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

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Language outcomes at age 5 years - hearing aid children

Mean

1 sd below median

Global language score

Age at first fitting (months)

Better 4FA
- 30 dB HL
- 50 dB HL
- 70 dB HL

Courtesy of Harvey Dillon, May 2014
AGE AT HEARING AID FITTING

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

- behavioural thresholds often deviate from predicted threshold by 10 dB, and occasionally by 20 dB (Stapells, 2011)
- in severe hearing loss, no ABR (Stelmachowicz, 2008)
- middle-ear disease and concomitant medical problems can complicate (Stelmachowicz, 2008)
- ABR typically absent in some populations e.g., auditory neuropathy (Roush et al, 2011)
Bridging the gap

Hearing aid fitting (e.g., 2-3 mths)

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

Wrexham, Wales
Improving the early care pathway

PARENTS:
- an aided response (of some sort) will provide reassurance
- motivate and encourage consistent hearing aid use

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

• Behavioural assessment
  – eye tracking??

• Physiological assessment
  – verify physiological detection e.g., using CAEPs
  – investigate physiological discrimination e.g., using acoustic-change-complex
Cortical Auditory Evoked Potential

Adult

Baby
Using CAEPs to SUPPLEMENT existing measures

Verifying physiological response

Source: Fig 4 from Rapin & Graziani [1967]
Gravel et al. Case Studies, Sem Hear, 1989, 10, 272-87

CASE ONE (7 mths): SEVERE SNHL & HA

CASE TWO (11 mths): CHL & BCHA
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)

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

65-1-G-grand average.avg —
65-2-G-grand average.avg —

Prominent positive response

Preceding negative wave

μV
-20.0
-15.0
-10.0
-5.0
0.0
5.0
10.0
15.0
20.0

ms
-200.0
-100.0
0.0
100.0
200.0
300.0
400.0
500.0
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
All participants showed a response to at least one, and most to at least two, stimuli.
No difference in SNR at vertex v high forehead

SNR
(corrected power)

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<th></th>
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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 a 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
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/

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**

- **CAEP**
- **VRA stim**
- **Embedded stim**

- **Low freq**
- **Mid freq**
- **High freq**

**HA2 (moderate loss)**

- **CAEP**
- **VRA stim**
- **Embedded stim**

- **Low freq**
- **Mid freq**
- **High freq**
Next steps cont’d

• **Phase Two: defining performance characteristics**
  – In what proportion is a CAEP present when stimuli audible/inaudible?
  – In what proportion of absent cases is there a 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 3-7 months at initial test (CAEP)
- Behavioural testing aged 8-9 months (VRA)
- CAEP and VRA use the same speech-like stimuli, for direct comparison
Mobile Hearing Unit

- **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, 3-7 months, for whom behavioural data are limited.
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No difference in SNR at vertex v high forehead

SNR (power)

SNR (corrected power)