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Auditory-Verbal Therapy Improves Auditory Perception of Mexican Children with Profound Hearing Loss Using Hearing Aids

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Abstract

Purpose: To analyze the auditory perception profile in a sample of children with profound hearing loss from Mexico, and to evaluate the effectiveness of the auditory-verbal therapy in improving their auditory perception.

Methods: An evaluation was done of auditory perception in 25 children 5 to 8 years of age with profound hearing loss who used 4- or 5-channel hearing aids. Following, ten sessions of personalized auditory-verbal therapy were provided to each child. Auditory perception was tested post-intervention.

Results: Significant improvements were observed in the children based on pre- and post-intervention auditory perception test scores. Boys tended to score higher than girls in most scales of the test, but all the children improved to different degrees in areas such as noises and sounds, and language acquisition.

Conclusions: In developing countries, such as Mexico, due to limited financial resources children with bilateral hearing loss are unlikely to receive cochlear implants, being the use of hearing aids the common practice. Even under these disadvantageous circumstances children can benefit from auditory-verbal therapy to improve their auditory perception and align their language learning process.

Keywords: Auditory-Verbal Therapy; Hearing Loss; Auditory Perception

Introduction

Up to 5.3% of the world's population presents hearing loss; 9 % are children [1]. Up to five out of every 1000 babies may be born with hearing loss or acquire it soon after birth. In México, 19.2% of the population with a hearing disability is not older than 9 years, and up to 28.9% 14 years or younger. Similar prevalence is observed in the State of Yucatan, where 18.0% of people with a hearing disability is 9 years old or younger, and 27.5% 14 years or younger [2]. Hearing loss in children from 0 to 14 years old (i.e. a hearing loss greater than 30 dB in the better hearing ear) has been linked to lifelong deficits in speech and language acquisition, poor academic performance, personal-social maladjustments, and emotional difficulties [3,4].

Research on the impact of hearing loss has shown that, if appropriate early auditory exposure and auditory brain development are not experienced, the results are linguistic and communication deficits which may be lifelong [5]. Children born with limited auditory function cannot adequately develop language capacities and this compromises their functionality and social integration, as well as their cognitive development. Thus, timely diagnosis is clearly needed to begin appropriate treatment as soon as possible [6]. Fortunately, during the last decades, the negative impact of early hearing loss has been reduced through significant technological developments such as hearing screening of new-borns, new objective diagnostic tests, use of digital hearing aids and cochlear implants. Furthermore, emerging neuroscience research is supporting the rationale for the combination of early diagnosis and fitting of hearing technology with early auditory brain stimulation, resulting in maturation of the auditory neural system, a precondition for development of listening and spoken language [5].

Restoring the physiological capacity to perceive sounds is a necessary precondition but is not sufficient alone for language development; auditory perception needs to be stimulated. Auditory perception is the ability to identify, segment and isolate the sound elements in the environment, attaching meaning to sound, giving them meaning, interpreting and associating them with information stored in the memory. Sound stimulus is transformed into a coherent mental representation with meaning that favors cognitive and intellectual development; if fully functional, it naturally leads to development of the capacities of their own language [7]. However, in case of early and long deprivation of auditory stimulation, the corresponding brain pathways might not organize and mature properly. One consequence might be that integration of combined auditory and visual information may be altered even after hearing is restored [8]. It is mandatory that physical auditory rehabilitation in children, by cochlear implants or hearing aids, be accompanied by auditory-verbal training to improve the cognitive sound assignment process [9]. This condition has demanded the development of training approaches in delivering auditory brain stimulation and developing listening and spoken language, such as Auditory-Verbal Therapy (AVT).

AVT is an education approach emphasizing audition for the development of the auditory skills needed for language acquisition, focusing on developing listening and spoken language through audition, using parents as the child's natural language teachers, with the aim of full inclusion in the mainstream. AVT relies on ten core principles related to early diagnosis, use of an appropriate state-of-the-art hearing technology and commitment of parents to be guided and coached to create an environment where the child can learn to listen, process verbal language and speak [5,10].

AVT is increasingly being employed worldwide by the parents and therapists of children with hearing loss with promising results [11,12]; yet, replicative evidence from diverse populations is required. It has been estimated that in Mexico 13.4% of children aged 0-14 years have hearing difficulties [13]. Continuous efforts have been made by the public health system and non-governmental associations to provide infants with the necessary treatment, but limited financial resources result in most children with profound hearing loss receiving a hearing aid rather than a cochlear implant.

The present study objectives were to

1. Analyze the auditory perception profile in a sample of children with profound hearing loss from Yucatan, Mexico, and
2. Evaluate the effectiveness of the AVT in improving their auditory perception.

Methods

Design and Participants

This quasi-experimental study followed a before and after intervention design with a single group. Authorization and ethical approval were received from the Research and Ethics committees of the School of Medicine, of the Autonomous University of Yucatan. All children were recruited from AYPRODA (Asociación Yucateca Pro Deficiente Auditivo / Yucatecan Association Pro-Hearing Impaired), the only non-profit civil society in the community working on prevention, detection, treatment, and consultancy for deafness and hearing impairment; it offers services to all in need regardless of residence, availability of medical insurance and socioeconomic status.

Inclusion criteria were: 1) diagnosis of profound bilateral sensorineural hearing loss as recorded in clinical files, 2) 5 to 8 years of age, 3) bilateral use of perfectly working hearing aids, 4) a status of "active patient" in the association (no more than two weeks since last visit), 5) no infection in ears. An initial review of clinical records found 29 children meeting these criteria; a meeting was held with their parents/tutors to offer AVT for children, regardless of acceptance to be part of the study. In order to be included in the study, the child must have agreed and at least one parent/tutor should have signed an informed consent form with no economic compensation involved. Although initially all 29 children were signed up, 3 could not initiate AVT due to difficulties to assist with the required frequency. A first meeting was held with each family of the remaining 26 children to establish rapport with the child and to ask parents/tutors to complete a brief socio-demographic interview on behalf of their child. A total of 22 weekly meetings were then scheduled, 20 for AVT and other two to assess the child's auditory perception capacity before and after the intervention.

Auditory Verbal Therapy (AVT) Intervention

Following Pollack, et al. [14], a personalized AVT plan was designed based on each child's deficiencies taking into consideration the initial results from the Auditory Perception Test [15]. AVT consisted of twice weekly 60-minute sessions for ten weeks for a total of twenty sessions. All sessions were private for each child with one primary care giver present, instructed to participate during the session but only to learn the exercises the child would need to practice at home. In each session, individual work was done with the child using cognitive-behavioral techniques such as sound and word examples, association of the mental representation of an image with each sound or word, and its conceptual representation and socialization in daily life. All sessions took place in AYPRODA's address and were conducted by the same graduated psychologist who is also a certified Auditory-verbal therapist.

Auditory Perception

Auditory Perception was assessed by a specific test developed in Spanish for native speakers [15]. This test includes a series of tasks to analyze independently the skills related to the perception of linguistic and not-linguistic sounds. It has a total of 127 items, all to be scored as correct or incorrect, and distributed in two blocks: 1) Noises and sounds and 2) Language. In order

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to have a simple outlook of the children's performance a cut-off point was set by authors: 60.0% or less of total items answered correctly was considered below normal whereas 60.1% or more of total items was considered normal. Table 1 summarizes the tasks of the two blocks and their corresponding subscales along with their number of items and the accorded cut-off points.

Table 1: Main Features of the Auditory Perception Test.

	Tasks	Number of items	Cut-off score
Block I. Noises and Sounds		46	27
Discrimination and Recognition	Identify different noises/sounds relating to the corresponding images	29	17
Auditory Figure and Background	Identify a sound stimulus (noise or word) masked by background noise and recognize two simultaneous sound stimuli (noise or words)	7	4
Auditory Analysis	Identify the noises and/or phonemes included in a sound message	3	1
Auditory Association	Associate a noise with the source or situation that produces it	4	2
Auditory Synthesis	Synthesize a series of sequential sound stimuli	3	1
Block II. Language		81	49
Auditory Recognition	Identify perceived sounds	21	12
Auditory Discrimination	Classify and select between two sounds, comparing a specific sound with other sounds; differentiate between speech sounds, as well as between diverse frequencies, intensities and phonological categories	24	14
Auditory Figure and Background	Identify a sound stimulus (noise or word) disguised by a background noise, recognize two simultaneous sound stimuli (noises or words)	10	6
Auditory Analysis	Identify noise and/or verbal sounds included in a message	8	4
Auditory Synthesis	Synthesize a series of sequential sound stimuli	3	1
Auditory Closure	Understand the totality of a word when part of the information is lacking	7	4
Suprasegmental Features	Recognize the different elements of speech (e.g. rhythm, intonation, accent)	8	4

Statistical Analysis

In order to analyze the auditory perception profile of children in both conditions (pre- and post-intervention) percentages of children scoring below the cut-off and mean scores were calculated for the individual scales and overall blocks. Possible differences by sex were explored with t-tests for independent samples. The effectiveness of AVT to improve auditory perception was tested by comparing (pre vs. post intervention) percentages with chi-square tests and mean scores with a series of t-tests for related samples. All statistical analyses were run with the SPSS v.20 software package.

Results

Regardless of having begun AVT, 1case dropped-out the intervention before the third session. The final sample included 25 children (52% girls and 48% boys), most from urban communities (64%) and nuclear families (68%). All were in school; 3 (12%) in preschool and 22 (88%) in elementary school. Hearing loss type and level were measured in AYPRODA by a certified audiologist. All participants had hearing aids of 4 or 5 channels. Age at diagnosis ranged from 2 to 7 years (2 years 8 months to 7 years 0 months) with an average of 4.65 (SD±1.49) years. Age at initial assessment ranged from 5 to 8 years (5 years 2 months to 8 years 4 months) with an average of 7.32 (SD±0.86) years. Time since diagnosis ranged from 0.83 to 5.50 years (10 months to 5 years 6 months) with an average of 2.67 (SD ±1.46) years. No significant differences by sex were found for any of these three variables.

It can be observed (Table 2) that overall, the children performed better on the Noises and Sounds section (64% scoring above the cut-off) than on the Language section (48% scoring above the cut-off). In two of the five Noises and Sounds subscales, more than half the children scored below the cut-off before the intervention (range 64% - 76%), but less than a fifth did so after the intervention (range 0% - 16%). In the Language section, more than half (range 68% - 100%) the children scored below the cut-off in three of the seven scales before the intervention, which decreased notably (range 52% - 72%) post-intervention. The Auditory Figure and Background, and Suprasegmental Features scales, both of the Language block, were the most difficult for the children; all (100%) scored below the cut-off in the pre-intervention assessment. Some post-intervention improvement was observed with below cut-off percentages dropping to 64% (Auditory Figure and Background) and 72% (Suprasegmental Features). Auditory Analysis, also of the Language section, was the third most difficult scale with 68% scoring below the cut-off before intervention and 52% after. The most challenging scales in the Noises and Sounds section were Auditory Figure

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and Background (76% below cut-off) and Auditory Synthesis (64% below cut-off). Intervention reduced these percentages to 16% and 12%, respectively. Pre-intervention, in the Noises and Sounds block, the children did best in the Auditory Recognition scale (0% below cut-off), followed by the Auditory Analysis scale (4% below cut-off). Post-intervention, all the children were able to correctly answer these scales.

Table 2: Comparison of Auditory Perception Test Results Before and After Auditory Verbal Therapy (N=25).

	n (%) Below Cut-off Point		$x^2_{(1)}$	Mean (SD)		$F_{(1,24)}$
	Pre	Post		Pre	Post	
Block I. Noises and Sounds	9 (36)	1 (4)	1.85	27.64 (5.95)	38.56 (4.98)	80.95***
Discrimination and Recognition	9 (36)	2 (8)	3.87*	16.96 (4.19)	23.92 (3.70)	61.20***
Auditory Figure and Background	4 (76)	4 (16)	1.50	4.32 (1.60)	5.72 (1.21)	32.67***
Auditory Analysis	1 (4)	0 (0)	-	1.96 (0.45)	2.84 (0.37)	53.78***
Auditory Association	9 (36)	3 (12)	6.06**	3.04 (0.89)	3.64 (0.70)	15.43***
Auditory Synthesis	16 (64)	3 (12)	1.92	1.36 (0.49)	2.44 (0.71)	71.12***
Block II. Language	13 (52)	2 (8)	2.01	51.92 (11.20)	63.20 (9.36)	32.72***
Auditory Recognition	0 (0)	0 (0)	-	18.36 (1.73)	19.96 (1.37)	16.70***
Auditory Discrimination	10 (40)	2 (8)	3.26	16.00 (4.74)	19.68 (3.46)	22.36***
Auditory Figure and Background	25 (100)	16 (64)	-	4.48 (0.59)	6.04 (1.37)	29.11***
Auditory Analysis	17 (68)	13 (52)	7.35**	4.64 (2.46)	5.60 (2.04)	6.36*
Auditory Synthesis	12 (48)	5 (20)	6.77**	1.76 (1.36)	2.44 (0.92)	8.82**
Auditory Closure	8 (32)	7 (28)	12.89***	4.76 (2.15)	5.32 (1.73)	3.03
Suprasegmental Features	25 (100)	18 (72)	-	1.92 (1.29)	4.16 (1.84)	34.78***

*p≤0.05, **p≤0.01, ***p≤.001

Pre-intervention, the boys scored significantly higher than the girls only in Noises and Sounds block (t(23)=2.11, p=.05) and its Auditory Association subscale (t(23)=2.19, p=.04). Improvement was observed in both groups, although this pattern continued post-intervention for both sexes: Noises and Sounds (t(23)=2.40, p=.03), and Auditory Association (t(23)=2.80, p=.01). The girls initially scored significantly higher than the boys in the Auditory Recognition subscale (t(23)=-2.05, p=.05), though this discrepancy disappeared post-intervention.

Though not always at a significant level, comparison of pre- and post-intervention outcomes suggests AVT led to general improvement in auditory perception. Significant changes were observed only in the Discrimination and Recognition and Auditory Association subscales (Noises and Sounds block), and the Auditory Analysis, Auditory Synthesis, and Auditory Closure subscales (Language block). Case distribution sometimes precluded application of the x2 test, even so, the percentage of below cut-off scores still declined. T-tests showed that all but one scale (Auditory Closure) exhibited significant post-intervention improvements, particularly in the Noises and Sounds block.

Discussion

In the children studied here, AVT resulted in improved scores in the auditory perception test. This is important because, as is well known, profound bilateral hearing loss can have negative impacts on quality of life, especially when it begins in early childhood. If therapeutic measures are not initiated in the neonatal or nursing stage, it can challenge a child's developmental and learning processes [16]. Although cochlear implants would be the gold recommendation for children with hearing loss, in developing countries such as Mexico financial constraints and cultural conditions frequently make this technology inaccessible [17]. Prevailing conditions in Mexico mean implants are not a viable treatment option for a large majority of the population, and therefore treatment models need to be developed and updated in accordance with the population's possibilities [18]. In response to this reality, AVT in the present study was applied to children using hearing aids. Although this condition might certainly be seen as disadvantageous for clinical and research purposes, it gives a natural condition to further the evidence of the effectiveness of AVT to improve auditory perception.

Absence of a hearing loss diagnosis during neonatal screening is one of the main causes delaying the timely treatment that can limit the consequences of hearing loss [19]. The present study is a good example of this since average age at diagnosis was four years, that is, the age at which it became obvious to adults that the child could not hear properly. Even after diagnosis, it took an average of two more years before the child was fitted with hearing aids and provided with AVT; that is, an average of six years between birth and treatment. These are

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vital years in a child's language development, and the loss of this extremely important stimulation can pose serious challenges to full integration into society [20]. It is worth to mention that in addition to receiving attention at AYPRODA, the studied children regularly attended public schools not provided with programs for handicapped students and applying the same type of teaching techniques to all students. In terms of development, this can be favorable for hearing impaired children because it provides stimulation and generates no stigmas or differences as they coexist with other children who can collaborate with them in adapting to their social surroundings.

Though not the primary focus of this study, the results showed similar participation rates and profiles in boys and girls. Some differences were observed in the initial test of audio-verbal abilities, with boys scoring higher in the Noises and Sounds section and girls in Auditory Recognition. These differences were not present in the final test scores, suggesting that both sexes responded satisfactorily to AVT. This differs from previous studies in other contexts showing that women perform better than men in auditory and verbal abilities for biological and cultural reasons [21-23].

Overall improvement between the pre- and post-test results demonstrated that AVT helped improved auditory perception in children with profound bilateral hearing loss using 4- or 5-channel hearing aids. This confirms its efficacy as reported in different studies and contexts [12,24-26]. Use of a cut-off in each section of Gotzens and Marro's auditory perception test showed the children to improve most notably in the Discrimination and Recognition, and Auditory Association scales of the Noises and Sounds section, which has been reported elsewhere [27]. They also improved in the Auditory Analysis, Auditory Synthesis and Auditory Closure scales of the Language section, again, these results are similar to those of previous studies Dijk et al., (2016) [28]. Overall improvement was corroborated using the net pre- and post-therapy values which were better in all scales except Auditory Closure; this occurred because in this scale the cut-off was very near the average values.

AVT has clear benefits in children with profound bilateral hearing loss [25], even in those, as shown by the present study, equipped with hearing aids rather than cochlear implants. Hearing aids alone will restore sensory function but need to be accompanied by auditory-verbal training to help with learning and interpreting sounds, understanding and contextualizing their meanings, and other abilities promoting assertiveness in the language learning process [29]. Diverse studies have repeatedly suggested that AVT can have a positive impact on developing speech and language skills in children with hearing impairment; yet, the lack of well-controlled studies is still an impediment to generalization of findings. Including other outcome measures such as academic performance and social integration, and further follow-up as well as controlling parents' rehearsal at home would be some points to take into account for subsequent studies. Perhaps the main concern regarding validity would be the lack of a control group; preventing any assumption of causality. This is not an unusual drawback when moving research from basic science to practice as one way to facilitate evidence-based service in natural settings [30]. Nevertheless, quasi-experimental designs should not be singled out from well-founded studies. Particular indicators of quality should be considered to evaluate the merits of a research accordingly to its design so that its contribution to determine whether a practice (e.g. AVT) may be considered evidence-based is not overlooked [31]. Research must respond the call for studies minimizing the role of external variables, as well as for longitudinal and collaborative multi-centre research, in order to strengthen the evidence- and values-based practice of AVT [12,24-26,32].

The studied children came from low-income families and were receiving free therapy at AYPRODA. An additional step needed as part of the therapy process is to educate parents and legal guardians about the advantages of AVT and thus enlist their support of and follow through on therapeutic recommendations. An ideal strategy would be to assist families in acquiring cochlear implants, the current technological gold standard in hearing loss rehabilitation. Although financial circumstances may hinder this procedure, children can still benefit from AVT to improve their auditory perception and align their language learning process [33,34].

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Declaration of Conflicting Interests

Authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Authors' Contributions

DE was responsible for protocol and study design. DE and HR were responsible for data collection. LG was responsible for analyses of data. All authors significantly collaborated on the writing of the manuscript and have approved the final version as it is.

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