Differences between Classic ABR Stimuli and the CE-Chirp® Family

Findings, Benefits and Recommendations

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Temporal requirements of ABR stimuli

- ABR components are very brief (<1ms)
- To resolve them we need a brief stimulus
- This ensures good “neural synchrony” and a well-defined ABR waveform
- Narrow band stimuli have a longer duration, smearing the ABR, esp at lower frequencies
In the beginning there was the click

- The standard click is a 100µs pulse
- However the cochlear travelling wave creates temporal smearing because:
  - HF fibres are triggered first
  - LF fibres are triggered later
- The resulting ABR is in response to all frequencies; some components combine destructively, producing a smaller ABR
Anticipating the cochlear travelling wave delay

- To ensure all nerve fibres are triggered simultaneously we give the LF a “head start” over the HF
- This is the CE-Chirp®
- Since all fibres fire at the same time, the ABR is larger

Let’s run a demo
How much larger?

- **Broadband CE-Chirp® / click ratio:**

<table>
<thead>
<tr>
<th>Adults</th>
<th>Infants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75 (Elberling et al 2010)</td>
<td>2.0 (Cebulla et al 2014)</td>
</tr>
<tr>
<td>1.8 (Maloff &amp; Hood, 2014)</td>
<td>1.4 (Stuart &amp; Cobb, 2014)</td>
</tr>
</tbody>
</table>

- **Narrow-band CE-Chirp® / 2:1:2 tone pip ratio:**

<table>
<thead>
<tr>
<th>Adults</th>
<th>Infants (Ferm et al 2013)</th>
<th>Infants (Rodrigues &amp; Lewis 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>4 kHz: 1.58</td>
<td>1.62</td>
</tr>
<tr>
<td></td>
<td>2 kHz: 1.52</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td>1 kHz: 1.60</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>.5 kHz: 1.31</td>
<td>1.31</td>
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</table>
Example: normal infant (from Ferm et al 2013)
How does that translate to test time?

• Let’s assume we want to achieve the same SNR
• SNR varies as the (sweeps)^2
• If the response is 50% bigger (x 1.5) then we need 1/(1.5)^2 sweeps i.e. only 44% of sweeps
• So instead of 3000 sweeps we need 1320
• We’ve more than halved test time
• In practice we will encounter fewer inconclusive results and/or get more done in a test session
Anything else?

• Because the response is larger, it is seen to lower levels, so the nHL – eHL correction is 5dB less than for tone pips (Ferm et al 2013)

• This also narrows the 90% confidence limits, improving the precision of the estimated audiogram

• For the same eHL we need 5dB less noise when masking
Any limitations?

• The advantage is less at higher levels (but recruitment helps and level-specific CE-Chirps® are being introduced)

• No studies yet on frequency specificity but the limiting factor is bound to be the cochlea (damaged hair cells have flattened tuning curves so are less frequency specific)

• CE-Chirps® are not available on all ABR systems
Recommendations

- NHSP guidance now includes CE-Chirps®
- eSP includes chirp data input
- Use CE-Chirps® when available
- If ANSD suspected revert to clicks
- Use Bayesian averaging if available
Bayesian Averaging

Adopt a more lax AR level

Residual noise measured in each 100-sweep block

Each block is weighted: $1 / \text{residual noise}$

Final average computed from weighted blocks

Advantages:
- Noisy periods have less destructive effect
- Average is dominated by periods of lower noise

Disadvantages:
- No benefit if noise in each block is similar
- Regular noise (e.g. cardiac activity) is not rejected
Effect of AR & Bayesian averaging