Correlates of Precedence Effect In Bilateral Cochlear Implant Users under the conditions of Direct Stimulation and in Free-Field

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ABSTRACT

Bilateral cochlear implants (BCIs) are being provided to a growing number of patients. Our previous study showed that sensitivity to binaural cues depends on the age of onset of deafness (AHO 2005, Abs. 168). Many of the same patients have now also participated in studies on the precedence effect (PE). The PE refers to the fact that the auditory system, like the other sensory systems, learns to optimize those inputs that best convey meaningful information. Physiological and psychophysical studies suggest that the binaural PE is more evident in children and adults with normal hearing than in adults with hearing loss (HL). The current study examines the PE in CI users for evaluating the efficacy of CIs. We measured the PE in 11 adult CI users who had bilateral experience <1 year (MH), mid-childhood (MH) or postlingually (PL). In a direct (FF) study, electrically pulsed signals were manipulated at pitch-reached via electrodes delivered to the ears using a SPC 3 processor to simulate a spherical stimulus were presented to CIs with varying source positions in space. Results from the FF study suggest that the PE occurred in all subjects with adult onset and in 2/3 subjects with mid-childhood onset: there was no evidence for PE in the subject with prelingual onset. This suggests that subjects with better HL binaural ITD sensitivity due to later onset of hearing loss are able to compensate for the advantage in reverberation time. PE is the PE was found in 6 subjects, but results were variable, was dependent on task and difficult to interpret. It is very difficult to interpret and the PE is not reproducible in different processors, resulting stimulus coding is not optimal for providing the neural circuitry with the appropriate set of cues to elicit the PE in the free-field.

BACKGROUND

With the increasing number of patients opting for bilateral implants, in part, to improve their ability to function in complex and reverberant acoustic environments, it is important to evaluate their performance on temporal tasks such as the Precence Effect (PE). The PE has been reported in the PE in CI users and the evidence also suggests that the binaural system contributes significantly to PE. ILD, which occurs at OTO and VOR, is the basis of the PE is known as a suppression, which refers to listeners' inability to detect changes in the location of the simulated source (lagging source). This effect is strongest at short delay due to increased interaural time difference, resulting in the weakening of the PE at simulated large acoustic spaces.

In this study we address a fundamental question of whether the PE occurs in bilateral implant users, and if so, how this phenomenon is similar to that observed in normal-hearing binaural listeners. Discrimination Suppression (Suppression) Suppression Suppression implies two conditions: (a) Free-field, whereby subjects use their clinically-arealized devices, with no obligatory synchronization between the ears, and (b) Direct stimulation, whereby electrically-pulsed signals are delivered to the ears using the SPC3 device, with precise delay, level, and angle. A part of this study was also presented at the 2006 Conference on Implantable Auditory Prostheses, Austin, CA.

RESULTS: PE with ITDs

5 of 11 subjects with adult-onset hearing loss and 2 of 3 subjects with mid-childhood onset hearing losses were able to do the task successfully with ITDs. PE lead discrimination was excellent with little lagging presentation providing important information. Performance was delay-dependent (p<0.05) and similar to the expected in NH listeners. Results suggest that with direct electrical stimulation via a simultaneous processor, important temporal effects such as the PE can be elicited more cleanly than with acoustic stimulation via two independent unsynchronized processors.

REFERENCES


CONCLUSIONS

1. The precedence effect (PE) in CI users is measured with bilateral experience decrements when direct electrical stimulation is used to stimulate lead-lag (source) pairs. This suggests that the PE may be a useful tool for CI users who can utilize necessary mechanisms to avoid important echo suppression effects.

2. The PE with ITDs does not occur with acoustic stimulation, suggesting that the PE is unique to binaural stimulation. This is important for the maintenance of the necessary mechanisms.

3. When measured with ILDs the PE was not observed (lag and lead performance were equal) for unknown reasons.

4. In free-field there is evidence for the PE, especially with click stimuli (onset vs. offset). However, it is unclear that in LH and NR subjects, the PE is weaker than that elicited using direct electrical stimulation.

5. With speech stimulus in free-field, the PE was present, but delayed. In this case, temporal processing, which is responsible for producing better results with this important everyday sounds.