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Linguistic competence of children with prelingual hearing loss implanted up to the age of two

ABSTRACT: Magdalena Magierska-Krzysztoń, Magdalena Olempska-Wysocka, *Linguistic competence of children with prelingual hearing loss implanted up to the age of two*. Interdisciplinary Contexts of Special Pedagogy, No. 21, Poznań 2018. Pp. 157–177. Adam Mickiewicz University Press. ISSN 2300-391X. DOI: <https://doi.org/10.14746/ikps.2018.21.09>

Early implantation and hearing and speech rehabilitation provide much wider opportunities to develop linguistic and communicative competence in children with hearing impairment. The article presents own research, the aim of which was to determine the level of linguistic competence in children with prelingual hearing loss, who had been provided with a cochlear implant until the second year of life. The study involved a group of 169 children with prelingual hearing loss. In the study the Ling 6 Sound Test, the MAIS scale, the MUSS scale and the TAPS test were used.

KEY WORDS: Cochlear implants, deaf, linguistic and communicative competence, children with hearing impairment, prelingual hearing loss

Introduction

Cochlear implants significantly changed the possibilities of development and formation of linguistic and communicative competence in children with hearing impairment. As indicated by statistical data, in Western Europe and Australia about 80–90% of children with congenital hearing loss (without multiple disability) undergo early implantation, in the US this number is about 50%¹. In Poland, over 6,000 implants² have been inserted in the last 25 years and this number is growing every year³. Thus, completely new developmental opportunities are created for children with hearing impairment, significantly increasing their chances of development identical to the development of their hearing peers. Referring to the theory of critical/sensitive periods of speech development in children by Robert J. Ruben, it should be remembered that there are specific time constraints in the acquisition of auditory skills, the development of neuronal connections, the formation of phoneme discrimination skills, the organization of speech sounds into larger units, as well as learning mother tongue. If the ability to receive hearing impressions is limited or impossible, during the language acquisition process, neural networks will develop without hearing connections that are necessary for the development of a verbal language⁴.

¹ G. Leigh, J.P. Newall, A.T. Newall, *Newborn screening and earlier intervention with deaf children: Issues for developing world*, [w:] M. Marschark, P. Spencer (ed.), *The Oxford Handbook of deaf studies, language and education*, vol. 2, pp. 345–359, 2010; S. Broersen, *Cochleairr implantaat openet de wereld*, *Medisch Contact*, 65, pp. 528–531, 2010.

² This number applies to both children and adults. Statistical data allow concluding that in 1992–1998, 130 CI implantations were performed, including 55 in children between 2.5 and 17 years of age (Geremek A., Skarżyński H., Szuchnik J., *Program implantów ślimakowych u dzieci – stan obecny*, *Audiofonologia*. Vol. XIII). By 2008, approximately 2 thousand CI were implanted including 63% in children (Szkielewska A., Skarżyński H., Piotrowska A., Lorens A., Szuchnik J., *Postępowanie u dzieci ze wszczepami ślimakowymi*, *Otorynolaryngologia* 2008, 7(3), pp. 121–128).

³ Source: <https://whc.ifps.org.pl/2018/02/miedzynarodowy-dzien-implantu-slimakowego-2/> [access: 20.04.2018].

⁴ R.J. Ruben, *A Time Frame of Critical/Sensitive Periods of Language Development*, *IJO & HNS*. Vol. 51, No. 3, July–September, pp. 85–89, 1999.

Roman Jakobson in the developed linguistic periodization emphasizes that in the first stage of speech, which is the stage of phonological system formation, the chronology of sound learning is permanent, independent of culture and language, and the majority of sounds is learnt around the age of 2⁵. Also Paweł Smoczyński⁶, signalling his connection with structural linguistics, explicitly and directly referring to the findings of R. Jakobson, indicates that the purpose of the child's speech development is not only learning of phoneme, but also of the entire phonological system by a child (the process of developing a sense of the phonological structure of the word in a child). In the process of language acquisition, the child assimilates elements of the system from its various levels. Each level has its own internal developmental order. In this theory, it can be noticed that the first two years of children's life, during which the formation of sounds of speech, the developing of a signalling role of the shout, imitation and self-imitation, the formation of a phonological system, the meaning of words take place, the size and structure of the dictionary changes, as well as the formation of syntax occurs, are the most important. Between the second and third year of life, as well as in the second half of the third year of life a significant increase in vocabulary, development of grammar, syntax, inflection, and semantics is observed. It is also important, as Robert V. Harrison points out, that the most intensive development of the auditory cortex occurs between the 1 and 2 year of children's life⁷.

The literature on the subject, numerous studies, as well as own practice allow noticing that younger and younger children are implanted before the 12th month of life, which gives them much wider opportunities to acquire linguistic and communicative competence, but this does not mean, as emphasized by Kazimiera Krakowiak,

⁵ J. Porayski-Pomsta, *O rozwoju mowy dziecka. Dwa studia*, Dom Wydawniczy Elipsa, Warsaw 2015.

⁶ P. Smoczyński, *Przyswajanie przez dziecko podstaw systemu językowego*, 1955.

⁷ R.V. Harrison, *Development of the Auditory System. From Periphery to Cortex*, Comprehensive Handbook of Pediatric Audiology, pp. 23-46, 2011.

that the access to speech sounds alone is sufficient for the full normalization of the development as well as for the full independence of communication. It is important to introduce here as early as possible and systematic procedures not only relating to speech therapy, but also pedagogical and psychological ones, which will aim to equalize opportunities and, above all, create conditions favourable for language acquisition, and development of communicative skills in natural conditions for every child⁸.

Aim of the study

The aim of the study was to determine the level of linguistic competence of children with prelingual hearing loss, who were implanted with a cochlear implant until the second year of life. The Authors, through their study, would like to obtain answers to the following research questions:

1. Does early implantation: up to the second year of life allow full reception of sounds (including speech sounds) through hearing?
2. Do children with prelingual deafness implanted with a cochlear implant develop the ability to differentiate, distinguish, identify and understand sounds through hearing, which is the basis for acquiring linguistic competence?
3. Are the acquired and continuously developed linguistic competence of children implanted with a cochlear implant sufficient to initiate and maintain verbal contacts with other hearing people?
4. Is the language used by implanted children functional in the social and communication aspect?

⁸ K. Krakowiak, *Propozycje zmian systemowych w zakresie kształcenia dzieci i młodzieży ze specjalnymi potrzebami edukacyjnymi spowodowanymi przez uszkodzenia słuchu (niestyszających, słabostyszających, niedostyszających)*, „Człowiek – Niepełnosprawność – Społeczeństwo” no. 2(32), 2016, pp. 49–66.

Materials, methods

The study involved a group of 169 children with prelingual deafness implanted with a cochlear implant. The implantation was performed until the second year of life. The surgeries were performed in the Department of Otolaryngology and Laryngological Oncology of the Poznań University of Medical Sciences. The average age at the time of implantation for the whole group was 15 months. All study children used hearing aids for a period of at least 6 months before the surgery. After surgery, 89 children continued to use hearing aids to optimally amplify residual hearing in the non-implanted ear. The study group included 83 boys and 86 girls. In twenty children, specialist examinations confirmed genetic determinants of hearing loss, while the remaining group (149 children) presented a differentiated etiology of hearing loss (Table 1). In 60% of children, no direct cause of hearing loss was found, this group is inscribed as etiologically unclassified: unknown cause. 90% of children from the analysed group were subjected to hearing screening tests in maternity and neonatal wards. Hearing loss or profound hearing impairment have been confirmed by further diagnostics. 163 small patients had normal intellectual capacity and additional studies and observations did not show co-occurring developmental dysfunctions. In six patients of the study group mild and moderate intellectual disability was observed, including two cases of co-occurring significant visual impairment and cerebral palsy, which prevented a proper motor development. Six children were born and raised in families, in which parents had significant hearing impairment and the leading language in family communication was sign language. This group of children, from the moment of implantation, was additionally supported by hearing people in their surrounding (aunts, uncles, grandmothers and grandfathers and so-called family friends), who by their presence motivated and created situations favouring the acquisition of language experience. The remaining part of the study group (163 children) originated from families in which all the relatives used sound language and the hearing did not

deviate from the norm. Patients from the moment of diagnosing hearing loss and later after implantation were covered by systematic surdologopedic and psychological rehabilitation in therapeutic facilities in the place of residence or, in the case of older children, at the school or kindergarten. The time of cochlear implant use was from a minimum of three to sixteen years (Table 2). The current educational situation is presented in Table 3.

Table 1. Etiology of hearing loss: congenital, perinatal and acquired factors (N=169)

Etiology of hearing loss	N	%
Congenital factors	148	87
Perinatal factors	18	10
Acquired factors	3	3

Table 2. Time of cochlear implant use in the study group (N=169)

Time of cochlear implant use	N	%
From 3 to 6 years	66	39
From 6 to 10 years	63	37
From 10 to 14 years	38	22
Over 14 years	2	2

Table 3. Current educational situation in the study group (N=169)

Time of cochlear implant use	Kindergarten	Primary school	Lower secondary school	Upper secondary school
From 3 to 6 years	50	16	0	0
From 6 to 10 years	3	60	0	0
From 10 to 14 years	0	28	8	2
Over 14 years	0	0	0	2

The preoperative level of oral speech and language was residual in over 90% of children, and vocal forms they used did not belong to the language system. The way of communicating with the environment at that time was limited to inarticulate sounds, as well as gestures and facial expressions that were aimed at satisfying children's basic needs.

As part of the implementation of the Poznań Program for the Treatment of Hearing Loss by the Method of Cochlear Implants⁹ (Department of Otolaryngology and Laryngological Oncology of the Poznań UM), specialists have developed a diagnostic and evaluation scheme including, among others, performing specific tests at specified intervals using a determined battery of tests. In the research performed for the purposes of this study, the Ling 6 sounds test¹⁰ was used to provide information on the level of auditory perception in the subjects¹¹. In addition, it showed the dynamics of development of discriminatory and identification skills within the presented phonemes on the auditory pathway. In the Poznań Center, the Ling Test is performed up to 3 years from the moment of connecting the speech processor or depending on the individual needs of the patient.

⁹ W. Szyfter, A. Pruszewicz, Z. Szmeja, E. Szymiec et al., *Poznański Program leczenia głuchoty dziecięcej metodą wszczepów ślimakowych*, Otolaryngologia Polska 1997, Vol. L, Supplement 22, pp. 174-178.

¹⁰ S. Scollie, D. Glista, J. Tenhaaf, A. Dunn, A. Malandrino, K. Keene & P. Folkeard, *Stimuli and normative data for detection of Ling-6 sounds in Hearing Level*. American Journal of Audiology, Vol. 21, pp. 232-241, 2012.

¹¹ The Ling 6 sound test, which was created by Daniel Ling, was developed as a quick and simple test that can be used to check the child's access to the minimum number of sounds required to hear, understand and control speech. The Ling test consists of six speech sounds: / m /, / u /, / i /, / a /, / sh / and / s / (in order from low to high sounds). Susan Scollie and Danielle Glista from the University of Western Ontario in Canada have developed a method of measuring the degree of speech detection for use in conditions of access and lack of access to hearing aid based on the basic assumptions of the Ling-6 test (source: <https://www.phonakpro.com/pl/pl/resources/narzedzia-doradcze/dzieci/test-mowy/test-mowy-prze-glad.html> [access: 20.07.2018]).

The MAIS (Meaningful Auditory Integration Scale: a scale of hearing and understanding sounds) scale was used to evaluate hearing and understanding sounds, and the use of speech for basic communication was assessed using the MUSS scale (Meaningful Use of Speech Scale: a scale of speech use for communication). These are tools that provide knowledge about children's functioning in the above-mentioned areas, but they require cooperation from parents and/or teachers, as they answer questions in the questionnaires. In the case of older children with sufficient linguistic competence, it is possible to fill in the questionnaire by the respondents themselves, but it should always be remembered that the assessment may be somewhat subjective. The authors of the MAIS scale are: S. Zimmerman-Philips, M.J. Osberger and A.M. Robbins¹². The MUSS scale has been developed by two authors: A.M. Robbins and M.J. Osberger¹³. The TAPS (Test of Auditory Perception of Speech) test, which was developed at the University of Basel based on the rehabilitation materials of the Cochlear AG company, was also used¹⁴. Adaptation to the conditions of the Polish language was made by G. Demenko and L. Richter within the framework of the Department of Acoustic Phonetics of the Institute of Fundamental Technological Research of the Polish Academy of Sciences with the participation of specialists employed at the Department of Ear, Nose, Throat and Larynx Diseases of the Poznan University of Medical Sciences¹⁵. The test checks the ability to detect, discriminate, identify, as well as recognize and understand speech sounds in closed and open sets, through hearing. If possible, it is recommended to conduct the test before the surgery (using hearing aids), and

¹² A.M. Robbins, *Developing meaningful auditory integration in children with cochlear implants*, "Volta Review" 1990, 92, pp. 361-370.

¹³ A.M. Robbins, M.J. Osberger, *Meaningful Use of Speech Scale*, Indiana University School of Medicine, 1991.

¹⁴ J. Reid, B. Bertram, *Tests of Auditory Perception of Speech for Children*, by Cochlear AG, Basel, Switzerland, August 1992.

¹⁵ G. Demenko, L. Rychter, A. Pruszewicz et al., *Testy do badania słuchowej percepcji mowy (TBPSM) dla dzieci z implantami ślimakowymi*, Otolaryngologia Polska, 1996, Vol. L50.

subsequently after 3 months, 12 months and 36 months of implant use. Additionally, the Linguistic Skills Research Sheet was used, the results of which allowed the analysis of the current children's functioning in terms of understanding, speech production, resources of concepts and articulation skills. It gave the opportunity to analyse the current level of linguistic competence of implanted children. The Linguistic Skills Research Sheet is a clinical, internal tool created for the needs of implementation within the Poznań Program. The authors of the Sheet are Magdalena Magierska-Krzysztoń and Jolanta Kociemba. The level of test tasks is linguistically differentiated, and the commands and tasks are selected depending on the physiological and auditory age of the child counted from the moment of connecting a speech processor. The physiological age conditioning certain linguistic skills is corrected by the current auditory age of the subject. The test using the above-mentioned tool is carried out after a minimum of 3 years of using a cochlear implant, also considering previously assessed preoperative linguistic competence of the study children. So far, the Linguistic Skills Research Sheet was applied to examine 481 patients using a cochlear implant in the Poznań Clinic. The Authors still conduct continuous research and collect information in order to estimate the validity and practical applications of the Linguistic Skills Research Sheet in clinical practice. The studies using the Ling test and the TAPS test were carried out 3 months after the speech processor was connected and then after one year and after three years of using the cochlear implant. Category IV of the TAPS test (understanding of speech through hearing: closed and open resources) was also performed at the current time corresponding to the maximum individual time of implant use.

Results

All study children, using a cochlear implant for about 3 months, flawlessly performed an attempt to detect phonemes through hearing in both the TAPS test and the Ling 6 sound test (Table 4).

Table 4. Detecting phonemes through hearing (TAPS test, level I, 6 Ling sounds test), N=169

Number and percentage of children performing correctly hearing tests		
Detecting phonemes through hearing	Ling 6 sound test	TAPS test, level I
169 (100%)	169 (100%)	169 (100%)

The results obtained by the subjects in the TAPS Test and in the 6 Ling sounds test at an analogous time interval of 3 months from the speech processor connection, demonstrate that the majority of study children learnt the ability to perceive speech rhythm patterns (Table 5, 6). The skill mentioned above is developed on average within up to 6 months of cochlear implant use. The deviation in this area is noticeable in the group of 6 children with co-occurring developmental deficits in the form of intellectual disability, cerebral palsy and visual impairment. This group will also learn the above-mentioned skills, but at a slightly later time as a result of intensified stimulatory and therapeutic actions.

Table 5. Results in the TAPS Test after 3 months of cochlear implant use, level II, N=169

Perception of speech rhythm patterns, percentage level of correct performances	Number of children
70%>	155
50%	9
50%<	5

Table 6. Results in the Ling 6 sounds test, discrimination of individual phonemes, after 3 months of cochlear implant use (N=169)

Discrimination of phonemes through hearing, percentage level of correct performances	Number of children
70%>	156
50%	9
50%<	4

The results obtained in the level III of the TAPS test, demonstrate that the majority of children (over 60%) after one year of implant use coped well with tasks requiring skills of perception of speech features (in the area of perception of suprasegmental and segmental elements of speech) and speech identification. Conducting a rehabilitation focused on the perception of speech sounds also enabled the achievement of such good results in such a short time. A different number of syllables in the test words was a hint to differentiate those speech sounds, the meaning of which children have not learnt yet. Identification of words with the same number of syllables through hearing, was the most difficult for the study children. It was related to the still low level of linguistic functioning, manifested by a small resource of passive and active vocabulary (Table 7). Identification of individual phonemes in the Linga Test after one year of implant use was not a problem for most subjects. Sounds were presented in the form of sound-imitating expressions, which are first acquired linguistic experience and that is why the children managed so well with this task (Table 8).

Table 7. Results in the TAPS Test after one year of cochlear implant use, level III (N = 169)

Perception of speech features, speech identification, the level of correct performances	Number of children
70%>	104
50%	45
50%<	20

Table 8. Results in the Ling 6 sounds test, identification of phonemes, after one year of cochlear implant use (N=169)

Identification of phonemes, the level of correct performances	Number of children
70%>	145
50%	20
50%<	4

Table 9. Results in the TAPS Test, depending on the time of cochlear implant use, level IV (N=169)

Time of cochlear implant use	Number of children with individual test performance levels: Recognition, understanding of speech					
	Closed sets			Open sets		
	70%>	50%	50%<	70%>	50%	50%<
1 year	60	52	48	55	50	55
3 years	94	46	29	79	48	42

The performance of test tasks at level IV in the TAPS test requires knowledge of the language at the functional level. Closed sets contain sentences consisting of a subject, a predicate and an object. For proper performance of tasks, it is necessary to correctly interpret the inflectional endings that give meaning to particular words. The results (Table 9) show that 48 children after one year of implant use did not achieve a result that would account for 50% of correct answers in the area of closed linguistic sets. Linguistic tasks from the open set do not have an equivalent in the test material, that is, the image designator. The reception and correct interpretation of language messages at this test level require the efficient use of language in different social situations. Knowledge of language in the semantic, syntactic and morphological aspect is essential in this area of tasks and guarantees communication success and satisfaction in verbal contacts with other people. Achieving a sufficient level of speech understanding through hearing within the test tasks turned out to be a difficult task for the study group even after three years of implant use (Table 9). The thematic circle to which the test tasks referred was known to children (a story taking place in a kitchen and in a room), but to properly interpret the issues heard, it was necessary to demonstrate a good knowledge of syntax and grammar, which are determinants of the level of linguistic competence. The obtained results show that 94 of the study children only three years after implantation achieve satisfactory results in the interpretation of language tasks and commands in closed sets.

A smaller number of subjects (79 children) achieve results above 70% validity in the test tasks from open sets. The remaining part of the group requires further intensive stimulation in language areas that are not sufficiently developed.

Table 10. Results, MUSS Scale, Meaningful Use of Speech Scale, depending on the time of cochlear implant use (N=169)

Time of cochlear implant use	The number of children with given scores in the Meaningful Use of Speech Scale														
	Voice control level					Speech use level					Level of communication attitude				
	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
From 3 to 6 years	0	0	3	40	23	0	0	12	33	21	0	0	13	35	18
From 6 to 10 years	0	0	5	14	44	0	0	5	13	45	0	0	4	13	46
From 10 to 14 years	0	0	0	7	31	0	0	0	6	32	0	0	0	8	30
Over 14 years	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2
Total	0	0	8	61	100	0	0	17	52	100	0	0	17	56	96

Legend: 0 - never, 1 - rarely, 2 - sometimes, 3 - often, 4 - always.

Table 11. Results, MAIS scale, Meaningful Auditory Integration Scale depending on the time of cochlear implant use (N=169)

Time of cochlear implant use	The number of children with given scores in the Meaningful Auditory Integration Scale														
	Device acceptance level					Level of reaction to sounds					Level of understanding sounds meaning				
	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
From 3 to 6 years	0	0	0	6	60	0	0	9	3	54	0	0	8	29	29
From 6 to 10 years	0	0	0	3	60	0	0	0	6	57	0	0	0	11	52
From 10 to 14 years	0	0	0	0	38	0	0	0	3	35	0	0	0	6	32
Over 14 years	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2
Total	0	0	0	9	160	0	0	9	12	148	0	0	8	46	115

Legend: 0 - never, 1 - rarely, 2 - sometimes, 3 - often, 4 - always.

The MUSS scale (Table 10) provides results concerning the active use of speech for daily communication by implanted children. It is noticeable that implanted children spontaneously use speech to communicate with family members or other people with normal hearing. In own opinion, as well as in the opinion of the parents, providing a cochlear implant causes that children are eager to use the voice, and develop a readiness and a specific communication attitude that results in starting dialogues, and the end result of such discourse is the acquisition of the necessary information. It can be observed that in the group who has used implants for the shortest time, that is for up to 6 years, there is a greater number of children who have difficulties in the area of controlling the intensity and tone colour of their own voice. Moreover, the level of speech use and the development of a communication attitude favourable for establishing contacts with others is burdened with difficulties in relation to the group of children using the implant for a longer time. The results obtained in the MAIS Scale (Table 11) also demonstrate that the problems associated with the reception and a complex process of perception of all surrounding sounds including speech decrease with the lengthening of implant use. The longer the time of implant use, the better the effects. It is related to the time needed by deaf children to learn language patterns that will enable building

Table 12. Results, Linguistic Skills Research Sheet, current level of performance in the study group depending on the time of cochlear implant use (N = 169)

Linguistic skills	Average level of language tests performance in children after different times of implant use			
	CI using time from 3 to 6 years (N=66)	CI using time from 6 to 10 years (N=63)	CI using time from 10 to 14 years (N=38)	CI using time over 14 years (N=2)
Understanding	58%	65%	75%	98%
Speech production	70%	75%	80%	100%
Resource of concepts	45%	65%	70%	95%
Phonation	70%	85%	88%	97%

and developing linguistic competence. This time is analogous as in the case of hearing children who need about six or seven years to become proficient in their mother tongue. A deaf child, although implanted, is still limited by a lower level of auditory functioning in comparison to his hearing peers, which may consequently interfere with the phonological processing process, which, as known from therapeutic experience, determines the acquisition of a phonemic analysis and synthesis skill.

Analysing the results in Table 12, it can be observed that children who use a cochlear implant for the longest time, over 10 years, obtain the highest scores in all studied areas. It can be noticed that linguistic competence increases proportionally to the time of cochlear implant use. The Linguistic Skills Research Sheet used in the study allows analysing in an individual way the level of linguistic functioning of a given child and on this basis creating a supportive therapeutic program that aims to minimize deficiencies and deficits. The greatest difficulty faced by the majority of implanted, even at such an early age, children is to build an adequate resource of concepts in comparison to the resources acquired by their hearing peers and the minimum age standard. Most probably, this difficulty is connected with the deprivation of the ability to receive acoustic features characteristic of given objects, surrounding phenomena, people and animals, in early childhood, before the implantation. The acquisition and consolidation of the mechanism of incorrect interpretation of reality, without acoustic components, resulted in a non-harmonious cognitive development. This impaired the process of concepts acquisition and resulted in the accumulation of further retardations in the development of speech and language. The results contained in Table 13 regarding the current level of TAPS test performance demonstrate a clear progression of skills in the field of auditory functioning of the study children in comparison to the results achieved in the third year of the functioning with the cochlear implant. The current level of performance of test tasks shows that the possibility of a long-term access to the oral language through hearing after implantation gives a chance to overcome the

Table 13. Results in the TAPS Test, level IV, depending on the time of cochlear implant use (N=169)

Time of cochlear implant use	Number of children with individual test performance levels: Recognition, understanding of speech					
	Closed sets			Open sets		
	70%>	50%	50%<	70%>	50%	50%<
From 3 to 6 years	60	5	1	55	9	2
From 6 to 10 years	62	1	0	60	3	0
From 10 to 14 years	38	0	0	38	0	0
Over 14 years	2	0	0	2	0	0

phonetic barrier¹⁶ (1), which is faced by deaf children with prelingual hearing loss for the rest of their lives. The early age of children at the time of implantation (up to the second year of life) shows that it is possible to achieve linguistic competence similar to the age norm, and the language used by the subjects is a living, dynamic formation that undergoes to a continuous development process. For the majority of children in the study group, the language is functional and serves to satisfy the needs, including those of a higher order. Implanted children are familiar with the smooth movement in the world of abstract concepts, as well as creative assimilation and accommodation in the linguistic sphere.

Discussion

Prelingual hearing loss is the kind of hearing loss with consequences that must be dealt with throughout whole life. The hearing impairment factor occurs in the period preceding the active development of speech. Lack of auditory perception of suprasegmental and segmental elements of speech causes disturbances in the matu-

¹⁶ Z.M. Kurkowski, *Mowa dzieci sześciolletnich z uszkodzonym słuchem*, UMCS Lublin 1996, pp. 60–70.

ration of the auditory cortex. Fortunately, a deaf child still has the so-called physiological "attitude and readiness" to learn speech, especially until the second or even third year of life. That is why the earliest possible implantation¹⁷, which prevents the occurrence of irreversible negative changes within the auditory pathway, is so important¹⁸. Children operated in the Department of Otolaryngology of the Poznań University of Medical Sciences are a group that was provided with a cochlear implant before the second year of life. Long-term observations regarding functioning in the auditory and linguistic sphere after implantation show that the study group achieves satisfactory results in speech rehabilitation, its better understanding, faster increase in passive and active vocabulary as well as a greater self-control of voice and correctness of spoken words. Similar conclusions were drawn by Szagun¹⁹, Miyamoto²⁰ and Lesinski²¹ based on the observation of the rehabilitation progress in children implanted before the age of five and three.

In the presented results, a difference between groups of children can be observed, which, although all were implanted before the second year of life, function in different ways both in terms of hearing and language, depending on the time of cochlear implant use. The longer the time of implant active use, the better the results in

¹⁷ A.F.M. Snik, M.J.A. Makhdoum, *The relations between age at the time of cochlear implantation and longterm speech perception abilities in congenitally deaf subjects*, Int. J. Pediatr. Otorhinolaryngol 1997, 41, pp. 121-131.

¹⁸ M. Manrique, A. Huarte, *Indications and contraindications for cochlear implantation in children*, Am. J. Otol. 1998, pp. 332-336.

¹⁹ G. Szagun, *The aquisition of grammatical and lexical structures in children with cochlear implants: a development psycholinguistic approach*, Audio Neurootol 2000, pp. 39-47.

²⁰ R.T. Miyamoto, K.I. Kirk, *Speechperception and speech production skills of children with multichannel cochlear implants*, Acta Otolaryngol (Stockh) 1996, 116, pp. 240-243; R.T. Miyamoto, K.I. Kirk, *Communication skills in pediatric cochlear implant recipients*, Acta Otolaryngol (Stockh) 1999, pp. 219-224.

²¹ A. Lesinski, R.D. Battmer, *Appropriate age for cochlear implantation in children: experience since 1986 with 359 implanted children*, Adv. Otorhinolaryngol. 1997, 52, pp. 214-217.

terms of understanding speech through hearing and using the language in social situations. Our observations seem to be analogous to the observations of Ponton et al²², who believe that as the rehabilitation related to the time of CI use continues, the auditory and verbal skills of implanted children increase. The results obtained by the study group in the Test of Auditory Perception of Speech (TAPS) indicate that after a long-term rehabilitation, children are able to achieve speech understanding in open sets and even the ability to talk over the phone. Our observations show that the time needed to achieve such skills is from 6 to 7 years from the moment of implantation with systematic therapeutic support. Numerous authors²³ present results similar to those obtained in the Poznań Centre, stating that 5 years after the implantation, all children achieve speech understanding in open sets in the TAPS test or other tests designed to assess the development of auditory speech perception.

Deaf children, early implanted (the average age at the time of implantation is 15 months) are quite good at understanding verbal messages, produce speech sounds that have meaning in the language system, but are they able to communicate effectively²⁴? The primary goal of rehabilitation of implanted children is to stimulate the development of speech and language in all its aspects, with particular emphasis on advanced, adequate formation of phrasemes. Research carried out with the use of a tool developed at the Poznań Centre (the Linguistic Skills Research Sheet) demonstrate that a long-term use of a cochlear implant (seven years or longer) seems

²² C.W. Ponton, J.J. Eggermont, M. Don, *Maturation of the mismatch negativity effects of profound children and cochlear implant use*, *Audiol. Neurootol* 2000, 5, pp. 167-185.

²³ C.W. Ponton, J.J. Eggermont, M. Don, *Maturation of the mismatch negativity effects of profound children and cochlear implant use*, *Audiol. Neurootol* 2000, 5, pp. 167-185; S. Archbold, M. Lutman, D. Marschal, *Categories of auditory performance*, *Ann. Otol. Rhinol. Laryngol.* 1995, 104 (suppl. 166), pp. 312-314; S. Archbold, M.E. Lutman, *Categories of auditory performance: inter user reliability*, *Br. J. Audiol.* 1998, 32, pp. 7-12; B. Mc Cornic, *Audiometric evaluation of hearing loss in children*, *Scand. Audiol.* 1997, 26 (suppl. 46), pp. 26-31.

²⁴ A. Mc Conkey Robbins, M. Svirsky, *Children with implants can speak but cant they communicate?*, *Otolaryngol Head Nesk Surg* 1997, 117, pp. 155-160.

to be enough for the language to develop sufficiently to communicate with other people. The knowledge of language code, although in many cases still not perfect and revealing certain limitations, provides the implanted children with the opportunity for everyday creative discovery and building their own, individual language. Children with an implant gain access to previously unavailable information sources. They have a chance to acquire knowledge according to the same rules as their hearing peers and do not feel isolated from the environment in which the dominant perceptual channel is hearing and receiving sounds from the environment and human speech with its use.

Conclusions

1. Children with prelingual hearing loss, implanted up to the age of two, are able to perceive, distinguish, recognize and remember acoustic stimuli.

2. The level of auditory perception for individual groups of the study children is determined, among others, by the time implant use.

3. The process of speech development and acquisition of linguistic competence by implanted children is subject to continuous development and improvement of already acquired structures.

4. All children implanted before the second year of life reached a level of linguistic competence, which is sufficient for full functioning in the linguistic sphere in the environment of hearing people.

Bibliography

- Archbold S., Lutman M., Marschal D., *Categories of auditory performance*, Ann. Otol. Rhinol. Laryngol. 1995, 104 (suppl. 166), pp. 312-314.
- Archbold S., Lutman M.E., *Categories of auditory performance: inner user reliability*, Br. J. Audiol. 1998, 32, pp. 7-12.

- Aronson L., Estienne P., *Telephone speech comprehension in children with multichannel cochlear implants*, *Am. J. Otol.* 1997, 18 (suppl), pp. 151-152.
- Broersen S., *Cochleairr implantaat openet de wereld*, *Medisch Contact*, 65, pp. 528-531, 2010.
- Demenko G., Rychter L., Pruszewicz A. et al., *Testy do badania słuchowej percepcji mowy (TBPSM) dla dzieci z implantami ślimakowymi*, *Otolaryngologia Polska*, 1996, T. L50.
- Geremek A., Skarżyński H., Szuchnik J., *Program implantów ślimakowych u dzieci – stan obecny*, *Audiofonologia*. Tom XIII, 1999.
- Harrison R.V., *Development of the Auditory System. From Periphery to Cortex*, *Comprehensive Handbook of Pediatric Audiology*, 2011.
- Krakowiak K., *Propozycje zmian systemowych w zakresie kształcenia dzieci i młodzieży ze specjalnymi potrzebami edukacyjnymi spowodowanymi przez uszkodzenia słuchu (niesłyszących, słabosłyszających, niedosłyszających)*, „Człowiek – Niepełnosprawność – Społeczeństwo”, no. 2(32), 2016, pp. 49-66.
- Kurkowski Z.M., *Mowa dzieci sześciolletnich z uszkodzonym słuchem*, UMCS Lublin 1996.
- Leigh G., Newall J.P., Newall A.T., *Newborn screening and earlier intervention with deaf children: Issues for developing world*, [w:] M. Marschark, P. Spencer (ed.), *The Oxford Handbook of deaf studies, language and education*, vol. 2, pp. 345-359, 2010.
- Lesinski A., Battmer R.D., *Appropriate age for cochlear implantation in children: experience since 1986 with 359 implanted children*, *Adv. Otorhinolaryngol.* 1997, 52, pp. 214-217.
- Manrique M., Huarte A., *Indications and contraindications for cochlear implantation in children*, *Am. J. Otol.* 1998, pp. 332-336.
- Mc Conkey Robbins A., Svirsky M., *Children with implants can speak but can they communicate?*, *Otolaryngol Head Neck Surg* 1997, 117, pp. 155-160.
- Mc Cornic B., *Audiometric evaluation of hearing loss in children*, *Scand Audiol* 1997, 26 (suppl. 46), pp. 26-31.
- Miyamoto R.T., Kirk K.I., *Communication skills in pediatric cochlear implant recipients*, *Acta Otolaryngol (Stockh)* 1999, pp. 219-224.
- Miyamoto R.T., Kirk K.I., *Speech perception and speech production skills of children with multichannel cochlear implants*, *Acta Otolaryngol (Stockh)* 1996, 116, pp. 240-243.
- Ponton C.W., Eggermont J.J., Don M., *Maturation of the mismatch negativity effects of profound children and cochlear implant use*, *Audiol. Neurootol* 2000, 5, pp. 167-185.
- Porayski-Pomsta J., *O rozwoju mowy dziecka. Dwa studia*, Dom Wydawniczy Elipsa, Warszawa 2015.
- Reid J., Bertram B., *Tests of Auditory Perception of Speech for Children*, by Cochlear AG, Basel, Switzerland, August 1992.
- Robbins A.M., Osberger M.J., *Meaningful Use of Speech Scale*, Indiana University School of Medicine, 1991.

- Robbins A.M., *Developing meaningful auditory integration in children with cochlear implant*, "Volta Review" 1990, 92, pp. 361-370.
- Ruben R.J., *A Time Frame of Critical/Sensitive Periods of Language Development*, IJO & HNS. Vol. 51, No. 3, July-September, pp. 85-89, 1999.
- Smoczyński P., *Przyswajanie przez dziecko podstaw systemu językowego*, Zakład im. Ossolińskich, Wrocław 1955.
- Snik A.F.M., Makhdoum M.J.A., *The relations between age at the time of cochlear implantation and long-term speech perception abilities in congenitally deaf subjects*, Int. J. Pediatr. Otorhinolaryngol. 1997, 41, pp. 121-131.
- Szagan G., *The acquisition of grammatical and lexical structures in children with cochlear implants: a development psycholinguistic approach*, Audio Neurotol 2000, 5, pp. 39-47.
- Szkiełkowska A. Skarżyński H., Piotrowska A., Lorens A., Szuchnik J., *Postępowanie u dzieci ze wszczepami ślimakowymi*, Otorinolaryngologia 2008, 7(3), pp. 121-128.
- Szyfter W., Pruszewicz A., Szmaja Z., Szymiec E. i in., *Poznański Program leczenia głuchoty dziecięcej metodą wszczepów ślimakowych*, Otolaryngologia Polska 1997, Vol. L, Supplement 22, pp. 174-178.
- <https://whc.ifps.org.pl/2018/02/miedzynarodowy-dzien-implantu-slimakowego-2/> [access: 20 April 2018].