Home auditory training program (HAP) for cochlear implantees and hearing impaired children using hearing aids—an outcome of a three-year research project

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Abstract

Introduction Use of cochlear implants has been a turning point in the life of the hearing-impaired children enabling them to participate in the world of sounds. Research shows that even after cochlear implantation auditory training is necessary as it facilitates the development of verbal skills. A number of kits for auditory training are available in the West. The author had an exposure to a number of auditory training kits in the US, as a part of her Fulbright Research Fellowship. In our country, there is a dearth of such material for auditory training. Besides this, India being a multilingual country, it becomes difficult if not impossible to develop language specific auditory programs. Hence, the need for the project proposal which was to develop material in Hindi and Marathi in the form of kit and CD-ROMs for the various levels of auditory training.

Methodology With the help of latest scientific techniques, material in the form of worksheets, audiocassettes and CD-ROMs were developed and field tested for all four levels of auditory training. Children with hearing impairment using hearing aids and cochlear implants were given auditory training using the developed material.

Results t-test which was carried revealed that there is a significant difference between pre and post training performance of children.

Conclusions A systematic approach in the form of a kit comprising of audio cassettes and CD-ROMs is now available in Hindi and Marathi for use at home for professionals and parents of children with hearing impairment.

Keywords Home auditory training · Systematic approach · Audio cassettes · CD-ROMs

Need for the study

A child with profound hearing impairment will not recognize any speech at all, even when appropriate amplification is provided. Providing a hearing aid to the hearing impaired is not an end in itself. The link between appropriate amplification and auditory training for speech when strengthened will result in substantial improvement in auditory skills.

Many hearing-impaired children use relatively few auditory cues because: parents and/or teachers may not recognize the extent to which residual hearing can be utilized for learning and communication (Hamaguchi, 1995). Hearing-impaired children, who have not been conditioned to utilize the auditory cues of speech, learn to rely on visual cues, (Oyer, Crowe, & Haas, 1987). Auditory training, speech teaching and speech correction are the hallmarks of communication training for children with hearing impairment. Auditory training constitutes a systematic procedure designed to increase the amount of information that a person's hearing contributes to his total perception.

In the west: With advances in technology a number of kits and manuals for practice of auditory training have been designed in the West. The author had an exposure to a number of auditory training kits in the US, as a part of the Fulbright Research Fellowship awarded to her which entailed training and research at Advanced Hearing Research Center, Callier Center for Communication Disorders, University of Texas, at Dallas. The author observed that each county has an auditory training curriculum. There are a

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number of materials in the form of kits and CD-ROMs in order to facilitate auditory skills of children with hearing impairment.

Indian context: India's first disability Census report (August, 2004) indicates people with hearing disabilities to be 5.8% of the disabled population. Current scenario has promoted use of binaural amplification (hearing aids) with most children with bilateral hearing loss. This has been boosted by Government of India Schemes available for rehabilitation. With advent of cochlear implants, there has been a change in the scenario. Use of cochlear implants has enabled the hearing-impaired child to participate in the world of sounds. Many parents are now opting for cochlear implants for habilitation of their hearing impaired children. Presently there are over 1000 cochlear implant recipients in India (as per the Nucleus cochlear implant representative's survey). Eight teams provide pre and post implant assessment and intervention facilities in the city of Mumbai, and a number of set ups exist in the country. Research shows that even after cochlear implantation auditory training is necessary as it facilitates the development of verbal skills.

Parents and professionals require simple readily available, easy to use and less time consuming materials to help provide auditory training to their children consistently. However, dearth of materials like kits, manuals, audio/video cassettes which provide a systematic approach towards auditory training exists. Also, India being a multilingual country, it is difficult, if not impossible to develop systematic, language specific auditory training programs. Hence, the need for the study and for the project proposal which was sponsored by Science and Technology Mission in Mode, District Rehabilitation Scheme, New Delhi.

Objective

The objective of the project was to develop a kit in Hindi and Marathi, comprising of audio cassettes and CD-ROMs for enabling parents and teachers to improve auditory skills of children with hearing impairment. The main aim was to develop the material for children using hearing aids; however, it was further extended so as to make it useful for cochlear implantees. The contents (final expected outcome) would be worksheets, audiocassettes, CD-ROMs.

Methodology

Selection and construction of stimuli for level 1 of auditory training, i.e. auditory awareness

Firstly, a questionnaire was prepared to get a feedback on the kind of stimuli used and activities for auditory train-

ing which are conducted by parents and teachers of special schools. As reported by nine parents and 12 teachers from three schools, the sounds frequently used were—drum, clapping, name call, door knock, khanjiri, bell, music, animal sounds, sound of duster, rattle, whistle, fall of vessel, sound of pressure cooker and car horn. Survey was done of the audio cassettes, CD-ROMs and nursery rhymes available in the market. Amongst 44 sounds screened 33 sounds were selected on familiarity basis. Analysis of the acoustic parameters of the sounds was done using Dr. Speech software. Stimuli were then placed hierarchically in terms of their pitch and intensity characteristics. 25 poems in Marathi, 15 in Hindi were composed in such a way so as to incorporate the 33 selected environmental sounds. Poems were made, instead of using environmental sounds in isolation as the survey done on parents revealed that all parents train their normal hearing child to be aware of various environmental sounds through poems. These poems were further recorded. A booklet of each poem was made using pictures of the sound stimuli and visuals of the sequence of the poem.

Procedure for level 1 i.e. auditory awareness

Field testing of the developed material was done on 2 groups of children. First group comprised of 19 children having severe to profound sensorineural hearing loss (12 Marathi & 7 Hindi, within 4–11 yrs of age) from a special school. The children were using the prescribed body level hearing aids, after getting ENT clearance from the ENT surgeon affiliated to AYJNIHH. The children had not received formal auditory training. The second group comprised of 18 children using hearing aids and 2 cochlear implantees. This group was further divided into preprimary group (age 3.5–4.5 yrs) and primary group (4.5–5.4 yrs). These children were also diagnosed as having bilateral severe or profound hearing loss and were using prescribed hearing aids. The two cochlear implantees (7–8 years of age) participated in the study 3 months post implantation.

Session 1 – Pre training Children were divided into 12 groups of 3 each. The stimuli were presented from a distance of 3 ft. and each child's response to each stimulus was recorded. Thirty percent of the children showed awareness of most of the sounds. Larger percentage (70%) did not show awareness of any sounds.

The demographic details of the children are depicted in table 1.

Auditory awareness training using one poem at a time was done.

Session 1 – The children were trained to pay attention to the auditory stimuli by stopping activity when the stimuli were presented and to identify the stimuli by pointing to the respective picture. School teacher was also asked to observe the sessions. Demonstration was provided to 19 parents to use the cassettes. Three parents were illiterate. On com-

Table 1 Pilot work: demographic information of field testing

Grp	Age in years	Mean age	No. of children	Hearing loss	PTA In dB	No. of yrs of training	Hearing aid used	Language
I	4–8	4.5	7	Bilateral Profound Mixed or SNHL	Rt-105 Lt-106	Less than one year	Body level-4 BTE-3	Hindi
	4.4–11	8.3	12	Bilateral Profound Mixed or SNHL	Rt-108.3 Lt-104.3	Less than one year	Body level-10 BTE-2	Marathi
II	3.5–4.5	4.1	9	Bilateral Profound Mixed or SNHL	Rt-107 Lt-108	Less than one year	Body level-0 BTE-9	Marathi
	4.5–5.4	4.9	9	--do--	Rt-108 Lt-107	Less than one year	Body level-0 BTE-9	Marathi
CI	7–8 Implanted at 6.9–7.8 yrs of age	7.5	2	Bilateral profound SNHL	Rt-108 Lt-107	3 months after implant	(C I)	Hindi-1 Marathi-1

Grp-Group; No.-Number; Lang.-Language; CI-Cochlear Implantees

pletion of five days of training the child at home, parents were asked to report to the institute and demonstrate the use of the cassettes. These sessions were video recorded. Opinion of the parents regarding utility of stimuli and ease of conducting activities was sought using another questionnaire. The questionnaire comprised of questions regarding familiarity of the recorded sounds, utility of the material and ease of conducting the activities. Program for auditory awareness training was also tried with two children using cochlear implants.

Results for level 1 i.e. auditory awareness

Session 7 – It was observed that 70% of the children were either doing actions corresponding to the sounds or pointing to the objects or pictures represented by the sound. 30% of the children needed two additional days of teaching. As a response to the questionnaire, 17 parents reported that the recorded sounds were familiar and were very useful as they were the ones which were occurring in the child's natural environment and the activities were easy to understand. A modification in 3 stimuli was suggested by two parents. Audio cassettes on auditory awareness and booklets were given to the parents and they were requested to train their child consecutively for seven days, using the material provided. 17 parents reported after a week and informed that the recorded sounds were familiar and were very useful as they were the ones which were occurring in the child's natural environment. The two cochlear implantees could identify the sounds within 2 sessions after training.

Validation of the selected sound stimuli was done using power of discrimination in which each sound was computed using paired t-test. The analysis revealed that there was a significant difference between the two groups, viz. high and low performing with respect to the stimuli. This confirmed the validity of the stimuli. Finalization of stimuli was done based on validity results.

Selection and construction of stimuli for level 2 of auditory training, i.e. auditory discrimination

Environmental sounds from level 1 were screened and were paired and categorized according to duration, loudness and pitch characteristics. Activities were designed for discrimination of duration, loudness and pitch features of the environmental sounds.

Procedure Here the concept of sameness and difference was introduced. The response cards consisted of 2 picture cards. First one consisting of two straight lines of same length, where as the second picture card had pictures of two lines of same length, but one was straight and the other was crooked.

Activity From amongst each pair, the sounds were presented consecutively one after the other. The children were instructed to point to the picture of two same straight lines if the two sounds had the same pitch/ loudness/ duration and to the picture of a straight and a crooked line if the two sounds had a different pitch/ loudness/ duration.

Results for level 2 i.e. auditory discrimination

There were two groups of children and nine students in each group. Group I consisted of children from pre primary level with in the age group of 3.5 to 4 yrs. Group II consisted of children from primary level with in the age range of 4.5yrs-5.4yrs. The children were provisionally diagnosed as having bilateral severe or profound sensorineural hearing loss. They were using either strong class or extra strong class BTE hearing aids as prescribed. Field testing was done for the second level of auditory training viz. auditory discrimination. It was observed that the primary children gave appropriate responses in 7 sessions. However, it was found that the pre-primary children found the concept of discrimination difficult to understand. Validation of the selected pairs of sound stimuli was done using power of discrimination in which each sound was computed using paired t-test.

The analysis revealed that there was a significant difference between the two groups, viz. high and low performing with respect to the stimuli. This confirmed the validity of the stimulus. Finalization of stimuli was done based on validity results. Both the cochlear implantees could discriminate the sounds within 3 sessions.

Selection and construction of stimuli for level 3, i.e. suprasegmental perception and identification and level 4 of auditory training, i.e. comprehension

Two Linguists, one Hindi and one Marathi were given orientation about the level of suprasegmental perception and the expected characteristics of the stimuli. (focus was on familiarity, picturability and importance of acoustic cues enabling better perception in hearing impaired). For each goal related to suprasegmental perception and comprehension, a picture plate was made consisting of two pictures. Thus, 51 pairs of stimuli (in the form of words and sentences) were constructed and for the level of comprehension 15 pairs of stimuli in the form of 2-3 sentence paragraphs were constructed. The pairs of stimuli were presented one after the other in a live voice. The expected response from the child was to listen to the word, sentence or paragraph spoken to and point out to the respective picture.

Procedure Subjects comprised of 10 hearing impaired children of Marathi medium having severe to profound sensorineural hearing loss and using BTE hearing aids and the two cochlear implantees. The mode of communication of these children was both verbal and nonverbal. Their speech intelligibility was rated as between 3 and 4, that is, can be understood by a sympathetic listener. The pairs of stimuli were presented one after the other in a live voice. The expected response from the child was to listen to the word, sentence or paragraph spoken to and to point out to the respective picture or perform activity relating to the verbal commands.

Results for level 3 i.e. suprasegmental perception and level 4 i.e. comprehension

It was observed that after 4 sessions of training, 90% of the children gave correct responses. Power of discrimination of each stimulus was done using paired t-test was done and a significant difference between two groups i.e. high performers and low performers, was found, indicating validity of the stimuli. The two cochlear implantees could perceive suprasegmentals differences within a week and could comprehend simple sentences within 10-15 days.

Designing and development of the CD-ROMs for the four levels of auditory training

The job task and order for production of CDs for all levels was given to a small scale software manufacturing com-

pany. The field tested and validated stimuli in the form pictures and audio files were provided to the computer technologist, who further designed a computer program for making the CD-ROMs interactive. Thus, the facilities available to normal hearing children were also provided to the hearing impaired children. The hearing impaired child whether using a cochlear implant or a hearing aid was through the software given the opportunity to listen to the sounds and speech, identify, discriminate or comprehend them and give his response by enabling a computer key.

The audio and visuals for the CD-ROM for level 1 (i.e. awareness) and working models for the other three levels of auditory training are completed. The developed CD-ROMs and the working models have been field tested in 5 special schools for hearing impaired (each having a capacity of at least 50 children) in rural set ups in Maharashtra. The response received from the school children was very positive. As reported, teachers (50 in number) were able to use the CD-ROMs with ease and could train their children with ease. Parents (five in number) of cochlear implantees and of hearing impaired children using hearing aids (36 in number) also gave a similar positive feedback. The cover design and final page/slides are being finalized, following which the CD-ROMs will be ready for demonstration, display and sale.

Use of the CD-ROM for level 1 after completion

After the completion of field testing the CD-ROM for auditory awareness was used for two children with hearing impairment using cochlear implants. The details of the same are as follows:

Two children 4 years of age provisionally diagnosed as having bilateral profound sensorineural hearing loss and who were using behind the ear hearing aids since the age of one year. They were implanted (Nucleus 24 CI—Sprint and Freedom processors were used by the children) at the ages of 3 years, 10 months. A selected portion of the CD-ROM was used for training the child to show awareness of environmental sounds. The children attended one session of therapy per week for 5 weeks. A soft copy of the selected environmental sounds was made and the mother was asked to carry out the activities at home. The parents reported that there was marked improvement in the children with respect to awareness of environmental sounds within fifteen days.

Discussion

Effectiveness of training using the stimuli and activities by parents and professionals was attempted. A paired t-test was carried out at every level to compare the responses of the children before training and after training. A significant improvement ($p < .05$), was observed for all the sounds except ticking of clock, hissing of snake and duck quack and for

all the other levels. Parents reported that the activities were helpful to teach. The activities were easy and these helped them to attract their child's attention. Program structure provides easy to follow instructions. Also, prior planning was not necessary for teaching.

The CD-ROM for auditory awareness in Hindi and Marathi which is ready is being used for both hearing impaired children using hearing aids and also for a cochlear implantees undergoing habilitation at AYJNIHH.

Conclusion

The hearing impaired children were provided with an ample variety of environmental sounds i.e. 33 sounds, in different contexts (poems). Poems were constructed to incorporate environmental sounds, which facilitated carryover in listening. Different types of responses to sounds were used and were not restricted to those traditionally used like 'raise your finger' for the level of auditory awareness. Stimuli for the other levels of auditory training were selected scientifically. Professionals, parents and children found the activities to be useful and enjoyable. The program builds early stage of perception while providing activities and concepts involving speech and language and varied responses. This is evidence of a systematic, structured and effective strategy in auditory training for the hearing impaired children. This can be used with cochlear implant children as well. They would require auditory training at higher levels which is also provided by

the 'Home Auditory Training Program'. Making use of advanced technology and making it scientifically available to the hearing impaired children will go a long way in making the hearing impaired children "fit for future".

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--Miami CHATS curriculum—Miami, Florida.
--SPICE curriculum, Central Institute for the Deaf, St. Louis, Missouri