**INTRODUCTION**

1. The precedence effect (PE) refers to a perceptual phenomenon in which greater peripheral weight is given to a leading source (lead) than to a simulated echo of that source (lag). The PE is thought to facilitate accurate sound localization in reverberant listening environments (Woolf et al., 1949). In normal-hearing (NH) listeners, the PE is studied by varying the temporal delay between the lead and the lag. Key features of the PE are:

   - **Fusion:** At brief lead-lag delays (LLDs), a single source is perceived. The echo threshold (ET) is the delay at which two sources are perceived on some proportion of trials (e.g., 50%). NH ETs are normally 30-50 ms for bilateral acoustic signals, such as clicks or brief noise bursts (Litovsky et al., 1999).
   - **Localization/Lateralization Dominance:** At brief LLDs (below and sometimes slightly beyond the ET), sound localization is dominated by the cues carried by the lead.

2. Prior studies have established that interaural time differences (ITDs) are particularly important for the PE (Knutholz & Nobbe, 2002; Brown & Stecker, 2013).

3. Users of bilateral cochlear implants (BiCIs) are generally exposed to ITDs and ITD sensitivity and are poorly sound localization in reverberant environments (Kerber & Seeber, 2013) where the PE is thought to facilitate accurate sound localization in reverberant listening environments (Wallach et al., 1949). In normal-hearing listeners, ITDs are particularly important for the PE (Krumbholz & Nobbe, 2002; Brown & Stecker, 2013).

**METHODS**

- **Subjects:** 5 bilateral cochlear implant (BCI) listeners with demonstrated ITD sensitivity and late-onset of deafness.

- **Stimuli:**
  - **Lead-lag:** pairs of biphasic pulses were delivered to a single electrode pair in the apical region of the electrode array.
  - Delivered to one ear, the pair was first matched for loudness and pitch, then electrically stimulated at current levels that were comfortable.
  - Stimuli were delivered via research processors that bypass the clinical processors and allow direct control over all aspects of the stimulation.
  - **Baseline ITD:** Single lead-lag pair with a LLD of 1-64 ms and lead carrying opposing 500 µs ITDs.
  - **Buildup ITD:** 12 lead-lag pairs presented at 4 Hz followed (after a 500 ms pause) by a final test pair.

- **Task:** Simultaneous fusion and lateralization task using large touch-sensitive monitors.

**RESULTS**

- **Studies show that NH listeners exhibit a robust build-up effect with 123-µs broadband monaural pulses (Brown & Stecker, 2013):**

- **Fusion:** (Fig. 2a, b): Fusion echo thresholds generally increase in Build-up conditions, mean data indicates a reliable effect of build-up.

- **Localization/Lateralization Dominance:** (Fig. 2c): Responses to a "right-leading" ITD in the Build-up condition still fall near the midline at long LLDs, suggesting reduced localization dominance.

**CONCLUSIONS**

- While all 3 of our BCI subjects experienced normal PE in the Baseline condition all 3 unsuccessfully demonstrated a build-up effect (cf. NH build-up data in Brown and Stecker, 2013).

- Listener ICM apparently experienced a total collapse of precedence, such that two images were heard at all tested lead-lag delays, including those that previously produced fusion in the Baseline condition.

- Localization dominance was generally weak, though this was not specific to the Build-up condition.

- Despite apparently normal fusion in the Baseline condition and good ITD sensitivity, subjects showed little or no build-up effect. In fact, ETs decreased in the Build-up condition for subjects IBC and ICT (Fig. 4).

- Localization dominance was generally weak in all three listeners, except at the briefest LLDs consistent with Brown et al. (2013).

- There were no obvious differences between Baseline and Build-up conditions (Fig. 5).

**ACKNOWLEDGEMENTS**

We would like to thank all our participants and Cochlear Ltd for providing equipment and technical assistance.

NIH-NIDCD (R01 DC003083 to RYL), and NIH-NICHD (P30 HD03352 to Waisman Center).