DEVELOOPMENT OF
ENVIRONMENT SOUND TEST FOR ASSESSING LISTENING SKILLS IN CHILDREN

Register No.M2kl4

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

All India Institute of Speech and Hearing
Manasa Gangothri
Mysore

MAY 2001

Dedicated to

My Great

&

Loving

Mother

CERTIFICATE

This is to certify that the Independent Project entitled : **"DEVELOPMENT OF ENVIRONMENT SOUND TEST FOR ASSESSING LISTENING SKILLS IN CHILDREN"** is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register No.M2kl4.

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Mysore
May 2001

CERTIFICATE

This is to certify that this Independent Project entitled : "DEVELOPMENT OF ENVIRONMENT SOUND TEST FOR ASSESSING LISTENING SKILLS IN CHILDREN" 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.

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DECLARATION

I hereby declare that this Independent Project entitled "DEVELOPMENT OF ENVIRONMENT SOUND TEST FOR ASSESSING LISTENING SKILLS IN CHILDREN" is the result of my own study under the guidance of Dr. Asha Yathiraj., HOD & Reader in Audiology, 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
May 2001.

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INTRODUCTION

Development of listening skill is an ongoing process. The basic factors contributing to development of sophisticated listening skills are sound awareness, discrimination, localization, intonational patterns and memory (Grammatico, 1975). For the development of listening skill of a young child, the environment should be enriched with both verbal and non-verbal sounds. Non-verbal sounds like sound of a horn, barking of dog etc. are the kind of stimuli for which child responds 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 to the non-verbal 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 (Grammatico, 1975). That is to say, he starts to not only differentiate between the environmental sounds but also identify them. He starts discovering how things work which help in the development of cognitive skills.

According to Ruben and Rapin (1980), environmental sound may be influential in the development of the central auditory nervous system. The effects of environmental sound in shaping the organisms ability to hear appear to occur before the 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 became functional till the maturation of the central nervous system.

The physiology of the auditory system is modified by environmental sound, judging by the deprivation studies. Auditory deprivation has been shown in animals to have electrophysiological consequences, both in the peripheral and central auditory system. The pattern of sound stimulation experienced by young rats during the first four months of life was found to influence the pattern of response at the collicular level (Clopton and Winfield, 1976). The firing rate of single units in the inferior colliculus increased selectively when stimulated with a familiar sound pattern compared to their firing rate with a novel sound pattern. This evidence indicates the level of the inferior colliculus can be modified by auditory experience. Other studies in animals have also reported of adverse effects of auditory deprivation (Gottileb, 1976; Tees, 1967 and Wolf, 1943).

The 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, 1993). Speech quality is usually markedly affected by the lack of both a normal input model and an auditory feedback loop (Boothroyd, 1982).

Some recent prospective investigations have demonstrated a relationship between early persistent otitis media and communication development in infants and preschool children expressive and/or receptive language, speech production, behaviour, and attention deficits have been demonstrated in some children with otitis media histories before school age (Wallace, Gravel, McCarton, Ruben, 1988a; Wallce, Gravel, McCarton, Stapells, Bernstein, Rubin, 1988b; Friel-Patti and Finite), 1990).

Moreover higher order auditory abilities specifically, understanding speech in a background of competition have been found to adversely affected by an early history of otitis media (Jerger, Jerger, Alford & Abrams, 1983; Gravel & Wallace, 1992).

The above studies have highlight the impact of auditory deprivation and that there is a correlation between the anatomical and physiological effects of deprivation and its behavioral consequences. As animal matures, auditory stimulation governs the physiological, behavioral and auditory abilities of the organism.

The assessment of ability to perceive environmental sounds will not only be of diagnostic use but will be of therapeutic purpose also. A few of the literature include environmental sound tests like sound effect Recognition test (Finitzo-Hieber, Matkin, Cherow-Skalka and Gerling, 1980), everyday sound test of Minimal Auditory Capabilities Battery (Owens, Kessler, Telleen, Schubert, 1981), Environmental sound test (Norton and Berliner, 1977). Based on the perceptual abilities of a child on these tests, different rehabilitative procedures can be recommended.

Assessment of the auditory skill includes testing with the verbal as well as non-verbal stimuli. The ability to notice the presence or absence of sound is determined using musical instruments, noises and speech (Sillon, et al. 1996). The assessment of the child's performance for the non-verbal stimuli, reflects the difficulty in assessing identification of verbal stimuli. The major benefit provided by devices such as the cochlear implant is detection of environmental sound (Eisenberg, 1985). 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 speed identification task.

Various therapeutic programs like Basic Guidance Program (Eisenberg, 1985) have been developed to help the profoundly hearing-impaired children adapt to the sounds with the devices on. During these programs, lessons progress in a hierarchy of difficulty; beginning with the perception of sounds where awareness is worked upon. Once awareness has been established, dismniination and identification activities are introduced. The sound stimuli used include speech, environmental sounds, speech and musical instruments. According to Eisenberg (1985), environmental sounds, in particular may play an important role in early stages of auditory stimulation.

Need for the study

The need of the study is as follows:

1) Develop a test which can be successful tool to determine the auditory identification ability of a child, who has not developed adequate speech.
2) The test i.e. developed should be interesting enough to hold the interest of children as young as 2 years of age.
3) The test is necessary to enable professionals to make rehabilitative suggestions for children who have not yet developed speech.
4) A test that can be used to indicate development in the auditory perceptual capabilities of the children from the age of 2 years to 5 years.
5) Tests developed in the western countries cannot be directly adopted for the Indian population because of the variation in the type of environmental sounds. For example, the sound made by trains in the west is not the same as that made in India.

Aim

The aim of the present is to develop an environment sound tests containing two lists. The test will be used to compare the performance of :-

a) children across the ages (2+ years - *2½* years, *2½+* - 3 years, 3+ to 3½ years, *3½+* - 4 years, 4+ - *4½* years, 4½ -5 years).

b) male vs. female subjects on list 1, list 2, and total scores of list 1 and list 2.

c) children on list 1 and list 2.

REVIEW OF LITERATURE

The perception 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 (Ruben and Rapin, 1980). The effects of environmental sound in shaping the organism ability to hear appear to occur before the central auditory nervous system matures.

A child is exposed to both verbal and non-verbal sounds like mother's call, cycle bell ringing, birds chirping etc. As the child grow up, 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 (Finitz-Hieber, Gerling, Matkin & Cherow-Skalka, 1977).

A child who is born with hearing impairment will be deprived of all auditory stimulation. This would result in a lack of development of aural/oral communication unless remediation through amplification and specific auditory/speech language training is provided (Gravel and Ruben, 1996). Those children who have deviant auditory identification 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.

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 and Rapin, 1980). This could include the use of cochlear implants and auditory training.

The critical nature of early auditory experiences on aural/oral language abilities has been supported by recent findings in children who have received cochlear implants. Cochlear implantation has provided an intervention alternative for some children with profound herring impairment who do not benefit from conventional acoustic amplification (Boothroyd, 1993).

The profound hearing impaired often miss, out environmental sounds in their world of silence. One of the subjective benefits commonly reported by implant patients is their perception of everyday sounds (Tyler and Kelsay, 1990) because it puts them back in touch with the world.

Cooper (1995) has found that many implant users find that the environmental sounds are confusing, or even in some cases unpleasant at first. There is clearly a period of learning involved in the perception of these sounds as there is for speech. 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.

Most auditory identification tests for children make use of speech as stimuli. These tests are usually designed for children older than 3 years of age (Erber & Alencewicz, 1976; Jerger, Lewis, Hawkins & Jerger, 1980; Erber, 1982). These tests may be used with these children, provided they have adequate vocabulary. However, most hearing impaired children have limited vocabulary and it is not possible to administer standard speech identification tests on them (Finitzo-Hieber et al, 1977).

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 children, after they have enrolled for therapy.

In order to evaluate the auditory identification abilities of children, without having to give them considerable training, environment sound tests could be utilized. The number of tests using environment sounds as stimuli are considerably less as compared to the tests using speech stimuli.

A few environment sound tests have been reported in literature. These tests are usually a part of a test battery. The following section discusses these tests.

Sound Effects Recognition Test (SERT) by Finitzo-Hieber et al. (1977)

This test utilizes gross environment stimuli which are presented via an audiocassette recording. The child is required to point tone of four pictures per picture plate. Presentation level is at 25 to 40 dB SL Reference : Speech Awareness Threshold (SAT). It includes thirty items (three equivalent ten item subtests) and is appropriate for children between the ages of 3.0 and 6.6 years.

Although there are only ten items in each of the three list, two or three lists can be administered. Not all of the sounds and pictures are familiar to all children, particularly those less than six years of age. Some of the sounds may be in appropriate. For example, there is a picture of a child playing in a pool and children do not use their devices in the water, hence they may not be aware of such sounds. The authors report that normal hearing three year olds score about 83% correct and five year old score about 97% correct(Tyler, 1355)

Finitzo-Hieber, Geling, Matirin & Cherow-Skalka (1980) pointed out that as a part of a paediatric test battery, the SERT maybe a viable indicator of a child's auditory capabilities at suprathreshold level, thus providing clinicians with information about auditory function in youngsters with very limited verbal abilities. More over, for children with extremely restricted language competence, for whom a test to monitor auditory development over time is desirable, the SERT can prove useful.

Staller, Dowell, Beiter & Brimacombe (1991) administered this test on children wearing Nucleus Implant and reported that fifty-seven out of fifty-eight children detected the presence of environmental sounds presented at 70 dB SPL. Thirty of fifty-eight (52%) children scored above chance on the Sound Effects Recognition Test.

This test has been used by many other researchers. Osberger et al. (1991) reported that twenty-four children (prelingual and post lingual combined) with the nucleus implant averaged 52% correct on this test. About 50% of the children scored above 40%. Thus, it appears that one half of the children with the nucleus cochlear implant can recognise environmental sound without visual cues. Learning to associate the sounds perceived through the cochlear implant while interacting with the environment will probably improve performance in most of these children.

The environment sound detection has also been used to compare different cochlear implants. Tyler, Moore & Kuk (1989) reported on some of the better patient with give different cochlear implants, which were Ineraid, Nucleus, Vienna, Chorimac and Duren/Cologne implants. Environment sounds were chosen to be appropriate for all the patient independent of their language background. Most of the better patients were able to recognise some environment sounds but there was a wide variation among subjects both within and across device. The scores average 23% (range = 8-36%) for the Chorimac, 21% (8-67%) for the Duren/Cologne, 41% (11-72%) for the Vienna, 44% (25-72%) for the Nucleus/Honnover, 58% (39-75%) for the Nucleus/U80 and 83% (56-100%) for the Ineraid

Environmental Sounds Test by Norton and Berliner (1977)

Norton and Berliner (1977) developed environmental sound test (EST) originally called, "The Original Hearing Rehabilitation Research Centre Environmental Sounds Test". The purpose of this test was to use it as an objective measure of environmental sound recognition and for a training program. It was originally designed to be used with adults with profound deafness using a single electrode cochlear implant. This test consisted of thirty sounds (seven categories) derived from commercially available records or recorded especially for this test. The seven categories are human voice, animal voice bell/horn/siron, music, machine, intermittent, miscellaneous. It was a five choice forced—choice task. Answer choices were randomly selected from seven sound category. All sounds used were readily identified by a group of ten normal hearing listeners. There were two forms of a test and two randomization of each form.

In 1979, revised form of this test was given where one form of the test was reduced to a two item task. The five test item most commonly chosen correctly in a thirty item test were removed, as were the five sounds that were most commonly missed. Sounds were recorded to be more equal in intensity and, where possible, in length. Four randomization of the two item test was taped.

Subjects were instructed to read the five answer choices and circle the one they heard. Sounds were presented once, and were repeated once, if necessary. Guessing was encouraged and the tester showed numbered cards to the subject indicate the test item number. These visual cues were used to augment the subject's minimal auditory capabilities, particularly during preoperative testing.

Study done by Thielmeir, Brimacombe & Eisenberg (1982) showed that scores on word, word stress and environmental sound discrimination on environmental sound test were all significantly better with the implant than with a hearing aid. The subjects were 135 adults, profoundly haring impaired and implanted with single electrode cochlear implant.

Test of Auditory Comprehension by Trammell et al,(1981)

Another test which is developed for individual use with pupils who are hearing impaired is, Test of Auditory Comprehension (TAC) (Trammell, 1981). The test assessed auditory functioning in the areas of discrimination, memory-sequence and figure ground for the individual with age range of 4-17 years . There are ten subjects out of which subtests 1, 2 and 3 examined a child's ability to discriminate suprasegmentals using speech and non-speech stimuli. Subtest 1 was a noise versus voice test (eg. horn or drum versus male or female voice). Subtest 2 tested linguistic (voice), human non-linguistic (coughing and sneezing) versus environmental (drum, dog bark) item. Subtest 3 examined common phrases that differ in stress, rhythm and intonation (eg. "wash your hands", and "where are your shoes?"). The remaining seven subtests were highly dependent on language and cognitive skills.

Results of TAC provides :

1. A measure of a variety of skills inherent in the auditory processing of speech.
2. A basis for selection of appropriate auditory skill objectives.
3. An evaluation of growth in the acquisition of auditory abilities.
4. An indicator for educational placement decisions.

Total 't' scores and 't' scores for each subtest are calculated. These scores are compared with the norms that are provided.

There have been studies which have used environment sounds the information about the exact nature of test is not known. Brimacombe, Edgerton, Doyle, Erratt and Danhauer (1984) compared the performance of 250 profoundly deaf adults and sixty-seven children (who have been implanted with the House single channel cochlear implant) with hearing aid and post operatively with cochlea implant. Test results have shown that the select population performs significantly better with the cochlear implants than with hearing aid on tasks on sound detection and closed set environment sound discrimination. The exact information about what test was made use of is not known. However, the authors mention that it was a twenty item, five alternative, forced choice test presented at 70 dB SPL. Even patients with the Nucleus device, designed to extract speech features, can learn to recognise environment sounds. This ability tend to improve over time for patients with all the devices, as patients learn to associate what they her with the objects that generate the sounds.

Test to assess the identification ability of environmental sounds has been used as a subtest in the Minimal Auditory Capabilities (MAC) Battery (Owens, Kessler, Telleen & Schubert, 1981) and Iowa Test Battery (Tyler, Preece & Tye-Murray,1986).

Minimal Auditory Capabilities Battery by Ownes et al, (1981)

MAC Battery is specifically developed to assess individual who are profoundly, post lingual hearing impaired. The test can be used for hearing aid users and the assessment of potential cochlear implant candidates. It serves an indicator of appropriate auditory rehabilitation placement and useful in hearing aid selection.

It consists of 13 auditory subtests and one visual lip reading subtest. Some tests are closed set and others are open set. Subtests range from easy to difficult and evaluate listeners' perceptual abilities for suprasegmental, segmental, sentence and speech reading tasks. Closed set subtests include question/statement discrimination, accent discrimination, noise versus voice discrimination, same/different discrimination of spondees, vowel recognition, spondee recognition. Open-set subtests include spondee identification, CID sentence identification, identification of words in context (low and high predictability sentences), monosyllabic word recognition (NU-6) and visual enhancement live-voice speech reading. A total of 15 sounds are tested. The stimuli are audio recorded (Owens etal, 1981).

Fifer, Stach & Jerger (1984) evaluated the auditory performance of nine post lingual and ten prelingual adults with severe to profound hearing loss on MAC Battery. Results for the identification of everyday sounds indicate considerable variability in performance for similar average of hearing level (AHL) values. The group trend, however suggests poorer performance on AHL increases.

Results demonstrated that the MAC can be used to establish a performance profile for prelingual hearing impaired adults. The Battery seemed to be promising as an evaluative tool for hearing aids and cochlear implants in both prelingual and post lingual hearing loss subjects.

In 1985, Owens, Kessler, Raggio & Schubert revised the MAC Battery. For the familiar sounds subtest the responses of several normal hearing listeners and hearing impaired patients to more than 30 common sounds were analyzed and they made change in the acceptable responses like Add "Chimes" as an acceptable response for doorbell and TV or radio announcer, news reader, etc. for person talking.

Cohen, Waltzman & Shapiro (1985) studied patients who were implanted with 22 channel cochlea prosthesis who underwent training. Training program consist of vowel and consonant recognition studies and speech tracking (DeFillipo & Scott, 1978). Following the training program a battery of test was administered to evaluate patients communicative abilities using me prosthesis. MAC everyday sound recognition test was administered and it was shown that there was an increased ability in the environmental sound identification for all the patient with improvement in speech recognition ability when the device is used in conjunction with lip reading.

Iowa Test Battery by Tyler, Preeece & Lowder (1983) and Tyler, Preece & Tye-Murray (1986).

Iowa test battery developed at Iowa University consists of 14 subtests with one of them being an environmental sound test while some of the subtests were presented through the auditory, visual or auditory-visual mode, the environmental test was presented through the auditory mode.

Gantz, Tyler, Preece, McCabe, Lowder & Otto (1985) did the longitudinal study on the performance characteristics of the three different implant designs i.e. Vienna (single channel intra-cochlea device, Melbourne (Clack) 21-channelunit and Angeles (House) single channel implant. Nine post linguaily deafened adults who used their implants for at least 11 months were included in this study.

The audiologic battery chose was the combination of selected items from the MAC battery (Owens et al, 1981) and 12 additional tests developed at the University of Iowa. The tests were organized into five categories : everyday sounds, prosody tests, closed sit and speech related tests, open-set and audiovisual tests.

Environmental sound awareness was assessed by the everyday sounds test. There were two formats open and closed out of which open set was presented first without reinforcement. Five of nine patients score at or above 70% on the closed set task (chance level is 20%) and eight patients were able to identify at least five of twenty sounds in the open format. Three patients were able to distinguish 50% or more of the sounds. All three of the cochlear implants evaluated were found to improve the communication skills of post-lingually deafened adults.

Gantz et al. (1988) evaluated the audiologic performance of 54 post lingually deafened adults wearing cochlear implants. The participants had 9 months or more experience with one of five different cochlear prostheses (Los Angeles, Single Channel (N=1l), Vienna single channel (N=4)), Melbourne Multi channel (N=18), Utah Multi channel (N=19), San Francisco Multichannel (N=2). The audiologic battery consists of tests from the MAC and tests developed at the University of Iowa. The multi channel designs enabled participants to recognize more environmental sounds, provided more speech reading enhancement and enabled most users to perceive speech compared to the single channel implant group.

Environmental sounds have been used not only in evaluation purpose but many authors emphasis upon the use of environmental sounds in therapy. Various programs have been developed which use environmental sounds as one of the stimuli while giving training such as the Montepellier Paediatric Cochlear Implant Program (Sillon et al. 1996), Therapy programs by Romanik (1990) and Jeffries and Jeffries (1991), Basic Guidance Program (Eisenberg, 1985) and Perceive and Respond Auditory Program (Sanders, 2000).

Montepillier Paediatric Cochlear Implant Programme by Sillion et al. (1996)

The emphasis is on selecting children for implantation who are under the age of five year and all the patients at the centre had received the nucleus multichannel cochlear implant.

Children are evaluated before cochlear implantation for the selection criteria. After the child is fitted with a device, habitation is worked upon. The progression of exercises is from detection of sound to comprehension of sound.

In the first step, the ability to notice the presence or absence of sound is determined using musical instruments, noises and speech. The aim of this step is to familiarize the child with hearing and to provide a sense to the sound environment. In the second step, child is allowed to differentiate sounds by their tone, their intensity and their pitch. Next step i.e. identification consists of speech stimuli especially vowels and then the child is encouraged to comprehend the speech stimuli.

Montepellier children's test battery consist of tests of perception and tests of speech production. Environmental sounds which is one of the subtest is an open set task often items.

Sillon et al. (1996) have reported that perception of the sound environment improves as time goes on and more and more everyday noises are identified (telephone, doorbell, barking etc). At the end of the first year, all the children were able to perceive short, associated words.

Basic Guidance Program by Eisenberg (1985)

The Basic Guidance Program developed by Eisenberg (1985) makes uses of similar progressive steps. In this program, environmental sounds are given comparatively more import.

Jeffries & Jeffries (1991) incorporate training of environmental sounds. The child has to report about the different parameters of sounds which he/she has heard in the environment. For example, the child would have to report as to which of the two sounds read about is louder or which of the pictures shown to the child make or do not noise.

Auditory skills program for students with hearing impairment (Romanik, 1990) makes use of environment sounds which are produced by the therapist in order to teach children to perceive suprasegmental features. Naturally produced sounds are not used.

Perceive and Respond Auditory Program by Sanders (2000)

It is similar to the Basic Guidance Programs which makes use of only environmental sounds. This program is meant for children of 5 years to adults. It is a comprehensive collection of audiotapes that includes activities designed to strengthen the listening skill that the classroom setting. The activities are suitable for children with attention deficit, poor auditory deficit and poor auditory discrimination. The environmental sounds which are audiotaped are the following : sounds from around the house, sounds of sport and recreation, musical instrument, sounds related to bodily function, sounds related to tools, animal and insect sound, sound of transportation and food preparation and sound of weather. The subjects are asked to identify and classify the above mentioned sounds.

Auditory verbal practice is the application of techniques, strategies, condition, and procedures that promote optimal acquisition of spoken language through listening, which becomes a major force in nurturing the development of the child's personal, social and academic life (Estabrooks, 2000; Ling, 1994). Goals taken for infants and toddlers include drawing attention to sounds in the environment, developing the learning to listen sounds and songs.

The model used in the auditory verbal practice is same as used in Basic Guidance Program, i.e., detection -> discrimination -> identification -> comprehension. In detection phase, the child learns to listen sounds like dog, horse, owl, rooster, crow, top, wheel etc. The sounds need not be only non-speech. Speech sounds like /p/ /t/, /bu/ etc. are also incorporated.

At identification level, a child is helped to label the sound as being long vs. short (speech vs. environmental) duration. Basically suprasegmental feature identification is worked upon with segmental like from phonemes to recognition of phrases etc.

The review of literature indicates that the tests for assessing listening skill using environment sounds are limited. The tests mentioned in the literature have been used for basic evaluation of a child's listening abilities, to establish initial base line and also to evaluate program in therapy. The tests are also made use of for comparing the performance of an individual using hearing aid and cochlear implants and also in comparative studies between different cochlear implants.

METHODOLOGY

The aim of the study was to construct an environmental sound test involving a picture pointing task, for the children in the age range of 2 years - 5 years. The test would be used to evaluate the auditory perceptual ability of children who do not have adequate speech to evaluate them with a speech identification test.

The study was carried out in three different stages :

The 1^{st} stage involved the development of the test material. It involved the selection of the test items, recording of the environmental sounds and developing pictures which will be used for obtaining responses.

The second stage, involving a pilot study was carried out on children in the age range *of 3½-4½* years.

The third stage involved the administration of the recorded test material on the target group.

DEVELOPMENT OF THE TEST MATERIAL

a) Selection of test item:

A list of thirty-five environmental sounds was made. Only those sounds that are usually present in the environment and would be familiar to children below the age of five were selected. To check whether the items were appropriate, the judgement of five adults was taken. The sounds that the five adults felt would be familiar to children were selected. The subsequent list had twenty-seven sounds.

b) Recording of the environmental sounds

The environmental sounds that adults felt would be familiar to children were recorded. The recording was done in situations where the ambient noise was relatively low.

All the sounds were natural produced ones. The sounds were recorded using a Sony MT (Sony Portable minidisk recorder MZ-R55 DC-RV) digital tape recorder.

The material was played to six adults who were instructed to name the sound that they hear. An item was selected only if it could be correctly identified by five of the six adults. It was found that all judges could identify twenty three sounds correctly. Four sounds were dropped, as they were not identified by the judges.

The material was then fed into the computer where it was edited using a Creative Sound Blaster card software. The duration of the sounds ranged from 4 to 6 seconds. Using the Audiolab software, scaling of signals was done so that the intensity of all the sounds was brought to the same level. The material was downloaded into a Sony Cassette using a Sony Cassette Deck TCFX 170.

c) Development of Pictures

The pictures, depicting the sounds were drawn by an artist. The pictures were shown to groups of five adults who were asked to label them. The modification suggested by them were incorporated. If any of the adults labeled the pictures incorrectly, the picture was redrawn. The same task was carried out on a group of five children in the age range of 3 to 5 years. Three of the pictures which were not identified readily by the children were modified.

PILOT STUDY

To check whether children could identify the sounds and carry out the required task, a pilot study was carried out. It was done on six children (three boys and three girls) who had no history of speech, language or hearing problems. They were in the age range of 3½ - 4½ years. Each subject was tested individually. The children had to carry out the following tasks :

a) Describe the sounds in an open ended task.

b) Match the sounds with the pictures.

The audio signals were presented through a computer. Ten pictures were kept in front of the child at a time. Each signal was presented once and the child was asked to describe the sound. Following this he/she had to indicate the picture depicting that particular sound. A sound was retained only when it was identified correctly by 4/6 children on both the tasks. Twenty-three sounds were found to be familiar.

Further, seven adults were required to categorize the sound as being high, mid and low pitch. Two lists were constructed each consisting of ten test items and two practice items. One practice item was common for both the lists. Each list consisted of 4 low, 1 mid and 5 high frequency sound. A 1 kHz calibration tone was also recorded before each list.

ADMINISTARTION OF THE MATERIAL ON THE CHILDREN

SUBJECTS: 50 subjects were chosen for the study. The criteria used for subject selection were as follows :

They should be within the age range of 2 years - 5 years. Six sub-groups were made, based on the age of the children (2+ years - 2½ years. 2½+ years - 3 years, 3+ years - 3½ years, *3½+* years - 4 years, 4+ years + - 4½ years , 4½+ years - 5 years). The younger two sub-groups had five children each, while the remaining sub-groups had 10 children each.

They should have normal hearing.

A. They should not have any otological history.

B. They should have normal speech, language and motor milestones.

INSTRUMENTAION

A Philips hifi tape recorder (AW606) was connected to the tape input of an audiometer. Madsen OB 822 audiometer which was calibrated according to ANSI 1989 standards was used. Headphones TDH 39 housed in MX-41/AR ear cushions or sound field speakers were used as transducers.

TEST ENVIRONMENT

The ambient noise level measured in the sound treated double room situation were the test was administered, was found to be within permissible limits, as recommended by ANSI 1991.

PROCEDURE

For children in the age range of 3+ to 5 years, pure tone audiometry was done while for those below three years, otoacoustic emissions and behavioural observation audiometry was done. This was done to screen for the presence of a hearing loss. Those children who fail on any of the screening tests were excluded from the study.

The VU meter was set to 0 for the l kHz calibration tone before starting to test the subject. Two practice items were presented before the test items. The child was helped in giving responses, only when the practice item were presented.

The signals were presented at 50 dB HL. For the children for below 3 years, the output was given through a speaker because the children were not cooperative with headphones, while for children of above 3 years the material was presented through the headphones.

For the children of below 3 years of age, five pictures were kept at a time in front of the child. While for children above 5 years of age ten pictures were placed in front of them. Before administering the test, the pictures were made familiar to the child. The subject was asked to point to the picture after hearing the sound.

Two examiners were required to carry out the test. One examiner presented the stimulus and the other examiner, helped the subject during the test, in the test room.

The inter-stimulus duration was varied depending upon the latency of each child's response. The maximum inter-stimulus duration was kept at 15 seconds. The inter-stimulus interval was varied using the paused button of the tape recorder. Children were not given any feedback of their responses. They were reinforced with sweets after the completion of each list.

SCORING

The responses were recorded on a scoring sheet. Correct responses were given a score of 1 and incorrect response given a score of zero. If the child took more than 15 seconds to respond, the response was not considered and a score of 0 was given. The total score was calculated for each child. The data thus obtained was subjected to statistical analysis.

RESULTS AND DISCUSSION

The raw data was statistically analyzed. Mean, standard deviation and 't' values were calculated for the following :

A. The performance of children across ages on total scores obtained on list 1 and list 2.

B. The performance of children

   i) between list 1 and list 2 -group performance
   ii) across age groups.

C. The performance of male vs. female subjects - total scores obtained on list 1 and list 2

The test retest reliability was measured using coefficient of correlation.

The performance of children across ages on total scores obtained on list 1 and list 2.

Table-la): Mean, range and standard deviation for the total scores (list 1 and list 2) of children across different age groups.

Age (in years)	No.of children	Mean	%	Range Raw score (in %)	% standard deviation
<3	10	13.8	69.1	11-17 (55-85)	1.75
3+3½	10	15.2	76	12-17 (60-85)	1.619
3½ - 4	10	16.6	83	15-19 (75-95)	1.34
4 - 4 ½	10	17.0	85	16-19 (80-95)	1.699
4½-5	10	17	85	15-20 (75-100)	1.7

Table lb: Value of 't' test and level of significance for the total scores (list 1 and list 2) of children across different age groups.

Age groups (in years)	't' value	0.05	0.01
<3 and 3+-3½	1.8	NS	NS
<3 and3½+*4*	4.0	N	**S**
<3 and 4+-4½	4.1	S	**S**
<3 and 4½+-5	4.6	**S**	**S**
3+-3½and3½+-*4*	2.107	**S**	NS
3+ -3½ and4+-4½	2.4	**S**	NS
3+-3½and4½+-5	2.9	**S**	**S**
3½+-4 and 4+-4½	1.6	NS	NS
3½+-4 and4½+-5	1.2	NS	NS
4+-4½and4½+-5	0.5	NS	NS

Graph-1: Performance of children of different age groups. (Maximum score possible = 20)

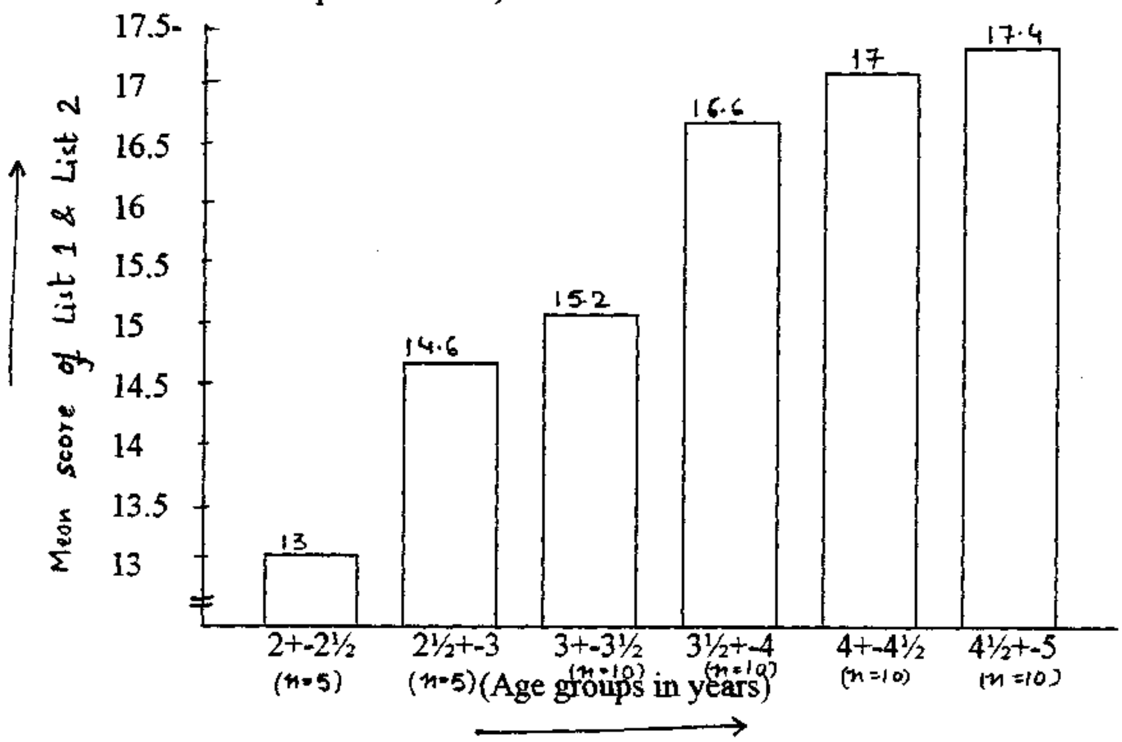

Table la gives the mean, range and SD of the scores obtained by the children, across different ages. The scores represent the average obtained from list 1 and 2. Graph 1 also depicts the mean scores. It is evident from Table la and Graph 1 that the mean score increases with age showing a developmental trend. The SD however, did not vary considerably across the given age groups.

To check for the significance of difference of means, across the different age groups, the 't'. test was administered (Table lb).

The performance of children between <3 years and *3+-3½* years did not differ significantly at the 0.01 and 0.05 level. However the scores obtained by children below 3 years of age were found to be significantly poorer at the 0.01 level when compared to the older three groups *{3½* + - 4 years, 4+ - 4½ years and 4½+ - 5 years). There was no significant difference among the other groups except the 3+ - 3½ years group with that of the oldest group, 4½+ - 5 years.

From the data, it is evident that there is not much of a change in the score obtained by children once they are 3 years of age.

The test of significance was also done for the two subgroups of the youngest age group i.e. *2-2½* years and *2½* to 3 years. The obtained 't' values showed that there was no significant difference in the performance of the two age groups.

Ryalls (1996) has reported that children younger than 3 years cannot be expected to provide reliable information about speech sound that they have heard. It is difficult to test their ability to identify speech sounds, even though they can be tested for their discrimination ability. The advantage of the environmental test that has been developed is that children as young as 2 years can be tested not only for their discrimination ability but also for identification skill. The reason as to why children younger than 3 years cannot be tested on a speech test is probably because it does not hold their attention. However the environmental sound test was found to be interesting by the youngest age group (2+ to *2½* years).

Finitzo-Hieber, Matkin, Cherow-Skalka and Gerling (1977) reported the findings of children on the Sound Effect Recognition Test (SERT) developed by them. They found that normal hearing and 3 years olds scored about 83% correct and 5 year olds scored about 97% correct.

In the present study the mean scores of the children in the age range of 3+ *-3½* years (Table la) were lower than that reported by Finitzo-Hieber et al. (1977). However, five of the ten children evaluated in the 3+-3½ years age group did obtain similar scores. The older age group of the present study i.e. 4½+-5 years, also obtained lower scores when compared to that reported by Finitzo-Hieber et al. (1977). Five children in the present study did get similar scores.

B. The performance of children

i) between list 1 and list 2 -group performance
ii) **across age groups.**

Table-2a: Mean SD and 't' value of the performance of the children on test 1 and test 2.

	List 1	List 2	't' value
Number of children	50	50	
Mean	8.14	7.86	1.226*
SD	1.04	1.305	

* not significant at the 0.01 and0.05 level.

Table-2b: Mean, Standard deviation and 't' values of the performance of children across different age groups, on list 1 and list 2.

Age group (in years	No.	List 1		List 2		't' values
<3	10	7.7	0.8	6.1	1.2	3.5 (S)*
3+-3½	10	7.5	0.8	7.7	1.15	0.4(NS)
3½+-4	10	8.3	1.15	8.3	0.6	-
4+ - 4½	10	8.5	0.8	8.5	0.17	-
4½+ - 5 years	10	8.7	1.15	8.7	0.8	

* at 0.01 level of significance

When the score of all the children were grouped, it was found that there was no significant difference between the scores obtained on list 1 and list 2 (Table 2a). However, when the difference in the performance on list 1 and list 2 was studied across the different age groups, it was observed that there was a significant difference in the performance of the youngest age group. No such difference was found for the older age groups. Hence for the older age group either list 1 and list 2 can be used.

Most of the children in youngest age group could not identify the sound of the train, hammered, bullock-cart and sneeze in list 2. Hence it is suggested that either only the original version of either list 1 be administered or a modified version of list 1 and 2 be used with the youngest age group (Appendix-C). The modified version consists of the items correctly identified by 80% of the children in the youngest group.

The performance of the subgroups of the youngest age group (2+ -2½ years and 2½+ - 3 years) was compared across list 1 and list 2 (Table 2c). There was no significant difference between List 1 and list 2, in the two subgroups at 0.01 level. However, at the 0.05 level, the performance of the subgroup 2+ - 2½ years was found to be significantly different on list 1 and list 2,with them performing poorer on list 2.

Table-2c: Performance of the subgroups of the youngest age group.

Age group (in years)	No.	List 1		List 2		't' value
		Mean	SD	Mean	SD	
2+-2½	5	7.4	0.8	5.6	1.019	2.77* S
2½+-3	5	8	0.63	6.6	1.2	2.06

* Significant difference only at 0.05 level but not at 0.01 level.

C. The Performance of male vs. female subjects - total scores obtained on list 1 and list 2

Table-3: Mean, Standard deviation of the raw score of male and females subjects - listl, list 2 and the total scores on list 1 and list 2. The 't' values were obtained for the above mentioned performance.

		N	Mean	SD	0.05	0.01
Listl	F	25	7.88	1.2	NS	NS
	M	25	8.12	0.8		
List 2	F	25	7.8	1.52	NS	NS
	M	25	8.16	1.213		
Total	F	25	16	2.43	NS	NS
	M	25	16.12	1.61		

The results indicate that there is not a significant difference between the mean scores of male and female subjects on the total scores of list 1 and list 2 at 0.05 level and 0.01 level.

Test-retest reliability was measured using coefficient of correlation.

Four subjects who participated in the study, were randomly selected, to check the test-retest reliability. From each of the four older age group, one child was selected. The coefficient of correlation was calculated which indicated high correlation (r=0.926) with probable error of 0.0345. Though the performance of the children was slightly better when the test was administered again, there was no significant difference between the performance at o.Ol level. This slight improvement could be attributed to the practice effect.

From the result of the study, it is evident that -

The environment sounds test that has been developed can be usefully utilized to determine auditory identification abilities in children above the age of 3 years.

Either list 1 or list 2 can be used for the above mentioned age group.

For children younger than the 3 years of age, either only the original version of list 1 be administered or a modified version of list 1 and list 2 (Appendix C) be used.

SUMMARY AND CONCLUSION

Environment sound is influential in the development of the central auditory nervous system (Ruben and Rapin, 1980). Many tests have been developed in western countries. A few of these include the Sound Effects Recognition test (Finitzo-Hieber, et al, 1977), Environmental Sounds Test (Norton and Berliner, 1977) and test of auditory comprehension (Trammel et al, 1981). These tests assess the ability of a child to perceive environment sounds which help in diagnosis. Based on the perceptual abilities of a child on these tests, different rehabilitative procedures can be recommended.

The tests developed in west cannot be adopted directly for the Indian population as there is a variation in the level and type of exposure to the environmental sounds. Further, none of the western tests evaluate identification ability of children as young as 2 years of age.

The aim of the present study was to develop an environment sound test for children in the age range of 2 years - 5 years. 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 ten test items and two practice items. One practice item was common for both the tests.

Fifty children who were divided into five age groups i.e. <3 years (2+-2½ and 2½ - to 3 years), 3+ to *3½* years, 3½ + - 4 years, 4+ - *4½* years and 4½ + - 5 years were evaluated using the two lists. Each age group had ten children each. The responses would be obtained using picture pointing activity.

Prior to conducting the test, the children were screened for the presence of hearing impairment using behavioral audiometric screening (for children > 3 years of age) and OAE and BOA (for children< 3 years of age). The stimulus was given through the headphone (for > 3 years) and through speaker for the children >3 years of age.

For children above 3 years, ten pictures were placed in front of the children. However, for children <3 years of age, only 5 pictures were placed at a time. The subjects were asked to describe the sound open endedly and to point to the picture depicting the sound.

The results of the present study were -

1) As the age increases, the scores on the test also improve. However, significant improvement was found to be present till the age of 3 years (0.01 level of significance).
2) No significant difference between the performance was found on list 1 and list 2 when the scores of all fifty children were grouped.

3) There was no significant difference between the two lists for any of the age groups except the youngest group which showed poorer performance on list 2. A modified list has been recommended for the youngest age group.

4) No significant difference was found in the performance of male vs. female subjects.

5) The test retest reliability was found to be very high with a very low probable error.

The following recommendation can be made from the present study:

1. The test developed can be administered to the children in the age range of 2 to 5 years.
2. Either list 1 or 2 may be used, since there is no difference in the performance of children above 3 years of age using the two lists.
3. For the children below 3 years of age, a modified list (Appendix C) should be made use of.
4. Though the test has been developed for children between 2 years to 5 years, it can be used on older individuals also.

Recommendations for further Research

Using the test material developed in the present study, the following research studies can be carried out:

1) Standardizing the test on deviant population such as the hearing impaired & mentally retarded children.
2) The usage of the test for pre-selection criteria for the cochlear implantation can be probed.
3) Using the developed material, the performance of the cochlear implantees can be studied.

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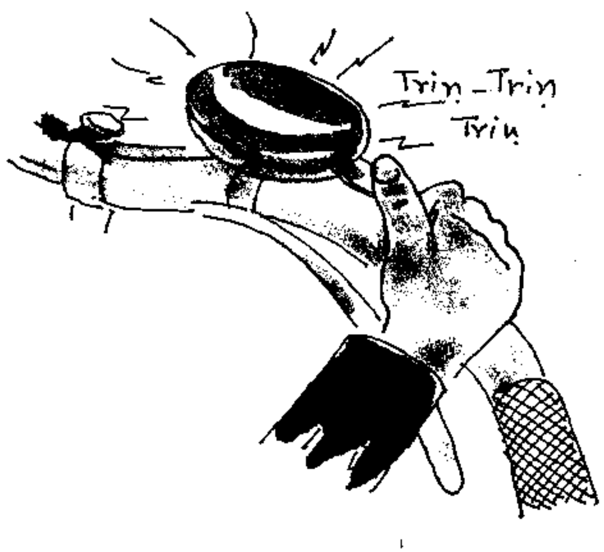
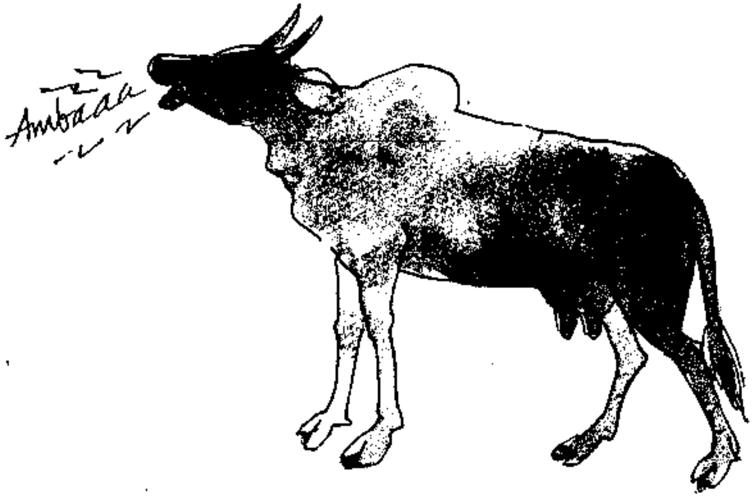
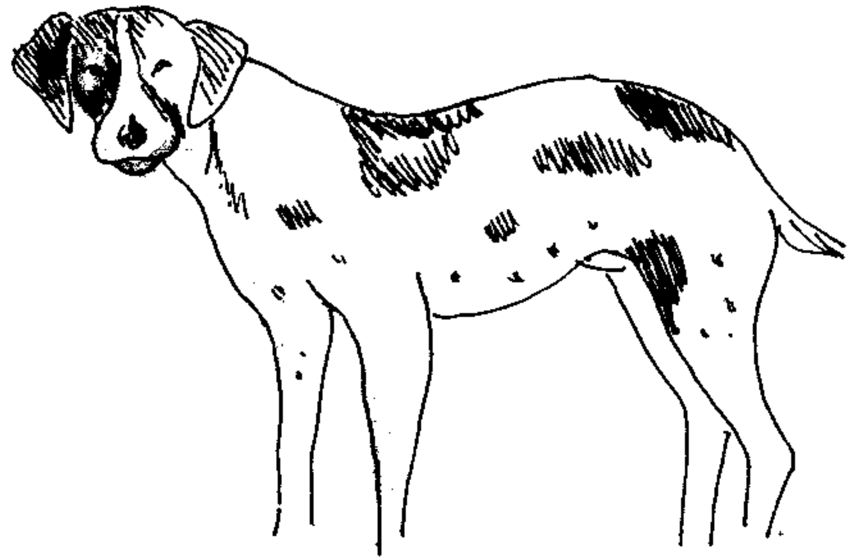
APPENDIX A

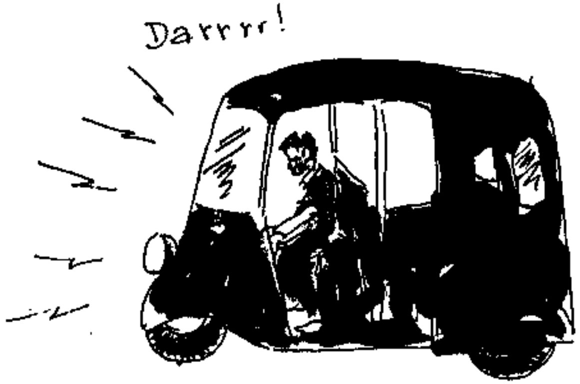
Listl		List 2	
Practice item		Practice item	
1	Cycle bell ring	1	Scooter passing
2	Bowl falling on the floor	2	Cycle bell ring
Test item		Test item	
1	Cow	1	Crow
2	Dog	2	Sneeze
3	Auto	3	Laugh
4	Whistle	4	Cock
5	Water running in the bucket	5	Train
6	Cough	6	Bullock cart
7	Knock	7	Horn
8	Baby cry	8	Bike
9	Phone	9	Hammer
10	Cab	10	Temple bell

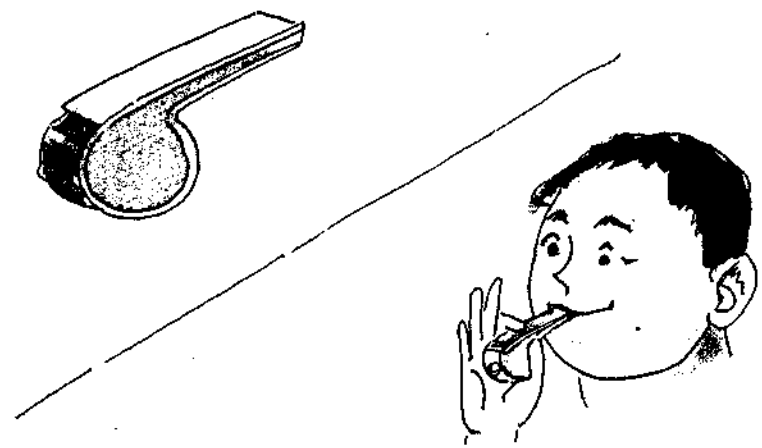
LIST-1
Practice - Items



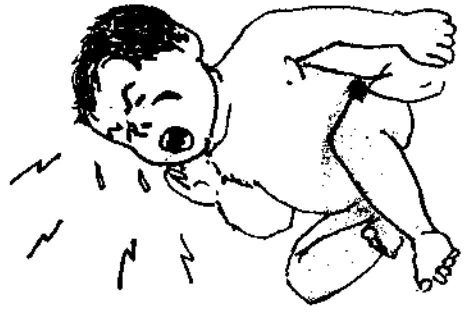


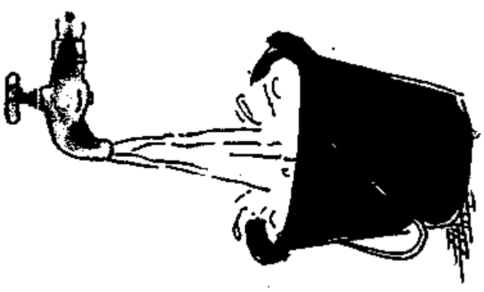


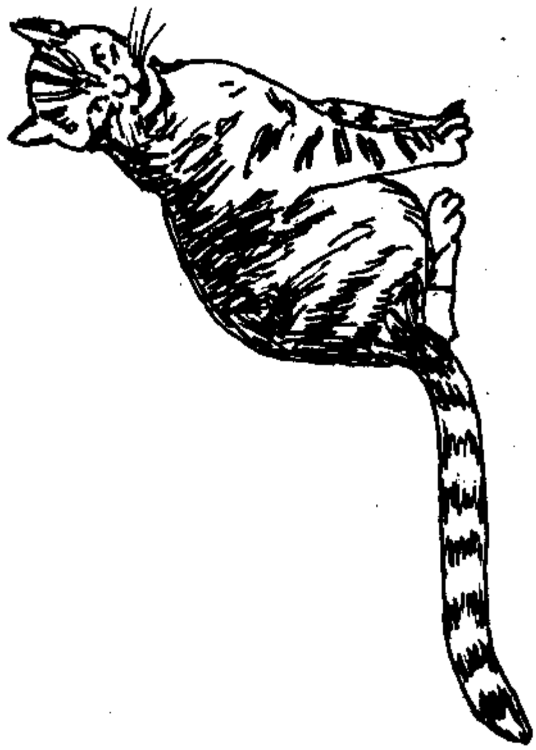


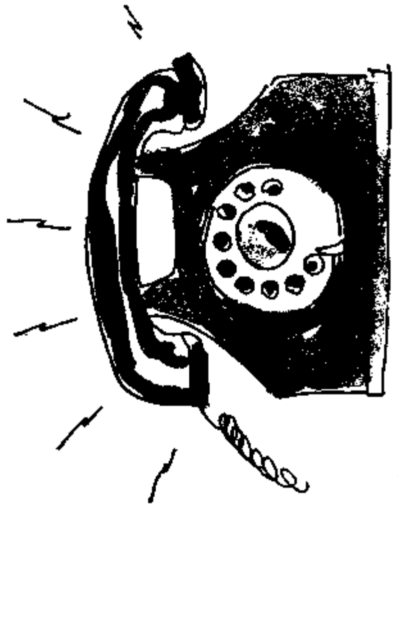


LIST-1 TEST ITEMS



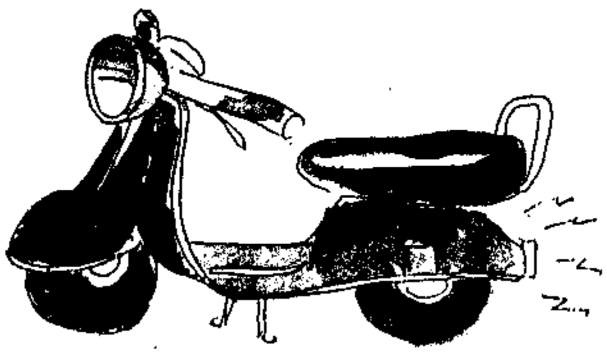


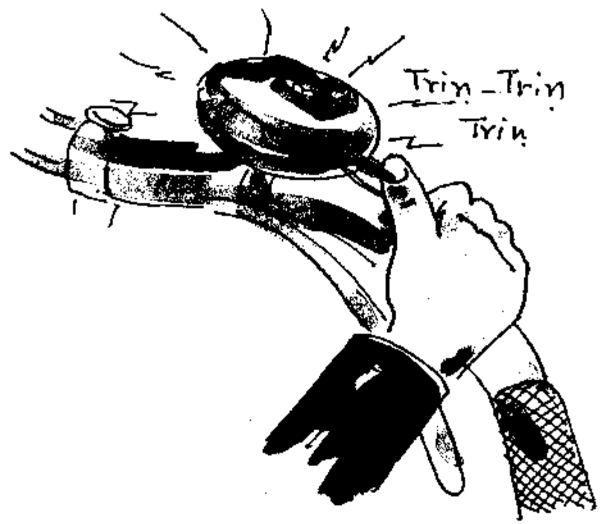


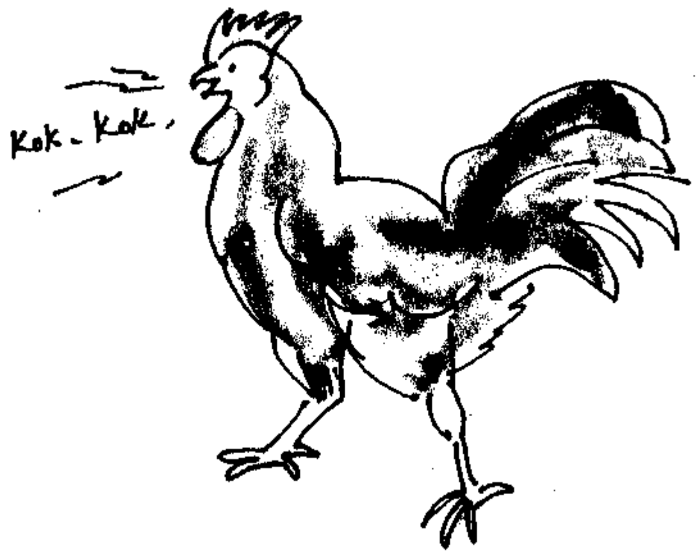


LIST - 2

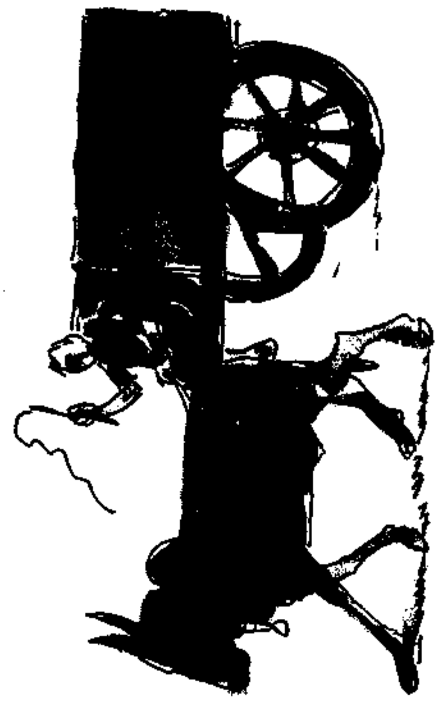
Practice - Items

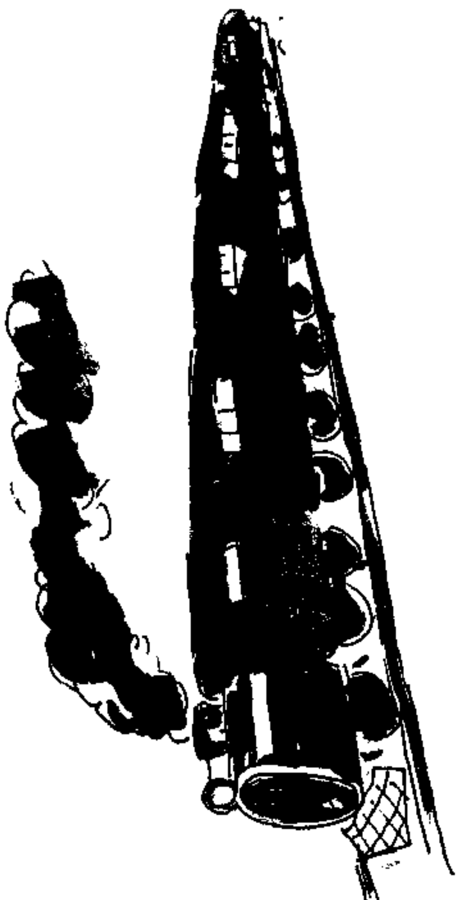


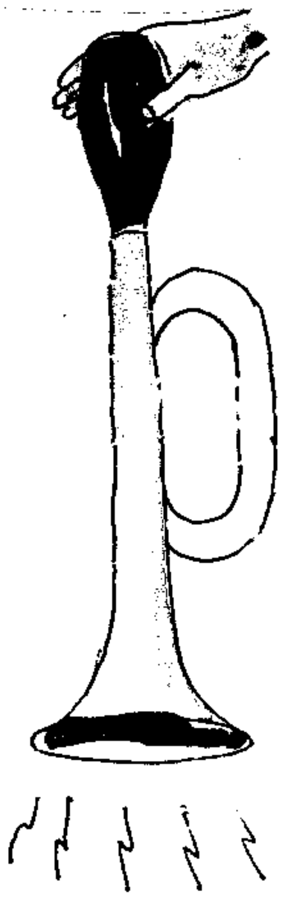


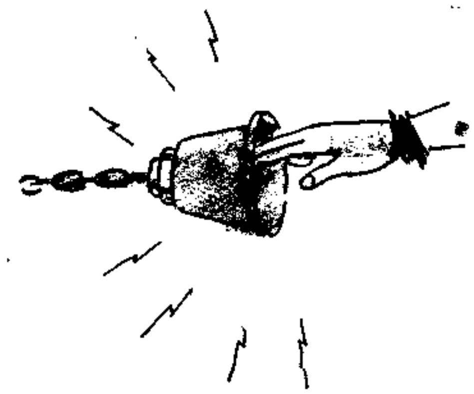


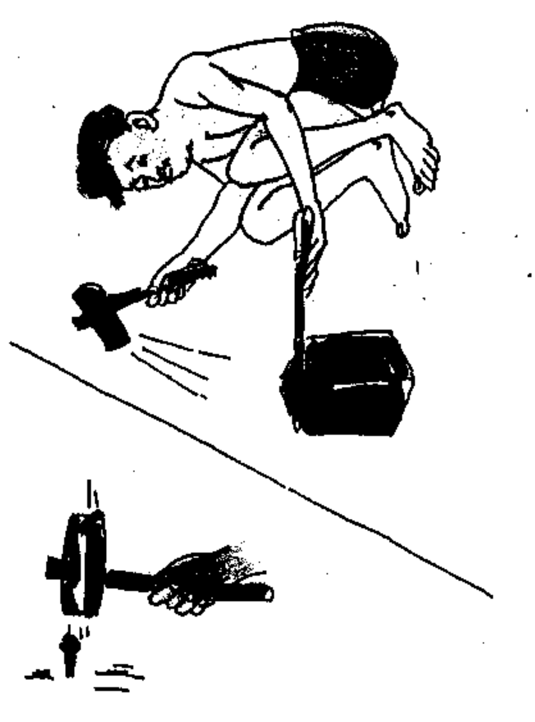
LIST-2 TEST - ITEMS











APPENDIX C

Modified version of list 1 and list 2 recommended for the children in the age group of 2+ - 3 years.

Cow

Dog

Whistle

Baby cry

Phone

Cat

Crow

Cock

Horn

Bike

Temple bell

APPENDIX-D

Calibration Procedure

Earphone Calibration

Both intensity and frequency calibration was done for the pure tones generated by the clinical audiometer (Madsen OB 822)

Intensity Calibration

Intensity calibration for air-conducted tones were carried out with the output of the audiometer set of 70dB HL (ANSI, 1989). Through the earphone (TDH 39 with MX-41/AR ear cushions) the acoustic output of the audiometer was given to a condenser microphone B&K 4144) which was fitted into an artificial ear (B&K 4152). The signal was then fed to a sound level meter (B&K 2209) attached to an octave filter set (B&K 1613) through a pre-amplifier (B&K 2616). The sound level meter was fitted with a half inch to one mch adapter (B&K DB 0962). At each of the test frequencies, i.e. 250 Hz to 8 kHz, the output sound pressure level (SPL) value was noted. A discrepancy of more than 2.5 dB between the observed SPL value and the expected value (ANSI Standards, 1989) was corrected by means of internal calibration.

Frequency calibration

A time/frequency counter (Radart 203) was utilized to calibrate the frequency of the pure tones. The electrical output of the audiometer was fed to the counter which gave a digital display of the generated frequency. If the difference between the dial reading on the audiometer and the digital display of a given frequency, exceed + or - 3% (ANSI Standard, 1989) of the characteristic or tested, then an internal calibration was done.

Sound Field Calibration

Intensity calibration

Intensity calibration for warble tones in the sound field was carried out with setting the audiometer output to 70 dB. A one inch condenser microphone (B&K 4145) with a 90 degree grid azimuth was placed at the point in the room where the head of the subject would be positioned during testing. The distance from the microphone to the loudspeaker was one meter. The microphone was connected to a sound level meter (B&K 2209) and the octave filter set (B&K 1613). The output SOL was compared for the frequencies 250 Hz to 6 kHz, with the values given by Morgan, Dricks, Bower (1979). A discrepancy of more than 2.5 dB between the observed SPL values and the expected values (Morgan et al. 1979), was corrected by means of internal calibration.

Microphone calibration

Microphone input calibration for speech audiometry was done by presenting a recorded 1 kHz signal at 70 dB. The VU meter gain was set so that the needle peaked at '0'. The placement of the sound level meter was similar to that done for sound-field warble tone testing. The output SPL was noted on the sound level meter on the linear scale and compared with the standards (Morgan et al, 1979). If the reading of exceeded 2.5 dB, internal calibration was done.

Linearity check

The linearity of the audiometer attenuator was checked. The procedure used was similar to that utilized to check the intensity calibration except that the intensity dial of the audiometer was set at the maximum level and the frequency dial was set to 1000 Hz. The attenuator on the sound level meter was set at a level corresponding to the maximum level on the audiometer. The attenuator setting on the audiometer was decreased in 5 dB steps till 30 dB and the corresponding reading on the sound level meter was noted. For every decrease in the attenuator setting the sound level meter indicated a corresponding reduction.

Frequency response characteristics of earphones and loudspeaker

The frequency response characteristics of the TDH-39 earphone and the free field loudspeaker were obtained using B&K signal generator (1023) microphone (B&K 4145/4144), B&K frequency analyzer (2107) and a graphic level recorder (B&K 2616). The electrical output of the signal generator (1023) was fed to the loudspeaker. The output picked-up by the microphone (B&K 4145) was fed to the frequency analyzer (B&K 2107). This output was recorded on the graphic level recorder (B&K 2616). The frequency response of the earphone was obtained using a similar procedure except that the pressure microphone (B&K 4145).