Real-time spoken word recognition in sentences by adult and child cochlear implant users

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Background. When processing speech, listeners must cope with temporary ambiguity. For example, at the start of a word *sand-*, it is unclear whether the target is *sandal* or *sandwich*. In response to this temporary ambiguity, normal hearing (NH) listeners activate multiple lexical candidates (Allopena et al., 1998; Marslen-Wilson, 1987). They then incrementally update this set as input accrues, until the target word is fully active and competitors are suppressed. The dynamics of real-time spoken word recognition are well-documented in NH listeners, but less is known about cochlear implant (CI) users, who may adapt these dynamics to cope with uncertainty and respond more flexibly to their impoverished input. Furthermore, prelingually deaf CI users (i.e., individuals who were born with hearing loss or lost their hearing prior to developing language) may differ from postlingually deaf CI users (i.e., individuals who lost their hearing after developing language) in word recognition dynamics. Farris-Trimble et al. (2014) found that with isolated words, postlingually deaf adult CI users process speech more or less incrementally. However, they are ~80 ms slower than NH adults to commit to the target and do not fully suppress phonologically overlapping competitors. McMurray et al. (2017) found that prelingually deaf adolescent CI users adopt a different strategy: they were even slower (250 ms) to commit to the target (than NH controls), and as a result showed less lexical competition. The additional delay and altered dynamics of prelingually deaf CI users may be because these individuals developed language via a degraded auditory signal, leading to more fragile lexical representations. It remains unknown how atypical word recognition dynamics manifest in sentences for both pre- and postlingually deaf CI users. We hypothesized that a small delay at the individual word level would compound across a sentence, leading to more pronounced effects on lexical competition when CI users listen to sentences rather than isolated words.

Methods. Forty-nine postlingually deaf adult CI users and 20 NH adults participated in a visual world paradigm experiment. CI users included 21 participants with electric-only stimulation (E-only) and 28 participants who combined a standard CI and a hearing aid (electric+acoustic or E+A stimulation). The E-only and E+A CI groups were analyzed separately to examine possible effects of access to acoustic hearing on the timecourse of spoken word recognition. Participants heard a target word within a neutral carrier phrase that differed each trial (e.g., *On the screen, click on the sandal*). On the screen were four pictures corresponding to the target, a cohort competitor (e.g., *sandwich*) and two phonologically unrelated items (e.g., *necklace*). Eye movements were monitored as participants heard the stimulus and selected the target picture.

Results and Discussion. For target words, both groups of CI users showed large delays in the timecourse of fixations (~145 ms delay, *p*'s < .001, Figure 1 top) and lower maximum proportion of looks (*p*'s < .05) relative to NH listeners. Crucially, for cohorts, both groups of CI users showed *delayed and reduced* peak fixations relative to NH listeners (*p*'s < .01, Figure 1 bottom), after accounting for looks to unrelated items. The E-only and E+A CI groups did not significantly differ in their patterns of fixations to targets or cohorts (*p*'s > .5).

Unlike words in isolation, these results suggest that in a sentential context, postlingually deaf CI users appear to wait until substantial auditory information is available before initiating lexical access. This delay leads to reduced competition from cohorts, because at this point there is more input to rule them out. This contrasts with the immediate and incremental processing shown by postlingually deaf CI users listening to isolated words. Because the carrier sentences lacked useful semantic information, the current results suggest that merely the presence of

additional spoken words is enough to alter the dynamics of word recognition in CI users. The findings have implications for clinical speech perception measures that use isolated words, which may underestimate the processing load experienced by CI users in running speech.

Forthcoming Analyses. Data have also been collected for 15 prelingually deaf children with CIs and 20 children with NH (ages 7-17 years). Analyses will compare the fixation patterns of children with CIs and NH to examine the dynamics of word recognition in sentence contexts for this developmental sample. Children with CIs may show even more delayed lexical activation and reduced competition when listening to sentences than isolated words, similar to adults with CIs. Conversely, because children with CIs already show delayed lexical access and reduced lexical competition with isolated words, listening in a sentence context may have a minimal effect. Results will improve our understanding of how children with CIs cope with a degraded auditory signal when listening to running speech in everyday life.

References

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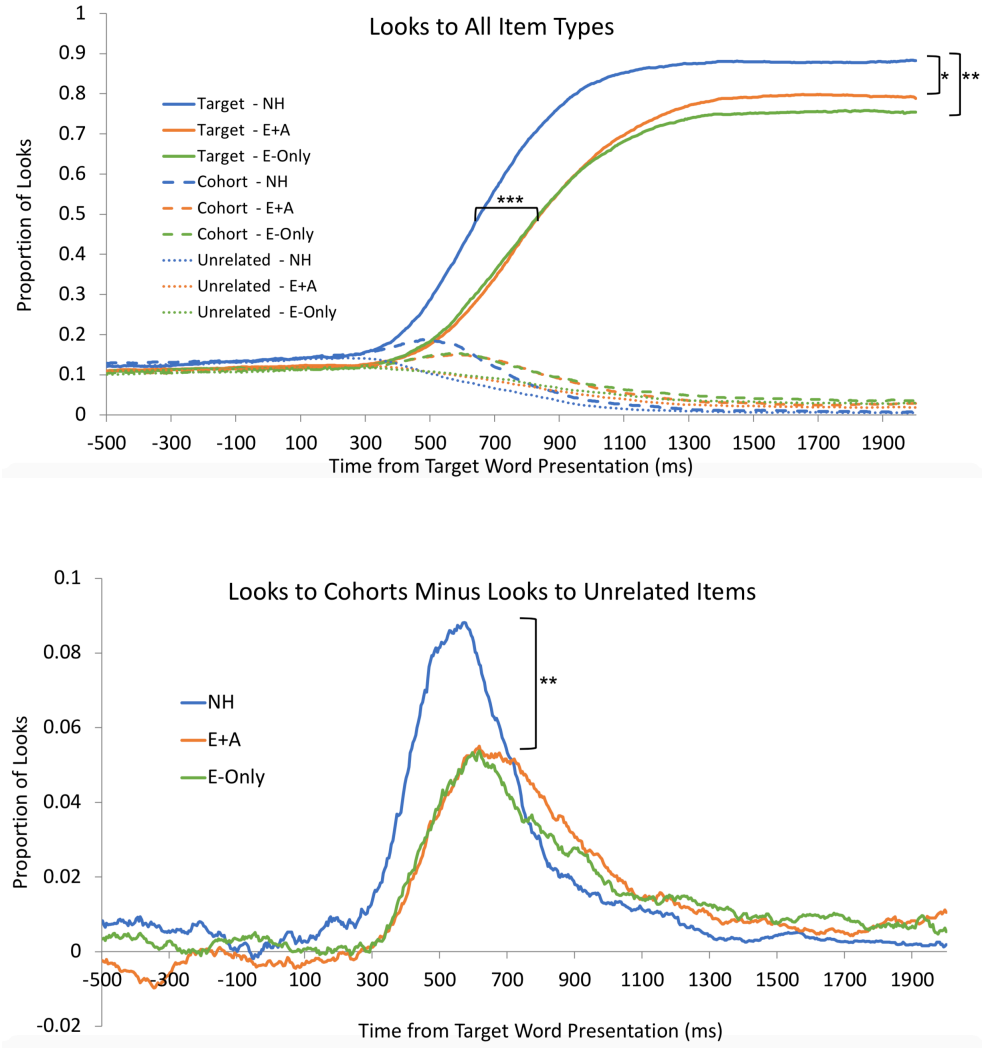

Figure 1. Proportion of looks to target words, cohort competitors, and unrelated items (top), and proportion of looks to cohort competitors minus looks to unrelated items (bottom). Figures and analyses include only accurate trials. Only data from adult participants are plotted here. *p < .05, **p < .01, ***p < .001. NH = normal hearing, E+A = electric+acoustic stimulation, E-only = electric-only stimulation