2015 Expert Series

Now August 28, 2015
@12PM ET

Evaluating the Amplification Needs of Hearing-impaired Infants Through Evoked Cortical Responses

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• Brought to you in cooperation with AudiologyOnline

• Submitted to AAA & IIHIS for one continuing education unit (CEU)

• Learning objectives for this course:
  • Participants will be able to describe a method of fine tuning the frequency compression using real ear measures to support an evidence-based method of hearing aid fitting.
  • Participants will be able to describe candidacy for frequency compression in the adult population.
  • Participants will be able to discuss real world expected benefit of frequency compression in adult hearing aid fittings.

Introducing Harvey Dillon, PhD
Evaluating the amplification needs of hearing-impaired infants through evoked cortical responses

Harvey Dillon
Bram Van Dun, Kirsty Gardner-Berry, Lyndal Carter, John Seymour, Suzanne Purdy, Maryanne Golding, Fabrice Bardy, Wendy Pearce

Audiology Online
2015

So baby, how does it sound?

Objective hearing aid evaluation for:
• young infants
• difficult-to-test people
Language outcomes at age 5 – hearing aid children

Language outcomes at age 5 – cochlear implant children

Ching et al, in preparation
Why cortical responses to evaluate hearing aid fitting in infants?

- Measurable in awake young infants
- More likely to correlate well with perception
- Can be elicited by a range of speech phonemes – close to desired outcomes
- Stimuli handled reasonably by hearing aids
- Can be very frequency specific if needed

Origin of cortical responses
Auditory cortex and current sources

Auditory cortex orientation (3)
Adults

Infants (1 per second)
Grand Average; n = 16 nh infants

Your turn

- With respect to a reference electrode at the mastoid, cortical responses have the greatest amplitude at:

A. the opposite mastoid

B. the forehead

C. close to the auditory cortex

D. close to the vertex
Answer

- With respect to a reference electrode at the mastoid, cortical responses have the greatest amplitude at:

  A. the opposite mastoid  ✗
  Incorrect. The answer is D: the vertex. Placing the other electrode on the other mastoid will result in a small response.

  B. the forehead  ✗
  Incorrect. The answer is D: the vertex. Placing the other electrode on the forehead would still provide good cortical responses however because the position of this electrode is above the auditory cortex.

  C. close to the auditory cortex  ✗
  Incorrect. The answer is D: the vertex. Placing the other electrode on the auditory cortex will result in a small response.

  D. the vertex  ✓
  Correct. This is optimal position. Watch out for the fontanelles though!

Practical issues in clinical testing

- Effect of sleep
- Distraction and head movement
- Testing with cochlear implants
- Special relevance for ANSD
A practical system for infants

Practical implementation of cortical testing: HearLab

Disclosure: NAL will get a royalty for each unit sold.

Thank you: The HearLab development team – Teck Loi, Barry Clinch, Isabella Tan, Ben Rudzyn, Lyndal Carter, Dan Zhou, Scott Brewer
Active electrodes

Modes of operation

• Speech stimuli /m/, /g/, /t/ delivered in the sound field

• Tonal stimuli (50 ms long) delivered over insert earphones or bone-conductors
Three speech sounds:

/m/ /g/ /t/

How do we measure CAEPs?

Speech sounds

/m/ /g/ /t/

65dBSPL

Free Field Speaker

3 sensors are placed on the head (the same as for ABR)

Baby sits on parent’s lap or in a high-chair in front of the speaker
Tools for keeping baby quiet, alert, awake

An example
Effect of sensation level on cortical responses:

- Aided versus unaided
- Sensorineural, ANSD and normal hearing
Growth of response amplitude with sensation level

High similarity of mean responses for different waveforms

Infants
speech sounds

Presence of cortical responses in infants

Kirsty Gardner-Berry

p = 0.005
Do hearing aids increase cortical response amplitude?

Amplification and cortical responses

- Aided
- 55 dB SPL input
- PG
- PG+10
- Unaided
- 0 dB 10 dB 20 dB

P2-N1 amplitude (uV)

Level:
- Low
- Med
- High

Hearing impaired
Amplification and cortical responses

- Amplification
  - $\rightarrow$ sensation level for hearing-impaired listeners
  - ⚠️ sensation level for normal-hearing listeners
- Amplification
  - $\rightarrow$ cortical response for hearing-impaired listeners
  - ⚠️ cortical response for normal-hearing listeners

......... up to about 30 dB SL
Response presence and latency: relation to functional hearing ability

Latency versus age

Latency of P1 wave (ms)

Age in years

- NAL - normal hearing
- Sharma - normal hearing
- NAL - hearing-impaired
Latency of cortical response for early and late-implanted children

Sharma (2007), IJA

CAEPs and speech discrimination ability in ANSD

Rance et. al. (2002)
Functional deficit vs number of cortical responses present

Number of corticals present

More cortical responses

N = 24; p = 0.001
12 sensorineural
7 auditory neuropathy
5 multiply disabled

Golding et al (2007) JAAA

Children with auditory neuropathy
Sharma et al. (2011) Int J Audiol

Figure 5. A: Mean IT-MAIS scores for children with normal, delayed, and abnormal P1 responses. B: IT-MAIS scores vs. P1 latency for children with normal (filled circles) and delayed (unfilled circles) P1 responses.
Aided, hearing-impaired adults

Detection of speech sounds - infants

Carter et al (2013) JAAA

Your turn

• The latency of cortical responses of an infant or child:

A. reflects the time that the child has been exposed to sound
B. depends on age, irrespective of auditory experience
C. is determined at birth, and changes little thereafter

Answer

• The latency of cortical responses of an infant or child:

A. reflects the time that the child has been exposed to sound ✓
B. depends on age, irrespective of auditory experience ✗
C. is determined at birth, and changes little thereafter ✗

Correct. Of course it depends on age as well as long the child keeps on being exposed to sound.

Incorrect. The answer is A. Of course it depends on age as well as long the child keeps on being exposed to sound.

Incorrect. The answer is A. The auditory cortex keeps on maturing into adolescence.
Your turn

• An absent cortical response indicates that:

A. the child may not have heard the sound
B. the child did not hear the sound

Answer

• An absent cortical response indicates that:

A. the child may not have heard the sound
   Correct. Cortical responses can sometimes be absent
B. the child did not hear the sound
   Incorrect
Clinical implications of corticals

Significant response is obtained to speech at 65 dB SPL

- Morphology normal for age → HA → audible speech
- HA → audible speech

No significant response is obtained to speech at 65 dB SPL or to speech at 75 dB SPL

- Morphology abnormal for age → Repeat test
- Repeat test

Low residual noise

- Re-check fitting; Repeat test
- Consider all options

High residual noise

- Draw no conclusion!

Automated detection of cortical responses

- Computers versus audiologists
Consistency across epochs

→ Also gives residual noise

Analysis using Hotellings t^2 statistic

- Divide each record into 50 ms time bins
- Average data points within each time bin
- Use these averages as variables in Hotellings t^2 analysis
- Result is probability of the waveform being random noise

\[ X = a_1X_1 + a_2X_2 + \ldots + a_9X_9 \]

Test: is there any set of weighting coefficients for which X significantly differs from 0?
**d' for adults**

![Graph showing d' for adults with different levels of sensation (dB)].


**d' for infants**

Normal hearing infants aged 7 to 16 months

![Graph showing d' for infants with different levels of sensation (dB)].

*Carter et al. (2010) J Amer Acad Audiol*
Frequency compression and verification of /s/ detection

Teresa Ching  Vicky Zhang

Methods

Subjects: 36 children aged 2.8 to 7.6 years
Mean 4FA HL = 61 dB HL
Evaluation of cochlear implants
Evaluation of cochlear implants

CI artefact obscures or impersonates CAEP

modify

hardware software

Hardware modification (1): Without

- Electrode cable contains an active preamplifier close to scalp
Hardware modification (2): With

- Modified electrode cable:
  - contains a front-end low-pass filter to avoid the artifact overloading the amplifier

Application to auditory neuropathy spectrum disorder
Your turn

- The cortical responses can be most easily measured if the baby is:

A. asleep

B. drowsy

C. awake and calm

D. awake and physically active
Answer

The cortical responses can be most easily measured if the baby is:

A. asleep  ×
B. drowsy  ×
C. awake and calm ✅
D. awake and physically active  ×

Incorrect. The answer is C: awake and calm. It is possible to record CAEPs whilst asleep, but they will be more difficult to interpret.

Incorrect. The answer is C: awake and calm. It is possible to record CAEPs whilst drowsy, but because the child shifts between arousal states, CAEPs will be affected negatively.

Correct. Corticals will have a recognisable morphology while testing awake, and noise levels will be acceptable when the child is calm.

Incorrect. The answer is C: awake and calm. The additional noise introduced by the child's movements will add more noise to the recording, and hence the recordings will generally...

Australian Hearing Centers testing cortical responses in infants
(Sep 2011)
Use of CAEPs within Australian Hearing Paediatric program

Ideally start aided test at 65 dB SPL: /m/, /g/ & /t/

- **65dB ✔ 55dB** → no change to device settings
- **65dB ✔ 55dB** → consider changing setting for soft sounds
- **65dB ✗ 75dB** → re-estimate audiogram +1 SD (10 dB) for that frequency
- **65dB ✗ 75dB** → re-estimate audiogram +1.5 SD (15 dB) for that frequency

Clinical Review - 2013

- Files of all children fitted between October and December 2012 & aged < 6mths at time of fitting
  - 4 clients excluded - no data available

- Sample size = 83
  - 5 (6%) Aboriginal/Torres Strait Islander
  - 32 (39%) 3FAHL < 45dBHL in the better ear
  - 64 (77%) Bilaterally aided

- Most children had completed their initial fitting program at time of review
55 (66%) Infants tested using HEARLab during initial fitting program

Interval between hearing aid fitting and first CAEP assessment

Reason for no CAEP’s (n=28, 34%)
How often were CAEPs used?

![Bar graph showing the number of times children were tested]

**Conclusion**

- The majority of children were able to be assessed in their initial fitting program
- Most commonly done within 8 weeks of fitting
- Main reason for non-assessment related to mild/unilateral hearing loss
- 70% of children only needed one CAEP assessment in initial program
- When children are able to condition for behavioural assessment this becomes the focus.
- CAEPs can be effectively integrated into the infant fitting program
Current research at NAL

• More complex single stimuli
• Very fast stimuli
• Measuring discrimination

Result overview – New stimuli for cortical audiometer N = 13
Grand average Data
Participants: 26 normally hearing infants (age: 3 – 25 months)

- Stimuli: 2 Complex-tones (CT)
- Duration of the stimuli: 50 ms
- Intensity: 65 dB SL binaural (insert earphones)
Rapid tone-pairs in infants

Result overview – New stimuli for cortical audiometer N = 13
Grand average Data
Discrimination: acoustic change complex

ACC – 3 x normal hearing
Thanks for listening

For more information .....  
http://HearLab.NAL.gov.au

For a training module.....  
www.hearnet.org.au