvement in audibility of pure tones and speech that is hoped to result from amplification.

It must be realized that the goal of amplification is not to achieve aided threshold responses as close to normal as possible. This could result in a reduction of maximum discrimination due to amplification beyond the optimal intensity level. The aim is to keep the amplified speech well with in the level of comfortable loudness (Pappas, 1998).

Assessment of hearing aid functions in children includes sound field aided audiogram, hearing aid electro acoustic analysis, real ear measurements and an observation (Carmichael & Manning, as cited in Pappas, 1998). Electro acoustic analysis of hearing aid measures hearing aid output performance as well as distortion.

Other information provided by the hearing aid analyzer is frequency response and the level of the gain at each frequency. For the convenience of testing young children, a formula approach towards determining and setting frequency response characteristics may be necessary (Bentler, as cited in Alpiner, & Mc Carthy, 2002). A number of targeting approaches have been forwarded over the years including the Berger (Berger, Hagberg, & Rane. 1977), Prescription of gain and output (POGO) [Mc Candless & Lyregaard, 1983], National Acoustic Laboratory (NAL) [Byrne & Dillon, 1986], Fig 6, DSL-Desired Sensational Level (specifically for children), procedures to name a few.

The clinician must always be cognizant of the probability that output from a prescribed hearing aid on a young child will be higher than that shown on manufacturer's specifications sheets, and use caution in determining appropriate SSPL90 values.

Some typical clinical procedures, such as giggling of keys, or banging on the examination table, may give a rough estimate of the validity of settings. Stelmachowicz (1991) further measured the output from a hearing aid with a variety of environmental inputs. Although measures of gain (difference in unaided and aided conditions) may be accurately obtained with a wideband complex, validation of maximum output necessitates use of a pure tone input so that the maximum possible output in any frequency region can be compared with the discomfort threshold at the same frequency (Bentler, as cited in Alpiner, & McCarthy, 2002). In this way, complex environmental stimuli will not exceed discomfort even in those peak frequency regions. Many audiologists use prescriptive hearing aid fitting formulae to adjust and customize the amplification response to the audiometric configuration of the infants hearing loss whenever possible. But this requires data from unoccluded (open) ear canal of the infant as measured with probe microphone system. It is well recognized, that, as an infant grows older, the ear canal changes in length, shape, and diameter, thereby altering the resonance characteristics of unoccluded ear canal. (Hayes & Northern, 1996)

Also, the current availability of programmable and digital based hearing aids has proven to be especially useful in fitting amplification in children. Major changes in the physical hardware and appearance of hearing aids have been seen, as well as computerized evaluation techniques to ensure improved fitting protocols. Each programmable hearing aid is adjustable to fit nearly any degree of hearing loss and almost every audiometric configuration. Its long-term benefit to hearing impaired children is very important. Programmable hearing aids offer flexibility to be altered electro acoustically to fit the child's changing needs and possible fluctuations in hearing levels. The selection of children's hearing aids requires special considerations. The procedures followed by the audiologist for selection of the hearing aid will be a function of the experience of the clinician. Considerable expertise is required to select the correct amount of gam, output and frequency response curves in multiple programs. The final selection may be influenced by the age and motor skills of the child, cosmetic considerations, etc. The wide range of programmability is especially valuable in children's fittings because of the possible incomplete or tentative hearing threshold measurements and the fact that the child's listening skills will likely change over time after the hearing aids are fitted.

A simple technique to demonstrate the "audibility'provided by hearing aids, basedan the traditional articulation index concept, was described by Mueller and Killion (1990). Their suggested procedure uses a template of 100 dots weighted and fitted into speech spectrum on an audiogram. The articulation index is a measure of the proportion of speech cues that are audible and therefore closely related to the intelligibility of speech. The patients hearing threshold are plotted on the count - the - dots template, the number of dots under the audiogram, representing speech sounds that the patient can hear, are counted and multiplied by 100 to express the value as a percentage. This presents a visual method that can demonstrate the potential benefit that will be obtained from hearing aids as well as to show the amount of communication handicap for normal level speech that might be experienced by a patient in an unaided and aided situation (Northern & Downs, 2002).

An important concept relative to children's amplification introduced by Gengel, Pascoe and Shore (1971) assumes that a positive correlation exists between aided speech discrimination scores (performance) and the area of speech spectrum received with amplification. Thus, the goal of hearing aid selection is to utilize a hearing aid that amplifies, at a comfortable gain setting, as much of the speech spectrum as possible.

Bands of noise corresponding to the intensity of corresponding segments in normal conversational speech are used to compute average speech spectrum levels for octaves over the standard frequency range. Gengel and colleagues (1971) computed approximate average speech levels for bands of noise centered at five test frequencies, when the overall SPL of the spectrum was 70 dB SPL, to be 60dB at 250 Hz, 61 dB at 500 Hz, 58 dB at 1000 Hz, 54 dB at 2000 Hz and 46 dB at 4000 Hz. The protocol of this evaluation is to establish aided thresholds with these selected narrow bands of noise when the hearing aid is set at a comfortable listening level. The difference values between the aided speech spectrum levels, in dB, represent the approximate sensation level at each frequency band of speech will be perceived during normal conversation (Sandlin, 1995).

Gengel and colleagues suggested that the hearing aid of choice is the one that amplifies the widest possible speech spectrum 10-20 dB above the aided threshold. The authors proposed this procedure for evaluating and selecting hearing aids for children with severe to profound hearing loss. Schwartz and Larson (1977) *confirmed* the value of this procedure with severely hearing impaired children.

The publications of Ross and Seewald (1988), and, Seewald (1988) have continued to develop this suprathreshold approach to select hearing aids for hearing impaired children. Their procedure has been to determine amplification target levels by using estimates of the average levels associated with LTASS relative to the child's unaided sound field detection levels. Although some controversy exists among researchers as to the exact intensity levels representative of frequency segments with in the long-term speech frequency spectrum (Olsen, Hawkins & Van Tasell, 1987), the overall concept is to provide children with an amplified speech signal that is audible through out the broadest frequency range possible. In general terms, the desired sensation level of the amplified speech decreases in an accelerated nonlinear function with increasing hearing loss (Seewald, Ross & Spiro, 1985). Although older children can be assessed with this technique through behavioral sound field measures, probe microphone measurement provides information regarding the real ear frequency characteristics quickly and easily in the child's ear canal. Hawkins (1987) described a similar procedure in which the child's auditory detection levels are determined in sound field using behavioral techniques. Real Ear Unaided Response (REUR) and Real Ear Aided Response (REAR) are obtained using a probe tube. By comparing REUR at threshold levels, with the REAR produced with the speech spectrum level input, an estimate can be made of the sensation level at each frequency of the amplified long-term speech spectrum.

Mc Candless and Miller (1972) described a technique for establishing hearing aid gain by use of acoustic reflex thresholds as measured with an immittance meter. With this procedure, the patient is fitted with a hearing aid to one ear and immittance probe tip is placed in the contralateral ear. Using constant sound pressure input of average environmental sounds or conversational speech, the gain control of the hearing aid is slowly raised until the acoustic reflex is barely observed in the contra lateral ear. A gain setting is accomplished by adjusting the controls just below this level, which will be safely under the patient's discomfort level. This technique appears to determine a gain level that provides maximum intelligibility for speech (Rappaport & Tait, 1976). In subjects with significant hearing loss, behavioral and acoustic reflex estimates of functional gams were found to be in good agreement (Rines, Stelmachowicz & Gorga, 1984).

Unfortunately, the acoustic reflex is often absent in severe to profound sensori-neural hearing loss. In addition, acoustic reflexes may be absent due to unilateral or bilateral middle ear effusion in young children. Hall and Ruth (1986) reported that acoustic reflex technique is probably useful only in 40-50% of the average pediatric population undergoing hearing aid evaluation.

At the start of a typical hearing aid evaluation, anyone of a number of different hearing aids might seem capable of doing an adequate job. One aid is ultimately chosen which yields best all round scores on the battery of audio-logical tests. Usually the one test most heavily weighted the discrimination (intelligibility) test, delivered from a list of monosyllabic words delivered through the aid.

Gengel, Pascoe and Shore (1979) conducted a study in central institute for the Deaf (CID), St. Louis. Missouri, where the aim was to find an aid which will fit the greatest possible extent of the frequency intensity area of speech into the restricted auditory sensation area of the child, using narrow bands of noise, centered at octave intervals between 0.25 and 4 kHz, to determine the maximum linear output, maximum gain and the maximum volume setting for linear output of hearing aids. Based on these physical characteristics, aids are selected for testing severely hearing-impaired children. With regard to environmental sounds, they have been little studied, in comparison to other main classes of naturally occurring sounds, speech and music.

A study by Gygi (2001), indicated that environmental sounds are similar to speech in spectral temporal complexity, robustness to signal degradation, in the acoustic cues utilized by the listener.

"Why environmental sounds?"

Learning how one listens to sounds in the world poses several problems. First, there is the problem of what one listens to. There is little dispute that the most important auditory 'event" in our daily lives is speech. After that is music, at least as reflected in the volume of research on the subject. Then 'everything else', much of which is regarded as, at worst, unwanted noise, or, more objectively, ambient sound. There are so many citations on speech and music perception and only dearth of studies on environmental sound perception and everyday sound perception.

Banik (1999) suggested that Auditory Training Program must train the child to perceive a wider variety of environmental sounds which will show the child to be alert to unexpected changes in his environment and this ensures his safety and well-being for his / her life and later it must train the child to perceive verbal signals too. The child needs to be exposed and made aware of various natural sounds he hears in his daily life. He says that children should be trained to differentiate various auditory sounds - environmental sounds, i.e., bells, drums, whistles, horns, etc at a discrimination level in training. In his list of auditory training materials, sounds such as telephone, dog bark, cats meow, cow's moo, horse neigh, moving train, singing bird, motor sound, fire engine, door bell, door knock, laughing, crying, aero plane sound and cycle bell are included.

Most audiometric tests use speech, tone or noise stimuli. Very few tests use natural non-speech sounds. The perception of non-speech environmental sound is important for orientation, room perception and feelings of confidence and comfort, which have implications for the process of rehabilitation. The purpose of the test "Sound Environment Identification Test" is to produce an instrument with which the ability to recognize and localize non-speech sounds can be assessed and followed.

Tyler, Baker and Bednall (1983) conducted a study in finding the difficulties experienced by hearing aid candidates and hearing aid users. They found that, of the hearing aid candidates, 13% had difficulty in hearing telephone bell and 12%, the doorbell. It is surprising that these numbers are only slightly less for the hearing aid users. Environmental aids were available in the clinic, although probably only a few of the patients were using them.

Barecham and Stephens (as cited in Tyler, Baker, & Bednall, 1983) observed more respondents having problem hearing the telephone (20%) bell and doorbell (24%). They also reported of difficulty in recognizing domestic signals i.e., difficulty in localization of environmental sounds such as door shut, kettle boiling, hearing clock or watch, recognizing environmental noises, alarms, sirens and horns.

Globek. Nowakowska, Siwie and Stephens (1988) used an open ended self report approach in a group of 69 patients and studied the overall pattern of benefits of hearing aids in them, In this study, 77.1 % reported benefits in hearing TV / radio, 1.2% reported of telephone bell, 2.4% reported of door-bell, and 36% reported of traffic.

Despite amplification devices being provided to the hearing impaired, the auditory signals heard by them, other interventions must be recommended to mitigate these deficits (Ruben & Rapin, 1980). This could include the use of cochlear implants and auditor)' training, in some.

The critical nature of early auditory experiences on aural / oral language abilities has been supported by recent findings in children who received cochlear implants. Cochlear implantation has provided an intervention alternative for some children with profound hearing impairment who do not benefit from conventional acoustic amplification (Boothroyd, as cited in Gravel & Ruben, 1996). The profound hearing impaired misses out environmental sounds often in their world of silence. One of the subjective benefits commonly reported by implant patients is their perception of everyday sounds (Tyler & Kelsay, 19^0) because it puts them back in touch with the world.

Parents of congenially hearing impaired with cochlear implants have reported that they are able to differentiate between two or three sounds with in the environment, such as door knocking Vs. a siren Vs. their name being called. Parents observed that objects in their environment are treated with more gentleness by their child, for example, less tendency to slam doors or bang things (Eisenberg, Berlin, Kirk & Tiber, 1983).

Pansier, Chute and Kramer (1984) reported that several tests are useful in evaluating the results of cochlear implant surgery, like monosyllable - trochaic - spondee word identification test, environmental sound test, in which the patient, while wearing a hearing aid is given a list of environmental sounds to identify which are presented at 70 dB SPL. Post-operative patients were able to identify an average of 12 out of 20 environmental sounds compared to pre-implanted patients. Although the implant gives nearly continuous exposure to non-speech sounds in everyday life, some therapists believe that systematic training with recorded or live material is useful to enhance the process of learning to discriminate and identify sounds.

A few auditory verbal identification tests are available for testing hearing-impaired children as young as two years, with limited vocabulary (Moog & Geers, 1990 and Begum, 2000). The children would have to be given training before they are evaluated. Such tests can usually be carried out on the hearing impaired, after they have enrolled for therapy.

In order to evaluate the auditory identification abilities of children, with out having to give them considerable training, environmental sound tests could be utilized. The number of tests using environmental sounds as stimuli are considerably less as compared to tests using speech stimuli. A few of the tests in literature include environmental sound tests like Sound Effects Recognition Test (Finitzo-Hieber, Matkin, Cherow-Skalka & Gerling, 1980), Everyday Sound Test of Minimal Auditory Capabilities (Owens, Kessler, Telleen, & Schubert, 1977),etc.

Among the above tests, environmental sounds are used as a sub-test of a test battery. All the above tests are western. Based on the perceptual abilities of a child on these tests, different rehabilitative procedures can be recommended. The assessment of the ability to perceive environmental sounds will help in determining the auditory identification abilities of a child and will help in making estimation of his performance on speech identification task.

In the Indian context, there is a test developed by Rawat, 2001. This environmental sound test was developed for testing the auditory identification ability of 3 - 5 year old children. A list of thirty-five sounds was made and sounds were checked for familiarity with adults and children. The final list, which was made after the pilot study, consisted of twenty-three sounds. Two lists, List 1 and List 2, were constructed, each containing two practice items and ten test items. One practice item was common for both the tests.

Fifty children who were divided into five age groups i.e., less than 3 years (2+ to 2 ½ years), 3+ to 3 ½ years. 3½+ to 4 years, 4+ to 4 ½ years, and 4 ½+ to 5 years were evaluated using the two lists. Each age group had ten children each. The responses were obtained using picture pointing activity. The subjects were asked to describe the sound open ended and to point to the picture depicting the sound. It was found that as the age increased, the scores on test also improved and that significant improvement was found to be present till the age of 3 years (0.01 level of significance). Secondly, no significant difference between the performances was found on List l and

List 2 when the scores of all fifty children were grouped. There was no significant difference between the two lists for any of the age groups, except the youngest age group, which showed poorer performance on List 2. A modified list or the original version of List 1 has been recommended for the youngest age group (less than 3 years of age). It was suggested that either List 1 or List 2 could be used for evaluating the auditory identification ability, since there is no difference in the performance of :hildren above three years of age using the two lists.

In the present study, the Environmental Sound Test developed by Rawat (2001) vas evaluated for its effectiveness as a tool for hearing aid selection.

METHOD

Subjects:

Thirteen hearing impaired subjects participated in the study. The subject selection criteria included:

- Age ranging from 3 to 5 years.
- Hearing impairment ranging from mild to severe degree of any type (i.e., conductive, sensorineural or mixed) and any configuration.
- They had undergone therapy or had been trained for auditory identification skill.
- They did not present with any associated problems.

Instruments used:

- Calibrated sound field audiometer GSI 61.
- Sony deck TCFX170
- CD (compact disk) on Environmental Sound Test (Rawat, 2001).
- BTE hearing aids (The hearing aids A, B, C, & D were preselected *with,* appropriateness to the subject's audiological findings. For each participant, two hearing aids, hearing aid 1 and hearing aid 2, were tried).

Test environment:

Air-conditioned sound treated double room suite where the ambient noise levels was with in permissible limits (as recommended by ANSI, 1991, as cited in Katz, 1994).

Procedure:

It included 3 stages, which are as mentioned below:

Stage 1: *Hearing evaluation*

The present status of hearing was evaluated using a calibrated sound field audiometer.

Stage 2: *Identification training*

The subjects were trained for picture identification task using the environmental sounds from List 1 of the ENVIRONMENTAL SOUND TEST (Rawat, 2001). This consisted of two practice items and ten test items. All the subjects were trained for three sessions each and each session was for a duration of 30 minutes to 45 minutes. These children had undergone therapy for around three months to two years.

The subjects were instructed in the following manner for identification training: "I'll present **sounds** of different animals, objects, etc., through the tape recorder. You should pay full attention to those and point to the corresponding pictures of those **sounds, from the book."** Gestures were also used to supplement the instructions.

The children were then presented with one sound at a time i.e., from the list of two practice items and ten test items. They were trained to identify the correct picture corresponding to those sounds. They were all trained in the audio mode. It was taken care that by the end of three sessions, there was a consistent picture identification ability exhibited by these children.

Stage 3: *Hearing aid selection*

Hearing aid was selected using narrow band noise and Environmental Sound Test (EST). This stage involved three sub stages:

a) Selection of hearing aid based on performance of children with narrow band noise:

The presentation level of narrow band noise was dependant on the degree of hearing loss of each of the subjects. Sound field hearing thresholds for narrow band noise centered at 250 Hz, 500 Hz, 750Hz, 1 kHz, 2kHz, 3kHz, 4kHz, 6kHz and 8 kHz were obtained. That is, the minimum level at which the conditioned responses were obtained 50% of the time, was noted. This was carried out under both unaided and aided conditions Under aided condition, the conditioned thresholds were obtained using two different BTE hearing aids [Hearing aid 1 (HA1) and Hearing aid 2 (HA2)]. These aids could be either of the two among A, B, C, and D which were randomly grouped as Hearing aid 1 and Hearing aid 2, for each of the subjects. Since it was carried out with two different hearing aids, it was referred to as Aided 1 (A1) and Aided 2 (A2) conditions. The thresholds obtained using Narrow Band Noise (NBN) under unaided, aided 1 and aided 2 conditions were converted to Articulation index (AI) [Popelka & Mason. 1987],

The hearing aid, which showed a higher articulation index (AI), was selected.

b) Selection of hearing aid based on performance of children with Environmental Sound Test:

Listl of EST, which consisted often environmental sounds, were presented at 40 dB HL. This was again carried out in three conditions, viz., unaided, aided 1, and aided 2 conditions. In the aided 1 and aided 2 conditions, the same two hearing aids (which were considered as HA 1 and HA 2), which were used for NBN, were used. Using HA 1 and HA 2, the identification scores for each subject were obtained. The hearing aid, which gave the best identification scores, was selected.

Tolerance was checked for the hearing aids selected using both NBN and EST. and no tolerance problem was noticed.

c) In the third stage, a comparison was made as to verify whether the hearing aid that gave better articulation index (AI), with NBN as stimuli, was the one, which gave the best identification scores using EST. That is. it was verified whether the hearing aid with best audibility was the one with best identification scores. The articulation index (AI) and identification scores in unaided, aided 1 (A1) and aided 2 (A2) conditions for each subject were tabulated and subjected to statistical analysis.

RESULTS

The raw data obtained from thirteen subjects were statistically analyzed using a Chi-Square test of significance (Garrett, 1979), which are represented in the following tables.

Table 1:

Comparison of scores on environmental sound test and articulation index (AI) of thirteen subjects with different hearing aids.

Client. No.	Environmental Sound Test - Identification Scores				Narrow Band Noise - Articulation Index			
	HA1	Identification Score	HA2	Identification Score	HA1	Articulation Index (AI)	HA2	Articulation Index (AI)
1.	C	100%	A	70%	C	0.506	A	0.137
2.	A	100%	C	50%	A	0.039	C	0
3.	C	100%	E	80%	C	0.518	E	0.323
4.	C	70%	E	90%	C	0.125	E	0.361
5.	A	70%	D	100%	A	0.225	D	0.444
6.	A	70%	B	90%	A	0.015	B	0.312
7.	C	90%	E	70%	C	0.30	E	0.081
8.	B	70%	D	100%	B	0.027	D	0.250
9.	A	80%	B	100%	A	0.152	B	0.378
10.	C	100%	E	90%	C	0.796	E	0.517
11.	A	60%	C	100%	A	0.007	C	0.20
12.	A	80%	C	60%	A	0.194	C	0
13.	A	90%	D	70%	A	0.096	D	0.006
Total	7		6		7		6	

Table 2:

Contingency table showing chi-square values of hearing aids selected with two different stimuli.

	Hearing aid 1	Hearing aid 2	
Environmental sound test	7 (A)	6 (B)	A + B = 13
Narrow Band Noise	7 (C)	6 (D)	C + D = 13
	A+C=14	B+D=12	N=26

Df=I $X^{2} = 0$

From Table 1, the letters A, B, C and D refer to the different models of hearing aids used in testing / selection and those in bold represent the hearing aids selected, based on the scores in environmental sound test and Articulation Index (AI). The values 7 and 6 under Environmental Sound Test, in Table 1, show that Hearing aid 1 (A / B / C / D) was selected for seven subjects and Hearing aid 2 was selected for six subjects. Similarly, values 7 and 6 under Narrow Band Noise indicates that Hearing aid 1 was selected for seven subjects and Hearing aid 2 was selected for six subjects, based on the identification scores and Articulation Index values obtained, respectively. From Table 2, it is inferred that the data obtained fromTable 1 was statistically analyzed using Chi-Square test of significance and this gave a value of '0' ($X^2 = 0$).

DISCUSSION

The present study aimed to study the effectiveness of environmental sound test (Rawat, 2001) in hearing aid selection for children in the age group from 3 to 5 years. The raw data obtained, as shown in Table 1 was statistically analyzed using Chi-Square test of significance and the results obtained showed a chi-square value of '0' (as shown in Table 2). The difference of '0' indicates that there is no significant difference between the stimuli used in hearing aid selection. That is to say, the subjective procedure using two different stimuli, environmental sounds and narrow band noise, are equally effective in hearing aid selection in the age group studied. This is evident from the fact that, the HA 1 selected for seven subjects in Environmental sound procedure, was the one selected, for those seven subjects, using narrow band noise as the stimuli. Also, six subjects in both Environmental sound test and Narrow Band Noise as stimuli selected **the** HA 2. This shows that both the stimuli, that is, narrow band noise and environmental sounds could be used equally effectively in hearing aid selection, for children in the age range of 3-5 yrs depending upon the level of auditory experience. Therefore, depending on technical / practical convenience of an audiologist, either of the test stimuli could be used in hearing aid selection. This shows that, the one (hearing aid), which brings about good audibility, is the one that brings about good identification scores.

SUMMARY AND CONCLUSIONS

Environmental sounds are influential in the development of the central auditory nervous system (Ruben & Rapin, 1980). Many tests, using environmental sounds, have been developed in Western countries. A few of these include Sound Effects Recognition Test (Finitzo-Hieber, Gerling, Matkin, & Cherowskalka, as cited in Flexer & Richards, 1994), Environmental Sound Test (Norton & Berliner, as cited in Mendel & Denhauer, 1997) and Test of auditory comprehension (Trammell et al, 1981). These tests assess the ability of the child to perceive environmental sounds, which help in diagnosis Based on the perceptual abilities of a child on these tests, different rehabilitative procedures can be recommended like hearing aid selection in pediatric population

The tests developed in the West cannot be adopted directly for the Indian population, as there is a variation in level and type of exposure to the environmental sounds. Further, none of the western tests evaluate identification ability of children as young as two years of age (Rawat, 2001).

For Indian population, there is only one test developed till now, developed by Rawat, 2001, and this test was used in the present study. The aim of the present study was to find the effectiveness of the "Environmental sound Test", developed by Rawat (2001), in hearing aid selection for paediatric population.From the three lists of sounds in the original test, List 1 consisting of two practice items and ten test items, was selected, as it was recommended for children above 3 years of age. These sounds, recorded on a CD, were presented through a CD player, for thirteen children in the age range from 3 to 5 years, who had hearing loss in the range of mild to severe degree.

For hearing aid selection, the responses were obtained using multiple-choice picture pointing activity for two different hearing aids, which were pre-selected based on the subject's audiological data. They were asked to point to the picture depicting the sound. These subjects were given training for around three sessions, with a duration of 30 to 45 minutes each. The number of correct responses with each hearing aid for each subject was recorded in percentage (%).

Once the identification scores using environmental sound test, was obtained, the same set of hearing aids were used to find the awareness thresholds using narrow band noise stimuli. These conditioned thresholds were found for frequencies, 250 Hz, 500 Hz, 750 Hz. 1 kHz, 2 kHz. 3 kHz. 4 kHz. 6 kHz and 8 kHz. Later these were converted into Articulation Index values (Popelka & Mason, 1987).

Based on the identification score and the articulation index (AI) values, one among the two hearing aids was selected, for each of the thirteen subjects. It was found that the hearing aid. which brought about good identification score, was the one with good audibility. It was also observed that the environmental sound test can sustain the child's attention for a longer duration than narrow band noise.

The following recommendations can be made from the present study:

The other lists (List2 & modified version) of the original test developed by Rawat (2001), can be used for the hearing impaired children to compare their performances on these two sets of stimuli (Narrow Band Noise and Environmental sounds) and to find out if there is any variation in hearing aid selection.

The usage of the Environmental Sound Test (Rawat, 2001) for pre-selection criteria for the cochlear implantation can be probed.

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