Measuring auditory speech perception capacity in young children

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Presentation to

A sound foundation through early amplification

Chicago, November 2004

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What is auditory capacity?

- the ability of cortical and subcortical systems to relay consistent and differentiable information about sound patterns to higher brain centers.
- places limit on potential for eventual auditory performance
- involves sensitivity and resolution
- is usually compromised in persons with sensorineural hearing loss – even when provided with appropriate hearing aids or cochlear implants.
Limitations of sensory assistance

Hearing Aid
- AMPLIFIER
  - +

Cochlear implant
- PROCESSOR
  - +

Not enough hair cells
Not enough channels, Not enough nerves

Diminished Auditory Capacity
Why measure auditory speech perception capacity?

1. Quantification and description
2. Decisions about sensory assistance
3. Evaluate outcomes
4. Early intervention (EI)
5. Evaluate outcomes of EI
6. Evidence-based practice
Ideal

Stimulus

Sensory device

Aided speech perception capacity

Child’s auditory system

Response
Real State:
- comfort, interest, attention, motivation

Knowledge:
- world (cognition)
- people (social cognition)
- language - phonology
  - vocabulary
  - syntax

Processing skills:
- auditory, linguistic

Motor skills:
- gross, fine, speech

Stimulus
Sensory device
Aided speech perception capacity
Auditory system

Task-related variables

Response?
Options

State:
- comfort, interest, attention, motivation

Knowledge:
- world (cognition)
- people (social cognition)
- language - phonology
  - vocabulary
  - syntax

Processing skills:
- auditory, linguistic

Motor skills:
- gross, fine, speech

Activities:
- developmentally appropriate
- varied

Tester:
- child-skills
- adaptability
- objectivity

Environment:
- attractive
- socially comfortable
Options

State:
- comfort, interest, attention, motivation

Knowledge:
- world (cognition)
- people (social cognition)
- language - phonology
  - vocabulary
  - syntax

Processing skills:
- auditory, linguistic

Motor skills:
- gross, fine, speech

Confirm that child understands and can perform required tasks.
Options

State:
- comfort, interest,
  attention, motivation
Knowledge:
- world (cognition)
- people (social cognition)
- language - phonology
  - vocabulary
  - syntax
Processing skills:
- auditory, linguistic
Motor skills:
- gross, fine, speech

Use nonsense syllables to eliminate vocabulary and syntax effects. Unfortunately cannot eliminate phonology
<table>
<thead>
<tr>
<th>State:</th>
<th>Knowledge:</th>
<th>Motor skills:</th>
</tr>
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<td>Processing skills:</td>
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The effect of processing skills cannot be eliminated. But one can try to ensure adequate prior learning opportunity.
Options

State:
- comfort, interest, attention, motivation

Knowledge:
- world (cognition)
- people (social cognition)
- language - phonology
  - vocabulary
  - syntax

Processing skills:
- auditory, linguistic

Motor skills:
- gross, fine, speech

Choose developmentally appropriate task. Confirm that skills are present (especially important with spoken response).
• Perception of phonologically significant contrasts, such as:

• Vowel Height – for example, “doo/daa”
• Vowel Place – for example, “doo/dee”
• Consonant Voicing – for example, “doo/too”
• Consonant manner – for example, “doo/zoo”
• Consonant place – for example “doo/boo”

• Necessary (though insufficient)
1. VRASPAC

- Visual Reinforcement Assessment of the perception of Speech Pattern Contrasts
- Perceptual task – detection of phonemic change
- Response task – conditioned head turn
- Developmental age – 9 months and higher
### VRASPAC Data Retrieval

#### Record 5: Numbers show % confidence after each trial

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<th>Final value</th>
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<th>ISI</th>
<th>count</th>
<th>window</th>
<th>std</th>
<th>dev</th>
<th>spac</th>
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<td>0.99</td>
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2. IMSPAC

- IMitative test of the perception of Speech PAttern Contrasts
- Perceptual task – detection of phonemic change
- Response task – imitation
- Developmental age – 2.5 years and higher, assuming adequate phonological and motor-speech development
- Best for acquired loss and/or auditory-oral intervention
IMSPAC (on-line)

Primary computer

Secondary monitor

Video

Speech

Noise

Tester

Mixer/amplifier

Imitation

Child

Visual Mask

Auditory mask
Sample OLIMSPAC data

Scores are shown in % re chance

Vowels
Consonants
Mean

Listening and looking
Just listening

Test Child
3. VIDSPAC

- **VIDeo-game test of the perception of Speech PAAttern Contrasts**
- Perceptual task – detection of phonemic change
- Response task – motoric (e.g. button press)
- Developmental age – 3.5 years and higher
- Avoids need for motor-speech development
VIDSPAC – Hardware setup

Alternative 1
Alternative 2
VIDSPAC – Testing

Boxes “saved” on response
To deviant utterance
VIDSPAC – End of test for single contrast
VIDSPAC – Animated cartoon reward
VIDSPAC – Display of results

<table>
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<tr>
<th>Audio-visual Contrasts (practice)</th>
<th>VHav</th>
<th>VPav</th>
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<tr>
<td>2/1</td>
<td>8/4/1</td>
<td>0/18</td>
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<td>100/100</td>
<td>63/80</td>
<td>100/99</td>
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<table>
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<th>Audio-only Contrasts</th>
<th>VH</th>
<th>VP</th>
<th>CV</th>
<th>CC</th>
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<tr>
<td>1/1</td>
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<th>Vowel and Consonant Contrasts</th>
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<th>C</th>
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<td>98/100</td>
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<th>Composite VIDSPAC score</th>
<th>Comp</th>
<th>Contrast</th>
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<tbody>
<tr>
<td>6</td>
<td>Runs averaged</td>
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<tr>
<td>15/24</td>
<td>Hits</td>
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<tr>
<td>7/68</td>
<td>False Positives</td>
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<tr>
<td>63</td>
<td>Percent Hits</td>
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<td>41</td>
<td>95% re chance</td>
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<tr>
<td>100</td>
<td>% Confidence</td>
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**Data Sample**

VIDSPAC 3.1
Limitations of behavioral tests

• Impossible to eliminate effects of phonological development
• Impossible completely to eliminate other task-related effects - both perceptual and motoric
• Perfect performance OK
• Causes of performance deficits uncertain (capacity vs. performance)
Duration of use effect in children

IMSPAC scores of Multi-channel, pediatric implantees as a function of length of use
Scores on a 3-interval forced-choice test of contrast perception (THRIFTSPAC) by 44 children with normal hearing.
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Possible benefits of cortical ERPs

- Resolution at the cortical level implies resolution at more peripheral levels
- Eliminates language and task-related factors

Possible limitations of cortical ERPs

- Time consuming
- Artifact-prone
- Attention and wakefulness may still be issues
Electrophysiological methods: The Acoustic Change Complex (ACC) (experimental)
Spectral change stimulus

Time in msec re stimulus onset

Frequency in kHz

/u/

/i/

Decibels

Hertz

0 2000 4000 6000 8000

0 20 40 60 80
Group mean waveforms

F2 change in Hertz

Response window

Time in msec re stimulus onset

10 µV
Percent correct re chance

ACC response amplitude in $\mu$V rms

Behavioral findings (Mean of 7 Ss)

Electrophysiology findings
ACC from adult with cochlear implant showing elimination of electrical artifact but presence of attentional factor – courtesy of Brett Martin
Role of plasticity?

• Is auditory capacity a malleable entity – subject to enhancement through stimulation and experience?
Conclusions

• Behavioral tests of auditory capacity
  - difficult to eliminate task-related factors
  - needs careful test (and task) design
  - needs high clinician expertise
  - needs careful interpretation

• Electrophysiological tests
  - not foolproof
  - still experimental
Needs

- Behavioral tests that separate sensory and task-related factors – to guide design, selection and adaptation of aids, implants and educational intervention
- Developmental studies to enhance predictive value of early data
- Valid and reliable electrophysiological approaches to assessing capacity
- Studies of the role of plasticity – (is auditory capacity fixed or can it be enhanced by training and experience?)
- Battery of tests to track emerging processing skills (what is the child doing with his/her auditory capacity?)