Aided corticals: bridging the gap between early fitting and behavioural assessment

Kevin J Munro
Language outcomes at age 5 years - hearing aid children

Median

1 sd below median

Global language score

Age at first fitting (months)

Better 4FA
- 30 dB HL
- 50 dB HL
- 70 dB HL
AGE AT HEARING AID FITTING

(Wood et al, 2015)
Frequency-specific ABRs provide an accurate prediction of hearing thresholds but ….

1. Behavioural thresholds often deviate from predicted threshold by 10 dB, and occasionally by 20 dB (Stapellos, 2011)

2. In severe hearing loss, no ABR (Stelmachowicz, 2008)

3. Middle-ear disease and concomitant medical problems can complicate (Stelmachowicz, 2008)

4. ABR typically absent in some populations e.g., auditory neuropathy (Roush et al, 2011)
Bridging the gap

Hearing aid fitting (e.g., 3 mths)

Behavioural assessment (e.g., 8-9 mths)

Wrexham, Wales
Improving the early care pathway

1. PARENTS:
   - an aided response (of some sort) will motivate and provide reassurance

2. HEARING PROFESSIONAL:
   - alert when current fitting may not be inappropriate
   - expedite alternative strategies e.g., frequency lowering devices, cochlear implant
Supplementing existing measures

- Behavioural assessment
  - eye tracking??

- Physiological assessment
  - e.g., verify **physiological detection** using CAEPs
  - e.g., investigate **physiological discrimination** using ACC
NAL/Frye HEARLab

Examples of useful features: (i) residual noise (ii) automated response detection & (iii) sound field calibration procedure
Detection of CAEPs in children with HL

Chang et al (2012)
- n=18 (3-15 mths)
- NAL/Frye HEARLab
- Audibility estimated from behavioural data with different stimuli
- no CAEP detected 30-40%

Van Dun et al (2012)
- n=25 (8-30 mths)
- NAL/Frye HEARLab
- CAEP and VRA at same time in older children
- no CAEP detected 22-28%
Preliminary CAEP study in infants

• HearLab clinical system: three conversational level speech stimuli (/m/, /g/, /t/, short duration ~20-30 ms)
• 150 accepted runs recorded for each stimulus
• recording Cz/Fpz to mastoid
• Analysis
  i. clinically feasible (duration, completion rates)
  ii. response detection
  iii. acceptable to families
**Recruited**: 104 infants age 5-39 weeks (passed newborn screen and no family concern)

<table>
<thead>
<tr>
<th>Analysis:</th>
<th>sample size:</th>
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<tbody>
<tr>
<td>Completion rates</td>
<td>104</td>
</tr>
<tr>
<td>Test duration</td>
<td>100</td>
</tr>
<tr>
<td>Acceptability</td>
<td>100</td>
</tr>
<tr>
<td>CAEP analysis</td>
<td>83 (tymp abnormal/not tested)</td>
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‘TYPICAL’ INFANT RESPONSE

Graph showing a typical infant response with a prominent positive response and a preceding negative wave.
RESULTS

• Completion rate >95%
  – behaviour state vital: 4 restless or asleep

• Test duration 27 mins (range 17-89)
  – preparation time 13 mins
  – data acquisition 13 min

• Parents reported all aspects of test acceptable

• Interviews revealed positive experience
Objective response detection

- All participants showed a response to at least one stimulus
- No difference in response SNR using vertex or high forehead electrode positions
Next steps: babies with hearing aids

- **Phase One: finalise methodology**
  - What are appropriate stimuli?
  - What is the optimal automated CAEP detection method?

- **Phase Two: defining performance characteristics**
  - In what proportion is a CAEP present when stimuli audible/inaudible?
  - In what proportion of absent cases is there response on retest?

- **Phase Three: clinical feasibility & caregiver acceptability**
  - Feasibility measured in terms of completion rates and test time
  - Is the procedure acceptable to caregivers
Babies with hearing aids

- Recruiting 200 hearing-impaired babies
- Age 3-6 months at initial test (CAEP)
- Behavioural testing aged 7-9 months (VRA)
- CAEP and VRA use the same speech-like stimuli, for direct comparison
- Testing takes place in our Mobile Research Unit
Excitation patterns of CAEP stimuli

HEARlab: /m/ /g/ /t/

Synthetic: 'm' 'g' 't'

(Adult: 33 mm meatus+concha length)
Erbograms of CAEP stimuli

**HEARlab** : /m/  /g/  /t/

![Erbograms of CAEP stimuli](image)

**Synthetic** :  'm'  'g'  't'

*(Adult length meatus+concha (Keefe et al., JASA1994). Greyscale normalised for each plot to a 30 dB dynamic range)*
Does hearing aid treat stimuli as speech?

**Unaided**

<table>
<thead>
<tr>
<th>CAEP</th>
<th>VRA stim</th>
<th>Embedded stim</th>
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| ![Waveform](waveform_unaided.png)

**HA2 (moderate loss)**

<table>
<thead>
<tr>
<th>CAEP</th>
<th>VRA stim</th>
<th>Embedded stim</th>
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| ![Waveform](waveform_ha2.png)
• **Convenience** - van visits families at their homes
• **Enthusiasm** from families/clinicians for mobile unit
• **Controlled environment** - sound-treated and electrically-isolated booth. Fully battery-operated.
• Infant CAEPs are clinically feasible, and theoretically useful for indicating physiological response to a range of sounds

• The current study seeks to validate the measure for use in clinical populations, 3-8 months, for whom behavioural data is limited
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Using CAEPs to **SUPPLEMENT** existing measures

Verifying physiological response

![Graph showing physiological response with and without a hearing aid.](source: Fig 4 from Rapin & Graziani [1967])

Source: Fig 4 from Rapin & Graziani [1967]
Cortical Auditory Evoked Potential

- P1
- N1
- P2
Morphology in awake babies

P1 (ca 200 ms)

N1b
N“late”
N350
Lunch – 12.30

Mittagessen