Realization of voicing by French-speaking CI children after long-term implant use: an acoustic study on VOT and comparison with NH children

Most studies on consonant production in children wearing cochlear implants (CI) are based on perceptual judgments and focus on developmental patterns before and after implantation (e.g. [1]) or on error patterns at specific time points after implantation (e.g. [2]). Acoustic studies of consonant production (stops, fricatives or affricates) are very scarce: only one acoustic study on stops to date ([3]) compares production of CI children with age-matched children using traditional hearing aids but does not include a normal-hearing (NH) control group.
Acoustic studies of stop production in NH adults have shown VOT to vary with place of articulation, aspiration and voicing (e.g. [4]). In French (e.g. [5]), VOT varies with voicing (positive VOTs for voiceless consonants, negative VOTs for voiced consonants) and place of articulation (for voiceless stops, the further back the consonant is produced, the longer the VOT).

In this paper, we present results from an acoustic study on stop production in French-speaking CI vs NH children, using VOT as a correlate of voicing and place of articulation. Our goal is to understand the impact of long-term use of cochlear implant on the coordination of articulatory gestures used in stop production, and the effects of factors such as chronological age, age at implantation and duration of implant use.
Participants were all monolingual French children: 13 CI children (chronological age: 6;6 – 10;7 yrs, age at implantation: 1;6 - 6;6 yrs, duration of implant use: 2;2 – 9;1 yrs) and 15 age-matched NH children (6;5 – 10;6 yrs).
The experiment was a picture-naming task under two conditions: repetition with audio model and production without audio model. The stimuli were 12 words with /b, d, g, p, t, k/ as word-initial consonants followed by /i/ or /u/ (e.g. *bille, 'marble'*; *bouton, 'button'*). Two elicitations of each word were recorded.
Children's productions were transcribed by the first author who judged (1) whether they were understood as the target word: word accuracy was higher ($p<.05$) for NH children (99.7%) than for CI children (95.3%); and (2) whether the target syllables were suitable for analysis, i.e. no breathiness or vowel devoicing: 82.1% for NH children vs 86.2% for CI children (n.s.). VOT was measured as the time difference between burst and first glottal pulse.

Statistical analyses (linear mixed effect models and multiple comparisons) show a difference in VOT between groups for voiceless consonants (shorter VOTs for CI children), with significance reached only for /k/, but no difference for voiced consonants. For both groups, a significant proportion of voiced consonants are realized with positive VOT.
For NH children, VOT increases slightly with chronological age, for all stops except for /g/, but it does not for CI children, for whom it varies with other factors: the later they have received the implant, the shorter the VOT, and the longer they have been using the implant, the longer the VOT.
Our study indicates that long-term CI use seems to have minor effects on voicing and on the acquisition of oro-laryngeal coordination. Most difficulties seem to be located on velars.

References

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