Psychophysical tuning curves as a measure of spectral resolution in children and adults with cochlear implants

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Abstract

Cochlear implants (CIs) are highly successful at restoring some hearing to individuals with severe hearing loss. However, outcomes are highly variable among individuals and difficult to predict. Performance outcomes are influenced by peripheral factors such as the electrode-neuron interface (ENI), defined as the quality of the interface between individual electrodes and the target auditory neurons. Measures of the ENI, including those that quantify spectral resolution, were obtained and their relation to speech perception abilities described. Eight children (twelve ears) and nine unilaterally implanted adults participated, all with Advanced Bionics CIs. Children were pre-linguistically deaf, received their first CI by age 2, and were tested between 11 and 17 years of age. Adults were post-linguistically deaf, implanted as adults, and were tested between 28 and 80 years of age. For all participants, detection thresholds were measured with a sweep procedure using a focused electrode configuration, sharpening electrical fields compared to the standard monopolar configuration. A focusing coefficient of 0.9. was used. These focused thresholds are related to the distance of electrodes to target neurons as estimated by CT imaging. Focused thresholds are also related to the health/density of neurons as assessed by evoked potential measures sensitive to neural health in animal models. Recently, we have also found that they relate to medial vowel identification scores. Psychophysical tuning curves (PTCs) were measured for one electrode using direct stimulation and a focused configuration with a coefficient of 0.5. Sharpness of tuning was quantified by averaging the slopes of the apical and basal sides of the tuning curves from the PTC tip in both directions. Speech perception was assessed by medial vowel identification in the /h/ vowel /d/ context. Medial vowel identification is a challenging measure of spectral resolution in CI listeners. Results showed that for both children and adults, those with sharper tuning also performed better on vowel identification (children, β= 0.5, p=0.04, adults, β= 3.73, p=0.02). A subset of children (N=3) show sharper tuning than what has been observed for adult CI listeners, both those in the present study and as reported in the literature. Demographic factors such as age of onset of hearing loss, age of implant, and duration of implant experience, among others, will be discussed in the context of these results. Preliminary findings suggest that children and adults with sharp tuning are better able to discriminate medial vowel sounds than those with broad tuning. Further, it is important to note that some pediatric CI listeners can have sharper

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tuning than their adult counterparts. PTCs likely reflect the quality of ENIs. This may be important for processing spectrally challenging sounds, such as vowels. This finding may guide future work to increase our understanding of the relation between PTCs and speech understanding as well as the development of spectral resolution in children who are learning speech and language through CIs.