Listening difficulties in children with language impairment

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Outline - specific

Neural coding of consonants in noise

What is listening difficulties?
Overlap
Children with language impairment

Current postdoc project

Wishlist😊

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Barnen i Bullerbyn

The Children of Noisy Village

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Main message

• Neural processing of consonants in noise is fundamental for language and reading development

• Tests used in the clinic need to capture
  1. The nature of perceptually challenging speech sounds
  2. Characteristics of everyday listening situations
     – Realistic
     – Quick
     – Methodologically precise

White-Schwoch et al., 2015,

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What is listening difficulties?

• According to ASHA (2005)
  “Difficulties in the processing of auditory information in the central nervous system”

• The diagnosis is given
  – when functional listening difficulties are observed in the presence of normal peripheral hearing and the child demonstrates deficits in one or more auditory skill areas that include discrimination, pattern recognition, temporal integration and ordering, dichotic listening, and the perception of degraded stimuli

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What is listening difficulties?

- The established term (C)APD = Central Auditory Processing Disorder

- Current diagnosis has several limitations
  - Diagnostic Test batteries differ among clinics
  - Protocols specifying type and number of failed tests for a diagnosis differ
  - Normative data for children are lacking
  - Listening in noise problems are not always supported*

Ludwig et al., 2014
Ferguson et al., 2011*
Ptok, Miller & Kuhn, 2016

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What is listening difficulties?

- Depending on the criteria used, the rates of the diagnosis of (C)APD may range from 7.3% to 96.0%.
- So, an APD diagnosis hardly says anything about the actual deficits a child is suffering from, unless a reference is made about the criteria being used.
- It is recommended not using APD as a global label for any kind of listening problems.

Wilson & Arnott, 2013
Overlap

- Close relationship between APD and other developmental disorders
  
  - Language Impairment (Dawes and Bishop 2009; Sharma et al. 2009; Ferguson et al. 2011)
  
  - Dyslexia (King et al. 2003; Dawes and Bishop 2009; Dawes et al. 2009)
Alternative explanation

• Auditory processing difficulties are perceptual rather than sensory, i.e. they involve decreased organisation, identification and interpretation of sensory information

• However, auditory sensory information is important
  – High frequency hearing loss associated with reduced spatial hearing
    • This may co occur in children with neurodevelopmental challenges

Cameron & Dillon, 2008
Moore et al., ongoing project
Language impairment

(Specific) language impairment

Språkstörning

Sprachstörung

Trouble d’acquisition de language

Јазично оштетување
Language impairment

Alfhild Tamm, 1912:

- "Hearing muteness" (hörstumhet)
  - Undeveloped sense for word timbre = "word muteness"

- Separated hearing muteness (hörstumhet) from deafness (dövstumhet)
  - Motor
  - Sensory
  - Perception-action theories of speech perception

- Caused by reduced memory and attention

Kuhl et al., 2014. Analysis by Synthesis

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Broader window for perceptual differences within phonetic categories

Kuhl, P, 1994
Noordenbos et al., 2013

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Language impairment

Affects 7% of the population

As common as:
Dyslexia
ADHD

Much more common than autism

Most probably multifactorial

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Language impairment

- Late talkers
- Unintelligible
- Unattentive
- Slow learners
- Reading impaired

- Misunderstandings with peers
- Low self esteem
- Poor academic achievement
- School drop out
- Underemployment

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Interaction

Top down

Bottom-up

Higher and lower levels interact in speech perception

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Background

[spɪʧsaʊndz] [sɪləbəls][wɜːrdz]
Background

GERKENS PROSODIC HYPOTHESIS
""WORD STRESS TEMPLATES"
OMISSIONS OF UNSTRESSED SYLLABLES

TALLAL'S TEMPORAL HYPOTHESIS
SPEECH SOUNDS OF SHORT DURATION ARE NOT DETECTED

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LEONARD'S SURFACE HYPOTHESIS
OMITS/CHANGES ACOUSTICALLY WEAK SEGMENTS THAT HOLDS GRAMMATICAL INFORMATION

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Current postdoc project

EMIL

von Mentzer, 2005

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Part 1 - Retrospective medical record study
- At present ≈ 120 caregivers have given their consent

Part 2 - Questionnaire-based study
- Addressed to the guardians of the same children as in part 1 using ECLiPS, Evaluation of Children's Listening and Processing Skills (Barry & Moore, 2015).

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American part

1. Use an American-English version of a speech perception test with minimal word pairs, the Listen-Say test (Nakeva von Mentzer et al. Ongoing) for children from 4 years of age.

2. Use the Enhanced QuickSiN adapted for children

3. Use a kit of cognitive and auditory tests:
   Cognitive; vocabulary, oral reading and processing speed.
   Auditory; pure tone audiometry including high frequencies (10-16 kHz), tympanometry, acoustic reflexes, Distortion product OAEs.

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The Listen-Say

- The Listen-Say test in Swedish children
  - 62 minimal word pairs
  - Seven consonant contrasts
  - Fixed signal-to-noise ratio +5 dB
    - speech 70 dB SPL
  - Quiet, Competing speech

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## Swedish Listen-Say

<table>
<thead>
<tr>
<th>Category</th>
<th>Phonetic contrast</th>
<th>IPA transcription</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>Place</td>
<td>/t-k, d-g, n-ŋ/</td>
<td>/'tɔna/ – /'kona/ (barrel/thin – can) /'sɔn/ – /'sɒŋ/ (such – song)</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>Manner</td>
<td>/b-m, d-n, g-ŋ/</td>
<td>/'bu/ – /'ma/ (boh – moo)</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>Voicing</td>
<td>/b-p, d-t, g-k, j-ç, v-f/</td>
<td>/'beta/ – /'peta/ (beet/feed – pick)</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td>Manner</td>
<td>/l-r-j/</td>
<td>/'len/ – /'ren/ (smooth – clean) /'le/ – /'je/ (smile – give)</td>
</tr>
<tr>
<td><strong>E</strong></td>
<td>Place</td>
<td>/s-ç-h/</td>
<td>/'sal/ – /'fal/ (hall – shawl)</td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>Manner</td>
<td>/s-t/</td>
<td>/'sal/ – /'tal/ (hall – number/speech)</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>Syllable complexity</td>
<td>/b-bl, f-fl, p-pr, f-fr, g-gn, k-kn, t-ťv, k-kv, s-sl, s-sn, s-st, s-sv/</td>
<td>/'boma/ – /'bloma/ (miss the mark – flower)</td>
</tr>
</tbody>
</table>

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Swedish Listen-Say

- Twenty-seven school children 7-9 years

- Overall, the children obtained high scores discriminating phonetic contrasts in both quiet (Mdn 95%) and against speech (Mdn 91%).

- A significant effect of 4T speech background was evident in three out of seven contrasts, connected to place of articulation, voicing and syllable complexity.

Nakeva von Mentzer et al., submitted

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Swedish Listen-Say

The Listen Say Test in Swedish

- Black = LI, n = 14
- White = TD, n = 33

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Swedish Data

- Statistically poorer performance in both conditions by children with language impairment

- Degree of LI was the only significantly associated factor with percent correctly discriminated contrasts in babble, $r_s = 0.675, p = 0.032$ ($n=10$)

Nakeva von Mentzer et al., ongoing

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The American Listen-Say

Assess children’s speech perception thresholds of 10 phonetic contrasts.

• 36 minimal word pairs
• Target words have been carefully selected with respect to
  – Phonetic features , CV words, /i, ɛ, ou/
  – Acoustic features
  – Visual confusion
  – Speech sound development
  – Age of acquisition
  – Word frequency

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The Enhanced QuickSiN for children

Rationale

- The inability of current speech tests to capture the complexity in real-world speech communication is a huge problem in the assessment and treatment of people with hearing loss.
The Enhanced QuickSiN for children

1. Competing speech.
   The listener listens to speech in four-talker babble noise.

2. Audiovisual presentation
   The listener listens and watches a video of speech in four-talker babble noise

3. Spatial cues.
   The listener listens to sentences that have been manipulated, so that they seem to be coming from different locations in the room.

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The Enhanced QuickSiN for children

• Compare children’s data to adult data

  – 50% Speech Reception Thresholds:
    – Babble = +2 dB
    – Audiovisual = -3 dB
    – Spatial = +1 dB
Wish list for the Children of NV

The Children of Noisy Village

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Wish list

• Early detection
  – More rigorous methods in detecting troubles with basic skills

• Rich language at home
  – Motherese
  – Shared book reading
  – Thirty million words
  – Phonological awareness
  – Letter knowledge

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Wish list

- Audability in educational settings
  - Lyberg et al. 2015

- Training of executive functioning
  - Diamond, Barnett, Thomas & Munro, 2007

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