

Original Article

Is There Any Association Between Language Acquisition and Cognitive Development in Cochlear-Implanted Children?

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OBJECTIVE: Different studies on normal children and children with a sensory or intellectual disability indicate a strong correlation between the child's vocabulary domain and his cognitive abilities. Based on this, the main focus of the present study was to investigate the cognitive performance of cochlear-implanted children after a cognition-based language intervention program.

METHODS: In this experimental study, 60 cochlear-implanted children were selected and randomly allocated into case and control groups. The control group received auditory verbal therapy (AVT), while the intervention group was trained by using both AVT and a language intervention protocol that was recently developed by the authors. Finally, the participants' communication abilities were assessed through the adapted version of the language subtest of Bayley Scales of Infant and Toddler Development – Third Edition (BSID 3). Five months later, the cognitive subtest was carried out. The data gathered were then analyzed using SPSS software.

RESULTS: The study was performed on 2 groups of 20- to 24-month-old cochlear implant users, and our results confirmed a high correlation between language acquisition and cognitive development ($r = 0.76$). In addition, the cognitive and language performance of the participants who were trained by the new and specifically designed language intervention protocol as well as AVT was significantly higher than that of the control group ($P \leq .001$).

CONCLUSION: The new and specifically designed language intervention protocol that was mainly established based on cognitive factors such as attention and semantic memory enhancement in cochlear-implanted children improved not only their language acquisition but also their cognitive development.

KEYWORDS: Cochlear implant, language intervention, cognitive development, vocabulary, children

INTRODUCTION

It is confirmed that a child's language development is accompanied by his ability to process conceptual information, and to discriminate objects and events in his environment. Communication with his caretakers, a healthy hearing system, and good learning capacity provide the child with an understanding of new words and structures in adult speech. In other words, it can be said that the demonstration of cognitive and conceptual representations is somehow within the child's language abilities.¹⁻³

This can be observed while focusing on a normal child's attempt to embark on using his native language by the way he chooses to represent his experiences and to talk about events and objects.⁴ Based on the cognitive psychologists' perspective, vocabulary

acquisition is concerned with the child's level of cognitive development.³ This theory is derived from studying language development in children with learning disabilities, whose language ability was correlated with the severity of their disability.⁵

In a normal child, language acquisition and cognition are mutually enhanced and promoted in parallel. However, some sensory deficits such as hearing loss necessitate cochlear implantation, which hampers normal language acquisition and language development.^{1,2} Generally, various factors, especially age at implantation, parents' cooperation, and timely language intervention programs influence language acquisition in cochlear-implanted children.⁶ Furthermore, it is proven in different studies that improvement in specific cognitive factors such as attention and visual and working memory play a role in language outcomes of a cochlear-implanted child.^{2,3,7,8}

In addition, the child's kinesthetic ability, which helps him explore the environment and manipulate objects, indirectly helps him develop cognitive abilities and consequently good language skills.^{9,10}

However, there are not many studies that simultaneously consider both language acquisition and cognitive development of cochlear-implanted children.¹⁰⁻¹² In addition, most of the language intervention programs are not established based on cognitive factors that facilitate the process of language acquisition.

Considering the deep negative impact of severe to profound sensorineural hearing loss, not only on language perception and speech but also on children's cognitive abilities,³ this study primarily focused on the correlation between language acquisition and cognitive development following a cognition-based language intervention program which helps equip the child with cognitive factors like working memory improvement.¹³⁻¹⁵

METHOD AND MATERIALS

At the beginning of this experimental study, we used convenience sampling to select 60 children (26 girls/ 34 boys) aged 20-24 months who had received the cochlear implant device 40 days earlier. The participants were selected from among the children who had been trained to learn lip reading before the surgery. The other selection criteria were having monolingual parents and no additional disabilities except the hearing impairment. The participants were randomly allocated into intervention and control groups. Each group included 30 participants. However, 9 of the participants (4 in the intervention group and 5 in the control group) refused to finish the rehabilitation program which lasted for almost 9-12 months. Therefore, the complete rehabilitation program was carried out on only 51 participants.

Informed written consent was obtained from the parents in both groups. It is necessary to indicate that all the procedures performed in the present study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

The control group received AVT, which is an accepted traditional intervention program for cochlear-implanted children,¹⁶ while the

intervention group was trained using both AVT and a language intervention protocol called "An educational package on receptive vocabulary development for Persian-speaking cochlear-implanted children" which was recently developed by the authors. It is necessary to point out that the basics of this newly developed language intervention program have been thoroughly explained in our previous studies.^{13, 14}

After almost 9-12 months of the rehabilitation program, the participants' communication abilities were assessed through the adapted version of the language subtest of the BSID 3, for Persian-speaking children.¹⁷ The BSID 3 evaluate the developmental functioning of 0- to 42-month-old infants and children in 5 separate domains, including the cognitive subscale, the language subscale (receptive and expressive communication), and the motor subscale (fine and gross motor subtests). The 2 other scales, the socio-emotional and adaptive behavior questionnaires, can be completed by the parents or by the child's caretakers.

At about at least 5 months following the intervention, the follow-up assessment was performed using the cognitive subtest of the BSID 3, in order to find any probable correlation between language acquisition and cognitive development.

The cognitive items in the BSID 3 cognitive subtest assess the child's memory and ability to habituate to visual and auditory stimuli. This subtest involves presenting novel visual and auditory stimuli after habituation of the infant to a familiar stimulus. Memory is assessed by measuring the length of time that the child spends concentrating on a novel stimulus when compared to a familiar one.^{3,18} The 91 questions of the cognitive subtest evaluate various aspects of cognitive processing including sensorimotor development, exploration and manipulation, object relatedness, and concept formation and memory. As for the other domains of the BSID 3, questioning using the cognitive subtest questions are stopped if correct responses are not obtained for 5 continuous questions.

Statistical Analysis

After evaluation using the language and cognitive subscales of BSID 3, the results were statistically analyzed using SPSS-21. Based on results of the Shapiro-Wilk test, the independent sample t-test was used to compare the group's composite language scores, while the Mann-Whitney U-test indicated the differences in the group's cognitive composite scores. Qualitative data analysis was done using the Pearson chi-squared test. The correlation between language and cognitive composite scores was evaluated using Pearson's correlation coefficient.

RESULTS

The descriptive analytic findings obtained from the independent samples t-test and Pearson's Chi-squared test indicated no significant difference between the groups in terms of age, gender, and parents' educational level, with the P value being greater than .65, .43, .98, and .87, respectively.

Based on the data demonstrated in Table 1, the mean scores of composite language subscale scores, as well as the composite cognitive scores of the intervention group were always higher than those of the control group.

Table 1. The Distribution of Mean Composite Cognitive and Composite Communication Scores in the Intervention and Control Groups

Group	Mean \pm SD	Minimum	Maximum	N
Composite cognitive scores				
Intervention	91.73 \pm 5.46	85	100	26
Control	81 \pm 16.6	65	95	25
Composite Language Scores				
Intervention	91 \pm 10.73	74	112	26
Control	73.64 \pm 8.7	62	94	25

Before comparing the 2 groups' language and cognitive abilities, the normality of the distribution of the above-mentioned variables was checked with the Shapiro–Wilk test.

Since the Shapiro–Wilk test depicted the normal distribution of the group's composite language scores ($P \geq .05$), the independent sample *t*-test was done to compare the groups in this regard.

The test results showed a significant difference between the mean composite language scores in the intervention and control groups ($P \leq .05$). The higher mean composite language scores of the intervention group (91 \pm 10.73 vs. 73.64 \pm 8.7) indicated their noticeably better language performance than the other group.

Based on non-normally distributed data of the groups' composite cognitive scores, the Mann–Whitney *U*-test was performed to compare the groups.

The better performance of the intervention group in composite cognitive scores is illustrated in the above table ($P \leq .001$).

Finally, the high correlation between language acquisition and cognitive development is depicted in Table 5.

DISCUSSION

The study results demonstrated that a newly introduced step-by-step language intervention protocol which was mainly established in accordance with cognitive factors such as attention and semantic memory enhancement in cochlear-implemented children,¹⁴ improved not only participants' language acquisition but also their cognitive development.

This finding confirmed the cognitive psychologists' perspective on the mutual correlation between language acquisition and cognitive development.³ Based on this point of view, the child's vocabulary acquisition is basically related to his cognitive status. As an example, in children with severe learning disabilities, for example, the children with autism spectrum, cognitive development, and language acquisition might simultaneously be encountered with major deficiency.^{5,19}

Table 2. Evaluation of Normal Distribution of Cognitive and Language Composite Scores

Group	Shapiro–Wilk Test	df	P
Composite cognitive	0.946	51	.021
Composite language	0.962	51	.102

Table 3. The Comparison of the Intervention and Control Groups' Composite Language Scores

Group N	Mean \pm SD	Leven's Test for Equality of Variances		T	df	P
		F	Sig.			
26(intervention)	91 \pm 10.73	1.7	0.91	6.33	49	.001
25(control)	73.64 \pm 8.7					

Table 4. The Comparison of the Intervention and Control Groups' Composite Cognitive Scores

Groups	Mean Ranks	Median	z	P
Intervention	35.33	90	-4.66	.001
Control	16.30	80		

As mentioned in the previous studies,^{12,14,20,21} this problem is mostly related to the child's inability in vocabulary acquaintance and retrieval from semantic memory storage. Therefore, the promoting the child's improvement in semantic memory abilities by repeating the words, providing a situation for a child to manipulate the objects that refer to a specific word, role playing²² and motor movement training,¹⁰ as well the use of familiar phrases and sentences in order to describe a new word, might increase the semantic memory capacity for a word's meaning reserve and consequently results in cognitive and language achievement.

A study focused on cochlear-implemented children and conducted almost 15 years ago to determine their cognitive skills indicated that symbolization, role playing, and memory development were linked to language acquisition after cochlear implantation. Although this study was carried out on a small number of children (17 cochlear-implemented children), its result was in agreement with our study findings, and a link between language development and cognitive skills after cochlear implantation was observed.²³

Another study similar to ours was performed in 2003 on 176 cochlear implant users in Indiana University, and its results showed the relationship between working memory and language acquisition after cochlear implantation. The working memory of the samples in that study was examined using the forward and backward digit span memory task of the Weschler Intelligence Scale for Children-III (WISC-III). However, our participants were evaluated by the cognitive

Table 5. The Correlation Between Language Acquisition and Cognitive Development

	Composite language	Composite cognitive
Composite language scores		
Pearson correlation	1	0.76**
Sig.		0.001
N	51	
Composite cognitive scores		
Pearson correlation	0.76**	1
Sig.	0.001	
N	51	51

**Correlation is significant at .01 (2-tailed)

and communication subscales of the BSID 3. Furthermore, our study findings were derived from 2 groups of cochlear-implanted children who were different in terms of the language intervention program, while results of the study by Pisoni et al. were gathered via the comparison of 176 cochlear-implanted children aged 8-9 years old who had undergone cochlear implantation 3 years earlier, with those of a group with normal hearing.

According to a cohort study conducted in 2013, parents who provided their cochlear-implanted children with sufficient cognitive stimulation such as free play sessions and problem solving enabled them to acquire language faster than the others. In this cohort study, 188 cochlear-implanted children under 5 years old were recruited from 6 centers across the US. Their oral language was assessed before and at 6, 12, 24, and 36 months after implantation, through the BSID 2. Their language performance after 24-36 months of implantation indicated the positive effect of cognitive stimulation on language acquisition. The language acquisition of children whose parents engaged them in more cognitive stimuli was delayed by 1.4 years, while the same was delayed by 2.6 years for children with less cognitive stimulation.²⁴

Finally, Surowiecki et al. (2002) found no significant cognitive differences between 2 groups of age- and gender-matched children, one comprising children who used a cochlear implant and the other of children who used hearing aids. Partial correlation analysis indicated that the children's visual memory skills, i.e., their recognition memory, delayed recall, and paired associative learning memory skills correlated significantly with their language skills. The overall results depicted that differences in visual memory skills may perpetrate some of the variance seen in the language abilities of cochlear-implanted and hearing-aid supported children.¹²

Although the above-discussed studies generally confirm the correlation between cognitive development and language acquisition, there are some questions about the priority of one over the other. For example, is language impairment the cause or the consequence of cognitive disorder? In spite of the fact that some of these studies are concerned with the diminished cognitive development in children due to hearing impairment^{11,15,20} and its negative effect on language acquisition, further research with a larger sample size is recommended. Also, as the present study was only performed on the cochlear-implanted children of Persian-speaking Iranian parents, it is suggested to conduct a study with non-Persian-speaking cochlear-implanted children for re-evaluation of the author's finding about the correlation between language acquisition and cognitive development.

CONCLUSION

Although children with hearing loss who have undergone cochlear implantation suffer from both language delay and cognitive impairment, the new specifically designed language intervention protocol that was mainly established based on cognitive factors such as attention and semantic memory enhancement in cochlear-implanted children enabled their improvement not only in language acquisition but also in cognitive development. Overall, the study results indicated the correlation between language acquisition and cognitive development in cochlear-implanted children.

Ethics Committee Approval: Ethics committee approval was received for this study (IR.USWR.REC.1394.69).

Informed Consent: The rehabilitation procedure was explained for the parents and written informed consent was obtained from them.

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