Cortical auditory evoked potentials in infants wearing hearing aids

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Overview

Evidence base
CAEPs with HA processing
Infant hearing impaired study
Clinical tips
What’s next
The three ‘corners’ of early habilitation

- Early identification
- Early intervention
- Evaluation/ongoing habilitation
CAEPs and HA’s in the literature

- Correlation between present aided CAEPs in infants and PEACH scores ($r=0.45; p=0.03$)

(Golding et al)
- Children aged 8 weeks to 3½ years
- Wearing bilateral hearing aids
- Speech sounds /m/, /g/, /t/
- Sound levels 55, 65, 75 dB SPL
CAEPs and HA’s in the literature

- Correlation between present aided CAEPs in infants and estimated sensation levels from VRA

(Chang and Dillon et al)

- Children aged ~ 3 to 13 months
- Aided and unaided
- Speech sounds /m/, /g/, /t/
- Sound levels 55, 65, 75 dB SPL
- ESL at ~ 13 months from VRA to narrow band noise
CAEPs and HA’s in the literature

- Improved detection of aided CAEPs to high frequency when nlfc active
  
  (Glista et al)
  
  - Small group of teenagers
  - Sloping high frequency loss
  - Wearing bilateral hearing aids with nlfc on and off
  - Tone bursts 2 and 4kHz
CAEPs and HA’s in the literature: caveats

- HA’s modify the stimulus:
  - Signal to noise ratio  
    (Billings et al)
  - Amplified gain of shorter CAEP stimuli 
    (Marynewich and Stapells)
  - Rise time 
    (Easwar, Glista et al)
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CAEPs with HA processing: adult study summary

- 16 adult subjects; normal hearing
- /m/, /g/, /t/
- 65dBNHL
- 100ms duration; 3s interstimulus interval
- 4 conditions: unaided; linear; wdrc; nlfc
  - 20dB gain; 2:1 wdrc CR & KP 30dB; 3:1 nlfc CR & KP 3.8kHz
- SNR >20dB
Adult study summary: results (amplitude)
Adult study summary: results (latency)

![Graph showing N1 latency for different HA conditions and speech sounds.](image)

- **HA condition**: unaided, linear, wdrc, nlfc
- **Speech sound**: /m/, /g/, /t/

N1 latency, ms
Adult study summary: stimulus analysis

![Graph showing stimulus analysis](image-url)

- Time, ms
- Voltage
- Unaided
- Linear
- Wdrc
- Nlfc

Note: The graph illustrates the response of the unaided, linear, wdrc, and nlfc conditions over time (0-120 ms) and voltage (-0.4 to 1.0).
Adult study summary: stimulus analysis

The graph shows the voltage over time for different conditions:

- **unaided**
- **linear**
- **wdrc**
- **nlfc**

The x-axis represents time in milliseconds (ms), ranging from 0 to 120 ms. The y-axis represents voltage, ranging from -0.4 to 1.0. The graph illustrates the voltage response over time for each condition, highlighting the differences in performance.
Adult study summary: stimulus analysis
Adult study summary: spectral analysis
Adult study summary: spectral analysis
Summary findings: adult study

CAEPs are recordable with HAs

Overall effect of aiding

HA strategy not significant

CAEP morphology follows the stimulus waveform

CAEPs appear less sensitive to frequency changes

Max HA gain reached in first 30ms
Infant hearing impaired study

PHOTO REMOVED
Study design

- 5 infants, 5-6 months of age
- Mild-moderate flat SNHL better hearing ear

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Gender</th>
<th>Hearing thresholds (dB eHL) better hearing ear</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>500Hz</td>
</tr>
<tr>
<td>1</td>
<td>6m</td>
<td>M</td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td>5m</td>
<td>M</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>5m</td>
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</tr>
<tr>
<td>4</td>
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</tr>
<tr>
<td>5</td>
<td>6m</td>
<td>M</td>
<td>30</td>
</tr>
</tbody>
</table>
Study design

- CAEPs evoked to speech sounds /m/, /t/
- 65dB rms SPL from loudspeaker
- 100ms duration; 3s interstimulus interval
- 3 conditions: unaided; wdrc; nlfc
- Probe microphone recordings of aided output
- 2 sessions of ~ 1½ hours
## Results

<table>
<thead>
<tr>
<th>HA Condition</th>
<th>Number of CAEP responses (p≤0.01)</th>
<th>/m/</th>
<th>/t/</th>
</tr>
</thead>
<tbody>
<tr>
<td>unaided</td>
<td></td>
<td>1/5</td>
<td>0/5</td>
</tr>
<tr>
<td>wdrd</td>
<td></td>
<td>4/5</td>
<td>4/5</td>
</tr>
<tr>
<td>nlfc</td>
<td></td>
<td>4/5</td>
<td>5/5</td>
</tr>
</tbody>
</table>

- No difference (p≤0.05) between speech sounds from aided CAEPs
CAEP waveform: unaided /m/ - nlfc /m/
CAEP waveform: nlfc /m/ - nlfc /t/
CAEP waveform: nlfc /t/ - wdrc /t/
Conclusions: infant study

CAEPs are recordable in young infants wearing HAs

Good indicator of improved audibility

nLfc increased audibility of high frequency in 1 infant

No strong differences between speech sounds

P1-N1 peak most predominant
Clinical implementation

- Experienced second tester invaluable
- Clear information to families optimises test session
- Some vocalisations and movement permissible
- Habilitation timeline

0mths

HI identified
HAs fitted
2-4 months

6mths

Start
behavioural
assessment
5-7 months

12mths
Clinical implementation

- Experienced second tester invaluable
- Clear information to families optimises test session
- Some vocalisations and movement permissible
- Potential habilitation timeline
What parents said

It’s kept me motivated to keep putting the HA’s in.

I’d like to understand how it relates to normal hearing children.

It’s great the results are better with HA’s – it’s what I thought.

Future work:

increase participant no; link to speech discrimination
With thanks to

Infants and families who participated in the study

Ani Sahakian, Laura Booth, Rachel McCarthy, Mary Richards

British Society of Audiology
References


Probe microphone measure

/t/ speech sound
wdrc = green
nlfc = pink
Probe microphone measure

/m/ speech sound

wdrc = orange

nlfc = blue