Karolinska Institutet

Institutionen för klinisk vetenskap, intervention och teknik

Effects of age and stimulation strategies on cochlear implantation and a clinically feasible method for sound localization latency

AKADEMISK AVHANDLING
som för avläggande av medicine doktorsexamen vid Karolinska Institutet offentligen försvaras i föreläsningssal B64, Barngatan 4, Plan 6, Karolinska Universitetssjukhuset, Huddinge.
Zoom: https://ki-se.zoom.us/j/63994272179

Fredagen den 16:e oktober 2020, kl 09.00

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Stockholm 2020

ABSTRACT

Treating prelingual deafness with cochlear implants paves the way for spoken language development. Previous studies have shown that providing the intervention at six to 11 months is better than at 12-17 months. However, interventions at even earlier ages have not been researched to the same extent, for example by comparing five to eight months with nine to 11 months. That is why we retrospectively assessed the surgical risks, and analyzed the longitudinal spoken language tests, of 103 children who received their first cochlear implant between five and 30 months of age. This research particularly focused on surgery before 12 months of age (Paper I). Apart from language development, we expected that early implants would provide access to the interaural time differences that are crucial for localizing low frequency sounds. We were interested to examine this in combination with novel sound processing strategies with stimulation patterns that convey the fine structure of sounds. Therefore, in addition to the retrospective analysis, we studied the relationships between stimulation strategies, lateralization of interaural time differences and horizontal sound localization in 30 children (Paper II). Then we decided to develop a method to objectively assess sound localization latency to complement localization accuracy. A method that assesses latency needed to be validated in adults with normal hearing, and in hampered conditions, so that the relationship between accuracy and latency could be clarified. In our study, the gaze patterns from the localization recordings were modelled by optimizing a sigmoid function (Paper III). Furthermore, we addressed the lack of studies on the normal development of sound localization latency of gaze responses in infancy and early childhood (Paper IV).

Our study of spoken language development showed the benefit of cochlear implantation before nine months of age, compared to nine to 11 months of age, without increased surgical risks. This finding was strongest when it came to the age at which the child's language could be understood (Paper I). When our group of 30 subjects underwent tests for interaural time differences, 10 were able to discriminate within the range of naturally occurring differences. Interestingly, the choice of stimulation strategy was a prerequisite for lateralizing natural interaural time differences. However, no relationships between this ability to lateralize and the ability to localize low frequency sounds were found (Paper II). The localization setup meant that detailed investigations of gaze behavior could be carried out. Eight normal hearing adults demonstrated a mean sound localization latency of 280 ± 40 milliseconds (ms), with distinct prolongation with unilateral earplugging. It is interesting to observe the similarity in latency, dynamic behavior, and overlap of anatomical structures between the acoustic middle ear reflex and sound localization latency (Paper III). In addition, normal hearing infants showed diminished sound localization latency, from 1000 ms at six months of age down to 500 ms at three years of age (Paper IV). Latency in children with early cochlear implants still needs to be studied.

The findings in this thesis have important clinical implications for counseling parents and they provide valuable data to guide clinical choices about the age when cochlear implants are provided and processor programming takes place. The fast, objective and non-invasive method of sound localization latency assessment may further enhance the clinical processes of diagnosing and monitoring interventions in children with hearing impairment.