The Late Auditory Potentials- 
A Research Review and 
Update

- C. G. Marx, Au. D., CCC-A
- Edward Goshorn, Ph.D., CCC-A/SLP
- Alaina Simmons, B.S.

Introduction

- This study is about agreement between an electrophysiological measure of brain activity (P1) and behavioral measures of language capability in children
  - i.e. do they measure the same things?
- This study is not about whether or not a language treatment method is effective
Maturation of Human Cortical Auditory Function

- Ponton, et al:
  - Investigated maturation of cortical auditory function in normal-hearing and children with CI
  - Collected P1, N1, P2 from different age groups of normal-hearing and CI to evaluate morphological changes
  - Finding: Normal hearing evolution—P1, N1, P2 (adult-like configuration) gradually appears during adolescence
    - Morphology changes from dominant P1 to adult-like appearance

...Maturation

- Normals and CI
  - P1 latency decreases with age
- CI
  - P1 latency reaches adult values some 4.5 years later than normal hearing
  - the typical N1/P2 components were missing in all but the children implanted youngest in the study
  - The delay in reaching adult-like values may correspond to the average delay in receiving the implant or period of deafness prior to implantation

Abnormalities in central auditory maturation

- Abnormalities in central auditory maturation in children with language-based learning problems (LBLP)
  - Gilley, et al
    - Compared AEPs of 26 children (6 to 13 yrs) with LBLP to 38 children without LBLP (5 to 12 yrs)
    - 17 of 26 LBLP subjects had abnormal CAEPs
  - compared to matched normals
  - 3 abnormal categories:
    1. Delayed P1 latencies and absent N1/P2
    2. Typical P1 but delayed N1 and P2
    3. Generally low amplitude responses
Research at USM

- The Use of Late Auditory Evoked Potentials as a Physiological Marker for Improvement Following Therapeutic Intervention in Children with Language Disorders
- 7 subjects ranging from 6 to 9 years of age (in 2010)
  - Each has hearing within normal limits from 500 – 4000 Hz.

...Research at USM: Late AEP Protocol

- Channel 1: Cz – Right Mastoid with ground at Fpz
- Channel 2: monitor eye movement
- Stimulus: 40 msec /da/ at 60 dB nHL
  - Presented to right ear only
  - At least 200 samples per replicated trial
- Obtained two trials with stimulus and two without
- Subtract channel 2 info (no stimulus) from stimulus trials to remove eye movement artifact
...Research at USM

- Child watched video cartoons with no sound to ensure attentiveness and minimize eye movement
- Used Sharma et al. regression analysis to determine 95% confidence levels of P1 latency per age group
- Compared changes in language assessment tools (TOLD-P-4 & CELF-4) with changes in P1 latency/amplitude following one year of therapeutic intervention

Rating Scales for Language Tests

- **TOLD-P-4**
  - Standard Score  
    - Rating
      - >130 Very Superior
      - 121-130 Superior
      - 111-120 Above Average
      - 90-110 Average
      - 80-89 Below Average
      - 70-79 Poor
      - >70 Very Poor
Rating Scales for Language Tests

- CELF-4
- Standard Score

<table>
<thead>
<tr>
<th>Rating</th>
<th>Standard Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Average</td>
<td>115 and above</td>
</tr>
<tr>
<td>Average</td>
<td>86-114</td>
</tr>
<tr>
<td>Marginal/Borderline/Mild</td>
<td>78-85</td>
</tr>
<tr>
<td>Low Range/Moderate</td>
<td>71-77</td>
</tr>
<tr>
<td>Very Low Range/Severe</td>
<td>70 and below</td>
</tr>
</tbody>
</table>

Results

- First, 2010 – 2011 data for each subject
- AEP raw data
- Graph: AEP P1 latency and amplitude
- Graph: TOLD or CELF Composite Scores

- Finally, a summary of the changes observed from 2010 – 2011 for AEP and behavioral testing (TOLD & Self)
Subject 1: Pt Latency and Amplitude in 2010 and 2011

Subject 1: TOLD-P-4 Composite Scores on Each Sub-Test in 2010 and 2011
Subject 2: P1 Latency and Amplitude for 2010 (no waveform in 2011)

<table>
<thead>
<tr>
<th>Numerical Value for Units Represented by Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Latency</td>
</tr>
<tr>
<td>No Data</td>
</tr>
<tr>
<td>No Data</td>
</tr>
<tr>
<td>p1lat_2010 For 2011</td>
</tr>
<tr>
<td>p1lat_2011 For 2011</td>
</tr>
<tr>
<td>p1amp_2010 For 2011</td>
</tr>
<tr>
<td>p1amp_2011 For 2011</td>
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</tbody>
</table>

Subject 2: TOLD-P Composite Scores on Each Subtest in 2010 and 2011

<table>
<thead>
<tr>
<th>Composite Score</th>
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</thead>
<tbody>
<tr>
<td>Subject 2: TOLD-P</td>
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</tr>
</tbody>
</table>
Subject 3: P1 Latency and Amplitude for 2010 and 2011

Numerical Value

<table>
<thead>
<tr>
<th>Subtest</th>
<th>p1Lat_2010</th>
<th>p1Lat_2011</th>
<th>p1Amp_2010</th>
<th>p1Amp_2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>10</td>
<td>12</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Latency</td>
<td>90</td>
<td>95</td>
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<td>45</td>
</tr>
<tr>
<td>Amplitude</td>
<td>20</td>
<td>25</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

Subject 3: CELF-4 Composite Scores on Each Subtest in 2010 and 2011

Composite Score

<table>
<thead>
<tr>
<th>Subtest</th>
<th>2010</th>
<th>2011</th>
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<tbody>
<tr>
<td>Reading</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>Vocabulary</td>
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<td>80</td>
</tr>
<tr>
<td>Grammar</td>
<td>80</td>
<td>85</td>
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<tr>
<td>Language</td>
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<td>95</td>
</tr>
<tr>
<td>Writing</td>
<td>70</td>
<td>75</td>
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</table>
Subject 4: Pt Latency and Amplitude for 2010 and 2011

Subject 4: TOLD-P-4 Composite Scores on Each Subtest in 2010 and 2011
Subject 5: P1 Latency and Amplitude for 2010 and 2011

Subject 5: TOLD-F-4 Composite Scores on Each Subtest in 2010 and 2011
Subject 6: Pt Latency and Amplitude in 2010 and 2011

NORMAL LATENCY

Composite Scores on Each Subtest in 2010 and 2011
Subject 7: P1 Latency and Amplitude for 2010 and 2011

Numerical values for each subtest in 2010 and 2011 are shown above each bar.

Subject 7: TOLD-P Composite Scores on Each Subtest in 2010 and 2011
Latency and Amplitude for P1 in 2010 and 2011 for Each Subject

Subject Number

Latency (msec)

Change from 2010 to 2011 in P1 Latency, P1 Amplitude, and Behavioral Average Composite Scores on Standardized Tests

Subject Number

Numerical Value for Units Represented by Each Bars

Agreement Between P1 & Behavioral Tests

<table>
<thead>
<tr>
<th>SIG CHNG LAT</th>
<th>SIG CHNG AMPL</th>
<th>SIG CHNG BEHAV</th>
<th>EITHER P1 MEAS AGREE W/ BEHAV</th>
<th>BOTH P1 MEAS AGREE WITH BEHAV</th>
</tr>
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<tbody>
<tr>
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<td>NO</td>
<td>NO</td>
<td>YES</td>
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</table>

Δ criteria: Lat > 15 ms PERCENT 0% 86% 57%
Conclusions

- P1 measures and standard behavioral measures were in "good" agreement
- P1 shows promise as a marker of change associated with therapeutic intervention
- More research is needed. What is the...
  - Optimum stimulus
  - Optimum measure of a component (latency, amplitude, width, area, etc.)
  - Optimum response (p1 or other)
  - Optimum protocol

References