

Audiovisual Perception of Mandarin Tones by Children with Cochlear Implants

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Cochlear implants (CIs) have made oral speech communication possible for many children with hearing loss. However, tonal perception is still challenging since CI devices cannot code pitch effectively. In most daily speech conversations, both audio and visual (e.g., speakers' mouth movements) cues are available. It has been shown that visual cues greatly benefit children with CIs to perceive vowels better, especially in noise [1], with children implanted earlier showing greater visual benefits [2]. However, it was unclear if this is also the case for tonal perception. Moreover, evidence shows that Mandarin tonal productions are characterized by distinct facial movements, but such movements are less distinct in connected speech (utterances) relative to citation forms [3]. It was therefore unclear whether visual benefits on tonal perception (if any) exist in both citation and connected speech contexts.

To address these issues, this study tested children with CIs' audiovisual perception of Mandarin tones in citation forms (Experiment 1) and connected speech (Experiment 2). We predicted that, in both contexts, the tonal recognition accuracy would be higher in the audiovisual (AV) condition relative to the audio-only (AO) condition, especially when noise is presented. Furthermore, children implanted earlier would exhibit a larger visual benefit in tonal perception.

Experiment 1 tested 82 3-7-year-old children with CIs (implantation age: 0.5-5 years) and 82 age-matched NH controls. Stimuli included 36 picturable monosyllables carrying all tones, video-recorded by a native female speaker. In each trial, a child was presented with a target stimulus in AO or AV modality and in quiet or noise (0dB babble), and then required to select the corresponding picture from two pictures varying in tones.

The results showed that only the CI group has improved their tonal recognition accuracy from AO to AV condition, but only in the noise condition (Figure 1). Pearson-correlation tests performed on implantation ages and visual benefits (accuracy differences between AV and AO conditions) for children with CIs reported a negative correlation in the noise condition (Figure 2).

Experiment 2 tested additional 63 3-7-year-old children with CIs (implanted age: 0.7-7 years) and 63 age-matched NH controls. The procedure was similar to that of Experiment 1, except that all target syllables were produced and presented with a carrier sentence “请找到 X 这张图” *please find X's picture*.

The results showed that, similar to Experiment 1, only the CI group has improved their tonal recognition accuracy from AO to AV condition in the noise condition (Figure 3). However, implantation ages were not correlated with visual benefits in any condition (Figure 4).

Our results, for the first time, demonstrated that children with CIs were able to use visual cues to facilitate their tonal perception when audio information is degraded in noise, and such visual benefits existed in both citation and connected speech contexts. Furthermore, children implanted earlier showed a stronger ability to integrate visual information into tonal perception in noise. The implications for hearing and speech rehabilitations and early neural plasticity in audiovisual integration are discussed.

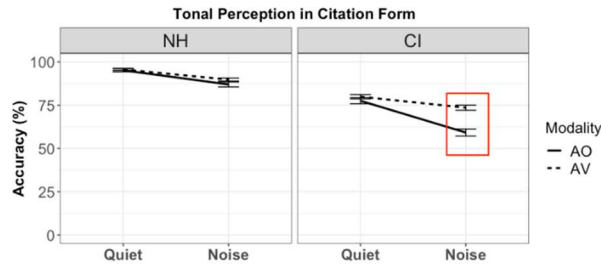


Figure 1. Tonal perception accuracy in citation forms by NH and CI groups. Red box indicates the statistical differences between AO and AV modalities (Experiment 1).

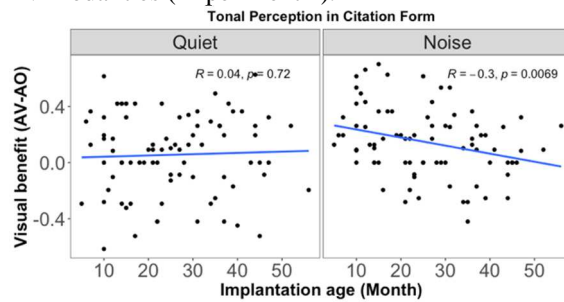


Figure 2. Correlations between implantation ages and visual benefits (accuracy differences between AV and AO conditions) for children with CIs in citation forms (Experiment 1).

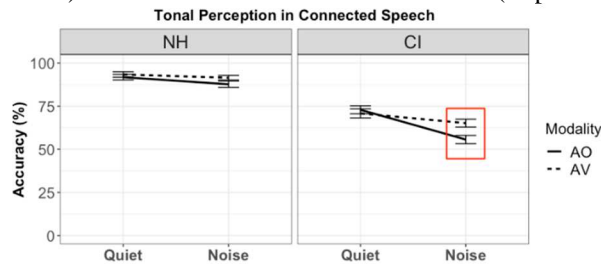


Figure 3. Tonal perception accuracy in connected speech by NH and CI groups. Red box indicates the statistical differences between AO and AV modalities (Experiment 2).

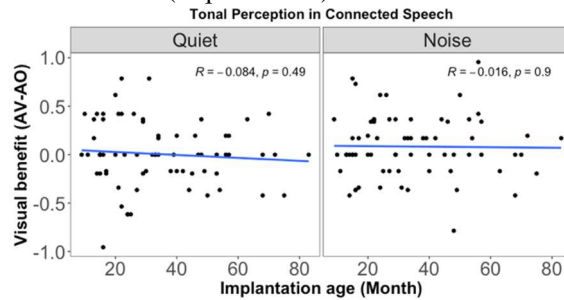


Figure 4. Correlation between implantation ages and visual benefits for children with CIs in connected speech (Experiment 2).

References

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