



Positive effects of hearing and speech rehabilitation on lexical range quality in hearing impaired children

Pozitivni efekti rehabilitacije sluha i govora na kvalitet leksičkog fonda dece sa oštećenim sluhom

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Abstract

Background/Aim. Initial experiences in rehabilitation of children with cochlear implants and frequent debates regarding the effects of their application have imposed the necessity to compare the effects of speech rehabilitation in children with hearing aids with those having cochlear implants. The aim of this study was to evaluate and compare the level of lexical development in hearing impaired children who are involved in the process of hearing and speech-language rehabilitation and who were amplified by hearing aids or cochlear implants. **Methods.** The sample consisted of 55 children aged 3–6 years, diagnosed with prelingual bilateral hearing impairment with a hearing threshold above 90 dB. All examined children had average intellectual abilities and no additional impairments. The sample was divided into 2 groups: E1 group consisted of 30 children with cochlear implants and E2 group consisted of 25 children who were amplified by individual hearing aids. Research methodology included a Test of Vocabulary. The testing was performed individually. A year after the testing, a retest was done. Statistical analysis was performed using the SPSS v. 17 for

Windows. **Results.** The largest number of children had average achievements on a Test of Vocabulary during initial testing. After a year (retest) significant improvements were noticed. A large number of children had above average achievements (46.7% in the E1 and 36% in the E2 group) while the number of children with below average achievements was significantly reduced (3.3% in the E1 and 8% in the E2). A comparative analysis of the test and those with hearing aids achievements showed that there was no statistically significant difference between children with cochlear implants and retest. **Conclusion.** Significant improvement of the achievements on retest in both groups can be explained by positive effects of systematic, planned, intensive and continuous rehabilitation of hearing impaired children, and not by application of certain type of hearing amplification.

Key words:

hearing disorders; child, preschool; hearing aids; cochlear implants; speech; rehabilitation; vocabulary; surveys and questionnaires.

Apstrakt

Uvod/Cilj. Početna iskustva sa rehabilitacijom dece sa kohearnim implantima i česte debate u vezi efekata njihove primene nameću neophodnost poređenja efekata rehabilitacije govora dece sa slušnim pomagalicama sa decom koja imaju kohearne implante. Cilj ovog rada bio je da se proceni i uporedi nivo razvijenosti leksičkog fonda dece oštećenog sluha koja su uključena u proces rehabilitacije slušanja i govora, a koja su amplifikovana slušnim aparatima ili kohearnim

implantom. **Metode.** Uzorak je obuhvatio 55-oro dece uzrasta 3–6 godina kod kojih je dijagnostifikovano prelingvalno obostrano oštećenje sluha sa pragom čujnosti od preko 90 dB. Sva deca, su imala prosečne intelektualne sposobnosti i bila su bez dodatnih oštećenja. Uzorak je podeljen na grupu dece koja su kohearno implantirana (E1 grupa = 30) i grupu dece koja su amplifikovana individualnim slušnim aparatima (E2 grupa = 25). U istraživanju je korišćen Test rečnik. Testiranje je obavljano individualno. Nakon godinu dana od testiranja, rađen je retest. Statistička ob-

rada rezultata izvršena je pomoću je programom SPSS v. 17 for WIDOWS. **Rezultati.** Najveći broj ispitanika pokazao je prosečna postignuća na Test rečniku, na prvom testiranju. Nakon godinu dana (na retestu) uočena su značajna poboljšanja. Veliki broj ispitanika imao je iznadprosečna postignuća (46,7% u grupi E1 i 36% u grupi E2), a smanjen je i broj ispitanika koji su imali ispodprosečna postignuća (3,3% u grupi E1 i 8% u grupi E2). Komparativnom analizom postignuća dece (na testu i retestu) sa kohlearnim implantom i dece sa individualnim slušnim aparatima primećeno je da između pomenutih grupa ispitanika nije bilo statis-

tički značajne razlike. **Zaključak.** Na osnovu dobijenih rezultata istraživanja možemo zaključiti da je značajno poboljšanje postignuća ispitanika na retestu u obe ispitivane grupe moguće objasniti pozitivnim efektima sistematski planirane, intenzivne i kontinuirane rehabilitacije dece oštećenog sluha, a ne primenom određenog tipa slušne amplifikacije.

Ključne reči:

sluh, poremećaji; deca, predškolska; sluh, pomagala; kohlea, implantat; govor; rehabilitacija; rečnici; ankete i upitnici.

Introduction

Verbal communication is a basic form of communication among people. The ability to speak enables a human being to "liberate" the mind and make it available to others. Speech nuclei as a specific human characteristics are presented at birth in the first newborn cry¹. From that moment, speech and language development are used through established interconnected and conditioned stages².

Speech and language difficulties are reflected in the overall development of a child's personality. For proper speech and language development, among many other factors, preserved auditory perception is necessary³. Poor auditory perception compromises spontaneous speech and language development and leads to a smaller or larger delays in its development⁴.

Hearing impairment researches (which include studying deafness and hearing loss in all aspects of a child's psychophysiological development as well as researches in otorhinolaryngology) in the last decade was characterized by audiology technology advancement and more expansive approach to cochlear implantation in children with severe hearing impairment as an alternative to hearing aids.

Initial experiences in rehabilitation of children with cochlear implants and frequent debates regarding the effects of their application have imposed the necessity to compare the effects of speech rehabilitation of children having hearing aids with those having cochlear implants.

In practice, such findings can contribute to further evaluation of quality and they can facilitate diagnostic choice of a certain hearing amplification type in the process of speech rehabilitation. In the same manner, this research aims to provide additional arguments to avoid simplifications, euphoric fashion or unfounded criticism.

Taking into account the experience and findings gained by researchers⁵⁻¹¹, it may be concluded that the application of a cochlear implant has recently given significant results in improving a hearing status in prelingually deaf children with severe hearing impairment.

Regarding speech and language development, some recent researches have shown that children with cochlear implant use age-appropriate learning strategies. They also have appropriate level of expressive vocabulary and semantic feature knowledge like children with normal hearing. In general, their cognitive capacities are adequate in managing the

knowledge of words and their usage and they are the same as in children with normal hearing¹².

On the other hand, there are some researchers who, although they agree with the fact that the children with implants achieve higher hearing threshold and have better speech and language abilities, hold the opinion that the results are individual and unpredictable¹³.

When analyzing the vocabulary, there are researches which confirmed that children with cochlear implants had less vocabulary knowledge than children with normal hearing. This researches also indicated that vocabulary knowledge of children with cochlear implants was highly related to the age of implantation, duration of implantation, chronological age and socioeconomic status¹⁴.

The aim of this study was to determine and compare the level of lexical development of hearing impaired children who are involved in a systematic, continuous and intensive process of hearing and speech and language rehabilitation and who are amplified by hearing aids or cochlear implants.

Methods

The research was conducted in 2008 and 2009 at the Department of Hearing and Speech Rehabilitation at the Institute for Otolaryngology and Maxillofacial Surgery of the Clinical Center of Serbia and at the "Children's Home" of the University Medical Center Zvezdara, Center for Persons with Hearing Impairments in Banja Luka and Institute for Psycho-physiological and Speech Disorders "Dr Cvetko Brajović" in Belgrade. The subjects were tested on two occasions – at the time when they were given consent for cochlear implants (test) and a year after the implementation (retest).

The sample included 55 pre-school respondents aged 3–6 years. All the children from the sample had mutual prelingual hearing impairment with the hearing threshold over 90 dB; they had average intelligence. No children had any additional impairment. In the period prior to obtaining consent for the cochlear implant, all examined children had been involved in intensive rehabilitation treatment which included the stimulation of hearing, speech and language development as well as the integration into the social environment. The treatment was carried out according to a plan and program which is a standard for the appropriate age, the type and degree of hearing impairment as well as the current level of speech and language development. In 30 children who were

tested, cochlear implant was placed (E1 group), while 25 patients continued to use individual hearing aids after receiving the consent for cochlear implant (E2 group). After our testing, all examined children continued with intensive, systematic and planned hearing and speech rehabilitation. The same principles in the area of vocabulary development were followed during rehabilitation of the examined children regardless the applied type of hearing amplification. First, words were adopted as a global unity after which their analytical shaping and processing of individual sounds were elaborated. The process of words acquisition was realized through the stages of detection, discrimination, identification, memory and functional use. At any time, primary impact was on auditory perception of words while visual perception was secondary. Connection between the auditory perception of words and the level of vocabulary development was strictly respected. After one year, a control test (retest) was conducted.

Test of Vocabulary by Vasić¹⁵ for estimation of lexical range was used for the whole sample. The testing was performed individually. The most of the words in this test were nouns (50%) which were the most frequent part of speech in children's vocabulary. The test consisted of 2 parts. The first part contained specific nouns which could be illustrated visually. The second part of the test included abstract nouns which needed to be tested since they indicated a level of child's language development and not only the richness of the child's vocabulary. The abstract nouns were chosen on the basis on their frequency in an active child's vocabulary. The number of specific nouns decreases as child gets older while the number of abstract nouns increases.

Each subtest regarding vocabulary referred to specific age. The test for the age between 3 and 4 years consisted of 20 nouns; for the age between 4 and 5, it consisted of 40 nouns; for the age of 5–6, another 20 nouns were added. The list of 100 words made the total vocabulary test.

Total marks on the test for 3-year-old children was 20 points; for those aged 4 – it was 40 points, for those aged 5 – it was 60 points, for those aged 6 – it was 80 points and for those aged 7 – it was 100 points. That is, each word from the test brought 1 point.

Based on the obtained testing results, we divided the subjects into 3 groups: unsuccessful, average and above average for the observed age.

The test for the age of 3 (test and retest): 0–4 – unsuccessful for the examined age; 4.5–4 – average for the examined age; >14.5 – above average for the examined age.

The test for the age of 4 (test and retest): < 14 – unsuccessful for the examined age; 14.5–20 – average for the examined age; > 20.5 – above average for the examined age.

The test for the age of 5 (test and retest): < 17 – unsuccessful for the examined age; 17.5–30 – average for the examined age; > 30.5 – above average for the examined age.

The test for the age of 6 (test and retest): < 25 – unsuccessful for the examined age; 25.5–40 – average for the examined age; > 40 – above average for the examined age.

Test for the age of 7 (test and retest): < 26 – unsuccessful for the examined age; 26.5–55 – average for the examined age; > 55.5 – above average for the examined age.

We designed a protocol applied in our research with the aim to collect data about subjects which we thought would be necessary and useful when analysing the testing results. The data were taken from children's medical records and through interviews with their parents. The protocol collected the information regarding the following: sex and age, intellectual capacity, the presence of any additional impairment, type and degree of hearing impairment, the time when the hearing impairment diagnosis was established, amplification time, amplification modality, the age when the cochlear implant was provided, the time when rehabilitation started and the length of rehabilitation process.

The obtained results were analyzed by descriptive statistical methods. The analysis of relation between dependent and independent variables was done by mathematical algorithms within the application of the correlation analysis which included defining a vector orientation as well as quality and quantity of relations between the compared variables. Statistical analyses were made in program SPSS v. 17 for Windows.

Results

The tested sample included 30 male and 25 female children with hearing impairment. In the E1 group there were 17 boys and 13 girls while in the E2 group there were 13 boys and 12 girls (Table 1).

Possible influence of time when diagnosis of hearing impairment was given on speech and language development as well as on the vocabulary richness is presented in Table 1.

The amplification time and the time of rehabilitation treatment commencement are significant for the level of developing lexical range in hearing impaired children. The largest number of children from the whole tested sample was amplified at the age of 19–30 months (30 children), while basically the same number of children was amplified at the age to 18 months (13 children) and after 30 months (12 children). When compared the E1 and E2 group, it may be noticed that the same number of children was amplified at the age of 19–30 months (15 children). In the E1 group 11 children were amplified at the age up to 18 months and 4 children at the age after 30 months, while in the E2 group only 2 children were amplified at the age up to 18 months and 8 children at the age after 30 months (Table 1).

The analysis of the time when the rehabilitation started showed that the largest number of children from the whole sample (27) started the rehabilitation at the age of 19–30 months.

The length of rehabilitation is also a very significant factor which influences the richness and quality of vocabulary in hearing impaired children. The length of rehabilitation of children according to mode of amplifiers is presented in Table 1.

Considering the children's age when the cochlear implant was placed, it is necessary to point out that only 4 children got the implant at the age of 2 years. Most of the children (20 children) were implanted at the age of 2–4; 6 children got the implant at the age over 4 (Table 1).

Table 1

Individual and functional characteristics of children according to mode of amplifiers			
Parameters	E2 (n = 25) n (%)	E1 (n = 30) n (%)	Total n (%)
Gender,			
male	13 (23.6)	17 (30.9)	30 (54.6)
female	12 (21.8)	13 (23.6)	25 (45.4)
The age when hearing impairment was diagnosed (months)			
< 18	11 (20)	15 (27.3)	26 (47.3)
19–30	8 (14.5)	11 (20)	19 (34.5)
> 30	6 (10.9)	4 (7.3)	10 (18.2)
The age when child was amplified (months)			
< 18	2 (3.6)	11 (20)	13 (23.6)
19–30	15 (27.3)	15 (27.3)	30 (54.6)
> 30	8 (14.5)	4 (7.3)	12 (21.8)
The age when child started with rehabilitation in (months)			
< 18	4 (7.3)	11 (20)	15 (27.3)
19–30	12 (21.8)	15 (27.3)	27 (49.1)
> 30	9 (16.3)	4 (7.3)	13 (23.6)
Duration of rehabilitation (years)			
< 3	2 (3.6)	5 (9.1)	7 (12.7)
3–5	19 (34.5)	18 (32.7)	37 (67.3)
> 5	4 (7.3)	7 (12.7)	11 (20)
The age when cochlear implant was done (years)			
< 2		4 (7.3)	4 (7.3)
2–4		20 (36.4)	20 (36.4)
> 4		6 (10.9)	6 (10.9)

E1 – group of children with cochlear implants; E2 – group of children amplified by individual hearing aids.

Before the analysis of Vocabulary Test results was made, we also analyzed the age of children during the first testing as well as during retesting (Table 2).

By using the Test of Vocabulary in our research, we had the aim to determine to what extent the children with hearing impairment developed their lexical knowledge, that is, to what extent they passed from the passive to active vocabulary phase. The testing results were presented in Table 2.

Results in Table 2 indicated that, at the Vocubular Test and retest, the children with cochlear implant achieved approximately the same results as the children with hearing aids.

The test results in both examined groups showed that the majority of children achieved the average results, a large

number of them achieved results which were below standards, while fewer of them achieved results above the group average.

Retest results showed improvement in lexical range in both tested groups. Children with cochlear implants had better results than children with hearing aids, but there was no statistically significant difference.

Average scores were the most frequent in both groups. However, the number of children with above-average achievements was higher while the number of children with below average achievements was reduced. Since the results in both groups followed the same trends, statistically significant difference was not observed ($p = 0.672$).

Table 2

Children' achievements at the Test of Vocabulary regarding the type of hearing amplification in the E1 and E2 group (number of children on defined examined level)

Parameter	Test, n (%)		Retest, n (%)	
	E2	E1	E2	E1
Age at first testing in years				
3–4	7 (28)	5 (17)	1 (4)	1 (4)
4–6	13 (52)	19 (63)	16 (64)	13 (43)
> 6	5 (20)	6 (20)	8 (32)	16 (53)
total	25 (100)	30 (100)	25 (100)	30 (100)
Achievements for examined age				
below average	8 (32)	11 (36.7)	2 (8)	1 (3.3)
average	11 (44)	13 (43.3)	14 (56)	15 (50)
above average	6 (24)	6 (20)	9 (36)	14 (46.7)
Total	25 (100)	30 (100)	25 (100)	30 (100)

E1 – group of children with cochlear implants; E2 – group of children amplified by individual hearing aids.

Discussion

Test results on the Test of Vocabulary showed that the largest number of children had average lexical knowledge. Somewhat smaller number of tested children had lexical range below standards, and the smallest number of children had lexical range above-average. Such results are the consequence of the Test of Vocabulary unconformity while applying to hearing impaired children (the test was standardized for the typical population of children). The criteria imposed by this test are too high for hearing impaired children, and, therefore, we were forced to classify the results achieved by subjects on this test according to maximum achievements of subjects from the specific group.

The aim of the retest was to determine any potential changes in the quality of developed lexical range, compared to the first testing, along with continuous and systematically planned and performed rehabilitation, and with applying a certain type of hearing amplification.

Retest results showed, like the ones from the test, that the majority of children had the average lexical range. However, there were significant changes in the groups of children with above-average and lexical range developed below average. The number of participants in the below significantly decreased (from 19 subjects on the Test to 3 subjects on the retest), while the number of subjects with lexical range above-average increased almost twice (12 subjects on the Test and 23 on the retest). Undoubtedly, a high-quality change happened to all children from our sample in development of the lexical knowledge. The obtained retest results indicated positive effects of systematically performed speech and language treatment on development of the lexical range in children with hearing impairment, no matter whether they had cochlear implant or individual hearing aid. These findings are in relation to the literature which confirmed that children with cochlear implant could benefit from the treatment focused specifically on learning language structures, despite their phonological deficits as a consequence of reduced auditory perception¹⁶. Other research pointed to a fact that acquiring spoken language was facilitated by good audibility which was provided by a cochlear implant as well as with memory abilities and phonological learning¹⁷. On the other hand, many researches dealing with language development in children with cochlear implants suggest that there was a good reason to suspect that even the most successful children with cochlear implants go through different lexical processes and representations than children with normal hearing, particularly in case of phonological representation and processing¹⁸. Our explanation would be based on the fact that success in lexical range development lies in an intensive speech and language treatment of hearing impaired children with cochlear implants or hearing aid. This systematically planned and performed speech and language treatment may provide children with hearing amplification of the same lexical processes that children with normal hearing get through.

An explanation about vocabulary acquisition given by Storkel¹⁹ may also be applied to the analysis of lexical development in hearing impaired children. This explanation po-

ints to at least 2 neurocognitive processes which are the base for learning words: learning from an input during training and memory evolution during periods between training sessions. Word acquisition by healthy adults consists of learning from an input which is swift and stable, whereas memory evolution may be vulnerable on the pathway to mastery. That means that success in learning from the input is linked to positive outcomes from memory evolution. Similar principle for learning words by hearing impaired children can be applied to intensive speech and language treatment, regardless the fact that these children have cochlear implants or hearing aids.

Comparison between testing and retesting results in children with cochlear implants and children amplified with individual hearing aids indicated that there was not a statistically significant difference between these two groups. The most of the children from both tested groups had average achievements on initial testing by the Test of Vocabulary. An improvement in development of lexical range was registered in both tested groups by applying retesting (an increased number of subjects with above-average results and decreased number of subjects with below average results). Children with cochlear implants showed small advantage over those ones with hearing aids, but that difference was not statistically significant. Therefore, achievements of children with cochlear implants and those with hearing aids were almost identical in the domain of active vocabulary development.

According to Ostojić's²⁰ exploration of Elber's views, children with cochlear implants made a progress in a similar manner to children with hearing aids. Regardless the time and effort made at different levels, auditory stimulation usually must be adjusted to a child's learning pace. One of the basic requirements in working with children is to respect the developmental phases. If any of the developmental phases is left out or late, a child needs to be stimulated and to be given time to adjust; later on, we should expect the learner's active participation in the next phase. This model is most often applied in rehabilitation of children with cochlear implants²⁰.

The mentioned views explain the absence of statistically significant difference in comparing results at the Test of Vocabulary of children with different types of hearing amplification due to equal absence or delay during developmental phases which caused equally good or bad results on the test. On the other hand, these results should serve as a guide in practical work on speech-language rehabilitation of these children, inhibiting the expectations of experts and parents to those elements in speech and language development of deaf children at whom the efficiency of cochlear implant is reasonably exaggerated in comparison to hearing aids (quality of the basic laryngeal voice and voice articulation).

Our research results definitely point to positive effects which intensive and continuous rehabilitation had on the development of lexical range in hearing impaired children. Generally speaking, the intensive rehabilitation provided significant improvement in children's lexical knowledge, but the efficiency of rehabilitation was also noticed in overcoming the obstacles that hearing impaired children have during speech-language developmental stages. This is the fact we should not neglect. It confirms the necessity of expert and

professional approach to early detection, diagnostics and rehabilitation of hearing impaired children.

The limitation of this study refers to the small number of respondents. Future studies which would include larger sample of hearing impaired children may demonstrate more clearly whether the model of auditory amplification has the positive impact on speech and language therapy or the intensive speech and language treatment has the major role in speech and language development of hearing impaired children.

Conclusion

Cochlear implant itself or applications of individual hearing aids do not guarantee successful rehabilitation without quality speech and language therapy. Technical aids, no matter the level of their technological perfection, are just aids. In

certain segments, they can improve the rehabilitation quality, but speech and language therapist with his/her expert knowledge, experience, good intentions and humane approach is of key importance. The best guarantee for speech and language development which also include lexical development in hearing impaired children is a good combination of a human factor in the form of (a speech and language therapist) and technical means and aids which we use in the process of speech-language rehabilitation.

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