The Listen-Say Test in Children: Phonetic discrimination and reproduction

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Children with language impairment (LI)

- Affects 7% of the population

- Heterogeneous condition
  - Reading disorders, 1.9-6.2 x risk (Pennington & Bishop, 2009)
  - 61% of children who had severe LI at 3 years had a neurodevelopmental disorder (ADHD or Autism Spectrum) at school entry (Westerlund et al., 2002)
An auditory sensory cause for language impairment (LI)?

Temporal processing (Benasich & Tallal, 2002)

Phonological representations (Sussman, 1993, 2001)

Neural encoding of consonants in noise (White-Schwoch & Kraus, 2013)
Current practice

- Face to face assessments
- Lack of knowledge how speech perception contributes to language and learning
- Too little interdisciplinary work

No reliable, validated and standardized tests are available to assess discrimination and reproduction of phonetic information in children who struggle with language and learning.
Aims

• Standardize the Swedish version of the Listen-Say Test

• Examine perception of phonetic contrasts in quiet and in speech noise in Swedish school children.
The Swedish Listen-Say test

- 63 Swedish children 7-9 years of age
  1. 27 mainstreamed children
  2. 10 children with LI
  3. 26 mainstreamed children*

- 62/29* minimal word pairs
  (e.g. Sol – Pol, Sal, Sot, Cat – Hat, Kit, Cap)

- Signal: Seven consonant contrasts, (70 dB SPL)
- Condition: Quiet, Four Talker Babble
- Fixed signal-to-noise ratio (+5 dB)
Overall hypotheses

Overall good discriminatory skills in quiet

Children with LI will be more affected by noise
Larger variation in performance
Speech production influences perception

Temporal acoustic cues most affected by masker
Voicing and place of articulation of stop consonants

Kuhl et al., 2014,
Ross et al., 2015
Vance & Martindale, 2012
Bradlow et al., 1999
Nishi et al., 2010
### Phonetic categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Phonetic contrast</th>
<th>IPA transcription</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Place</td>
<td>/t-k, d-g, n-ŋ/</td>
<td>/ˈtɔnə/ – /ˈkɔnə/ (barrel/thin – can)</td>
</tr>
<tr>
<td>B</td>
<td>Manner</td>
<td>/b-m, d-n, g-ŋ/</td>
<td>/ˈbu/ – /ˈmu/ (boh – moo)</td>
</tr>
<tr>
<td>C</td>
<td>Voicing</td>
<td>/b-p, d-t, g-k, j-ç, v-f/</td>
<td>/ˈbetə/ – /ˈpɛtə/ (beet/feed – pick)</td>
</tr>
<tr>
<td>D</td>
<td>Manner</td>
<td>/l-r-j/</td>
<td>/æ/ – /jɛ/ (smile – give)</td>
</tr>
<tr>
<td>E</td>
<td>Place</td>
<td>/s-ç-fi/</td>
<td>/sɔl/ – /ʃɔl/ (hall – shawl)</td>
</tr>
<tr>
<td>F</td>
<td>Manner</td>
<td>/s-t/</td>
<td>/sɔl/ – /ʃɔl/ (hall – speech)</td>
</tr>
<tr>
<td>G</td>
<td>Syllable complexity</td>
<td>/b-bl, f-fl, p-pr, f-fr, g-qn, k-]\n</td>
<td></td>
</tr>
</tbody>
</table>
The child holds a USB dual-button control (red/blue)

Presses a button after each word (target/contrast)

<table>
<thead>
<tr>
<th>Minimal word pair</th>
<th>DISCRIMINATION</th>
<th>REPRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>/'tōna/ – /'kōna/ (thin – can)</td>
<td>/'kōna/</td>
<td>/'tōna/</td>
</tr>
<tr>
<td>Listen to...</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
## Mainstreamed children high scores

<table>
<thead>
<tr>
<th>Phonetic category</th>
<th>n</th>
<th>Quiet</th>
<th>Babble</th>
<th>p (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td><strong>A</strong></td>
<td>27</td>
<td>93.6</td>
<td>11.4</td>
<td>87.0</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>27</td>
<td>94.1</td>
<td>8.3</td>
<td>92.8</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>27</td>
<td>92.8</td>
<td>9.9</td>
<td>88.4</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>27</td>
<td>79.8</td>
<td>9.8</td>
<td>80.5</td>
</tr>
<tr>
<td><strong>E</strong></td>
<td>27</td>
<td>90.5</td>
<td>11.7</td>
<td>88.1</td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>27</td>
<td>91.8</td>
<td>16.8</td>
<td>89.3</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>27</td>
<td>90.8</td>
<td>14.0</td>
<td>84.0</td>
</tr>
</tbody>
</table>
Children with LI more affected by babble

<table>
<thead>
<tr>
<th>Phonetic Category</th>
<th>N</th>
<th>Quiet</th>
<th>Babble</th>
<th>p (2-side)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>A</td>
<td>10</td>
<td>84,6</td>
<td>13,6</td>
<td>70,4</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>85,2</td>
<td>12,8</td>
<td>85,2</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>82,6</td>
<td>11,7</td>
<td>75,6</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>86,7</td>
<td>15,7</td>
<td>83,3</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>85,2</td>
<td>8,0</td>
<td>77,9</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>92,2</td>
<td>9,1</td>
<td>73,3</td>
</tr>
<tr>
<td>G</td>
<td>10</td>
<td>88,6</td>
<td>6,7</td>
<td>77,7</td>
</tr>
</tbody>
</table>
Improvements Swedish test

- Ceiling effects
- Testing time
- Memory load
- Balancing
- Order effects

Shorter version
Balancing of test order and phonetic categories
Mainstreamed school children
N=26, 8.9 years

An overall effect of noise on discrimination accuracy
Acc: 93.2% / 91.7%,
$z = -2.4, p = .015$
No difference for RTs
RTs: 2.02 s / 2.00 s

Connected to place of articulation
93.3% / 83.3%
American Listen-Say

- Detection of phonetic discrimination in quiet and in noise in preschoolers
- Early intervention
- More rigorous method in controlling the acoustic and phonetic variables
Aims

• Develop an improved US English version

• Relate phonetic speech skills to hearing ability and cognitive performance
Procedures

• Speech Discrimination and Reproduction

• Hearing
  – Tone Audiometry (1, 4, 8, 12.5 and 16 kHz)
  – Tympanometry
  – Middle Ear Reflexes
  – DPOAEs

• Cognition
  – Vocabulary
  – Reading
  – General Processing Speed
Speech stimuli: 24 monosyllabic age-appropriate familiar words

Phonetic contrasts: perceptual confusion and typical speech development

<table>
<thead>
<tr>
<th>Vowel</th>
<th>STOPS</th>
<th>FRICATIVE</th>
<th>NASAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/i/</td>
<td>Bee</td>
<td>See</td>
</tr>
<tr>
<td>2</td>
<td>/ɛ/</td>
<td>Bear</td>
<td>Fair</td>
</tr>
<tr>
<td>3</td>
<td>/ɔʊ/</td>
<td>Bow</td>
<td>So</td>
</tr>
<tr>
<td></td>
<td>/d/</td>
<td>D</td>
<td>Share</td>
</tr>
<tr>
<td></td>
<td>/t/</td>
<td>Dare</td>
<td>Hair</td>
</tr>
<tr>
<td></td>
<td>/k/</td>
<td>Tea</td>
<td>He</td>
</tr>
<tr>
<td></td>
<td>/p/</td>
<td>Key</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/t/</td>
<td>Toe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/k/</td>
<td>Go</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/s/</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Speech sound development

Age (years)

1  2  3  4  5  6  7

/m/ as in me
/b/ as in be
/h/ as in he
/k/ as in key
/d/ as in “D”
/t/ as in tea
/s/ as in see
/f/ as in she

Grunwell, 1981
Sander, 1972
Smit et al., 1990
Homogenization results

- 10-13 NH adults
- 12 different SNRs (-3 to -25 dB)
- 90% and 70% SRT in noise for each word

Tea: 70% SRT = -8.0 dB; 90% SRT = -6.0 dB
XAB design

- Touchscreen
- Quiet
- Speech shaped noise
  90% SRT, 70% SRT
- Phonological categories
- Different recordings
- Confusion matrices
Summary

• First procedures in Swedish 7-9 year school children showed that noise affected place of articulation, voicing and syllable complexity

• Children with LI more affected by speech noise

• 4-5 year old American children with and without a diagnosed language impairment will be assessed with the improved version

• Phonetic discrimination skills will be analyzed in relation to hearing and cognitive performance
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