Auditory and Vestibular Research

The Receptive Vocabulary Knowledge of Persian-Speaking Children with Cochlear Implants Compared to Normal-Hearing Peers

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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 knowledge of deaf children who had received cochlear implant (CI) compared to their normal-hearing (NH) peers.

Methods: This is a descriptive-analytical study with a cross-sectional design that was conducted on 90 Persian-speaking children (30 with CIs and 60 with normal hearing). The hearing age (HA) of children with CIs ranged from 2 to 57 months, and their chronological age (CA) was in the range of 32-71 months. The Persian version of the Peabody picture vocabulary test (RPVT-P) was used to evaluate the children's vocabulary knowledge. The t-test and Pearson's correlation test were used to analyze and compare the data.

Results: There was a significant relationship between the total RPVT-P score and CA in both NH children ($r= 0.842$, $p<0.001$), and CI children ($r = 0.824$, $p<0.001$). There was a significant relationship between the total RPVT-P score and HA in children with CI ($r = 0.658$, $p<0.001$). There was a significant difference between the two groups of children in the scores of each RPVT-P item ($p<0.001$).

Conclusion: Persian-speaking children with CI gradually develop their receptive vocabulary knowledge, but they do not reach the same level of skills as their NH peers. Children with CI can learn various vocabularies.

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

Highlights
- Persian-speaking children with CI can learn various vocabularies
- Persian-speaking children with CI have lower vocabulary knowledge than NH peers
- Children's vocabulary increases with gaining 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 perception; therefore, vocabulary is an indicator of the verbal learning level [2]. All children need to understand several number of words for academic development. Marchman and Fernald found that the children'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 with CI and those using hearing aids showed the influence of CIs on verbal language development [4,5]. Baldassari et al. showed that children with CI had a larger receptive vocabulary compared to hearing-impaired children with hearing aids [6]. However, language skills of children with CI are never on par with those of normal-hearing (NH) peers [5]. Lund concluded that vocabulary knowledge of children with CI is poorer than that of NH peers in schools [7]. In many studies, the tool used to assess vocabulary comprehension is the Peabody picture vocabulary test (PPVT) which contains 228 items grouped into 19 sets each with 12 items [8]. Many studies have reported that the mean PPVT score of children with CI is lower than that of NH peers [9,10].

Eisenberg et al. compared the receptive vocabulary scores of children with CI, children with NH, and children with hearing loss. They found a delay in vocabulary development in children who received CI [11]. 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 the earliest nouns that NH children use include name of foods, animals, and numbers [2].

This study aimed to assess the receptive vocabulary knowledge of Persian-speaking children with CI. We used the Persian version of the RPVT (RPVT-P) [14]. It includes 240 color pictures (items) divided into 15 subtests including tools, objects, body parts, verbs, clothes, edibles, animals, transportation vehicles, adjectives, occupations, animal body parts, places, plants components, colors, and nature. Each subtest consisted of 16 pictures. The current study is an attempt to answer the following questions: Is vocabulary comprehension related to hearing age (HA)? Do children with CI understand vocabulary across different RPVT-P items?

Methods
Study design and participants
In this descriptive-analytical study with a cross-sectional design, participants were 90 Persian-speaking children from both genders, 60 with normal hearing aged 30-71 months and 30 hearing-impaired children aged 32-71 months using unilateral CIs (with a cochlear implantation duration or HA of 2-57 months, all received unilateral CIs after the age of 12 months and 73% were implanted before 3 years old). Prior to cochlear implantation, all hearing-impaired children had used hearing aids and participated in a speech therapy program. The sampling was conducted at medical/teaching hospitals and kindergartens in Yazd city. The NH children's parents completed the age & stage questionnaire (ASQ) [15]. Based on the scores for each domain, the communication, fine motor, gross motor, personal, social and problem-solving skills of children were all within the normal range. Based on the parents' reports and clinical reports, the children in two groups had no history of neurological problems, seizures, brain damage or any verbal, structural, or functional abnormalities. The hearing-impaired children had severe to profound hearing loss and were able to hear using a CI. All of them had experience with hearing aid use before getting the CI. The HA was calculated as chronological age (CA) minus age at cochlear implantation [2].

Measure
The RPVT-P was used for the evaluation of receptive oral language [14]. Hassanpour et al. developed the paper-based version of RPVT-P (first version). They reported a Cronbach's α value of 0.909, indicating good internal consistency [16]. Hydarpanahi et al. developed the computerized version of the RPVT-P, by including 105 Persian-speaking children aged 30-71 months. They reported a Cronbach's α value of 0.95, indicating good internal consistency [14]. Jalilevand et al. examined the psychometric properties of the computerized version of RPVT-P. The participants in their study were 434 Persian-speaking NH children aged 30-71 months and 16 children with Down syndrome. They suggested that RPVT-P is a valid and reliable tool to measure receptive vocabulary in preschool Persian-speaking children [17]. We used the computerized version of RPVT-P. A laptop was used to display pictures to the children. Each page of the test contained 4 pictures. The first author (an experienced speech-language pathologist with previous training to perform the RPVT-P) examined all participants. The RPVT-P was performed individually. The examiner asked the children to point to the picture associated with the word after hearing each word. The examiner then check marked on the test form. Each check mark was equal to 1 point. In the RPVT-P, the score of each subtest ranges from 0 to 16, and the total score ranges from 0 to 240.

Statistical analysis

Statistical analysis was carried out in SPSS v.17. The Kolmogorov–Smirnov test results confirmed the normal distribution of data. Therefore, parametric statistical tests were used. The statistically significance level was set at 0.05. The t-test was used to compare the two groups. The correlation between variables (CA, HA, and total RPVT-P score) was measured using the Pearson correlation test. A correlation coefficient in the range of 0.70-1.00 (or from -0.70 to -1.00) represents a strong correlation between the study variables.

Results

The characteristics of participants including age and sex is shown in Table 1. CA, age at cochlear implantation, HA, and total RPVT-P score of participants with CI (Table 2). As can be seen, 50% of these children received cochlear implantation at the age of 14-28 months and 23% at the age of 30-35 months. There was a significant relationship between the total RPVT-P score and HA in children with CI ($r = 0.658$, $p<0.001$) (Fig.1)

Table 3 shows the mean total RPVT-P scores of children with CI and NH children. There was a significant relationship between the total RPVT-P score and CA in NH children ($r = 0.842$, $p<0.001$) and in children with CI ($r = 0.824$, $p<0.001$) (Fig. 2). Table 4 shows the mean scores for each item of the RPVT-P and the t-test results for comparing children with CI and NH children. There was a significant difference in total RPVT-P score between children with CI and NH children (t=7.481, $p<0.001$). Additionally, there was a significant difference in the score of each item of the RPVT-P between the two groups of children (p<0.001). Table 4 shows the maximum mean scores of items "objects" and "edibles" in two groups. The mean scores for adjectives, occupations, plant components and colors were lower in both CI and NH children compared to other items.

Discussion

Hearing-impaired children receive CI to restore their hearing and verbally communicate with others. However, their verbal communication skills vary and depend on several factors. The neurosensory of the auditory system is developed from the 25th weeks of gestation to 5-6 months of age [18], and communication skills dramatically increase between 8 and 12 months of age [19]. There is an evidence that children understand words at the 9-15 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.

In response to the first question of the study, the results showed a positive relationship between HA and total RPVT-P scores. Therefore, as children's auditory experience with CI increases, their understanding of words improves. Additionally, there was a positive relationship between CA and total RPVT-P score. Therefore, as children with CI grow older and gain more hearing experience, their vocabulary knowledge increases. In the current study, none of the children with hearing problems had bilateral CI and none of them were implanted before the age of one year; 73% had received unilateral CI between the age of 14 and 35 months, and 27% were implanted after the age of 3 years. The results showed the total RPVT-P score of children with CI was lower than that of NH children. Busch et al. studied the receptive vocabulary of 88 children with bilateral CI aged 3-16 years [21]. They found that the receptive vocabulary of CI children was lower than that of NH children. Our findings are consistent with their findings. A meta-analysis study also showed that CI children had significantly poorer receptive vocabulary skills. In this research, it was reported that mean age at implantation ranged from 16 to 46.5 months with the majority received CI before 30 months of age [7].

The HA and CA of NH children are typically the same, but there is a significant difference between them in CI children. As a result, their auditory experience is less than that of NH children. Culbertson et al. concluded that implantation at earlier age can lead to more significant improvement in hearing skills [22]. Wenrich et al. studied the effects of early intervention for receiving a CI and suggested that cochlear implantation in infants is crucial for developing their receptive vocabulary skills [23]. Connor et al. reported that the receptive vocabulary scores of those who received CI between 12 and 30 months of age was close to the scores of NH children [24]. Hayes et al. evaluated children with CI who were implanted before the age of five years. Their results showed that children who were implanted before the age of two had receptive vocabulary scores close to the scores of NH children [10]. Therefore, a delay in the onset of hearing can have an adverse effect on the processing of speech sounds [25]. Fagan and Pisoni evaluated the receptive vocabularies of children with CI aged 6-14 years, with HA (duration of CI 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 lower than the scores of NH children [2]. Culbertson et al. concluded that early intervention with bilateral CI promotes the development of auditory skills [22]. Alshahrani et al. in a systematic review study also revealed that bilateral CI enhance the auditory communication [26].

In response to the second question of the study, the data analysis revealed a significant difference in score of each item of the RPVT-P between CI and NH children. Therefore, the vocabulary knowledge of children with CI was not equal to that of NH children in the current study. The highest mean score among children with CI was for the "edibles" and "objects" items. The NH children also had the highest mean scores in these items. However, there was a significant difference between the two groups. Therefore, edibles and objects seem to be simple word categories for learning. The mean scores for adjectives, occupations, plant components and colors were lower in both CI and NH children compared to other items. It seems that adjectives, occupations, plant components, and colors are difficult word categories for learning. The vocabulary knowledge of children may depend 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 CI understood words from all categories of the PPVT-III; however their vocabulary size varied according to their auditory experience or HA [2]. The current study had a small sample size of CI children. It is recommended that future research be conducted with a higher number of these children.

Conclusion
Children with hearing impairments who have received CI can acquire vocabulary knowledge. Increasing auditory experiences can significantly affect their ability to learn more vocabulary. Children with CI can learn various vocabulary categories but their vocabulary knowledge is less developed compared to NH 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

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

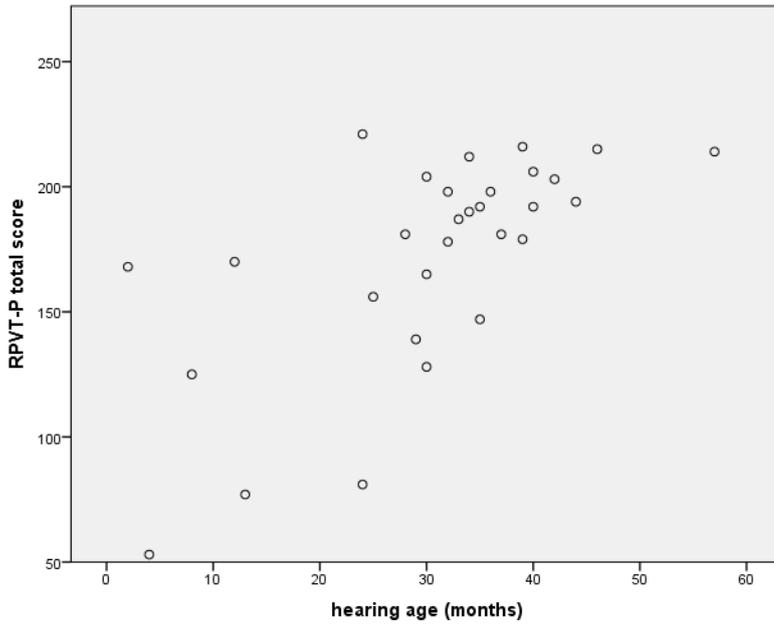| NO.	Chronological ages (months)	Age of Implantation (months)	Hearing ages (months)	RPVT-P Total scores
1	67	65	2	۱۶۸
2	32	28	4	53
3	61	53	8	125
4	58	46	12	170
5	36	23	13	77
6	41	17	24	81
7	69	45	24	221
8	47	22	25	156
9	52	24	28	181
10	53	24	29	139
11	70	40	30	204
12	70	40	30	128
13	60	30	30	165
14	69	37	32	178
15	71	39	32	198
16	57	24	33	187
17	67	33	34	212
18	60	26	34	190
19	49	14	35	147
20	59	24	35	192
21	71	35	36	198
22	71	34	37	181
23	69	30	39	179
24	70	31	39	216
25	63	23	40	192
26	71	31	40	206
27	68	26	42	203
28	68	24	44	194
29	70	24	46	215
30	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

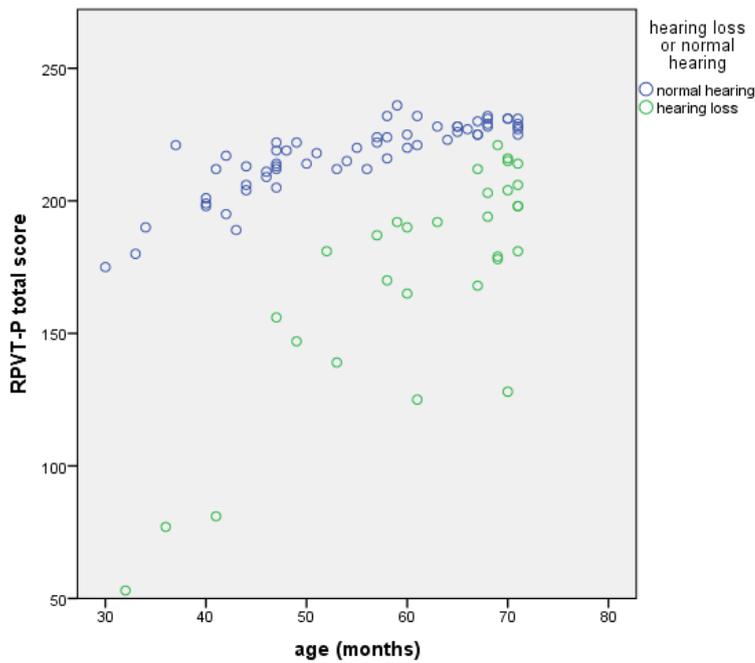| Chronological ages (months)	Group	N	Mean	(±SD)	Max	Min
30-40	NH	٧	١٩٤/٨٥	١٤/٠٧	٢٢١	١٧٥
	CIs	٢	٦٥	١٢	٧٧	٥٣
٤١-50	NH	١٨	٢١٠/٨٨	٨/٤٥	٢٢٢	١٨٩
	CIs	٣	١٢٨	٣٣/٤٣	١٥٦	٨١
٥١-60	NH	١٣	٢٢١/٢٣	٦/٨٧	٢٣٦	٢١٢
	CIs	٧	١٧٤/٨٥	١٧/٣٨	١٩٢	١٣٩
٦١-71	NH	٢٢	٢٢٧/٩٥	٢/٨٦	٢٣٢	٢٢١
	CIs	١٨	١٩٠/٦٦	٢٦/٨٥	٢٢١	١٢٥
30 -71	NH	60	217.52	13.29	236	175
	CIs	30	172.33	43.06	221	53

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