CURRENT STATUS OF THE AUDITORY STEADY-STATE RESPONSE AND TONE-EVOKED ABR FOR ESTIMATING AN INFANT'S AUDIOGRAM

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(and others!)

Clinical ABR/ASSR website:
www.audiospeech.ubc.ca

ASSRs: The good news...

ASSR good news:
ASSRs can be detected automatically using one of several response detection algorithms

Picton et al. unpublished
ASSR good news:
Responses to several stimuli and both ears may be obtained simultaneously (e.g., four frequencies per ear)

"multiple ASSR"

Many studies in adults indicate good threshold estimation using ASSRs

Multiple ASSR & SNHL
ADULTS
AC stimuli

Herdman & Stapells, 2003

Dimitrijevic et al., 2002

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THRESHOLD ESTIMATION: ADULTS WITH SNHL
(AC stimuli)

Assessment of Auditory thresholds

ASSR and TONE-ABR THRESHOLD ESTIMATION SIMILAR
(adults; AC stimuli)

ASSR good news:
Equipment choices are rapidly increasing

ASSR PROBLEMS:
ARTIFACTUAL/SPURIOUS ASSRs
Adults with severe/profound hearing loss

But: the profusion of new equipment also is a problem.
ASSR problems:

Artifactual ASSRs and
high-intensity air-conduction stimuli

Individuals with severe/profound SNHL

Papers demonstrating spurious/artifactual ASSRs:
Small & Stapells, 2003; in press: BONE and AIR conduction
Gorga et al., 2004: AIR conduction
Jeng et al., 2004: BONE conduction
Picton et al., 2004: simulations

• Some spurious responses due to aliasing
  ➔ signal processing issue
• Some spurious responses likely physiologic but not auditory
  ➔ possibly vestibular responses
• CLINICAL IMPLICATIONS: Some "responses" in infants with profound SNHL may not be auditory

ASSR PROBLEMS:
What is "normal" in infants?

CURRENT CLINICAL ASSR EQUIPMENT

• New "clinical" ASSR equipment may use relatively untested stimulus and/or response detection paradigms
• Some equipment is so new, there is no report in literature; no independent evaluation
• Need for "independent" evaluation: Some studies/researchers are not arms-length from sales of equipment

CAVEAT EMPTOR

ASSR PROBLEMS:

ASSR THRESHOLDS IN INFANTS AND ADULTS WITH NORMAL HEARING

<table>
<thead>
<tr>
<th></th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>36</td>
<td>30</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>Adults</td>
<td>16</td>
<td>19</td>
<td>15</td>
<td>14</td>
</tr>
</tbody>
</table>

Infants are different (higher threshold)!
NORMAL INFANT AC ASSR THRESHOLDS

<table>
<thead>
<tr>
<th>STUDY</th>
<th>ASSR THRESHOLD (dB SPL)</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver 2003</td>
<td></td>
<td>42</td>
<td>30</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>Melbourne 2001 (SING: Levi et al.)</td>
<td></td>
<td>45</td>
<td>34</td>
<td>29</td>
<td>38</td>
</tr>
<tr>
<td>Ottawa/Havana 1996 (MULT: Lins et al.)</td>
<td></td>
<td>45</td>
<td>29</td>
<td>26</td>
<td>29</td>
</tr>
<tr>
<td>Seattle 1995 (SING: Levi et al.)</td>
<td></td>
<td>56</td>
<td>58</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Melbourne 1994 (SING: Richards et al.)</td>
<td></td>
<td>53</td>
<td>31</td>
<td>(1500 Hz)</td>
<td>45</td>
</tr>
<tr>
<td><strong>Mean</strong> MEAN (SPL)</td>
<td></td>
<td>48</td>
<td>38</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td><strong>Mean</strong> (HL)</td>
<td></td>
<td>42</td>
<td>38</td>
<td>35</td>
<td>27</td>
</tr>
<tr>
<td>Tone-ABR (SPL) (meta-analysis)</td>
<td></td>
<td>42</td>
<td>42</td>
<td>34</td>
<td>42</td>
</tr>
</tbody>
</table>

ASSR literature: "Infants" with Hearing Loss

<table>
<thead>
<tr>
<th>STUDY</th>
<th># of HL</th>
<th>Age@ASSR</th>
<th>Comparisons</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>JALA, 2002</td>
<td>~190</td>
<td>3.2 mos</td>
<td>Behav</td>
<td><strong>Best study</strong> problems with severe/profound</td>
</tr>
<tr>
<td>JALA, 2002</td>
<td>~28</td>
<td>2mos-3yr</td>
<td>Click ABR, 500Hz ABR*</td>
<td>- no behavioural</td>
</tr>
<tr>
<td>JALA, 2003</td>
<td>~50</td>
<td>31 mos</td>
<td>Click ABR, 500Hz ABR*</td>
<td>- mild, not severe</td>
</tr>
<tr>
<td>Ottawa/Havana, 2000</td>
<td>10</td>
<td>32 mos</td>
<td>Click ABR</td>
<td>- only normal detected</td>
</tr>
<tr>
<td>Int. J. Ped. Otol. 2004</td>
<td>10</td>
<td>7 mos</td>
<td>Click ABR</td>
<td>- click ABR</td>
</tr>
<tr>
<td>Arch. Otol-HNS, 2004</td>
<td>~34</td>
<td>18 mos</td>
<td>Click ABR</td>
<td>- <strong>tone ABR problems</strong></td>
</tr>
<tr>
<td>Arch. Otol-HNS, 2004</td>
<td>10</td>
<td>13 yrs</td>
<td>Behav</td>
<td>- all severe or profound</td>
</tr>
<tr>
<td>Otol, in press</td>
<td>40</td>
<td>6 mos - 5yrs</td>
<td>Behav</td>
<td>- no &quot;noise&quot; criterion</td>
</tr>
</tbody>
</table>

ASSR PROBLEMS:

Limited clinical database for infants with hearing loss

- Relatively few studies – total sample size not large (especially for multiple ASSR)
- Of these studies, many compare only to click-evoked ABR. Inappropriate comparison
- Two studies have compared infant ASSR to tone-ABR: but only for 500 Hz – significant methodological problems
- Few studies compare ASSR to behavioural threshold
- AC only. No BC. No conductive or mixed HL

ASSR problems:

No infant bone-conduction data (and very few in adults)
Infants are significantly different from adults!

**ASSR CLINICAL ISSUES**

**OPTIMAL STIMULI AND ANALYSES NOT YET DETERMINED**

This, in itself, is not a problem

**HOWEVER**, small clinical database with each using different protocols

*For example:*
- Single vs multiple, especially at different intensities
- AM, AM/FM, exponential, noise, transient (brief tones, clicks)
- F-test analyses: $p<.05$ vs $p<.01$; noise criteria (!)
- Stopping rules (especially re: noise criteria)
- How to handle false positives (i.e., $p<.05$ when subject cannot hear)
- Issues concerning practice of performing multiple statistical tests while recording

**ASSR CLINICAL ISSUES**

**ASSESSMENT OF PROFOUND SNHL:**

- **HIGH-INTENSITY STIMULI MAY RESULT IN ARTIFACTUAL/SPURIOUS RESPONSES**
  - stimulus artifact or non-auditory response

- **DURATION OF HIGH-INTENSITY STIMULATION COULD RESULT IN ACOUSTIC TRAUMA**
  - stimulus on/off time ("duty cycle" and max time)

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**ASSR PROBLEMS:**

**VERY LIMITED CLINICAL DATABASE (SUMMARY)**

**ADULTS & OLDER CHILDREN**
- Reasonable clinical database for single and multiple ASSR (AC stimuli) for adult subjects with SNHL
- NO data for conductive or mixed hearing loss
- Limited data for bone-conduction ASSR in adults with normal hearing
- NO data of BC-ASSR and SNHL

**INFANTS**
- NO adequate study of infants with SNHL with cotemporaneous tone-ABR threshold evaluation
- Few (3) AC-ASSR studies of infants with SNHL with behavioural audiogram follow-up. Overall, very few subjects with mild or moderate SNHL. Studies: 1 large (Rance & Rickards, 2002: single ASSR), 1 medium (Han et al., in press: multiple), 1 very small (Luts et al., 2004: multiple).
- NO study of infants with conductive or mixed hearing loss
- Only one study of BC-ASSR in infants with normal hearing (Pre-term: Small et al., 2004). NO study of BC ASSR in infants with impaired hearing
Auditory Steady-State Response (ASSR) vs Tone-evoked ABR?

- November, 2004: Only the tone-evoked ABR has the necessary clinical database to be recommended for general clinical implementation.
- Only the tone-evoked ABR can be recorded to both air- and bone-conduction stimuli (no data for BC ASSR; artifact issues).
- ASSR is promising and, with more clinical research, is “just around the corner”. Currently, ASSR should only be used IN CONJUNCTION WITH AC/BC tone-evoked ABR.
- Remember too: If no response or if auditory neuropathy/dysynchrony (or other neurophysiologic problem) suspected/present, ABR recordings to high-intensity clicks essential.

PRINCIPLES OF INFANT AUDIOMETRY

- Same audiometric measures as adults (i.e., AC and BC, frequency-specific).
- Evidence-based procedures.
- Infant-based normative and clinical database.
- Experienced/trained clinicians.
- Timely assessment.

Currently: ASSR must be combined with tone-ABR

Combined tone-ABR/Multiple-ASSR Test Sequence

For up-to-date info & protocols

Clinical ABR/ASSR website:

www.audiospeech.ubc.ca