Interaural time differences in fine structure and envelope in bilateral electrical hearing

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State of research & questions

- CI listeners are sensitive to ITD in fine structure (Laback, Majdak and Baumgartner, 2004)
- Lateralisaiton discrimination (LD) depends on the pulse rate, duration and stimulation level
- Current bilateral cochlear implant system:
  - Two independently working systems
  - Uncontrolled change of fine structure ITD (ITD_{FS})
- Question: Bilateral synchronization of:
  - speech processors to each other (ITD_{FS} = 0)?
  - fine structure to ITD_{ENV} (ITD_{FS} = ITD_{ENV})?
Method & Parameters

- **Lateralisatation discrimination (LD):**
  - 2-interval, 2 AFC
  - 60 repetitions for each item
- **Binaurally balanced, pitch matched electrode pair**
- **Pulse Rates:** 100...1600pps
  - Inter Pulse Intervals (IPI): 625µs...10ms
  - Preselected in pretests for each subject
- **ITD\textsubscript{FS}**: 0...800µs, 0...IPI
- **ITD\textsubscript{ENV}**: 0...800µs, IPI/4 (max. sensitivity)
Stimuli & Subjects

- Amplitude modulated pulse trains

- $\text{ITD}_{FS}$ - Information (FS):
  - Delay of each pulse for one ear

- $\text{ITD}_{ENV}$ - Information (ENV):
  - 4 Trapezoids (Total duration: 300ms)
  - Fast rising/falling edges
  - Gaps between trapezoids

- 4 CI listeners (most of them used: C40+/C40+)
- 4 NH subjects with a simulation of CI stimulation
Expected results

- ITD_{ENV} = 0 \mu s
- ITD_{ENV} = low
- ITD_{ENV} = high

Lateralisation discrimination

- 0%
- 100%

ITD FS
Results for lower pulse rates

CI3 - 400pps

[Graph showing results for lateralisation discrimination with ITD FS in µs on the x-axis and lateralisation discrimination in % on the y-axis. The graph includes lines for different ENV settings (0 µs, 625 µs, 800 µs) and markers for mean values.]
Results for lower pulse rates

![Graph showing the results for lower pulse rates, with curves indicating lateralisation discrimination in % over ITD FS in µs for CI2 at 400pps and 100pps. The graphs compare ENV at 0, 625, and 800 µs, showing mean values.](image)
Results for lower pulse rates

Cl2 - 100pps

Laterisation discrimination in % vs ITD FS in µs

Laterisation discrimination in % vs ITD ENV in µs
Results for higher pulse rates

**CI8 - 800pps**

- LAT = 0 µs
- LAT = 625 µs
- LAT = 800 µs

**CI3 - 1600pps**

- LAT = 0 µs
- LAT = 625 µs
- LAT = 800 µs
Synchronization of fine structure

- Relevant, if latereralisation discrimination **depends** on ITD

<table>
<thead>
<tr>
<th>Pulse Rate</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 pps</td>
<td>0,0001</td>
</tr>
<tr>
<td>600 pps</td>
<td>-</td>
</tr>
<tr>
<td>800 pps</td>
<td>0,0001</td>
</tr>
<tr>
<td>938 pps</td>
<td>0,45</td>
</tr>
<tr>
<td>1600 pps</td>
<td>0,31</td>
</tr>
</tbody>
</table>
Synchronization to the envelope

- Relevant, if:

\[ \text{LD}(\text{ITD}_{FS} = \text{ITD}_{ENV}) > \text{LD}(\text{ITD}_{FS} = 0) \]
Synchronization to the envelope

- Interaction between ITD_{FS} and ITD_{ENV}!
Summary for CI listeners

- High sensitivity to $\text{ITD}_{FS}$ – low to $\text{ITD}_{ENV}$
- Strong variability of performance
- Synchronisation of speech processors:
  - appears to be necessary up to ~800pps
- Synchronisation of $\text{ITD}_{FS}$ to $\text{ITD}_{ENV}$:
  - Improvement of performance up to ~600pps

- Open questions:
  - Effect of artificial stimuli? Broadband stimuli?
  - Lateralisation? Binaural unmasking?