Original Article

A comparison of Linguistic Skills between Persian Cochlear Implant and Normal Hearing Children

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Objectives: A large number of congenitally deaf children are born annually. If not treated, this will have destructive effects on their language and speech development, educational achievements and future occupation. In this study it has been tried to determine the level of language skills in children with Cochlear Implants (CI) in comparison with Normal Hearing (NH) age-mates.

Methods: Test of Language Development was administered to 30 pre-lingual, severe-to-profound CI children between the ages of 5 to 8. The obtained scores were compared to a Persian database from scores of normally hearing children with the same age range.

Results: Results indicated that in spite of great advancements in different areas of language after hearing gain, CI children still lag behind their hearing age-mates in almost all aspects of language skills.

Conclusion: Based on the results, it is suggested that children with average or above average cognitive skills who use CI have the potential to produce and understand language comparable to their normally hearing peers.

Keywords: Cochlear Implant, Language Development, Phonological Skills, Semantic Skill, Syntactic Skill

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Introduction

A large number of congenitally deaf babies are annually born. If untreated, this deafness will have destructive effects on their language and speech development, educational achievements and future employment. The most effective communication system for children with impaired hearing loss is controversial. Some children learn a sign language, others wear an external hearing aid or receive a cochlear implant to enhance their ability to sense auditory stimuli and acquire the perception and production of spoken language (1). Since those with a severe hearing loss cannot hear conversational speech at all (although they can perceive speech and environmental sounds) and individuals with profound loss cannot hear any sound whether speech or environmental, to facilitate their perception of clear and intact spoken language and environmental sounds, consistent use of appropriate amplification is suggested.

It is suggested that any degree of hearing loss that affects the ability to acquire acceptable speech and language skills is devastating. Children with impaired hearing fail to overhear the language around them, leading to delayed affective development, ineffective reinforcement and difficulties in monitoring their environment. Everything they learn must be directed towards them. Consequently, they have limited experience, which affects their behavior in novel situations (1).

Since most of a child's learning occurs through hearing and that profound hearing loss has a significant effect on the reduction of the received environmental information and consequently a decrease in language learning, and while also adding that post cochlear implant evaluations and post therapies exhibit that these children demonstrate less abilities compared to their coetaneous even at further stages, the recognition and the examination of language skills assist the therapists and the therapy team to set their treatment procedures based on such research findings so that the language distance between these children and normal children is reduced to the most possible extent.

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Better understanding of the technology and of which children would be suitable for cochlear implant will emerge as valid research methodologies describe the progress of these children, implanted at different ages with differing social, cognitive and support profiles (2). Studies have explored the language skills of children with Cochlear Implants (CI)s compared to Normal Hearing (NH) peers. (3-14).

They indicate some areas of language are more difficult for these children to have command on than other areas. In some studies, vocabulary was a particularly strong language skill and scores on expressive vocabulary reached age-appropriate levels sooner following cochlear implantation than scores on receptive vocabulary tests which may have been associated with teaching strategies that encourage labeling in beginning language instruction (4). Other studies tried to describe the speech recognition, where some participants in the CI group approached levels of performance comparable to those of the NH children (5).

Recent works have investigated the gap between the semantic skills of children with CI and children with NH. These works have examined receptive and expressive vocabulary and grammar achievement. Half the participants displayed language levels on par with similar-age peers at the word level; less than half the children obtained average performance at the sentence level. In three of these profiles, comprehension of sentences was impaired (7).

Other works have studied the differences between the syntactic skills of CI and NH children and the productivity of lexical categories of hearing-impaired CI children (8-12). It was suggested that the morphological development of CI children did not follow the typical developmental pattern, but rather was influenced by the extent to which morphological forms were perceptually prominent. Copula probes were higher than noun plural probes for almost all the participants. This trend was different from the development pattern in normal children as well as from the development pattern in speech/language impaired subjects (10). It is suggested that spoken language grammar remains an area of delay for many such children. And there is a need to ensure that the ongoing educational management of these deaf children with implants addresses their spoken grammar delay in order that they can benefit more fully from formal education (12).

Differences in phonological production skills between NH children and CI children have also been investigated (13,14).

Since the discussions on cochlear implantation are almost a recent topic of interest, every piece of research is of utmost value and is welcomed. Although a plethora of studies have been carried out on different aspects of linguistic abilities of disabled children in developed countries, to the best of the knowledge of the present researchers, no study has been carried out on this aspect in the context of Iran. It seems that such a study is needed in this context on the Persian language with its specific semantic, syntactic, and phonological features.

Moreover, each of the studies reported above have focused on only a particular linguistic aspect. In other words, there is a need for a thorough investigation of the language ability of CI children and a comparison with their normally hearing age mates.

The Current Study

The main purpose of the present study is to determine the linguistic ability (that is, semantic, syntactic, and phonological knowledge) of CI children between ages 5 to 8 in comparison with NH children with the same age range. More specifically, the study aims at answering the following questions:

1. Is there a significant difference between the semantic skills of children with CI and those of NH children?
2. Is there a significant difference between the syntactic skills of children with CI and those of NH children?
3. Is there a significant difference between the phonological skills of children with CI and those of NH children?

Methods and materials

Participants

For the administration of this study, there were two groups of participants, a group consisting of CI children and the other, NH children. The needed data were collected from the implanted group during a six month period, while the data for the hearing group were gathered occasionally and according to the implanted group. Form the 30 participants (18 male and 13 female patients) in the CI group, 25 children were those that had been operated in the CI center in Khalili Hospital, Shiraz, Iran, or had visited the hospital for the follow up therapeutic sessions, while 5 other participants were selected from Soroush Kindergarten, Shiraz, Iran, a nursery especially for those children with hearing inabilities. The CI group ranged in age from five to eight. The criteria for selecting the subjects were as follows:

1. The participants who had been born congenitally as severe to profound hearers;
2. They had no indispositions other than hearing
3. They were expected to have at least one year of experience with the device;

In order to control the effect of intelligence, the IQ level of these children was determined, too; this would ensure us that they were similar to NH children with respect to this variable and that any probable differences were not due to their intelligence.

The second group comprised of 30 NH children who were matched based on gender and age with the first group within the same age range as CI group, ± 3 months. The participants in this group were selected from Kharazmi School, Ayineha Kindergarten, and Navid Language Institute. These children, too, took an IQ test to ensure that they were at the same level as the CI children.

The participants of the each group were divided into two groups based on their age and the measure of IQ assessment: under six (from 5 to 6) and over 6 (from 6 to 8). The mean age for the under six in the CI group was 5.5 with a mean IQ score of 107; the mean age of the participants in the under six in the NH group was 5.5 with a mean IQ score of 117. The mean age for the participant over six in the CI group was 6.10 with a mean IQ score of 96. The participants in the over 6 NH group with a similar mean age as the CI group gained a mean IQ score of 108.

Materials

The first material used in the present study was an IQ test. The test was the nonverbal subscale of the Wechsler Intelligence Scale for Children-Revised (WISC-R) and WIPSI. The WISC belongs to the set of Wechsler intelligence scales by David Wechsler (15). It is an individual test that is presented orally and consists of 13 subscales divided into two scales: a verbal scale and a performance scale. The six verbal scale tests use language-based items and the seven non-verbal scales use visual-motor items. Verbal subscales except for one are oral questions without time limits. Non-verbal subscales all of which are timed are nonverbal problems. Some of which allow bonus points for extra fast work. Subscale scores, Although IQ scores, and factor index scores are based on the scores of the 2,200 children originally tested in a very carefully designed, nationwide sample; interpretation for any individual must be done with great care, especially in those who have unusual patterns of strengths and weaknesses. As with any test, internal and external factors such as anxiety, motivation, fatigue, rapport, and experience may invalidate test scores.

For this study, only the nonverbal subscale of the IQ test was made use of. From the eight subscale of the nonverbal component of the test, picture completion, picture arrangement, block design and object assembly were used. The Persian version of the test was standardized by Shahim in 1984/ 1363 and 1985/ 1364 in Shiraz and measures the IQ score of children ages six to fourteen years old. From the seven subscales of the nonverbal component of WISC-R, picture completion, picture arrangement, block design, and object assembly were used. The subscales of animal house and animal house retest, picture completion, mazes, geometric design, and block design were exploited from the WIPSI.

The WPPSI (1967) is designed for children aged from 4 to 6 and a half. The test is divided into six verbal and five performance subscales. For the purpose of this study, only the performance subscales of animal house and animal house retest, picture completion, mazes, geometric design and block design were exploited.

The performance part (non-verbal) of the test was used in order to find the IQ score of participants under 6 in both groups. This test was standardized by Shahim and Razavieh in 1367. The Wechsler Intelligence Scales for Children and Wechsler Preschool and Primary Scale of Intelligence are used for different purposes one of which is in determining the presence of a learning disability or a developmental delay as well as tracking intellectual development.

For the assessment of language development, Test of Language Development (TOLD) was used. The Test of Language Development (TOLD) by Newcomer and Hamill (1998) is an individually administered oral-response test that assesses the spoken language skills of children aged 4 to 12. TOLD is sometimes used as a language achievement test but it is mostly given to identify the strengths and areas that need to be worked on to aid in diagnosing mental retardation as well as speech delays, articulation problems, and other language disorders. This 225-item test involves a variety of activities including defining words, pronunciation, word/picture identification, and sentence imitation. Nine subscales cover the following areas: Picture Vocabulary (30 questions), Relational Vocabulary (30 questions), Oral Vocabulary (28 questions), Syntactic Understanding (25 questions), Sentence Imitation (30 questions), Morphological Completion (28 questions), and Word Discrimination (20 questions), Word Analysis (14 questions) and Word Articulation (20 questions). The test is un-timed but usually takes 40 minutes. Results are reported in terms of standard scores, percentile rankings, age equivalents, and a language quotient. Subscale scores are combined to produce assessments in the following areas: overall spoken language; listening (receptive language); speaking (expressive language); semantics (word meanings); and syntax (grammar) (16).

These subscales measure different aspects of oral language. The results of these subscales can be combined to form composite scores for the major dimensions of language: semantics and grammar; listening, organizing, and speaking; and overall language ability (16, 17). For the administration of this study all of the nine subscales of the standardized Persian version were used. For the assessment of syntax the three subscales of Syntactic Understanding, Sentence Imitation and Morphological Completion were exploited. In semantics Picture Vocabulary, Relational Vocabulary and Oral Vocabulary subscales were presented. For Phonology, Word Discrimination, Word Analysis and Word Articulation subscales were implemented.

Data Analysis

The Statistical Package for Social Sciences (SPSS) version 16 was used for data analysis. Independent Samples T-test was used to find the difference between the syntactic, semantic and phonological skills of CI and NH children.

Results

The Comparison between the Semantic Skills of CI and NH Children

The semantic component of TOLD is composed of 3 subscales of picture vocabulary, relational vocabulary, and oral vocabulary, all of which examine the participants' semantic competence in their language. The scores of each of the 3 subscale are added together to form the combinational score for semantics. CI and NH children were compared with respect to this language component. Table (1) presents the results of independent t-test run for the comparison between these two groups.

Table 1. T-test results for the difference between Semantic skills of CI and NH children

	t-test for Equality of Means			
	T	df	Sig.(2-tailed)	Mean Difference
Semantics	12.875	58	.000	-21.233

The analysis of the scores reveal that the mean score for semantics in CI children (M=25.4) is almost half of that of the NH children (M=46.63). The results of t-test indicate that the variation in the performance between the NH and the CI group is significant (t=-12.875, p<.001), which means that NH children had a higher semantic knowledge than their implanted peers.

The Comparison Between different subscales of semantics between CI and NH Children

Table (2) presents the means and SDs of the three subscales in semantics for CI and NH children as well as the results of t-test for the difference between the means of the two groups on the subscales.

Table 2. Means and standard deviations for individual semantic subscales

	Group	N	Mean	Std. Deviation	Std. Error Mean
Picture	Cochlear	30	7.50	2.529	.462
	Normal Hearing	30	21.40	1.037	.189
Relational	Cochlear	30	9.93	3.657	.668
	Normal Hearing	30	13.10	1.826	.333
Oral	Cochlear	30	7.97	2.606	.476
	Normal Hearing	30	12.13	1.592	.291

The analysis of the data presented in Table 2 shows that the mean for picture vocabulary in CI children (M=7.5) is far below the mean obtained from the performance of NH children (M=21.4). Furthermore, the table shows that the performance on relational vocabulary with the mean score of 9.93 for CI children appears to be less than that of the NH children (M=13.10). In addition, the results indicate that the mean score of oral vocabulary for CI children is 7.97 while the mean for NH children is 12.13.

Table 3 T-test results for the difference between Picture Vocabulary, Relational Vocabulary and Oral vocabulary of CI and NH children

	t-test for Equality of Means			
	T	df	Sig. (2-tailed)	Mean Difference
Picture	-27.851	58	.000	-13.900
Relational	-4.243	58	.000	-3.167
Oral	-7.473	58	.000	-4.167

Moreover, table (3) illustrates the results of three independent t-tests run to compare the performances of the two groups on the three subscales. As the data in the table indicate, the results show that the difference between the CI and NH group on picture vocabulary subscale is significant (t=27.85, p <0.001). This indicates that the vocabulary knowledge of NH group is better than CI group. Results also indicate that NH had a better performance on the relational subscale than CI (t= -4.243, p<.001). As for the oral subscale, results indicate that for this subscale, too, NH children perform better than their implanted peers (t=-7.473, p<.001).

The Comparison between the Syntactic knowledge of CI and NH Children

The syntactic component of TOLD is composed of 3 subscales of syntactic understanding, sentence imitation, and sentence completion. The scores of the 3 subscale are added together to form the combinational score for syntax. Table (4) presents the descriptive statistics and results of an independent samples t-test run to compare the syntactic knowledge of the two groups.

Table 4. T-test results for the difference between the syntactic skill of CI and NH children

	t-test for Equality of Means			
	T	df	Sig.(2-tailed)	Mean Difference
Syntax	-20.460	58	.000	-31.267

The analysis of the data presented in Table 4 shows that the mean score for syntax as a whole for CI children (M=15.1) is way below that of NH children who attain a mean score of 46.36. The t-test results are indicative of the better performance of the NH then the CI group (t=-20.460, P<0.001). This means that the scores of NH children for syntax in general exceed those of CI group.

The Comparison Between the performances of the two groups on syntax subscales

Table (5) presents the means and SDs of the three subscales in syntax for CI and NH children as well as the difference between the performances of the two groups on these subscales.

Table 5. Means and standard deviation for individual semantic subscales

	Group	N	Mean	Std. Deviation	Std. Error Mean
Understanding	Cochlear	30	7.70	2.731	.499
	Normal Hearing	30	16.60	1.163	.212
Imitation	Cochlear	30	4.00	2.449	.447
	Normal Hearing	30	14.90	2.074	.379
Completion	Cochlear	30	3.40	2.711	.495
	Normal Hearing	30	14.87	2.569	.469

The analysis of the data presented in Table (5) shows that NH children manage to achieve a mean score of 16.6 in syntactic understanding which is almost twice as big as the mean scores obtained from CI children (M=7.7). It also shows that the performance of CI children in sentence imitation (M=4) is far less than that of NH children who managed to achieve a mean score of 14.9. Further analysis shows that CI children are no better than other subscales in sentence completion and achieve a mean score of 3.5. On the other hand, NH children managed to get a mean score (M=14.87) that is almost five times better than that of CI children. As illustrated in the table (6), all these differences are significant.

Table 6. T-test results for the difference between the syntactic understanding, sentence imitation, sentence completion of CI and NH children

	t-test for Equality of Means			
	T	df	Sig.(2-tailed)	Mean Difference
Understanding	-16.423	58	.000	-8.900
Imitation	-18.602	58	.000	-10.900
Completion	-16.813	58	.000	-11.467

The Comparison between the Phonological Skills of CI and NH Children

The phonological component of TOLD is composed of 3 subscale of word discrimination, word analysis and word articulation. In this section, however, the test manual has not provided a combinational score under the label of phonology as a whole. We therefore only analyzed the subsets of this section. Table (7) indicates the descriptive statistics for the performances of the two groups on these subscales as well as the results of independent samples t-tests for the difference between these two groups on these subscales.

Table 7. Descriptive statistics for individual phonological subscales

	Group	N	Mean	Std. Deviation	Std. Error Mean
Discrimination	Cochlear	30	5.97	3.718	.679
	Normal Hearing	30	17.43	.817	.149
Analysis	Cochlear	30	9.03	2.428	.443
	Normal Hearing	30	9.27	2.392	.437
Articulation	Cochlear	30	3.83	2.102	.384
	Normal Hearing	30	17.53	.776	.142

The data presented in Table (7) show that the mean score for CI children in word discrimination subscale is 5.97. This score for the NH group is 17.43. Moreover, it shows that the performance of CI children (M=9.03) and their NH peers is about the same in word analysis with NH group slightly outperforming (M=9.27) their implanted peers. The table also represents that mean score on word production of NH children (M=17.53) is much higher than CI children (3.83).

Table 8. T-test results for the difference between word discrimination, word analysis word articulation of CI and NH children

	t-test for Equality of Means			
	T	df	Sig.(2-tailed)	Mean Difference
Discrimination	-16.497	58	.000	-11.467
Analysis	-.375	58	.709	-.233
Articulation	-33.485	58	.000	-13.700

Asindicated in table (8), the t-test results for these subscales show that the difference between the performance of the two groups on discrimination subscale is significant (t=-16.497, P<0.001), which means that NH children perform better than their implanted peers in word discrimination. The same is true with respect to the performance of the two groups on articulation (t=-33.485, P<0.001), which means that NH children perform better than their implanted peers in sentence imitation subscale. However, the results reveal no significant difference between CI and NH group on analysis (t=-0.375, P>0.05).

Discussion

The aim of the first question was to find the differences between the semantic skills of CI and NH children. Three subscales of TOLD were presented to the participants. CI children exhibited satisfactory results on receptive vocabulary although specific deficiencies were observable in their receptive vocabulary. In word description tasks, CI children had difficulty explaining about an object or an entity. Although they might have known a word, they had problems talking about it due to their smaller vocabulary repertoire. This was also observable in tasks of relating two words with each other which demanded a wide depository for words. On receptive vocabulary tasks, there was an observable common trend by which children were able to identify concrete words better than abstract words. This lag is also observable in NH children since as a rule of thumb, any child would learn concrete words faster and before concrete words. Yet, with regard to concrete words, all of the CI participants were able to identify words such as love and affection. Results however indicate the NH children are better in their semantic performance in all three subsections as well as in componential semantics and semantics as a whole. In other words, despite their explicit progress in language, the CI children are behind their age mate peers in semantic skills.

The findings are in line with the findings from other studies reporting lower scores in both comprehension and production of vocabulary than their NH peers (3,5,6,) while other studies proved to be contradictory. (4,8).In these studies, it was reported that children with CIs have better vocabularies than normally hearing children in the initial stages of language acquisition which may be a consequence of their more advanced cognitive development in comparison to hearing children. This was also suggested to be the consequence of adult input language, as mother's speech input to cochlear-implanted children contains a high proportion of repetition of content words, and language intervention programs would appear to favor the teaching of labels for objects and properties of objects. Moreover, it could be a result of their impaired hearing, as content words receive stress and are therefore perceptually more salient than function words (8).

Despite the fact that all studies emphasize the CI participants' better performance on receptive vocabulary skills and a lag in expressive vocabulary skills (3,4,5,6,) one particular research claims the opposite and reported that participants' performance on receptive vocabulary was below the expected range for age for hearing children. On the other hand, their expressive vocabulary fell within normal limits (7).

The second question investigated the gap between the syntactic skills of CI children with their hearing age mates. Results from three subscales of TOLD revealed that the receptive syntactic subscale of the test (grammatical understanding) was where almost all children demonstrated their best command of the grammar of their language. In this subscale, active simple sentences were easily identified. Nevertheless, their ability to choose the correct picture diminished as more and more complex sentences with multiple passive structures were introduced. However, it was observable once again that the syntactic skills on NH and CI children are vast. The NH children outperformed their CI peers in all aspects of the syntactic component of the test.

The findings are in congruity with the results from other studies reporting lower syntactic skills and slower grammatical process of CI children (3,4,8,9,10,11,12). Lower scores in syntax may reflect deficiencies in aspects of language that are difficult to hear or produce (4), the perceptual prominence hypothesis (10) or the result of early auditory deprivation (12). Furthermore, it is argued that many important grammatical markers rely upon the detection of high frequency, unstressed speech sounds, which are particularly difficult to perceive in noise, and therefore more difficult for these children to acquire (12). Significant differences from normally hearing children persist in more than one third of the lexical categories analyzed-number of words and utterances, negation adverbs, place adverbs, action communicators, possessive determiners, prepositions, pronouns, reflexive pronouns, existence verbs, infinitive verbs, modal lexical verbs, and possessive verbs (e.g., have). Lexical impairments are mainly related to verb access, verb-related words (e.g., function words). Although implanted children have good lexical diversity, they showed significantly reduced productivity (9).

Grammatical cues vary with respect to their degree of perceptual salience. If marking occurs in the form of suffixes on content words which receive stress it should be easier to perceive. This would explain why children with CIs do well on plural inflections on nouns and verb inflectional morphology. Lack of perceptual salience would account for why children do less well on acquiring function words such as articles (18). However, lack of perceptual salience alone cannot explain why children's deficits are greatest in the area of case-marked function words, modal verbs and forms of the copula (8). Because some speech sounds cannot be differentiated fast enough, incoming speech is processed insufficiently which can influence the construction of incoming grammatical cues. She suggests that children may miss grammatical cues in incoming speech because they focus on grasping the meaning transmitted to a large extent by content words.

With regard to the third question, three subscales of the test which comprise the phonological component of TOLD were administered to the participants. Results revealed that except for one subscale, the NH children performed better that their implanted age mates. With regard to phoneme production, although /ž/ exists in the phoneme inventory of Persian language, all CI participants but one who had been implanted before age two, lacked this phoneme. This means that their phoneme inventory did not include this specific phoneme. Instead, they substituted other phonemes such as / ž / or /š/ in place of this particular phoneme since it is suggested thet a sound may not exist in a child's repertoire of sounds (19). Moreover, most participants had difficulty producing alveolar fricatives /s/ and /z/, palate-alveolar affricates /č/ and / ž /, velar plosives /k/ and /g/ and uvular plosive /q/. It is believed that there was a clear preference for more complete production of visible consonants compared to consonants with less visible place of articulation. Fricatives and affricates are the consonants to be learnt in later stages because of their low frequency of occurrence (20). There was also a tendency to omit word final consonants such as /čaŋgā(l)/ (fork) or /bošqā(b)/ (plate) in more than 50% of the participants.

It can be then inferred that on the whole the CI children lag behind their hearing age mates in phonology as well. In one subscale of phonology, both groups performed equally well. Since the findings here was not in line with other studies (3), the test administers then concluded that the similarity in answers of both groups were the result of the way the questions were presented to the CI group. Although it was mentioned in the test manual that no oral cue could be given to participants during test administrations, since the participants could not make the objective of the test clear, a series of hand clues were accompanied with the questions which made them easier and more fun to the CI children (3).

In an only contradictory analysis, it was justified that with intensive therapy, children can catch up to normally hearing age-mate peers (13).

Conclusion

The purpose of this study was to compare the language skills of CI children with NH children and to investigate the effect of factors of age at implantation, chronological age at testing, gender and IQ on the language outcome of CI children. It can be concluded from the results that despite their lag in language production (language comprehension was observed to be near average range in most participants) children with average or above average cognitive skills who use CI have the potential to produce and understand language comparable to their normally hearing peers. In conclusion, the continuation of further studies on the development of language skills of deaf children being implanted is compulsory for the better understanding of such children and their needs.

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