Utility of the Middle Latency Response in Diagnosis of Auditory Processing Disorder

Jeffrey Weihing, Ph.D.
Eliane Schochat, Ph.D. – Sao Paulo University
Frank Musiek, Ph.D. – University of Connecticut
• We have no relevant financial or nonfinancial relationships in any products or services described, reviewed, evaluated or compared in this presentation.
What is the Middle Latency Response?

~40 msec

- Nagle & Musiek, 2009
Neural Generators

Kraus & McGee, 1995
Broad-symmetrical topography suggests deep, midline generator (polymodal thalamus?)

Narrow-lateralized topography suggests generator near surface (thalamocortical auditory connections or AC?)

Kraus & McGee, 1995
Why use it?

• An objective measure of central auditory function

• Provides assessment of high brainstem and cortex

• Not as heavily influenced by supramodal factors as other cortical measures
Overview

• Recording the Middle Latency Response
• Why Use Ear and Electrode Effects?
• Considerations in MLR Acquisition
• Relationship to Behavioral Measures
• Two Studies
  – Ear and electrode effects reduce within-group variability in middle latency response amplitude measures (Weihing et al, 2012)
  – The influence of aging on interaural asymmetries in the middle latency response (Weihing & Musiek, Submitted)
Recording the Middle Latency Response
Ear & Electrode Effects – Intratest Measure
Ear Effect = | X - Y |
Electrode Effect = | X - Y |
Recording parameters

- **Stimulus**: Click or tone-pips
- **Levels**: 70 dBnHL
- **Repetition Rate**: 9.7/sec
- **Time Window**: ~50 msec for Na-Pa
- **Trials**: ~800 accepted
- **Filter**: 20-1500 Hz, 20-250 Hz
- **Electrode Montage**: depends
- **Stimulation**: Generally monaural
Why Use Ear and Electrode Effects?
Why Ear & Electrode Effects?

1. Reduce Within Group Variability
   1. Subtracts out the influence of individual variables
   2. More cohesive normative values
      1. E.G.- Calorics

2. Some CANS Issues are Asymmetrical
Neural Contributions to Ear & Electrode Effects

- **Electrode Effects**
  - Noted in cortical lesions

- **Ear Effects**
  - Noted in subcortical lesions
    - Kaseda et al, 1991; Fischer et al, 1994
  - Less certain of this mechanism
Left ear pathway
Left & right ear pathway
Probable cause of electrode effect
Possible cause of ear effects ...
Considerations in MLR Acquisition
Considerations

- Nb-Pb
- Post-auricular muscle artifact
- Effects of sleep/attention
- Maturation effects
Nb-Pb

• Nagle & Musiek, 2009
Post-Auricular Muscle

O’Beirne & Patuzzi, 1999
Effect of Sleep

- Osterhammel et al, 1985
• Kraus et al, 1989
Maturation Effects

- Schochat & Musiek, 2006
Relationship to Behavioral Measures
• Pa Index = ([Larger Response – Smaller Response] / Larger Response) * 100

• Ibanez et al, 1989
Case 3
S: BV, Age: 80, Sex: M

Pure Tone Audiometry

Aided Speech Results

- Jerger et al, 1993
• Jerger et al, 1991
• Leigh-Paffenroth et al, 2011
Schochat et al, 2010
• Purdey et al, 2002
Ear and electrode effects reduce within-group variability in middle latency response amplitude measures (Weihiing et al, 2012)
Purpose

• To determine if ear and electrode effect calculations reduce within-group variability in pediatrics

• To establish normative values for ear and electrode effects in this population
Methods

• Subjects
  – 155 pediatrics
    • 7 to 8 years, N=31
    • 9 to 10 years, N=34
    • 11 to 12 years, N=30
    • 13 to 14 years, N=30
    • 15 to 16 years, N=30
  – Normal peripheral & central auditory function
    • 20 dB HL or better 500-4000 Hz, normal Tymps
    • Normal performance on the dichotic digits test
  – History negative for:
    • Neurological, psychological, or language disorder
• Equipment/Stimulus Settings
  – Nicolet Spirit 2000
  – 100 microsecond clicks presented monaurally at 70 dBnHL via insert earphones at 9/7/second
  – 1000 accepted to trials, replicated, and then averaged together
  – Time window: 72 msec
  – Filters: 20-1500 Hz online, 20 to 200 Hz offline
• Electrode Montage
  – C3 & C4 referenced to A1 and A2
  – Ground located at Fz
  – Recordings were made from both scalp electrodes on stimulation of left or right ear
  – Impedances maintained at 7 kΩ

• Na & Pa Measurement
  – Na: negative most repeatable peak from 14 to 21 msec
  – Pa: positive most repeatable peak from 22 to 35 msec
  – Na-Pa: peak to peak voltage difference between Na and Pa
Calculating Indices

Average ear effect = \(|(\text{Left ear C3} + \text{Left ear C4})/2 \) 
\(- (\text{Right ear C3} + \text{Right ear C4})/2|\)

Average electrode effect = \(|(\text{C3 Left ear} + \text{C3 Right ear})/2 \) 
\(- (\text{C4 Left ear} + \text{C4 Right ear})/2|\)

Ear effect at C3 = \(|\text{Left ear C3} - \text{Right ear C3}|\)

Ear effect at C4 = \(|\text{Left ear C4} - \text{Right ear C4}|\)

Electrode effect for left ear = \(|\text{C3 Left ear} - \text{C4 Left ear}|\)

Electrode effect for right ear = \(|\text{C3 Right ear} - \text{C4 Right ear}|\)
Results - Variance Values

Collapsed across all age groups
Do Ear and Electrode Effects Significantly Decrease WGV?

<table>
<thead>
<tr>
<th>Absolute Amplitude</th>
<th>Average Ear Effect</th>
<th>Ear Effect at C3</th>
<th>Ear Effect at C4</th>
<th>Average Electrode Effect</th>
<th>Electrode Effect for Left Ear</th>
<th>Electrode Effect for Right Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3-A1</td>
<td>6.92</td>
<td>6.97</td>
<td>7.01</td>
<td>22.14</td>
<td>18.32</td>
<td>22.14</td>
</tr>
<tr>
<td>C3-A2</td>
<td>5.04</td>
<td>5.00</td>
<td>5.17</td>
<td>20.21</td>
<td>16.10</td>
<td>19.73</td>
</tr>
<tr>
<td>C4-A2</td>
<td>4.04</td>
<td>4.04</td>
<td>4.11</td>
<td>18.23</td>
<td>14.38</td>
<td>19.09</td>
</tr>
</tbody>
</table>

Pitman’s T (all significant at p<.002)
Ear/Electrode Effect Variance x Age

The graph shows the variance of ear/electrode effects across different age groups. The x-axis represents age groups (7-8, 9-10, 11-12, 13-14, 15-16), and the y-axis represents variance. The data points indicate a decrease in variance from the 7-8 age group to the 11-12 age group, followed by an increase in variance for the 13-14 and 15-16 age groups.
<table>
<thead>
<tr>
<th>Age</th>
<th>Average Ear Effect</th>
<th>Ear Effect at C3</th>
<th>Ear Effect at C4</th>
<th>Average Electrode Effect</th>
<th>Electrode Effect for Left Ear</th>
<th>Electrode Effect for Right Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 to 8</td>
<td>.48</td>
<td>.47</td>
<td>.54</td>
<td>.14</td>
<td>.22</td>
<td>.16</td>
</tr>
<tr>
<td>9 to 10</td>
<td>.42</td>
<td>.46</td>
<td>.46</td>
<td>.16</td>
<td>.22</td>
<td>.20</td>
</tr>
<tr>
<td>11 to 12</td>
<td>.26</td>
<td>.31</td>
<td>.27</td>
<td>.18</td>
<td>.16</td>
<td>.22</td>
</tr>
<tr>
<td>13 to 14</td>
<td>.23</td>
<td>.31</td>
<td>.28</td>
<td>.19</td>
<td>.24</td>
<td>.23</td>
</tr>
<tr>
<td>15 to 16</td>
<td>.24</td>
<td>.39</td>
<td>.37</td>
<td>.21</td>
<td>.32</td>
<td>.21</td>
</tr>
</tbody>
</table>
Why the greater variance for Ear Effects?
The influence of aging on interaural asymmetries in the middle latency response (Weihesting & Musiek, In Preparation)
Purpose

• To determine if ear effect calculations reduce within-group variability in adults of various ages

• To determine if the magnitude of ear effects change as a function of age

• To determine if the introduction of noise increase the influence of age on ear effects
Methods

• Subjects
  – 30 Adults
    • Younger, M=24 SD=2, N=10
    • Middle Aged, M=54 SD=3, N=10
    • Older, M=74 SD=4, N=10
  – “Normal” peripheral function
    • 25 dB HL or better 500-2000 Hz, normal Tymps
    • No interaural asymmetry >10 dB
  – No central test given
  – History negative for neurological issues
• Equipment/Stimulus Settings
  – Nicolet Spirit 2000
  – 10 ms 1000 Hz tone pips (4-2-4) presented monaurally at 60 dB SL re: tone pip threshold via open dome
    • Presented in quiet and with 30 dB “EM” of 1000 Hz narrowband noise at +/- 45 degrees azimuth
  – 800 accepted to trials, replicated, and then averaged together
  – Time window: 40 msec
  – Filters: 20-1500 Hz online, 20 to 250 Hz offline
• Electrode Montage
  – Cz referenced to nape of neck
  – Ground located at Fz
  – Impedances maintained at 8 kΩ with no more than a 3 kΩ difference between electrodes

• Na & Pa Measurement
  – Waveforms checked for PAM
  – Na: negative most repeatable peak from 12 to 21 msec
  – Pa: positive most repeatable peak from 21 to 38 msec
  – Na-Pa: peak to peak voltage difference between Na and Pa
Calculating Indices

Average ear effect = \(|(\text{Left ear C3} + \text{Left ear C4})/2 - (\text{Right ear C3} + \text{Right ear C4})/2|\)

Average electrode effect = \(|(\text{C3 Left ear} + \text{C3 Right ear})/2 - (\text{C4 Left ear} + \text{C4 Right ear})/2|\)

Ear effect at C3 = \(|\text{Left ear C3} - \text{Right ear C3}|\)

Ear effect at C4 = \(|\text{Left ear C4} - \text{Right ear C4}|\)

Electrode effect for left ear = \(|\text{C3 Left ear} - \text{C4 Left ear}|\)

Electrode effect for right ear = \(|\text{C3 Right ear} - \text{C4 Right ear}|\)
Do ear effects decrease variance?
Are ear effects affected by aging?

Age (F(2, 27): 4.24, p<.03)
Case-wise consideration of data

![Graph showing case-wise consideration of data]
SL confound?
Effect of Noise

• No significant impact of noise
  – Background Noise
    • (F(1, 27): .001, p= .98)

  – Background Noise x Age interaction
    • (F(2, 27): .75, p= .48)
Conclusions

• Ear effects decreased within-group variability for the youngest adults only
  – No adults screened for CAP issues
    • These cases would be more common with age
    • The inclusion of these subjects in the database could increase within group variability

• Significantly larger ear effect in the oldest adults may point to a CAP issue

• Noise did not impact findings
  – Were levels too low?
  – Were effects symmetrical?
Future studies in the older adult population

• Relationship between ear and electrode effects and:
  – Behavioral CAP measures
  – Hearing in noise ability
  – Hearing aid satisfaction & success

• Identification of subjects who may be auditory training candidates
Overall Summary
Middle Latency Response

• A objective measure of thalamocortical auditory function
• Can be easily administered in the clinic with some attention to confounding factors
• Appears to be related somewhat to behavioral measures
• Ear and electrode effects appear to reflect the impact of neurological insult, delayed maturation, and late aging
• These measures also reduce within-group variability in pediatrics
Thank You!

jeffrey.weihing@gmail.com