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Editorial

Prelinguistic Vocalizations of Children with Cochlear Implants: Clinical Value for Early Assessment

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Editorial

Early implantation of deaf children has been long advocated as the optimal procedure for restoring hearing in infants and young children, thereby allowing them to acquire spoken language to a full extent, much alike their hearing peers [1-5]. However, some research indicated that such an endeavor is not quite well- achieved [6] and that implanted children continue to face difficulties with spoken language acquisition. Other researchers [7] have documented that implanted children have impoverished skills and capacity for short-term memory and phonological processing and these difficulties back channel into developmental delays in language acquisition.

In addition it has been documented that roughly 30%-40% of children that are implanted nowadays have been diagnosed with additional developmental problems or handicaps, since hearing loss is often one of the symptoms in pediatric disorders or other medical conditions in childhood [8]. A major concern, then, after a child receives a cochlear implant is how quickly and efficiently they can acquire spoken language.

From infant research, it is known that during the first months infants babble in a quite uniform fashion but later on they develop babbling patterns and vocalizations that are more complex but also phonetically adapted to the child's particular language environment [9]. For children with developmental communication disorders or hearing disorders, the study of the infant's vocal development is considered a crucial research area since it can potentially provide early evidence and prognostic signs for the final outcome of language acquisition. Several researchers [10-12] have acclaimed that babbling is an important precursor for language development as it precedes the onset of words. Oller [13], in his infraphonological model, suggested that the babbling of infants is a rule-based system with different developmental stages that gradually lead the infant to produce adult-like patterns, i.e. words, around the first year of life. In later versions of Oller's model, the vocalization types of infants were classified into five stages in SAEVD [14]. These ranged from reflexive and vegetative sounds and quasi-resonant nuclei, to volitional sounds such as fully-resonant vowels, consonant-like sounds, marginal syllables and later on well-defined consonant vowel sequences and complex patterns of syllabic combinations. Recent research, for practical purposes serving clinical practice, has modified these stages, merging them into three basic categories, namely pre-canonical babbling, canonical babbling and advanced forms [15,14].

However, regardless of the taxonomy used, the early stages of babbling are not revealing for reaching a prognosis regarding the efficiency of the speech mechanism and furthermore for language development. Recent and past evidence [16-18] indicated that the prelinguistic vocalizations classified as Pre-Canonical (PL) are relative immature and are equally observed in the babbling productions of both typically developing children and children with hearing aids. Consequently, they are not able to provide diagnostic and prognostic indications about the CI effect.

On the other hand, the late stages of babbling are considered important milestones of early phonological development. The first one is the stage of canonical babbling which is composed of well-formed consonant-vowel syllables, with rapid transitions from consonant to vowel. The canonical babbling forms represent a significant step towards adult-like speech [19]. For English-speaking infants, the onset of canonical babbling is between 5-10 months [20] whereas advanced, complex forms in multi-syllabic combinations occur around 9-18 months.

Several researchers have emphasized the potential diagnostic value of the stage of canonical babbling and its onset for the detection of developmental speech disorders brought by hearing-impairment, dysarthria, apraxia and phonological disorders [21-22]. In particular, for hearing impairment of severe-to profound degree, a major finding has been that deaf infants babble as long and as frequently as their hearing peers [23-25,16] but have smaller than typical phonetic and syllable shape inventories [26-27], preference for less advanced forms and canonical babbling patterns than hearing peers [28,27,17,16]; as well as late onset of canonical babbling [20,16].

Yet, what happens with deaf infants or very young children who have received a cochlear implant and acquired near- normal hearing? Are they lagging behind their peers during the prelinguistic stage or do they follow normal patterns of babbling development in their first year of implantation? Several studies have been conducted with English-speaking children [15,18,29-30]; Dutch-speaking [31], Hebrew-speaking children [32] and German-speaking infants [22] and very young children, aiming to track the development of babbling, mostly at the stages of canonical babbling and advanced form, in comparison with normally-hearing peers.

All of the above studies revealed that cochlear implanted children progress through the stages of babbling, including canonical babbling, at a faster pace as compared to their hearing peers with equivalent

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auditory experience. More specifically, [18] reported on a case study of a girl implanted at were replicated for small groups of cochlear-implanted children, who babbled either spontaneously during adult-child interactions [33,31] or merely via elicitation techniques [30] within 1–4 months post-surgery and 6.5 months, respectively. For English-speaking infants and young children, [29] differentiated among three groups, depending on age of implantation: a) one late-fitted child achieved canonical babbling prior to implantation b) several implanted children, fitted between 12-36 months progressed though the babbling stages of canonical babbling and advanced forms much alike the normally-hearing-peers, and c) one early-implanted child followed a different progression reaching the advanced forms of babbling first and subsequently exhibiting canonical babbling. Notably, a child with multi-handicap failed to establish the stage of advanced forms after 24 months of CI use. A subsequent study by [15] examined the prelinguistic vocalizations of 13 English-speaking infants and young children with CI, aging from 8 to 35 months and compared their patterns to 11 typically-developing infants, aged 6 months. Findings indicated that the implanted infants and very young children did not differ in their babbling productions as compared to the typically-developing children. To the contrary, the implanted young children exhibited more advanced forms of babbling as compared to the typically-developing 6-month olds at similar post-implant ages. A similar finding was reported for Hebrew-speaking children by [32] where implanted infants with a mean implantation age of 18.9 months reached the stage of canonical babbling, via reduplicated CV patterns, mostly around 5-7 months post-implant.

It appears that findings overall tend to support the" advanced maturity" hypothesis where the speech mechanism in young implantees has gained substantial control for movement of articulators and coordination patterns, and consequently, prelinguistic vocalizations emerge and evolve rapidly as soon as the child gains auditory experience, within a few months [29], indicated that the late-fitted children reached the advanced stages of babbling earlier than the early fitted ones, a finding that provides further support for the "advanced maturity hypothesis. Alternatively, some other studies mentioned above [32,30] have shown that infants or young children with CI reach the stage of babbling at similar rates to normally-hearing infants.

However, the role of audition in the above cases cannot be underscored as studies [34,20], as canonical babbling appeared to be delayed in deaf infants, first emerging at ages over 10 months. As the authors state "these children begin with pre-canonical vocalizations but stop before the transition to the canonical stage". In conclusion, only those deaf children that have received a cochlear implant and therefore had gained access to the auditory speech signal can exhibit advanced forms of babbling.

Since the finding on the precipitation or age-appropriate acquisition of advanced babbling patterns is a robust one for implanted infants and young children, accomplished as a result of restored audition, it is worth investigating the contribution of language-particular influences in infants or young children with cochlear implant since these influences are apparent in the advanced stages of babbling of typically-developing infants [9,13]. An interesting question then is: Are babbling patterns of implantees adapted to the phonetic and phonological characteristics of the particular spoken language in the child's environment much alike their hearing peers with equivalent auditory experience?

As Oller indicated, the analysis of the phonetic repertoire of babbling is a hazardous process that does not yield reliable results [35]. Alternatively, the study of the dominant prosodic structures of babbling may prove to be a promising avenue for tapping into the language-particular influences that appear in the advanced stages of babbling in children with CI.

Unfortunately, the taxonomies used in the different studies are variable, ranging from Stark's SAEVD-R, 1993[36] to Oller's [13] and later revised versions of Oller's infraphonological stages [15]. Thus, for English-speaking infants it is very difficult to draw conclusions about the particular structures occurring in CB stage and further. For example, [14] used the SAEVD-R and documented the emergence of the canonical babbling stage, occurring between 9-20 months, by productions of single CV syllables, while [32], examining Hebrew-speaking infants/young children regarded the reduplication of CV as the adopted criterion for CB stage. From the above, only one study [14], systematically reported on the most dominant pattern of babbling at the CB stage for typically-developing English-speaking children which was the single syllable of consonant-vowel production (CV).

Recent evidence from a dissertation study [37], examining the protophone development in 7 Greek-speaking, cochlear-implanted children, aged 1;10-4;00 years, over a period of 11 months post-implant, revealed that the most frequent structure in their vocalizations was the CVCV type [38]. This held for both early fitted (< 24 months) and late-fitted (> 24 months) children. Notably, the same trend was found in the hearing controls that had an equivalent auditory experience, i.e. 8- to 10- month olds. The results agreed with [39] for hearing infants. Based on the above, a hypothesis is put forth, suggesting that the dominant babbling structures at the CB stage are influenced by the infant's language environment. Namely, English contains a lot of monosyllabic words whereas Greek contains a lot of disyllabic words and in both cases hearing infants pick up that trend and produce similar forms in their babbling. Of equal importance is the finding that cochlear-implanted children seem to also perceive and produce these language-specific characteristics of prosodic structure as they showed different types of dominant patterns in their productions of the CB stage.

More research is needed in the babbling patterns in different languages to support the above hypothesis. It appears that the study of babbling patterns can be developed to serve as an early diagnostic tool for children with cochlear implants, providing indications for the onset of language-specific processing.

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