1. INTRODUCTION

The localization and segregation of sound sources in a sonically complex environment requires the binaural processing of interaural acoustic cues, such as the interaural time (ITD) and interaural level (ILD) differences in the sounds arriving between the ears. For bilateral cochlear implant (BCI) users, ITD encoding in existing CI technology is poor, as only ITDs in the signal’s envelope are represented because of the temporal response structure is configured with constant high-rate electrical pulse trains. Previous work has shown that many adult BCI users with post-lingual onset of deafness exhibit sensitivity to ITDs from tones that are delivered through synchronized processors to single interaural electrode pairs at low stimulation rates (100 pulses per second or per pair). Sensitivity generally increases as the pulse rate increases to 1000 pulses per second; however, it has also been demonstrated that BCI users show sensitivity to ITDs contained in the envelopes of amplitude modulated, high-rate pulse trains. This is important because CI speech encoding currently achieves good speech understanding by utilizing high pulse rate stimulation (1000 pulses per second) delivered to multiple electrodes.

As a first step towards understanding how ITD cues on multiple electrodes are combined and utilized by BCI users, there is a need to systematically investigate sensitivity to ITDs when multiple electrodes are stimulated.

2. SUBJECTS AND DESIGN

- **Listeners:** Post-lingually deafened BCI Cochlear Nucleus 24, Freedom, or NS users.
- **Participation:** One of the two experiments listed below.
- **Equipment:**
  - **Stimuli:**
    - Low-rate (100 pulses per second) electric pulse trains
  - **Procedure:**
    - **T1:** used a post-lingually deafened BCI Cochlear Nucleus 24, Freedom, or NS users
    - **Stimulus:**
      - Low rate (1000 pulses per second) electric pulse trains
      - Pulses delivered through synchronized processors to bilateral interaural electrode pairs
      - Simulated 5 electrodes resulted in the best performance in 5 out of 8 subjects (Fig. 4, stars). For the other 3 subjects, thresholds typically fall within the range of single electrode thresholds.

3. METHODS

**ITD Discrimination**

- **Single Electrode Pairs:** Ability to pair a single electrode with a baseline electrode to achieve the best threshold.
- **Multi-Electrode Combinations:** Ability to pair multiple electrodes with a baseline electrode to achieve the best threshold.

**ITD Sensitivity:**

- **Single Electrode Pairs:** Ability to pair a single electrode with a baseline electrode to achieve the best threshold.
- **Multi-Electrode Combinations:** Ability to pair multiple electrodes with a baseline electrode to achieve the best threshold.

**Multi-Electrode Combinations:**

- **ITD Discrimination:** Ability to pair multiple electrodes with a baseline electrode to achieve the best threshold.
- **ITD Sensitivity:** Ability to pair multiple electrodes with a baseline electrode to achieve the best threshold.

4. ITD SENSITIVITY: LOW RATE

**Results**

- **Single Electrode Pairs:**
  - **ITD threshold:** All subjects were able to detect ITD thresholds.
  - **Multi-Electrode Combinations:**
    - **ITD sensitivity:** All subjects were able to detect ITD thresholds.

**Within-Subject Reas Combos**

- **Stimuli:**
  - Low rate (100 pulses per second) electric pulse trains
  - Simulated 5 electrodes resulted in the best performance in 5 out of 8 subjects (Fig. 4, stars).

5. ITD SENSITIVITY: HIGH RATE w/ AM

**Results**

- **Single Electrode Pairs:**
  - ITD threshold: high rate–low rate stimulus
  - ITD threshold: high rate–low rate stimulus

**Within-Subject Reas Combos**

- **Stimuli:**
  - Low rate (100 pulses per second) electric pulse trains
  - Simulated 5 electrodes resulted in the best performance in 5 out of 8 subjects (Fig. 4, stars).