Word frequency effects on phonemic accuracy of children with cochlear implants in comparison to their normally hearing peers

The present paper discusses the effect of whole word frequency (WF) on the phonemic accuracy of that word. Furthermore, the influence of hearing impairment on phonological development is studied by comparing normally hearing (NH) children and children with cochlear implants (CI). The effect of WF on phonemic accuracy has not been studied yet, nor the comparison between NH and CI children in that respect.

Frequency effects are omnipresent in the language development of NH children. For phonological development, mostly phonotactic probability (PP) is considered: the higher the odds of a phoneme sequence in the target language, the more accurately the sound is produced (Edwards, Beckman, & Munson, 2004). However, WF effects have only been studied in lexical development: highly frequent words in child-directed speech (CDS) emerge earlier in children's lexicon (Storkel, 2004). Closed class words are an exception: they are the most frequent, but appear late in children's lexicon. With respect to the lexical development of CI children, Guo, McGregor, and Spencer (2015) found no effect of WF (nor of PP) on the lexical development of CI children with unilateral implants, hypothesizing that those CI children are not sensitive to language statistics. We study whether WF affects accuracy – and not lexical development – of CI children as compared to NH peers.

Data consisted of monthly video-recordings of the spontaneous speech of 9 CI children with unilateral implants and 30 NH children from word onset up to age 2;0 (years;months). Mean age at implantation of CI children was 1;00 (SD = 0;5). Phonemic accuracy is calculated in a dynamic cost model of Levenshtein distance (Wieling, Prokic, & Nerbonne, 2009). WF is operationalised as the log frequency of words in CDS. In contrast to the literature, a corpus of CDS to study participants is used, which results in a direct image of frequency effects. Statistical analyses were done in R by means of multilevel modelling in order to consider variation in the data.

Analyses show that highly frequent are more accurate in both NH and CI children, except for words in the highest frequency regions, i.e. closed-class words ($p < 0.001$). This is in accordance with the literature on PP and lexical development of NH children. The present paper adds to the body of knowledge with respect to WF by showing that WF affects not only on lexical development, but also on word accuracy. Next, analyses show that WF has as more outspoken impact on the phonemic accuracy of CI children as compared to that of NH children ($p < 0.001$). This observation contradicts Guo et al. (2015), who concluded that CI

children with unilateral implants might be less sensitive to input frequency. In contrast, our results suggest that CI children are sensitive to input effects and even to a larger extent than NH children. A possible explanation is that CI children are less attentive to speech sounds in the ambient language (Houston & Bergeson, 2014). Highly frequent words are more likely to be perceived and adequately segmented and stored. Clinical implications will be discussed.

Number of words: 500

References

Edwards, J., Beckman, M., & Munson, B. (2004). The interaction between vocabulary size and phonotactic probability effects on children's production accuracy and fluency in nonword repetition. *Journal of Speech, Language and Hearing Research,* 47(2), 421 - 436. doi: 10.1044/1092-4388(2004/034)

Guo, L., McGregor, K., & Spencer, L. (2015). Are young children with cochlear implants sensitive tot he statistics of words in the ambient spoken language? *Journal of Speech Language and Hearing Research,* 58, 987 - 1000. doi: 10.1044/2015_JSLHR-H-14-0135

Houston, D., & Bergeson, T. (2014). Hearing versus listening: attention to speech and its role in language acquisition in deaf infants with cochlear implants. *Lingua,* 139, 10 - 25. doi: 10.1016/j.lingua.2013.08.001

Storkel, H. (2004). Do children acquire dense neighborhoods? An investigation of similarity neighborhoods in lexical acquisition. *Applied Psycholinguistics,* 25, 201 - 221. doi: 10.1017.S0142716404001109

Wieling, M., Prokic, J., & Nerbonne, J. (2009). *Evaluating the pairwise string alignment of pronunciations*. Paper presented at the Proceedings of the 12th Meeting of the European Chapter of the Association for Computational Linguistics, Athens, Greece.