Original Article

The Role of non-Linguistic Variables in Production of Complex Linguistic Structures by Hearing-Impaired Children

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Objectives: Language development is often very slower in hearing impaired children compared with their normal peers. Hearing impairment during childhood affects all aspects of speech production and language acquisition. It seems that hearing impaired people suffer from language and speech impairments such as production of complex linguistic structures. The purpose of this study is to determine the role of non-linguistic variables in production of the complex linguistic sentences in children with hearing impairment.

Method: Twenty normal children, aged 6-7 years and twenty children with severe to profound hearing impairment, aged 8-12 years were selected in a simple random sampling from normal kindergartens and schools, and exceptional schools for hearing impaired people. This research was a case-control research. The confirmation of the audiologist in the exceptional schools for hearing impaired people and the information recorded in the history of these students were considered in order to determine the kind and degree of hearing loss, and other non-linguistic variables. The production of complex sentences was tested by Elicitation Test. The content validity of the production test was determined and then the reliability was confirmed with Cronbach Alpha Test. Data collected were analyzed by statistical tests such as Pearson's Correlation, Independent Samples T-Test and Mann-Whitney U Test and using SPSS software.

Results: The results of this study showed that there was no correlation between the non-linguistic variables such as early detection and early intervention, and production of complex linguistic structures in hearing impaired children.

Conclusion: In the first months of life, children have to deal with natural language to create the foundations for linguistic health and complete development of syntax. If language input is not rich and available during the critical period for learning a first language, the syntactic competence cannot grow naturally. Therefore, two non-linguistic variables, early identification and early intervention will be the main predictors for production of complex linguistic structures.

Key words: Hearing Impairment, Non-linguistic Variables, Complex Linguistic Structures, Production

Introduction

It seems that the deviations in hearing-impaired children's communication result from insufficient language input in an appropriate development age. They use innate linguistic capability of rule production to hear things. Therefore, they create functional but deviational strategies, for which provide the possibility of the production and comprehension of complex linguistic constructions. In face to face communication, they can choose their own

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strategies; and basic and effective language exchanges can occur (1).

If auditory system does not receive the necessary inputs from the inner ear, it will not grow enough. In infancy, the auditory system, which is flexible and evolvable, can change and grow by receiving different stimulations from the environment. Inadequate stimulations prevent the full development of the auditory nerves, because afferent and efferent nerves of the brain cortex impose a bilateral control on each other.

From physiological aspects, the auditory system of children is flexible and is affected by not only the anatomical changes, but also changes in the received auditory stimulations. According to Ruben & Rapin (2), peripheral and central auditory systems have mutual control on each other. When the inner ear is matured, its inputs are essential for development of at least a part of auditory nerves. When the peripheral auditory system is fully developed, its inputs appear to be essential for neural maturation and development of parts of the central auditory system. Therefore, since the beginning of the activity of the inner ear and the eighth cranial nerve until the maturity of central nervous system (that is almost from the fifth month of fetal life to the age of 18 to 22 months), environmental sounds have the greatest impact on formation of hearing ability (3, 4).

Beside linguistic variables, non-linguistic ones are likely to affect linguistic production of hearing impaired children and subsequently their communication. These factors include severity of hearing impairment (5), age of hearing impairment onset, or time of detection of hearing problem (6), and enrollment in early intervention (7), use of cochlear implants and/or other hearing aids (8, 9), duration of the using conventional devices (9, 10), use of sign language or cued speech or other communication approaches (11), family background and history and so on.

Some studies have attempted to explain whether there is a relationship between the linguistic competences achieved by the hearing impaired person and non-linguistic factors. However, how these factors interact with each other and have impact on language development is still under debate.

It is important to note that many hearing losses in children are preventable, but it will be possible only when it is identified as soon as possible (7, 12, 13), and their therapeutic services are implemented. Obviously, if early diagnosis of hearing loss does not occur, the reduction of the difference created in the child's language development will be more difficult than normal people (14). The hearing impairment which has occurred during the first three years of life, has a strong deterrent effect on individual's acquired linguistic skills, regardless of the type (congenital, acquired, transitional, or sensorineural), which will later affect his/her psychological, social, educational, and occupational aspects. Therefore, reducing the harmful effects of hearing loss on language acquisition, especially during the first three years of life, is of special importance (7, 15, 16). This goal can be achieved when there is early diagnosis of the impairment, early medical intervention and rehabilitation, and its follow-up (using a suitable audio-amplifier and continuous verbal stimulation program) (8, 17-19).

The first 36 months of life are considered as the critical period of language learning, so that language is not possible to acquire with that speed at any other time (20). Therefore, to minimize the negative effects of hearing loss, professionals rely on early identification and follow-up of rehabilitation services at an early age, which this goal is possible to achieve by performing the controlled newborn screening programs (21, 22).

Reports (23) indicate that language development in children with hearing impairment depends on the age of beginning rehabilitation services. In a study in Lexington Deaf School, children who were adopted before the age of 16 months in this center, were compared with children who had registered there between the ages of 16 to 24 months. Children who had been adopted before the age of 16 months, showed statistically, at the age of 40 months (3.4 years), higher scores in speech and language comprehension and social communications. Mother-child relationship in the children who were adopted at lower age was higher–the factor which may have had more impact on achieving this success (7,15,24).

Many recent studies have shown that if comprehensive programs of early intervention are provided until the age of six months, some English-speaking hearing impaired children can acquire receptive and expressive language skills compared to normal peers (6, 25, 26).

Moeller (7) studied the relationship between age of enrollment in intervention program, and language ability (vocabulary skills) in a 112-member group of pre-linguistic hearing impaired children aged five years with mild to profound sensorineural hearing loss. The researcher found a significant negative

relationship between the two variables above, which means that the children who were under early intervention programs showed better language scores at the age of five years, compared with children who were enrolled later (for example, after the age of 11 months). Their level of vocabulary growth was comparable to that of their normal peers. Participation and cooperation of families and enrollment age in intervention programs significantly justify the huge differences and changes in the language ability at the age of five.

About 43% of children receiving cochlear implants at the age of 2 years, are able to develop language up to age of 8-9 years, while only 16% of children with cochlear implants before the age of 4 years successes to achieve a good language ability (19, 27, 28).

Nicholas & Geers (29) and Ledeberg & Spencer (30) believe that there is a critical and vital period for the effectiveness of cochlear implants. The cochlear implant which is performed before the age of 2, can be effective in the development of language (including syntax) with intonation and severity of more natural changes, unlike the cochlear implant received after it (31).

Although it is generally accepted and indisputable that hearing impairment can retard the development of natural abilities of language (32), the degree of hearing loss in the language acquisition has an unclear and ambiguous role.

Several studies that have examined the relationship between the degree of hearing loss and speech production and comprehension skills in different languages, have not yet seen the correlation between these two factors (8, 33-39).

To investigate relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing, Blamey et al. (8) studied the language ability and speech comprehension in an 87-member group of children with moderate, severe or profound hearing impairment. Result of this research suggests that the degree of hearing loss was only correlated with speech comprehension. However, the assumption that greater hearing loss is associated with more severe language and educational deficits is not supported by the present data.

Norbury et al. (34, 37) also presented similar results in English-speaking children with mild to moderate hearing loss. In the first research, degree of hearing loss or age of receiving hearing aids was not directly related to performance, but other language measures were. The subset was also significantly younger than the rest of the SNH group, suggesting that acquisition of finite verb morphology may be delayed in children with hearing impairments (37). In the second research, children with SLI did poorly on tests assessing knowledge of Binding principles and in assigning thematic roles in passive sentences whereas hearing-impaired children performed close to control levels, indicating that poor speech perception cannot account for this pattern of deficit. However, the pattern of errors on syntactic tasks and the relatively weak correlation between different indicators of syntactic deficit seemed incompatible with a modular hypothesis (34).

Tuller & Jakubowicz (38) studied the comprehension and production skills of French-speaking hearing impaired children with 37 to 64 dB of hearing impairment. In this study, different features and aspects of French grammar, including the use of articles, morphemic pronouns and verb conjugations; and many differences were observed between the performances of subjects. In people with hearing impairment who were tested, some features were few, incomplete and inadequate, and others were less or were not damaged at all. But these phenomena were not correlated with the degree of hearing loss, the age of hearing loss diagnosis and the age of beginning the use of hearing aid. The effect of age was only taken into consideration when younger children have shown more problems than older children in learning and mastering their language.

Sztermann and Friedmann (33) studied the comprehension and production of sentences derived by syntactic movement, in orally trained school-age Hebrew-speaking children with moderate to profound hearing impairment, aged 7.8–9.9 years. The results showed that hearing impaired children are unable to comprehend the topical sentences and object-relative clauses. Similarly, in other research, the same researchers (33) found that individual performance was strongly correlated with the age of intervention: only children who received hearing aids before the age of 8 months performed well in the comprehension tasks. Type of hearing aid, duration of cochlear implant, and degree of hearing loss did not correlate with syntactic comprehension.

Materials and Methods

In this case-control study, twenty normal children, aged 6-7 years and twenty children with severe to profound hearing impairment, aged 8-12 years were selected in a simple random sampling from normal schools, and exceptional schools for hearing impaired people. Subjects in both groups spoke one

language. The normal children were matched with the hearing impaired children on the basis of linguistic age. Also among 20 children in the control group, 10 were male, and 10 were female. Their average age was 6.5 years; 50 percent were studying in pre-school level and 50 percent were in the first grade.

Average age of hearing-impaired students was 10.5 years, 65% of the hearing-impaired group were boys, and 35% were girls. The children did not have any confirmed diseases or neurological disorders, except hearing loss in students with hearing impairment.

To determine historical variables, such as age of onset of hearing loss or initiation of early intervention, kind and degree of hearing loss and so on, the information was obtained by the principals of the exceptional schools for hearing-impaired people from children medical history. Type of hearing impairment among all hearing-impaired children was sensorineural. Hearing impairment of all hearing-impaired children was detected up to three years.

All these children suffered hearing loss in both ears. They used behind the ear hearing aid. 25% began using hearing aids at the age of eight, 20% in six years old, and the rest at lower age.

Each child was tested individually in three to five sessions. There was no time limit on any of the tests; and the tester repeated several times each part, as the subject wanted.

Production of non-canonical sentences was tested by using a researcher-made task called Eliciting. The subject hears a sentence that is read by the native Persian-speaking tester, afterwards the tester asks the subject "Which child/girl/boy do you like (the most)?". Then, he/she sees two pictures on one page: one on top and another on bottom of the page. While answering the question, s/he produces a sentence.

Type of constructions of the production task of eliciting, is classified in terms of word order in two general groups:

1- Sentences with canonical word order (subject clefts, object-subject relative)
2- Sentences with non-canonical word order (object clefts, subject-object relative)

To analyze the data, Independent T-Test, Mann-Whitney U test, Pearson's Correlation and the software SPSS were used. To determine the difference between deaf and normal-hearing children in producing the complex sentences, independent t-test was used for those scores that had normal distribution and Mann-Whitney U test was used for those series of scores that were not normally distributed. To assess the correlation between variables, the Pearson's Correlation was used.

Results

To identify the non-linguistic factors which are correlated with the ability to produce the non-canonical constructions by the hearing impaired children, we considered the mean of scores of the subjects in the production tasks of the subject and object relative clauses and the subject and object clefts. Then we discussed its correlation with these variables: age of hearing loss detection, age of beginning intervention and the use of behind the ear (BTE) hearing aid, type of hearing impairment and the degree of hearing impairment.

As shown in Table 1, the calculated t-value (3.18) is significant at the alpha ′0.05′ level; so there is a significant difference between the mean of kind of hearing loss and the total score of production in hearing impaired children.

More exactly, it can be said that the children whose hearing were impaired before the age of language learning, were more successful in gaining total score of production, compared to children with congenital hearing loss.

Table 1: Mean of total score of production and type of hearing loss based on Independent T-Test

Index	Type of hearing loss	Total	mean	standard deviation	Degree of freedom	t-value	level of significance	Result
total score of comprehension	before the age of language acquisition	9	13.33	5.96	18	3.18	0.005	The difference is significant
	Congenital	11	8.73	7.47				

Table 2 shows that the correlation between the degree of hearing loss of both ears of hearing impaired children and the total score of production of the non-canonical sentences is significant at the alpha ′0.05′ level.
Considering that the correlation is negative, there is a significant inverse relationship between increased levels of hearing impairment and reduced production of the complex sentences. In other words, reducing/ increasing the degree of hearing loss (dB increase in hearing loss) results in the production of the non-canonical sentences by the hearing impaired children to be increased/ reduced.

Table 2: Correlation between the degree of hearing impairment and the total score of production

Index		total score of production
level of hearing loss in left ear	level of correlation	-0.50
	level of significance	0.02
	Total	20
level of hearing loss in right ear	level of correlation	-0.52
	level of significance	0.02
	Total	20

As is evident from the data in Table 3, the correlation level (0.032) at the alpha ′0.05′ level is not significant in this case. Therefore, no relationship can be considered between the duration of the use of behind the ear (BTE) hearing aid and total score of production. So, it can be said that the duration of the use of behind the ear (BTE) hearing aid has no effect on the production in children with hearing problems.

Table 3: Correlation between the duration of the behind the ear (BTE) hearing aid usage and the total score of production

Index		Total score of production
duration of the use of behind the ear (BTE) hearing aid	level of correlation	0.032
	level of significance	0.89
	Total	20

As is shown in Table 4, the correlation between the age of hearing loss detection and the total score of production (-0.05) and also between the age of intervention onset with the total score of production (-0.08) is not statistically significant. Therefore, the mentioned variables (age of hearing loss detection and age of intervention onset) have no impact on the level of the development of skills of the non-canonical sentences in hearing impaired children.

Table 4: Correlation between total score of production and age of hearing loss detection/age of intervention onset

Index		Total score of production
age of hearing loss detection	level of correlation	-0.05
	level of significance	0.84
	Total	20
age of intervention onset	level of correlation	-0.08
	level of significance	0.73
	Total	20

Discussion

In general, according to results of similar studies on Hebrew language (39) English (40, 41), and French (42), the performance of normal and hearing impaired children concerning the non-canonical sentences was clearly different. Obviously, what is important is to identify the non-linguistic variables which are correlated with the ability to produce the complex linguistic constructions by the hearing impaired children.

Some results of treatment of non-canonical constructions in other populations such as individuals with agrammatic aphasia (43-46) and Specific Language Impairment (47-49) suggest the production skill of the non-canonical constructions can be improved through the simple trainings.

The results of this study showed that the hearing impaired children whose hearing was impaired before the age of language acquisition, their production was better and more in the area of complex linguistic structures, compared to children with congenital hearing loss. Therefore, the findings of the study suggest that the type of hearing impairment can be associated with syntactic performance.

We found that degree of hearing loss was inversely correlated to linguistic production. If the degree of hearing loss was higher, production of the complex constructions would also be subject to defects and disorders; and if the hearing loss was reduced, production of the mentioned constructions would also increase. But some previous researchers have reported a lack of relationship between degree of hearing loss and expressive oral communication skill (7, 50-52). It seems that the degree of hearing loss in the language acquisition has an unclear and ambiguous role and this does not mean that hearing loss itself does not influence linguistic achievements.

In contrast, the age of hearing impairment detection, the age of beginning intervention services or the age of the use of behind the ear (BTE) hearing aid, and duration of use of this tool were not correlated with the production of complex linguistic structures. Lack of the relationship between these variables is due to the fact that hearing impairment in many of these children has been detected after the critical age of language acquisition, and intervention services have been also delayed. Hence, there was no correlation between many non-linguistic variables and production skill. Therefore, considering late diagnosis of hearing impairment and late intervention of rehabilitation and treatment of these children, the results of this study are consistent with findings published by Calderon & Naidu (53). They indicate that the performance of children whose hearing impairment was diagnosed from birth to the age of one year was significantly better in the tasks of receptive and expressive language than children whose hearing impairment was diagnosed between the ages of 13 and 36 months.

Similarly, the findings of Yoshinaga-Itano (13) and Yoshinaga-Itano and A puzzo (25) suggest that intervention before the age of 6 months is a strong predictor for several measures of language development.

Also, according to studies published by Yoshinaga-Itano *et al*. (6) and Moeller (7), the children having normal cognitive skills who are identified as deaf or hard hearing before the age of 6 months improve their language skills to the natural levels at an early age, in case of timely and appropriate intervention; and their cognitive skills would be commensurate with their language skills. Regardless of the degree of hearing impairment, gender, race, socio-economic conditions, age at time of problem detection , or type of communication method, these children can acquire language skills appropriate to the age from 12 to 36 months (6).

However, according to the same studies, abilities of receptive and expressive language in children who are identified later, standard deviation is lower than children who have been identified in a timely manner. In other words, if the children with normal cognitive skills are identified later, they will acquire score 60 out of 100 during the early years of life, for general language quotient. If early and appropriate intervention is made after diagnosis of hearing loss, hearing impaired children who are identified at ages 6-30 months, will use the same language quotient. But, language skills of these children are significantly lower compared to the children who have been identified before the age of 6 months in a separate study (54).

Conclusion

In the first months of life, children have to deal with natural language to create the foundations for linguistic health and complete development of syntax. If language input is not rich and available during the critical period for learning a first language, the syntactic competence cannot grow naturally. Therefore, two non-linguistic variables, early identification and early intervention will be the

main predictors for production of complex linguistic structures and, the role of other non-linguistic factors has not been certified by the other research.

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