Am J Otolaryngol 40 (2019) 724–728

Contents lists available at ScienceDirect

Am J Otolaryngol

journal homepage: www.elsevier.com/locate/amjoto

The effectiveness of cognitive rehabilitation program on auditory perception and verbal intelligibility of deaf children

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ARTICLE INFO

Keywords:
Auditory perception
Deaf children
Cognitive rehabilitation
Verbal intelligibility

ABSTRACT

Linguistic information and cognitive rehabilitation has more related with auditory perception and verbal intelligibility. The aim of the present study was to assessment of the effectiveness of cognitive rehabilitation program on the auditory perception and verbal intelligibility of deaf children.

This study was a quasi-experimental study with pre-test, post-test and control group design. Participants were 24 deaf children from Ava rehabilitation center of mother child in Isfahan city, Iran. Participants were selected by convenient sampling method. They were randomly divided into experimental and control groups, each group consisted of 12 children. The experimental group participated in the cognitive rehabilitation training program in 10 sessions for 45 min, while control group did not participate this program. The instruments of present research were Categories of Auditory Performance (CAP) and Speech Intelligibility Rating (SIR). The data were analyzed using multivariate analysis of covariance (MANCOVA) in 24th version of SPSS.

The results of MANCOVA showed that cognitive rehabilitation program had significant effect on the auditory perception and verbal intelligibility in the experimental group at post intervention stage ($P < 0/0001$).

There was a positive and significant increase in auditory perception and verbal intelligibility of experimental group. Our findings showed that Cognitive rehabilitation program training led to promote of auditory perception and verbal intelligibility of deaf children.

1. Introduction

To be deaf, or even hard of hearing, often places an individual in a difficult place somewhere between the word of the hearing and the word of the deaf [1]. Hearing loss is associated with changes in brain volume in regions supporting auditory and cognitive processing [2]. A hearing impairment can put an individual at risk for isolation and isolation caused primarily by language development, communication problems, auditory perception and verbal intelligibility [1]. Even if the hearing impairment isn't severe enough for a person to be classified as deaf, but rather as hard of hearing, the person with a hearing impairment is at a distinct disadvantage in virtually all aspects of language development, auditory perception and verbal intelligibility [3].

Linguistic information has more related with auditory perception and verbal intelligibility [4]. Auditory perception can be defined as the awareness, recognition and interpretation of auditory stimuli received in the brain. Verbal intelligibility can be defined as the degree to which a speaker has intended other listeners can recover message [5]. Good speech perception is essential in language development [6]. The importance of the language development, auditory perception and verbal intelligibility in each society, particularly in preschool-related activities is obvious. Many of the problems that deaf children have in preschool and school are due primarily to their difficulties [7]. For many years, it has been believed that deaf children could not learn to speak and cognitive rehabilitation program could not appropriate for these children [8]. Deaf children frequently have problems in auditory perception and verbal intelligibility which are constantly reported by parents and teachers [9]. On the other hand, attitudes of professionals have changed and it is recognized that deaf children can learn to better speak if taught appropriately [1].

Cognitive rehabilitation is a systematic approach to improve higher brain function in each person [10,11]. Cognitive rehabilitation is a therapy program designed as an intervention to help people with cognitive deficits [12]. For that reason, the interest in cognitive rehabilitation has been growing over the last decades [13]. Cognitive rehabilitation can be defined as the set of techniques and that procedures are aimed to improve intellectual efficiency, and the adjustment to labor environments, social, familiar, and of people suffering special

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https://doi.org/10.1016/j.amjoto.2019.06.011
Received 20 June 2019

impairments [14]. Using systematic approaches such as cognitive retraining, the individuals are helped to be integrated into society [15]. Cognitive rehabilitation is a therapy program designed as an intervention to help people with cognitive, behavior and emotional and linguistic deficits [16].

Research about deaf children indicates that phonological awareness tasks improved auditory perception and speech production scores in deaf children [17]. The results of study indicated that auditory perception and verbal intelligibility of deaf children are considerably poor and inappropriate [18]. A research investigated A study investigated the enhancing parent-child communication and parental self-esteem with a video-feedback intervention on prelingual deaf and hard of hearing children. The results indicated that the rehabilitation intervention significantly improved in the language skills, auditory perception and speech intelligibility in experimental group [19]. Another research assessed the effectiveness of auditory rehabilitation program on communication skills of cochlear implantation candidates. Their findings indicated that auditory rehabilitation program improved communication, auditory perception and speech production scores in deaf children participated in the study [20]. The effects of rehabilitation and cognitive rehabilitation programs showed on language skills, communication skills, auditory perception, speech production and social and emotional skills in deaf children deaf children [21–23]. The results of study indicated that direct attention, memory, and metacognitive strategy training coupled with the adoption of internal and external compensatory supports to reduce cognitive and functional disability at the post-acute stage of brain injury recovery [24]. The application of cognitive rehabilitation also improved cognitive function in elderly persons, the memory test showed increased and significantly different pre and post intervention [25].

According to some study, deaf children showed problems in the auditory perception and verbal intelligibility. Moreover, finding of some studies demonstrated that the auditory perception and verbal intelligibility are related together in deaf children [17,18]. Deaf children have problems in language and communication skills which has negative effects on auditory perception and verbal intelligibility skills. Also, deaf children have many problems in the communication skills in comparison with hearing children. Considering this, cognitive rehabilitation training is of very beneficial for them. When deaf children participated in cognitive rehabilitation training program, they were able to enhance auditory perception and verbal intelligibility. In addition, although deaf children process similar steps of language development in the same order as normal children, but stages may be obtained posterior and may not developed as some activities and skills. Therefore, the aim of this research was to determine the effectiveness of cognitive rehabilitation training program on auditory perception and verbal intelligibility of deaf children.

Two hypotheses were formed in this study: the first hypothesis of this research was to determine the effectiveness of cognitive rehabilitation training program on auditory perception of deaf children. The second hypothesis of this research was to determine the effectiveness of cognitive rehabilitation training program on verbal intelligibility of deaf children.

2. Materials and methods

2.1. Participants

Twenty-six deaf preschool children with sensory-neural hearing loss (11 boys, 15 girls) participated in the study in 2019 academic year. Participants were selected by convenient sampling method from Ava rehabilitation center of mother child in Isfahan city, Iran. They were randomly divided into the experimental and control groups, each group consisted of 12 children. Their demographic characteristics are shown in Table 1.

According to Table 1, the mean age of the experimental and control groups were 5.22 years (SD = 0.28) and 5.26 years (SD = 0.24) and their mean IQ scores were 98.67 (SD = 3.21) and 99.18 (SD = 3.14), respectively. They were from middle socio-economic status. These children were bilaterally and prelingually deaf, and monolingual Persian. They used a behind-the-ear (BTE) hearing aids before the age of 3 years. Parents of all children have normal hearing. Pure-tone audiometry (PTA) test used to measure hearing sensitivity and identify hearing threshold levels of participants. Accordingly, hearing loss the participants were in the range of 50 to 70 dB.

Table 1
Demographic characteristics of study participants.

Variable	Category	Experimental group (n = 12)	Control group (n = 12)
Age (years)	M (SD)	5.22 (0.28)	5.26 (0.24)
Sex	Male	5 (42%)	6 (50%)
	Female	7 (58%)	6 (50%)
Race/ethnicity	Iranian/ Persian	12 (100%)	12 (100%)
	Iranian/Non-Persian	0 (0%)	0 (0%)
Preschool education (month)	< 12	4 (33%)	3 (25%)
	12–18	8 (67%)	9 (75%)
IQ	M (SD)	98.67 (3.21)	99.18 (3.14)
Hearing threshold levels	M (SD)	61.37 (2.05)	61.44 (2.13)

The inclusion criteria were being diagnosed prelingually deaf with sensory-neural hearing loss in both ears, being hearing loss in the range of 50 to 70 dB (dB), being hearing aids in both ears, IQ between 95 and 105, aged 4–6 years old and living with parent. Participants would be excluded from research if there was any symptom of neurodevelopmental disability or significant health problems with the exception of deafness. Also, those who were currently receiving similar training program were excluded from the study.

This research was approved by Ethics Committee of Exceptional Education Organization in Iran. The importance of research was described to the preschool principals and parents of participants, ensuring that all participants would be protected against any probable harm. Parents of participants gave written informed consent before participating in the research.

2.2. Procedure

All participants answered to Categories of Auditory Performance (CAP) and Speech Intelligibility Rating (SIR). To evaluate the auditory perception, categories of auditory performance II (CAP II) was used. This is well-known test for assessing auditory perception that developed by Archbold, Lutman and Marshal and revised by Archbold, Lutman and Nikolopolous in 1998 [26]. It was designed for obtained useful information about auditory receptive abilities of deaf children. The CAP quantifies the auditory receptive abilities of linguistically compromised profoundly deaf children in a clinical setting. The CAP is a nine-point rating scale ranging that was scored based on Likert from 1 (displays no awareness of environmental sounds) to 9 (can use a telephone with a familiar talker) [18]. Archbold and et al. reported validity and reliability are well documented in their research. Gilmour reported inter-rater reliability based on average Cohen's kappa coefficient was 0.76 [27]. In Iran, [31] reported test-retest reliability for CAP was 0.82 and inter-rater reliability based on average Cohen's kappa coefficient was 0.73. The concurrent validity of the scales was 0.64 and construct validity was between 0.58 and 0.74.

To evaluate the verbal intelligibility, speech intelligibility rating (SIR) was used. This is well-known test for assessing verbal intelligibility that developed by Allen et al. in 1998 [28]. It was designed for obtained useful information about speech intelligibility abilities of deaf children. The SIR quantifies the verbal intelligibility abilities of deaf

children in a clinical setting. The SIR is a five-point rating scale ranging that was scored based on Likert from 1 (pre-recognizable words in spoken language) to 5 (connected speech intelligible to all listeners). The reliability of this scale has been evaluated, and a high rate of agreement found between observers using the scale to assess the speech intelligibility of deaf children [18]. Allen et al. [28] reported inter-rater reliability based on average Cohen's kappa coefficient was 0.53 In Iran, Hasanzadeh (2015) reported test-retest reliability for SIR was 0.99 and inter-rater reliability based on average Cohen's kappa coefficient was 0.70. The concurrent validity of the scales was 0.69 and construct validity was ranged between 0.66 and 0.69.

In the later stage, experimental group participated in 10 sessions in the cognitive rehabilitation training program (two times a week; each lasting for 45 min), while control group did not receive this program and participated in common program of preschool. Cognitive rehabilitation training program has been applied in the several research studies. This program was designed based on Sholberg & Mateer reported in Table 2 [29].

In the final stage of the research, each of the two groups was assessed by CAP and SIR as post-test.

2.3. Data analysis

Participants were assessed with CAP and SIR. Data analyses were conducted using descriptive and inferential statistics. For investigation of the effectiveness of cognitive rehabilitation program on the auditory perception and verbal intelligibility of deaf children in experimental and control group, a multivariate analysis of covariance (MANCOVA) was used. The obtained data were analyzed by MANCOVA using statistical package for social sciences software (version 24, SPSS Inc., Chicago, IL). For all comparisons, $P < 0.05$ was considered statistically significant.

3. Results

The descriptive indexes (Mean scores and standard deviation) of auditory perception and verbal intelligibility of deaf children in experimental and control group in pretest and posttest are shown in Table 3.

MANCOVA was used because of the presence of one independent variable and two dependent variables and the moderate pre-test effect. After checking and confirmation of the normality of research variables, Box's test approved equality of variance-covariance matrices ($P > 0.05$). Also, the assumption of variance equality was approved by using Leven's test ($P > 0.05$). Therefore, MANCOVA test could be applied. The overall score Wilk's lambda was significant ($F_{(2,19)} = 4.03$, $P = 0.0001$), indicating that experimental and control groups had significant difference, at least in one variable. In order to determine differences among scores of auditory perception and verbal intelligibility between control and experimental groups, MANCOVA test was used, whose results are reported in Table 4.

Table 3
Descriptive statistics auditory perception and verbal intelligibility in study groups.

Subscales	Situation	Experimental group		Control group	
		Mean	SD	Mean	SD
Auditory perception	Pre-test	5.63	0.56	5.67	0.49
	Post-test	7.29	0.60	5.72	0.47
Verbal intelligibility	Pre-test	2.58	0.23	2.55	0.23
	Post-test	4.01	0.23	2.61	0.19

Table 4
Summary of MANCOVA result.

Depended variable	Source	SS	df	MS	F	Sig	η^2
Auditory perception	Pre-test	16.35	1	16.35	4.90	< 0.002	0.21
	Group	81.74	1	81.74	24.54	< 0.0001	0.56
	Error	70.09	21	3.33			
	Total	179.44	23				
Verbal intelligibility	Pre-test	7.21	1	5.21	6.05	< 0.001	0.24
	Group	23.71	1	23.71	27.56	< 0.0001	0.59
	Error	18.09	21	0.86			
	Total	50.64	23				

To analyze the obtained data, pre-test variable was moderated because of its correlation with post-test. According to Table 4, the type of the group has effect on post-test scores significantly, and there are significant differences between scores of auditory perception and verbal intelligibility in experimental and control groups ($P < 0.0001$). As can be seen from the Table 3, the results of MANCOVA showed that cognitive rehabilitation training had positive and significant effect on the auditory perception ($F = 24.54$, $P < 0.0001$) and verbal intelligibility ($F = 27.56$, $P < 0.0001$). According to eta square (η^2), this could be explained that %56 and %59 of the variation in each variable of auditory perception and verbal intelligibility, respectively are due to the effectiveness of cognitive rehabilitation training in experimental group at post-test stage.

4. Discussion

In this section, we will discuss the two research hypothesis of this study one by one. First we investigated the effectiveness of cognitive rehabilitation training program on auditory perception of deaf children in experimental and control groups before and after intervention. Second we investigated the effectiveness of cognitive rehabilitation training program on verbal intelligibility of deaf children in experimental and control groups before and after intervention.

These hypotheses were confirmed. The present research was conducted to investigate the effectiveness of cognitive rehabilitation

Table 2
The content of cognitive rehabilitation training sessions.

Session	Objects	Context of sessions
1	Communication and introduce the program	Explain the structure of the sessions, planning, targeting, cognitive practices and exercises
2	Improvement of visual memory	Teaching with mnemonics, visual memory training like face reminder games
3	Improvement of audio-visual memory	Instruction of study methods, listening to sounds and maintaining attention to visual stimulus.
4	Improvement of visual-spatial memory	Providing games related to the speed of information processing and visual-spatial coordination
5	Improvement of numerical memory and words association	Saying numbers by pattern, direct and reverse patterns, completing word tables, paired associations
6	Improvement of event memory and cognitive expansion	Change in attention in event memory, selective attention and attention processing, verbal organization, semantic extension
7	Reinforcement of time and space memory	Time and space illustration, Recall of recent and immediate past experiences
8	Reinforcement of Motion memory	Implementing one-step and multi-step motion guidelines such as classification and differentiation
9	Reinforcement of meta-memories	Illustration and problem solving mentally, scheduling, gradually removing memory cues
10	Exit the program and Conclusion	Review the content of the sessions and prepare the subject to exit the program.

training program on auditory perception of deaf children. Also, this study evaluated the effect of cognitive rehabilitation training program on verbal intelligibility of deaf children in experimental and control groups before and after intervention.

The present research supports the effectiveness of cognitive rehabilitation training program on auditory perception of deaf children. The result of this study was consistent with Fardafshari et al. [17] stating the effect of phonological awareness tasks on auditory perception and speech intelligibility in pre-school severe and profound deaf children. Outcome of this study was similar to the study results of Lam-Cassettari et al. [19] which reported that rehabilitation intervention significantly improved in the language skills, auditory perception and speech intelligibility in experimental group. Current study result was similar to study findings of Hasanzadeh & Nikkhoo [20] representing the effectiveness of auditory rehabilitation program on communication, auditory perception and speech production scores in deaf children. Result of current research was similar to the study results of Cicerone et al. [24] stating the effect of cognitive rehabilitation program on attention, memory, and metacognitive in individuals with brain injury.

For explain of these finding, it can be stated that the interest to cognitive rehabilitation programs has been growing over the recent decades [13]. Because of these programs are a systematic approach and procedure to improve brain function in each individual [11]. Cognitive rehabilitation included attention, mental speed, executive functions, language, learning, memory and visuo-spatial functions [10]. On the other hand, deaf children have problems in auditory perception and verbal intelligibility. The development of auditory perception and verbal intelligibility have always been a significant problem for deaf children, especially children with severe and profound hearing impairment, as they do not have the auditory capacity to monitor their own speech or to hear the speech of normal hearing people [18]. When deaf children participated in cognitive rehabilitation program, could improve brain functions, auditory skills and communication activities [1]. Then, it is expected that cognitive rehabilitation improves of language and communication skills as well as improves of auditory perception and speech intelligibility in deaf children. When child grow up and his or her interaction with parent or other children improves, the cognitive, visual and auditory system become very important and are accompanied by other language skills.

In addition, deafness is a condition of deficiency in hearing, which affects the auditory perception as well as the verbal intelligibility [20]. In fact, auditory perception and speech intelligibility related to hearing status as well as requires to attention, mental speed, executive functions, language, memory and visuo-spatial functions [5]. Hearing aid improves hearing status of mild and moderate deaf children, and cognitive rehabilitation improves of other cognitive and linguistic functions of these children [3]. Also, appropriate memory tasks are used for deaf children who have language problems to help improves their auditory perception and speech intelligibility [30]. As a result of this improvement in auditory perception and speech intelligibility, it can be assumed that cognitive rehabilitation training program can have significant and positive effects. Cognitive rehabilitation training increase the neuroplasticity of nervous system of children, leading to improvements in desirable skills and behaviors and increase language learning capacity. Accordingly, it improves spontaneous auditory perception and speech intelligibility in deaf children.

One major limitation is that this study only examined the effect of cognitive rehabilitation program on the auditory perception and verbal intelligibility in the prelingually deaf children aged 4–6 years old with sensory-neural hearing loss in the range of 50 to 70 dB. A second limitation is that this study was disregard to the diversity in the hearing condition and socio-economic status in parents of subjects. A Third limitation is that this study was without follow up stage, because of the time limitation, opportunity for follow up stage was not provided. Therefore, these limitations made it difficult to generalize the findings of the study to the other population and clearly this is an area that needs further research.

This study created several recommendations for further study. First, it is recommended that regarded the pre-lingually and post-lingually deaf children in different ages with type of hearing loss. Second, regarded the hearing condition and socio-economic status in parent of subjects. Third, provided opportunity for follow up stage. Moreover, since auditory perception and verbal intelligibility are multi-dimensional and complex phenomenon, deaf children require special rehabilitation program.

5. Conclusion

This study provides promising information about the effectiveness of cognitive rehabilitation training program on auditory perception and verbal intelligibility skills of deaf children. Also, cognitive rehabilitation facilitates the improvement of the communication and speech skills in deaf children. Thus, paying attention to cognitive rehabilitation training plays a crucial role for enhancing auditory perception and verbal intelligibility in these children. Ultimately, the present study indicated that significant improvement in auditory perception and verbal intelligibility of deaf children were reinforced after receiving cognitive rehabilitation training program. The findings of this study should be evaluated in future longitudinal, experimental studies.

Funding sources

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Declaration of Competing Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgement

We would like to thank all participants for their participation in this research.

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