Auditory and Vestibular Research

Evaluate the receptive vocabulary of Persian-speaking children with cochlear implants based on hearing age and their understanding of various type of vocabulary

Shokoufeh Zare[1], Ali Ghorbani[1,2] Nahid Jalilevand[1,2*], Mohamad Kamali[2,3]

Shokoufeh Zare[1]
[1]Department of Speech Therapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran,
https://orcid.org/0009-0005-8207-1893

Ali Ghorbani[1,2]
[2] Rehabilitation research center , Iran University of Medical Sciences, Tehran, Iran.
https://orcid.org/0000-0002-4817-7476

Nahid Jalilevand[1,2*]

https://orcid.org/0000-0002-4158-495X

Mohamad Kamali[2,3]

[3] Department of Rehabilitation Management, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran

https://orcid.org/0000-0002-4261-7362

Abstract

Background and Aim: Early intervention with cochlear implantation for deaf children helps them acquire receptive and expressive language. Word learning is one aspect of language acquisition. The current study aimed to evaluate receptive vocabulary in deaf children who received cochlear implants (CIs).

Methods: A descriptive-analytical cross-sectional survey was conducted with 90 study participants. The participants included thirty children with CIs and sixty normal-hearing children. The hearing ages of the children with CIs ranged from 2 to 57 months, with chronological ages between 32 and 71 months.

The Receptive Picture Vocabulary Test in Persian (RPVT-P) was used to evaluate children's vocabulary. Parametric t-tests and Pearson correlation were used to analyze and compare the data.

Results: There was a significant relationship between the total score of the RPVT-P and chronological ages of NH children ($r = 0.842$, $p < 0.0001$), and children with CIs ($r = 0.824$, $p < 0.0001$)

There was a significant relationship between the total score of the RPVT-P and hearing age of children with CIs ($r = 0.658$, $p < 0.0001$). There was a significant difference between children with CIs and NH children in the total scores for each item of the RPVT-P

($p < 0.0001$).

Conclusion: Children with cochlear implants gradually develop their understanding of vocabulary, but they do not reach the same level of skills as typically developing children. Children with CIs can acquire various types of vocabularies.

Key words: Cochlear implants, deaf, hearing impairment, receptive language, vocabulary

Highlights

Children with cochlear implants (CIs)can learn vocabulary in various categories
Children who received a late CIs demonstrate lower vocabulary knowledge than NH peers
Children's vocabulary increases with more auditory experience after CI

Introduction:

Vocabulary is the foundation of language. It consists of all the words that an individual understands and uses for communication. Receptive vocabulary refers to the ability to understand meaning of words that are heard. Vocabulary knowledge helps individuals use words appropriately in communication. It is divided to receptive and productive vocabulary [1].Vocabulary knowledge is a criterion for evaluating speech understanding; therefore, vocabulary is an indicator of the level of verbal learning [2]. All children need to understand a wide range number of words for academic development. Marchman and Fernald found that child's vocabulary knowledge predicts their language and cognitive abilities in school age [3].

Cochlear implants (CIs) enable deaf children to learn spoken language. A comparison of the language comprehension and expression abilities of deaf children who use cochlear implants and deaf children who use hearing aids shows the influence of cochlear implants on oral language development [4,5].

Baldassari et al. showed that children who received CIs had a larger receptive vocabulary compared to those who were deaf and used hearing aids[6].

However, language skills of children who received CIs are never on par with those of their normally hearing peers [5]. Lund concluded that vocabulary knowledge of children with CIs is poorer than their peer in school [7]. In many studies, the tool used to assess vocabulary comprehension is the Peabody Picture Vocabulary Test (PPVT). The PPVT contains 228 items grouped in 19 sets with 12 items each [8].

Most of studies have found that the mean PPVT scores of children with CIs were lower than those of typically hearing peers [9,10]. Eisenberg et al. compared the receptive vocabulary scores of children in a group with CIs to those of children with normal hearing and children with hearing loss . They found a delay in vocabulary development in children who receive CIs [11]

Studies show that there is a significant difference in vocabulary knowledge between deaf children and their NH peers[12]. However, early intervention through cochlear implantation helps deaf children rapidly learn vocabularies and approach the abilities of NH children [13]. NH children quickly acquire vocabulary . The number and complexity of words they use reflect the opportunities they have experienced. The most common words that young children use are nouns and verbs and among earliest nouns NH children use food and animals and count nouns [2].

The goal of this study was to examine receptive vocabulary in Persian-speaking children with CIs. We utilized the Receptive Picture Vocabulary Test for Persian – speaking children (RPVT-P)[14]. The RPVT-P included 240 color pictures (items) divided into 15 subtests including tools, objects, body parts, verbs, clothes, edibles, animals, means of transportation, adjectives, occupations, animals body parts, places, plants components, colors, and nature. Each subtest
consisted of 16 pictures.

The current study aimed to answer the following questions:

- Is vocabulary comprehension related to age of hearing?
- Do children with cochlear implants understand vocabulary across different categories?

Methods:

Participants

Participants in the current descriptive-analytical , cross-sectional study were 90 children aged 30 to 71 months. This group included 60 children with normal hearing and thirty children of both genders aged from 32 to 72 months, who had been unilateral CIs users. The duration of implantation ranged from 2 to 57 months. All of the children received unilateral CIs after the age of 12 months. 73% of children with CIs were implanted before 3

years old. Prior implantation all of them had used hearing aids and participated in a speech therapy program. The sampling was conducted at medical, educational centers and kindergartens in Yazd city.
The typically developing children's parents completed the Age & Stage Questionnaire (ASQ) [15] and the scores for each domain including communication, fine motor, gross motor, personal, social and problem-solving skills were all within the normal range. They had no history of neurological problems, seizures, brain damage or any oral structural or functional abnormalities.
The hearing-impaired children had severe to profound hearing loss and were able to hear using a cochlear implant. All of them had experience with hearing aid before getting the implant. Their chronological ages ranged from 32 to 71 months . Hearing ages (HA) were calculated as chronological age (CA) minus age at implantation [2] .
Based on the parents reports and clinical reports, the children who used CIs had no history of neurological problems, seizures, brain damage or any oral structural or functional abnormalities .

Materials:
The RPVT-P was used for the evaluation of receptive oral language [14].
Hassanpour e t al. developed the paper-based version of RPVT-P (first version). They reported a value of 0.909 for Cronbach's α, indicating good internal consistency [16].
Hydarpanahi et al developed the computer-based version of the RPVT-P. The sample size in this study was 105 Persian-speaking children aged 30-71 months. They reported a value of 0.95 for Cronbach's α, indicating good internal consistency [14].
Jalilevand et al. studied the psychometric evaluation of the computer-based version of RPVT-P. The participants in this study divided in 2 groups: 434 typically developed Persian-speaking children aged 30-71 months and 16 children with Down syndrome (DS). The RPVT-P is a valid and reliable tool to measure receptive vocabulary in preschool Persian-speaking children [17].

Data collection:
The computer-based version of RPVT-P was used for receptive vocabulary assessment [14]. A laptop was used to display pictures to the children. Each page of the test contained 4 pictures. The examiner (first author) an experienced speech language pathologist examined all participants. She was trained to use the computer-based version of RPVT-P. The assessment of RPVT-P has been conducted individually.
The examiner encouraged the child to point to the picture associated with the word after hearing each word . The examiner then marked a check (√) on the test form. Each check (√) equals 1 point.
The RPVT-P includes 240 color pictures (items) divided into 15 subtests , with each subtest consisting of 16 pictures. Therefore, the minimum score for each subtest is zero and the maximum score is 16. The minimum total score for all 15 subtests is zero and the maximum score is 240 .
Statistical analysis

Statistical analysis was carried out in SPSS v.17 software. A Kolmogorov–Smirnov test was conducted to analyze the distribution of the data. The normal distribution of data was confirmed and parametric statistical tests were used. The statistical significance level was $P<0.05$. A t-test was performed to compare two groups: NH children and CIs users' children with a confidence interval of 95% and a significance level of 0.05 were considered. The correlation between variables (the chronological age, Hearing age and the total scores of RPVT-P) was measured using the Pearson correlation coefficient (r). Correlations between 0.70 and 1.00 (or -0.70 and -1.00) represent strong relationships between variables.

Results:
Table 1 presents the characteristics of participants including the mean age with standard deviation as well as the number and percentage of participants based on sex.
Table 2 shows the chronological age, cochlear implantation age, hearing age and total RPVT-P scores of each participant child with CIs. It shows that 50% of children with CIs received implantation between 14 and 28 months of age and 23% between 30 and 35 months of age.
There was a significant relationship between the total score of the RPVT-P and hearing age of children with CIs ($r = 0.658$, $p < 0.0001$).

Figure 1 shows the relationship between RPVT-P scores of children with CIs and their hearing age.
Table 3 shows the mean (±SD) total scores of the RPVT-P results for children with CIs and NH children. There was a significant relationship between the total score of the RPVT-P and chronological ages of NH children ($r = 0.842$, $p < 0.0001$), and children with CIs ($r = 0.824$, $p < 0.0001$).
Figure 2 shows the relationship of RPVT-P scores and chronological ages of two groups.
Table 4 shows the mean (±SD) total scores for each item and total scores of the RPVT-P as well as t- test results comparing children with CIs to NH children. There is a significant difference in total scores of the RPVT-P between children with CIs and NH children (($t(88) = 7.481$, $p < .0001$). Additionally, there is a significant difference the total scores for each item of the RPVT-P between children with CIs and NH children ($p<0.0001$).
Table 4 shows the maximum mean (±SD) total scores of items objects and edibles in two groups. The mean scores for adjectives, occupations, plant components and colors were lower for children with CIs and NH children compared to other items.

Discussion:
Nowadays hearing-impaired children receive cochlear implants to restore their hearing and communicate with others using verbal communication. However, their verbal communication skills vary and depend on several factors.
The neurosensory of the auditory system develop in the period from 25 weeks' gestation to 5 to 6 months of age[18] And communication skills dramatically increase between 8 and 12 months [19] Many evidences demonstrated that children understand words between 9 and 15 months of age[20] Therefore, the deaf children who do not receive auditory experiences before the age of one are likely to fall behind their hearing children peers in terms of language development in the future.
The goals of the current study were to answer two questions. In response to the first question, the results showed a positive relationship between hearing age and total scores of RPVT-P. Therefore, as children's auditory experience with cochlear implants increases, their understanding of words also improves. Additionally, there was a positive relationship between chronological age and total RPVT-P scores. Therefore, as children with CIs grow older and gain more experience with hearing , their vocabulary knowledge will also increase. In the current study, none of the participants with hearing problems had bilateral implants and none of them were implanted before the age of one year .73% of participants received unilateral implantation between 14 and 35 months of age, and 27% were implanted after the age of 3 years old. The results showed the total RPVT-P scores of children with CIs were poorer than those of NH children.
Busch et al. studied the receptive vocabulary of 88 children with bilateral CIs aged 3 to 16 years[21]
. They found that the receptive vocabulary of children with CIs was lower than that of NH children. Our findings align with those of Busch et al. [21]
The findings of a meta-analysis research showed that children with CIs in all studies had significantly weaker receptive vocabulary skills [7]. In this meta-analysis research, Lund reported mean ages of implantation ranging from 16 to 46.5 with the majority of children being implanted before 30 months of age [7].
The hearing age and chronological age of normal children are typically the same. However there is a significant gap between the hearing age and chronological age of implanted children. As a result, their auditory experience is less than that of normal children. Culbertson et al concluded that the earlier the age of implantation the more significant the improvement in hearing skills [22]. Wenrich et al. studied the effects of early intervention for receiving a CIs and reported that cochlear implantation in infants is crucial for developing receptive vocabulary skills [23]. Connor et al. reported that the receptive vocabulary scores of those who received CIs between 12 and 30 months of age approached the average scores of normally hearing (NH) children [24]. Hayes et al. evaluated children with CIs who were implanted before the age of five. The results showed that children who were implanted before the age of two had receptive vocabulary scores within the normal range for typical children [10]. Therefore, a delay in the onset of hearing will have an adverse effect on the processing of speech sounds [25]. Fagan and Pisoni evaluated the receptive vocabularies of children with CIs between the ages of 6 and 14 years, with hearing ages (duration of cochlear implant use) ranging from 3.7 to 11.8 years . They utilized the PPVT-III and found that all participants understood all PPVT-III content categories but their mean scores were below the standard scores for hearing children [2].

Culbertson et al. concluded that early intervention with bilateral CIs promotes development of auditory skills [22]. Alshahrani et al reached the same conclusion in a systematic review study which revealed that bilateral implantation enhance auditory communication [26].
The answer to the second research question in the current study is as follows:
The RPVT-P includes 240 items divided into 15 subtests covering tools, objects, body parts, verbs, clothes, edibles, animals, means of transportation, adjectives, occupations, animals body parts, places, plants components, colors, and nature.
The data analysis revealed a significant difference in total scores for each item of the RPVT-P between children with CIs and NH children. Therefore, the vocabulary knowledge of children with CIs was not equal to that of NH children in the current study.
The mean (±SD) total scores of each item on the RPVT-P indicated the abilities of children in all 15 subtests. The highest mean score among children with cochlear implants was for the edibles and objects items. The NH children also had the highest mean scores for edibles and objects. However, comparing the mean scores of edibles and objects in both groups showed a significant differences. Therefore, edibles and objects are likely simple word categories for learning. The mean scores for adjectives, occupations, plant components and colors were lower for children with CIs and NH children compared to other items. It seems that adjectives, occupations, plant components and colors are difficult word categories for learning. It appears that the vocabulary knowledge of children depends on the extent of their experiences.
Hart and Risley suggested that repetition and frequency exposure have an effect on learning words[27]
Fagan and Pisoni reported that children with CIs understood words from all areas of the PPVT-III; however their vocabulary size varied according to their auditory experience or hearing age [2].
The current study included 30 participants with CIs. It is recommended that future research be conducted with a larger sample size of children in this group.

Conclusion:
Children with hearing impairments who have received cochlear implants acquire vocabulary knowledge . Increasing auditory experiences can significantly impact their ability to learn more vocabulary. Children with CIs can learn various vocabulary categories but their vocabulary knowledge is less developed compared to typically hearing children.

Ethical Considerations
This study was approved by the Research Ethics Committee in IUMS (IR.IUMS.REC.1402.1125). All of the parents completed and signed informed consent.

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Conflict of interest
The authors declare no conflict of interest.

Author contributions
SZ: Study design, acquisition of data, interpretation of the results, statistical analysis, and drafting the manuscript;
AG: Study design, interpretation of the results, and drafting the manuscript;
N J: Interpretation of the results and drafting the manuscript, editing.
MK: study design, statistical analysis.

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Table 1. Descriptive statistics of participants

Groups	Chronological age (months)	N	Chronological age(months) Mean±SD	Sex N Girls	N Boys
Normal hearing	30-71	60	54.81±11.52	31	29
Children with CIs	32-71	30	61.33±11.09	17	13

CI: Cochlear Implants
N: Number
SD: Standard Deviation

Table 2. Receptive Picture Vocabulary Test in Persian total scores in children with Cochlear Implants

NO.	Chronological ages (months)	Age of Implantation (months)	Hearing ages (months)	RPVT-P Total scores
۱	۶۷	65	2	۱۶۸
۲	32	28	4	53
۳	61	53	8	125
۴	58	46	12	170
۵	36	23	13	77
۶	41	17	24	81
۷	69	45	24	221
۸	47	22	25	156
۹	52	24	28	181
۱۰	53	24	29	139
۱۱	70	40	30	204
۱۲	70	40	30	128
۱۳	60	30	30	165
۱۴	69	37	32	178
۱۵	71	39	32	198
۱۶	57	24	33	187
۱۷	67	33	34	212
۱۸	60	26	34	190
۱۹	49	14	35	147
۲۰	59	24	35	192
۲۱	71	35	36	198
۲۲	71	34	37	181
۲۳	69	30	39	179
۲۴	70	31	39	216
۲۵	63	23	40	192
۲۶	71	31	40	206
۲۷	68	26	42	203
۲۸	68	24	44	194
۲۹	70	24	46	215
۳۰	71	14	57	214

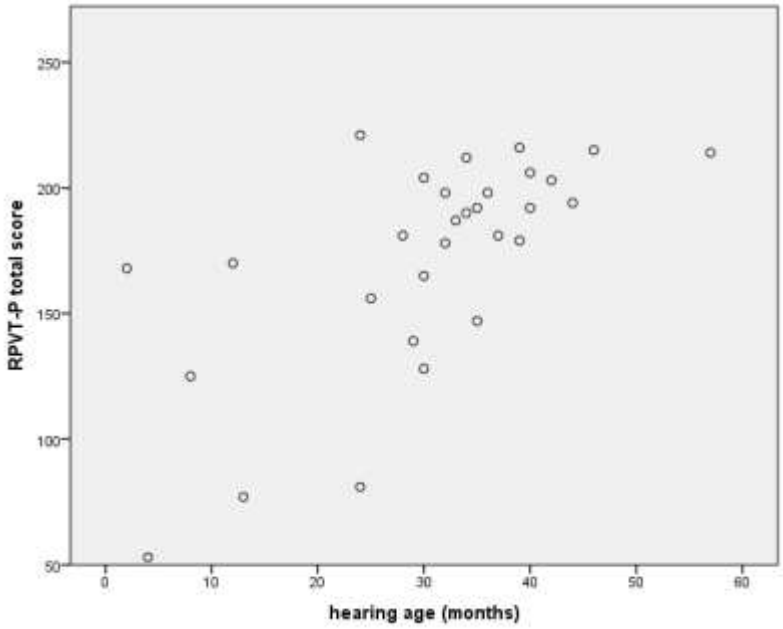

Figure 1 The relationship between Receptive Picture Vocabulary Test in Persian scores of children with Cochlear Implants and their hearing age

Table 3. The mean (±SD) total scores of the Receptive Picture Vocabulary Test in Persian results for children with Cochlear Implants and Normal Hearing children

Chronological ages (months)	Group	N	Mean	(±SD)	Max	Min
30-40	NH	۷	۱۹٤/۸٥	۱٤/۰۷	۲۲۱	۱۷٥
	CIs	۲	٦٥	۱۲	۷۷	٥۳
٤۱-50	NH	۱۸	۲۱۰/۸۸	۸/٤٥	۲۲۲	۱۸۹
	CIs	۳	۱۲۸	۳۳/٤۳	۱٥٦	۸۱
٥۱-60	NH	۱۳	۲۲۱/۲۳	٦/۸۷	۲۳٦	۲۱۲
	CIs	۷	۱۷٤/۸٥	۱۷/۳۸	۱۹۲	۱۳۹
٦۱-71	NH	۲۲	۲۲۷/۹٥	۲/۸٦	۲۳۲	۲۲۱
	CIs	۱۸	۱۹۰/٦٦	۲٦/۸٥	۲۲۱	۱۲٥
30 -71	NH	60	217.52	13.29	236	175
	CIs	30	172.33	43.06	221	53

N: Number
SD: Standard Deviation
Max: Maximum
Min: Minimum

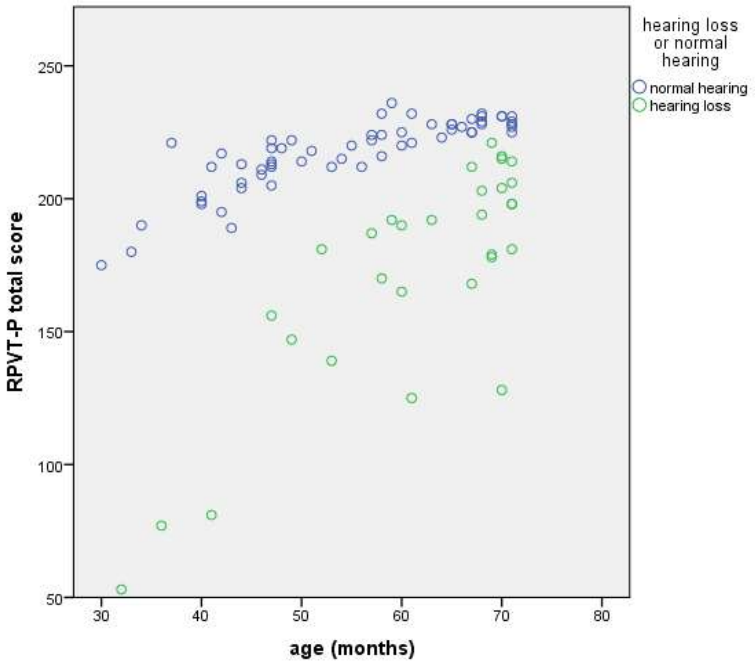

Figure 2. The relationship of Receptive Picture Vocabulary Test in Persian (RPVT-P) scores and chronological ages of two groups

Table 4. The descriptive statistics and t-test results of total scores of each item of the Receptive Picture Vocabulary Test in Persian

Items	CIs	NH	df	t	P
Tools	11.67 (± 2.79)	14 (±1.67)	88	4.940	0.000
Objects	14.40 (± 2.51)	15.92(±0.42)	88	4.571	0.000
Body parts	12.60 (±2.061)	14.52(±1.24)	88	5.494	0.000
Verbs	12.83 (±3.04)	15.58(±0.96)	88	6.422	0.000
Clothes	11.70 (±3.06)	14.72 (±1.46)	88	6.340	0.000
Animals	12.03 (±3.16)	14.45 (±1.38)	88	5.045	0.000
Edibles	13.47 (±3.12)	15.73 (±0.51)	88	5.497	0.000
Means of transportation	11.73 (±3.29)	14.63 (±1.72)	88	5.497	0.000
Adjectives	8.90 (±3.82)	13.47 (±1.97)	88	7.482	0.000
Animal body parts	11.47 (±3.26)	14.75 (±1.24)	88	6.881	0.000
Occupations	9.59 (±3.53)	13. 10 (±1.96)	88	6.224	0.000
Places	11.80 (±3.67)	15.05 (±0.98)	88	6.444	0.000
Plants components	9.50 (±3.97)	13.97 (±1.58)	88	7.616	0.000
Nature	11.20 (±3.56)	14.68 (±1.18)	88	6.875	0.000
Colors	9.53 (±3.54)	12.95 (±1.38)	88	6.568	0.000
Total scores	172.33 (±3.54)	217.52 (±43.06)	88	7.481	0.000

CIs: Cochlear Implants
NH: Normal Hearing