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Assessing Language Development in Children with Cochlear Implants: Challenges and Perspectives in Czech Practice

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ABSTRACT

The aim of this contribution is to introduce the current situation regarding the assessment of language development in children with cochlear implants (CI) in Czechia. There is a lack of unified methodology that would allow for reliable monitoring of spoken language development in this population. As a result, information on the communicative development of CI children is insufficient, and the progress of individual cases is difficult to track. This article discusses current practices in Czechia and illustrates some of the related issues and shortcomings through qualitative pilot research, including a case study and interviews with parents and speech therapists. We also report our own research programme which addresses language development in CI children, using the Czech adaptation of the MacArthur-Bates Communicative Development Inventories that we adjusted for assessment of communication specificities in children with cochlear implants.

KEYWORDS

cochlear implants, early intervention, language assessment, diagnostic, MacArthur-Bates Communicative Development Inventories (MB-CDI)

INTRODUCTION

A cochlear implant is a neuroprosthesis that replaces the function of damaged hearing cells and mediates auditory perception by direct electrical stimulation of the undamaged auditory nerve (Wilson & Dorman, 2008). This is different from hearing aids, which work by amplifying sound using the remaining natural hearing. Since more than 95% of children with hearing impairment are born into hearing families (Mitchell & Karchmer, 2004), further therapeutic intervention is in most cases aimed at the development of spoken language. The benefits of cochlear implants for the development of spoken communication are indisputable, as evidenced by many studies, although the specific language outcomes are characterized by considerable variability, which is still not fully understood and is being researched (e.g. Tamati et al., 2022). One factor that promotes the development of hearing-impaired children's communication skills, and cognitive and social development in general, is early exposure to sign language (Pontecorvo, et al., 2023), even if the child's parents are not native signers (Caselli et al., 2021; Delcenserie, 2024). The development of communicative skills in sign language, as well as the influence of early sign-language input on later speech development are important aspects of both research and clinical practice in work with deaf or hard of hearing children. However, this article specifically focuses on the assessment of communicative development in spoken language.

According to data provided by the Institute of Health Information and Statistics (IHIS) of the Czech Republic, a total of 231 individuals underwent cochlear implantation in the Czech Republic in 2022; at implant centers in Prague, Brno, Ostrava and Hradec Králové. Of these, 68 cases (i.e. about 30%) involved children under 6 years of age. One child underwent bilateral[1] implantation before their first birthday, and twenty-three children were implanted during their second year of life (20 bilaterally and three unilaterally. Eighteen children were implanted between the second and third year of age, (12 bilaterally and six unilaterally) and 11 between the third and fourth year (five bilaterally and six unilaterally). The size and composition of the population of implanted children in the Czech Republic are illustrated in Figure 1, which presents the number of implants in children up to six years of age, between 2013 and 2022.[2]

[1] Based on the IHIS data cited, it is unclear how many bilateral implantations were performed simultaneously versus sequentially, or the timescales involved. The data only report the number of children who received bilateral implants within a single year. We thank an anonymous reviewer for highlighting this ambiguity.
[2] The graph is based on data provided by the IHIS, Czech Republic.

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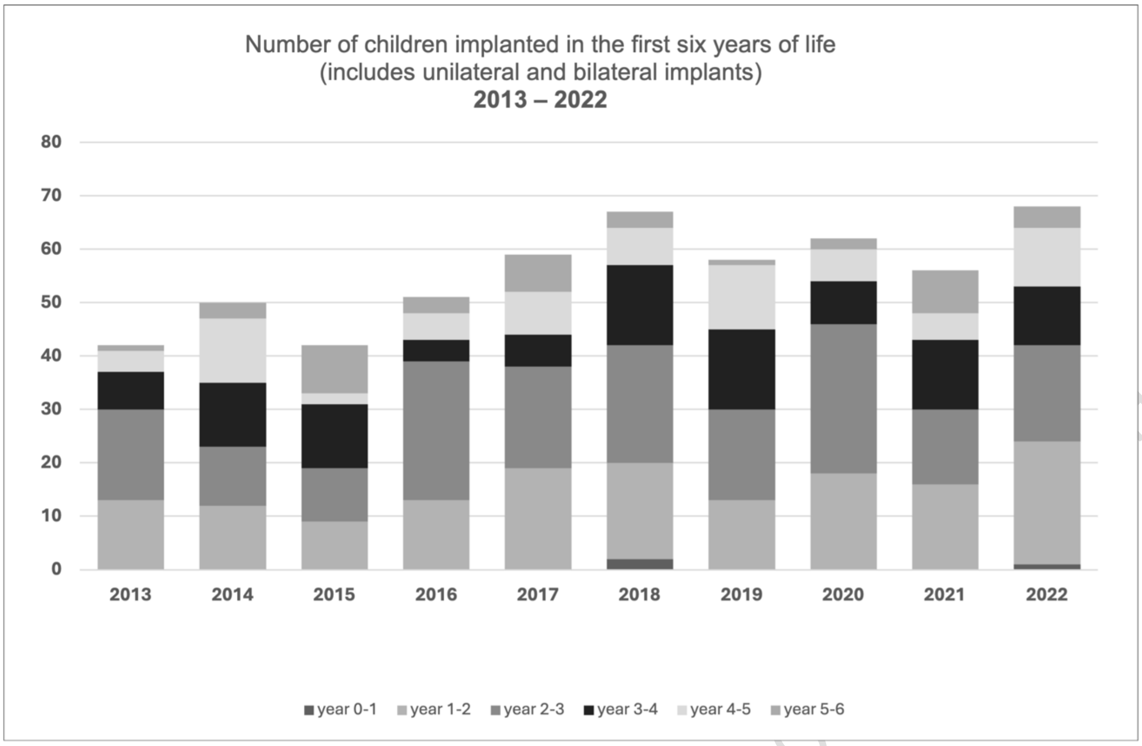

Figure 1. Number of cochlear implantations in children under the age of six between 2013 and 2022. Data provided by the Institute of Health Information and Statistics of the Czech Republic.

The implantation data indicate a clear trend toward initiating auditory compensation with this neuroprosthesis at the earliest possible age. Following the introduction of nationwide newborn hearing screening (Bulletin of the Ministry of Health of the Czech Republic No. 14/2021), based on transiently evoked otoacoustic emissions (TEOAE), the number of children diagnosed with hearing loss at an early age has increased substantially. It is considered optimal to follow the 1-3-6 diagnostic protocol: otoacoustic emissions should be reliably assessed by the end of the first month of life, hearing thresholds should be determined by three months of age (using methods such as BERA or SSEP), and hearing aids should be fitted by six months where indicated. For various reasons, however, this protocol is not always fully implemented. If hearing aids prove insufficient and cochlear implantation is being considered, the child (or adult) must meet specific indication criteria. These criteria are assessed through interdisciplinary collaboration and are described in more detail by, for example, Černý (2020). A speech-language therapist specializing in hearing impairment plays a key role in the care of children who are candidates for implantation. Their role encompasses not only post-implantation rehabilitation, but also pre-implantation intervention. Hearing aids should be fitted prior to implantation in children with confirmed hearing loss. At this stage, the clinical speech-language therapist evaluates whether the child can develop spoken language on the basis of residual hearing with the support of hearing aids alone. If spoken language development without a cochlear implant appears unlikely, the therapist works (typically through play) on strengthening the child's conditioned responses to auditory stimuli mediated by residual hearing, where present. This skill is essential for subsequent implant programming, as the child must learn to indicate what they hear and whether the sound level is comfortable.

It is the speech-language therapist specializing in hearing impairment who should be able to professionally monitor the progress a child makes in language development over time with the support of a cochlear implant. It is important to note that when a child is born with hearing loss or loses hearing early in life, a discrepancy arises after implantation between chronological age and so-called hearing age, which is typically calculated from the first activation of the device.

However, international research demonstrates that a fetus with typically developing hearing begins to process the acoustic properties of speech and non-speech stimuli with considerable precision between 30 and 36 weeks of gestation (Starr et al., 1977; Lecanuet et al., 1986; Daneshvarfard et al., 2019), if not earlier (Mahmoudzadeh et al., 2017). Individuals with intact hearing are therefore exposed to the characteristics of their native language in utero. As a result, even in the early neonatal period they are able not only to recognize their mother's voice (Mills & Meluish, 1974; DeCasper & Fifer, 1980), but also to discriminate at least some phonemes of their native language (Urbanec et al., 2024) and to distinguish their native language or language variety from a foreign language or language variety (Mehler et al., 1988; Moon et al., 1993; Dvořáková et al., 2025). Prenatal auditory experience also appears to shape early prelinguistic production, as reflected, for example, in differences in the prosodic patterns of infant crying between some languages (Mampe et al., 2009; Wermke et al., 2016).

These findings suggest that the perceptual disadvantage faced by children with congenital deafness has deeper developmental roots than might originally have been assumed. There are strong grounds to propose that the advantage in language development associated with auditory perception begins to emerge even before birth in children with typical hearing.

For this reason, careful attention must be paid to early hearing diagnosis and timely intervention in order to minimize the gap between chronological age (i.e., time since birth) and hearing age (i.e., time since activation of the hearing device). This enables the child to access auditory input as early as possible and to establish appropriate neural connections. Kral & Sharma (2012) demonstrated that, with regard to the plasticity of central auditory structures, cochlear implantation is optimal when performed before two years of age. Additional studies suggest that age at implantation may be one of the most significant predictors of spoken language outcomes in children with cochlear implants, particularly in the domains of vocabulary and grammar development (see, for example, Levine, 2016).

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Although hearing screening and diagnostic procedures conducted within paediatric care can provide relatively reliable information about the degree and nature of hearing loss and the potential for its compensation, monitoring the development of language and communication skills represents a far more complex task. Hearing is, of course, a fundamental prerequisite for the development of spoken language. In children with cochlear implants or hearing aids up to approximately three years of age, auditory perception, responsiveness to sound, and prelinguistic vocal development can be assessed to some extent using standardized rating scales and parent-report questionnaires, several of which are available in Czech. These include the Integrated Scales of Development (ISD) developed by Cochlear, IT-MAIS developed by Advanced Bionics, LittlEars developed by MED-EL, and the NAMES protocol developed within the Nottingham Auditory Implant Programme. A brief description of these instruments is provided in Table 1.

Instrument	Age	Charcteristics	Scoring	Evaluation
ISD	0-48 months of hearing age	6 categories of monitored behaviour, each with varying number of subdomains	Percentually (0-100 %)	Interpreted according to normative data from the hearing population; 100% corresponds to typical performance at 36–48 months
IT-MAIS	<3 years of chronological age	10 items	1–4 points based on frequency of described behaviour	Total score converted to a percentage according to hearing age
LittlEars	<2 years of hearing age	35 questions	Yes/No responses	Interpreted according to normative data from the hearing population
NAMES	3 years post-implantation (particularly children implanted before 2 years of age)	5 milestones, each including 10 evaluated phenomena	Scored on a 0–2 scale based on the frequency of observed behaviour	Enables longitudinal tracking of an individual child's progress; not norm-referenced

Table 1. Brief characteristics of questionnaire-based instruments that are available in Czech and that are used to assess the level of auditory perception and related behaviours in children with cochlear implants.

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Although primarily designed to assess auditory perception in children with cochlear implants, these questionnaire-based tools are also used to evaluate hearing aid benefit. In such cases, the results can indicate the adequacy of the current amplification system and inform decisions regarding cochlear implantation (Černý, 2020). It should be emphasized, however, that these instruments focus exclusively on the development of sound perception and do not allow for detailed monitoring of language acquisition. Auditory perception and its development, which are the main targets of these monitoring questionnaires, are essential prerequisites for the acquisition of spoken language. While these tools can support the observation of early communication skills, their assessment of language itself remains rather superficial.
Moreover, a survey by Horáková (2017) across institutions involved in the care of children with hearing impairments (including cochlear implant centers, special education facilities, early intervention programs, and clinical speech therapy clinics) indicates that these tools have not yet become fully established in Czech practice. Among the instruments surveyed, the Integrated Development Scales (ISD) appear to be the most widely used: of sixty experts contacted, twenty-eight reported using ISD in their work. Given the characteristics of the sample, many of these respondents were likely professionals at the Tamtam Centre for Children's Hearing. This centre has long used its own adaptation of the ISD, which, in addition to standard categories related to auditory perception and spoken language (auditory perception, receptive and expressive language, verbal expression, cognitive abilities, and social communication), also includes categories addressing the perception and production of sign language. The results of the ISD can be presented graphically (see Figure 2), in a clear and engaging format that is accessible to parents, helping to motivate and guide their interactions with the child. However, the validity and reliability of this tool remain somewhat uncertain. that is, the extent to which it accurately measures a child's specific abilities. Consequently, although the results can serve a motivational and informative role, they do not provide a detailed or comprehensive assessment of language development.

One of the possible ways of reporting the findings from the Integrated Developmental Scales is illustrated in Figure 2, drawn from the case study of the boy R described below. The plot is an output from the early care intervention at the Tamtam Centre for Children's Hearing. For each domain assessed and at each month after implantation, three points are plotted: one for biological age (i.e., the child's chronological age), one for hearing age (chronological age minus the age at which the cochlear implant was activated), and one for developmental age based on the child's performance in the relevant communication-related category (an integration of criteria from eight different measures). Points for each of the three ages are connected to form a curve. Ideally, the curve representing the child's current level should be as close as possible to the curve corresponding to their biological age. As shown in the plot, this child even exceeded his biological age in some areas, particularly in the linguistic aspects of speech, while in sign language he lagged behind, which naturally reflects the family's focus on spoken language development; signing was used primarily to support early communication and was gradually abandoned once speech emerged.

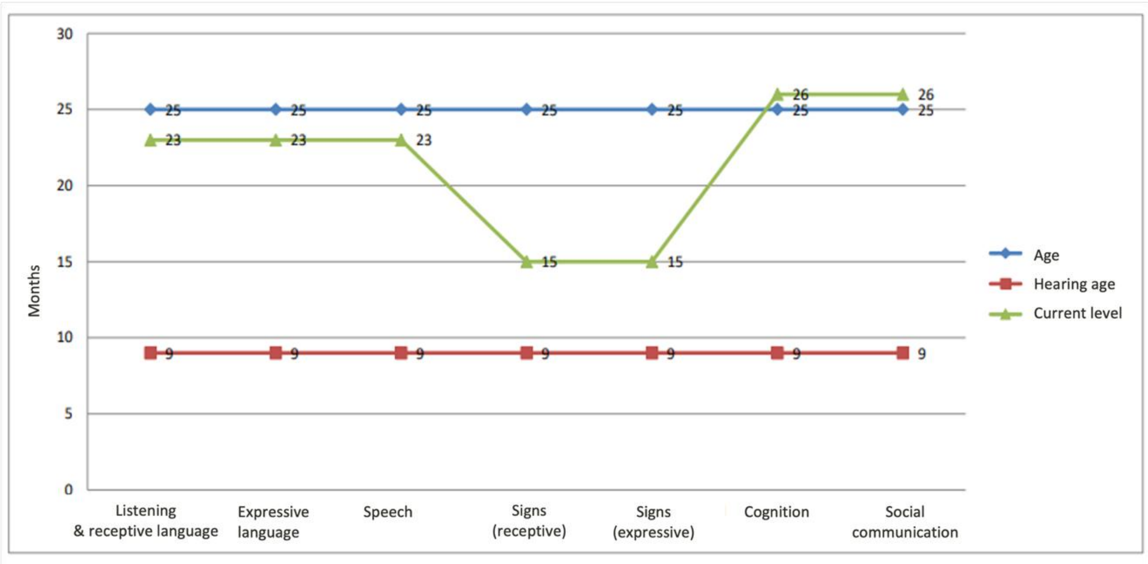

Figure 2: Attested output from measurements using Integrated Developmental Scales. Adapted from a report that was kindly provided by a parent of a cochlear-implanted child.

In Horáková's (2017) survey, only four of sixty respondents reported using the LittleEars tool, and four used IT-MAIS. The NAMES was adapted for the Czech Republic by Drahotská (2020); prior to this adaptation, no Czech version was available, and consequently, there are no data on its frequency of use in practice. Horáková (2017) also found that speech therapists assess the benefits and basic functioning of cochlear implants in young children using less comprehensive methods, such as the Ling Six Sounds Test, which tests the discrimination and identification of six phonemically distinct sounds: /a/, /i/, /u/, /m/, /ʃ/ and /s/. However, this quick screening test evaluates only auditory perception and is influenced by the device settings and current functionality; it does not measure language development. The Nottingham scale (CAP) operates similarly, providing only a tentative estimation of general perceptual abilities across eight levels, from failure to detect ambient sounds to using the telephone. Therefore, the Horáková (2017) survey suggests that when evaluating language development and progress, speech therapists tend to rely on observations of children's behaviour in the clinic and on information obtained from parent interviews during visits.

CASE STUDY

To provide an example of how a diagnostic process may unfold, we describe a concise summary of the case study of a boy, R, conducted as part of our own qualitative pilot study. The course of the child's primary diagnostic history is illustrated in Figure 3.

The boy, R., was born at full term via spontaneous vaginal delivery, without complications. There was no family history of hearing impairment or other disabilities. Measurements in the hospital indicated absent auditory emissions, which represents one of the risk factors for hearing impairment. After several unsuccessful attempts in the following months, a successful follow-up was performed at five months of age, yielding normal results. This initially alleviated the parents' concerns, which however re-emerged around the child's first year when the parents noticed that they child was not producing words spontaneously and did not respond appropriately to auditory stimuli.

Following these observations, the child's hearing was reassessed using TOAE at 14 months, and later via steady-state evoked potentials (SSEPs), which definitively confirmed binaural perceptual hearing loss at the level of severe to profound deafness at 16 months. The boy was subsequently listed as a candidate for cochlear implantation and underwent auditory stimulation with hearing aids under the guidance of a speech therapist. According to the boy's mother, the hearing aids supported some vocabulary development, which made her hesitant to decide whether to proceed with implantation.

As part of the speech therapy evaluations, which are included in the implantation criteria, no formal assessment of language development was conducted to guide parental decision-making. The parents hesitated for some time and were ultimately persuaded to proceed with implantation following the results of visually enhanced audiometry (VPA) conducted at the Tamtam Centre when the child was 20 months old. Bilateral implantation was performed after final brainstem evoked potential (BERA) testing at 24 months.

The mother reports that no formal evaluation of language development took place at the speech therapy clinic within the implantation centre following the procedure, an experience she rated rather negatively. An independent interview with a speech therapist from the clinic confirmed that standardized tools were not used there. Parents did, however, maintain a partial overview of their child's communication development through regular assessments using developmental scales at the Tamtam Centre, which indicated a noticeable acceleration in language acquisition within a year after implantation.

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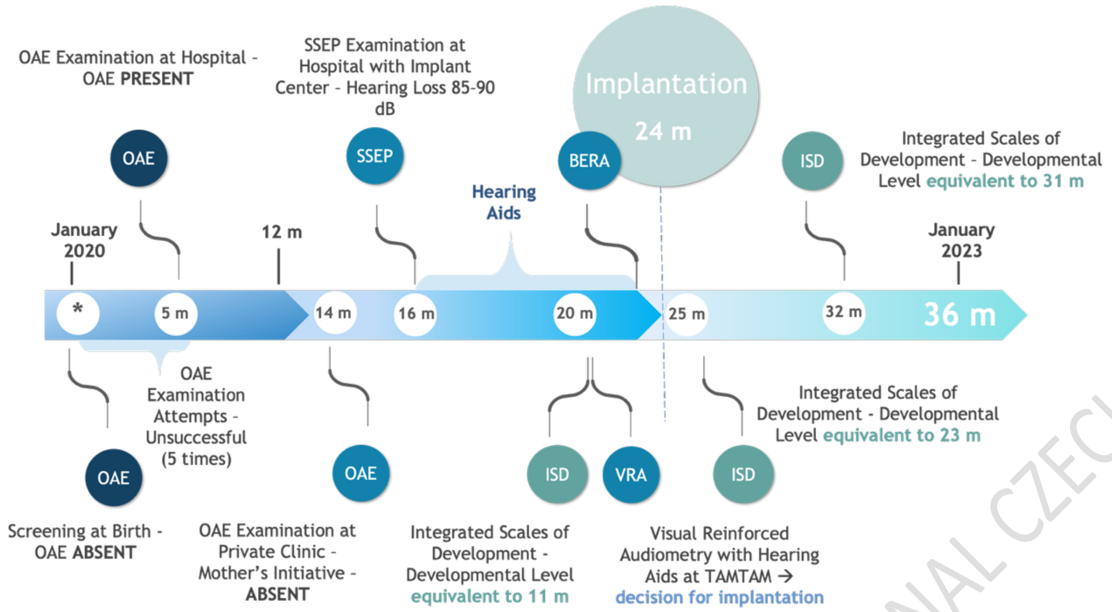

Figure 3: History of hearing assessment and language development in boy R.

Due to the lack of systematic use of formalized methods, no reliable quantitative data are currently available in the Czech Republic on the progress of language acquisition in children with cochlear implants, its developmental trajectory, inter-individual variability, or the factors that may influence it. Research on this population has not yet been a focus for Czech-based linguists or psychologists, aside from qualitative assessments of selected linguistic aspects in individual cases (e.g., Jungwirthová, 2009; Baslová, 2023). Based on our current understanding, we identify four main reasons for the absence of such research: (1) the population in question is both very small and highly sensitive; (2) this population is also highly heterogeneous, with numerous factors influencing the development of each child – hence, in terms of assessment, it has been referred to as a "constantly moving target" (Geers, 2006; Gillis, 2018); (3) until recently, quantitative research has not been strongly established in Czech speech therapy practice; and (4) the workload of practicing speech therapists, combined with the demands of the profession, is in most cases incompatible with systematic research activities.

The findings of our recent qualitative study suggest that time pressure is one of the reasons for why a comprehensive monitoring of language skills in CI children is not routinely integrated into speech therapy practice. This issue, which pertains to language diagnostics in clinical speech therapy more broadly, is reflected in Neubauer (2018) who claims that materials derived from more comprehensive linguistic assessments are not effectively usable in practice due to time constraints.

However, several additional factors appear to contribute. The experts we consulted also noted a certain distrust in the reliability of available tools, particularly those that depend on the child's direct cooperation in the speech therapy clinic, a setting in which the child may behave atypically due to situational factors such as mood, shyness, or fatigue. Our respondents also considered simpler parent-report questionnaires to be overly subjective, with results that are difficult to verify from a clinical perspective. It should be noted, however, that standardized instruments, such as the Czech adaptations of MacArthur-Bates Communicative Development Inventories, possess high validity and reliability, and their results provide meaningful information about the child's communication development relative to neurotypical norms.

This topic raises numerous questions and challenges. We argue that understanding the patterns of language development in children with cochlear implants is in the interest of all stakeholders, in addition to the children themselves, including: (1) parents, who naturally wish to monitor their child's development over time, particularly when they invest substantial time and effort in rehabilitation; (2) clinical professionals, for whom comparing a child's development with that of the broader population can help identify potential delays or difficulties; and (3) the scientific community, who aim to characterize language development in Czech-speaking implanted children and thus enrich the current knowledge base. These considerations raise the question of how to establish effective interdisciplinary collaboration to generate knowledge that is both comprehensive and practically applicable. In the Czech Republic, care for children with hearing impairments is distributed across three ministries: the Ministry of Health, the Ministry of Labour and Social Affairs, and the Ministry of Education. This situation further prompts the question of whether a more unified methodology should be developed to enable the objectives outlined above.

DISCUSSION

Longitudinal data on language development in children with cochlear implants are currently being collected as part of the first author's dissertation project, at the Faculty of Arts of Charles University and the Czech Academy of Sciences, Institute of Psychology. The ongoing study aims to provide the first quantitative description of vocabulary and grammar development in Czech-speaking children with cochlear implants, limited to those with a hearing age of 36 months or less and a biological age of seven years or younger. To reduce variability, the study focuses on children of hearing parents without additional disabilities.

Questionnaires are distributed through the Tamtam Center and all special education centres for children with hearing impairments listed in the Catalogue of Support Measures were also contacted. For this initial survey, we chose to use existing instruments: the Czech adaptations of the MacArthur-Bates Communicative Development Inventories (MB-CDI) (Fenson et al., 1993; Jarůšková et al., 2024; Paillereau et al., 2023; Smolík et al., 2017). These are Dovyko I (MB-CDI: Words and Gestures), which primarily assesses language comprehension and includes norms for children aged 8 to 18 months, and Dovyko II (MB-CDI: Words and Sentences), which focuses on word production and the use of basic grammatical constructions in children aged 16 to 30 months.

Research indicates that early vocabulary size is a strong predictor of later language competence (Lee, 2011; Duff et al., 2015); accordingly, vocabulary questionnaires are considered highly relevant tools that can also help identify developmental risks. We selected these instruments for our target population based on validation studies by Stallings et al. (2002) and Thal et al. (2007), which demonstrated their suitability for assessing vocabulary in children with cochlear implants.

Additionally, we supplemented the word checklist (the main and most comprehensive component of both questionnaires) with an option to indicate whether the child also uses a sign-language gesture for a given concept. It is important to emphasize that no diagnostic tools or normative data exist for Czech Sign Language development, and our adaptation is therefore relatively basic, allowing rather superficial monitoring of competence in Czech Sign Language. Nonetheless, this represents the first attempt to map the extent to which Czech parents use these (albeit isolated) signs to support early communication development.

CONCLUSION

Children whose hearing loss is compensated by cochlear implants represent a highly specific population, whose language development exhibits considerable variability that remains insufficiently understood. In the Czech context, quantitative studies on language development in hearing-impaired children are lacking, as are reliable and valid tools for assessing their language development. Consequently, no uniform methodology exists that would enable practitioners to systematically record, evaluate, and compare developmental progress. The goal of our research programme is not only to describe spoken language development in hearing-impaired children with CIs, but also to motivate the identification and implementation of necessary adjustments in therapeutic strategies for individual children, particularly when other approaches fail to yield developmental progress.

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