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Frequency Discrimination in Children with APD or SLI

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Disclosure

- Employed by the City University of New York.
- Author of several articles and presentations on auditory perception.
Learning objectives

- Describe $\Delta f$ thresholds in children.
- Compare and contrast the effect of APD or SLI on frequency discrimination ability.
- Understand the importance of supra threshold $\Delta f$ detection.

Outline

- Introduction
- Review of clinical profiles of APD and SLI
- Overview of auditory brain
- $\Delta f$ detection in - typically developing children
  - children with APD or SLI
- Suprathreshold frequency discrimination
- Clinical implications
- Summary, Q & A
Introduction

- Why is frequency discrimination important?

- Language learning (e.g., Noonan et al., 2008)

- Speech perception (e.g., Tallal & Percy, 1973; Benasich & Tallal, 2002; Kuhl, 2004).

Spectral Cues

- Formants identification (Bailey & Snowling, 2002)

- Frequency cues are important (Kleindienst & Musiek, 2011)
Clinical Profiles

- **Specific Language Impairment** is characterized by a difficulty in acquiring language, in the absence of known neurological disorder, or a cognitive, emotional, or sensory deficit (Leonard, 2014).

- **Pediatric Auditory Processing Disorder** includes difficulty in one or more of the following (ASHA, 2005; AAA, 2010):
  - Sound localization
  - Auditory discrimination and auditory pattern recognition
  - Dichotic listening
  - Auditory performance in noise

Why is testing for APD important?

- The prevalence of pediatric APD is about 3% of school-aged children (Musiek & Chermak, 2014).

- APD is often associated with language impairment (e.g. Rota-Donahue, 2014), BUT, not always assessed in atypically developing children (e.g., Bishop, 2007).
Brain Bases of Auditory Perception

- Maturation of the auditory pathways.
- Individual brain characteristics.

Maturation

Image by Bockel, Openclipart
Decussation of the Auditory Pathways

Posterior Superior Temporal Gyrus (pSTG)
Detection in Typically Developing Children Behavioral Measures

- Δf threshold in typically developing (TD) children (Rota-Donahue, 2010).
- Using two continuous tones – base frequencies of 500 Hz and 3000 Hz – with no change and with a change.
- Examples:
  - 500 Hz – no change
  - 500 Hz to 520 Hz
  - 3000 Hz – no change
  - 3000 Hz to 3120 Hz

Behavioral Δf thresholds in TD children

- Δf thresholds in the order of 1% of the base frequency at 500 Hz and 3000 Hz (Rota-Donahue, 2010).
- In the order of 1% of the base frequency at 1000 Hz for “good performers” (Moore et al., 2008).
- Other studies with mixed results and great variability (e.g., Sutcliffe and Bishop, 2005).
Δf detection in TD children
Electrophysiology A Review

What is electroencephalography (EEG)?

- Recording of electrical activity at the level of the scalp.
- Using caps with electrodes.
- Spontaneous EEG vs. responses time locked to an event.
P1-N1-P2 component

From: Creative Commons

T-complex
Mismatch Negativity MMN

- Large $\Delta f$ (40% of the base frequency): expected response clearly visible.

- $\Delta f$ threshold, around 1% of the base frequency.

Rota-Donahue, 2010
T-Complex

$\Delta f$ detection in TD children
Electrophysiology

- $\Delta f$ thresholds in the order of 1% of the base frequency at 500 Hz and 3000 Hz (Rota-Donahue, 2010).

- In the order of 2% of the base frequency at 1000 Hz for some participants (Ahmmed et al., 2008).

- Other studies with mixed results and great variability (e.g., McArthur and Bishop, 2005).
Δf detection in children with APD or SLI

Background

Some atypically developing children show auditory deficits:

- **Behaviorally**
  - Poor frequency processing linked to language impairment (e.g., Noonan et al., 2007).
  - Elevated Δf thresholds in some children (e.g., Moore et al., 2008).
- **Electrophysiologically**
  - Obligatory P1,N1, P2 immature (e.g., Bishop, 2007)
  - Reduced MMN (e.g., Bishop, 2007).

More recent research studies on Δf

Non typical children show frequency perception deficits:

- **Behaviorally**
  - Δf thresholds around 10 % of the base frequency (Moore et al., 2008).
  - Compounding negative effect if children have both APD and SLI, (Rota-Donahue et al., 2016).
- **Electrophysiologically**
  - Obligatory P1,N1, P2, no significant waveform differences at FCZ but differences at T7 and T8 (Rota-Donahue et al., 2014).
  - Weak MMN and elevated Δf thresholds in some children, (Ahmmed et al., 2008)
  - Reduced MMN amplitude in children with both APD and SLI (Rota-Donahue et al., 2014).
Δf detection in non TD children
Behavioral Measures

- Examples (Rota-Donahue et al., 2014)

- Method:
  - Population: 10-12 year-old children screened for hearing, attention and neurological deficits; tested for non verbal intelligence, language and auditory processing.
  - Procedure: two alternative forced-choice procedure.
  - Stimuli: four pure tones (see next slide).

Stimuli
Analysis of behavioral data
Sensitivity Index – d’

Why d’?

- Sensitivity Index, (Green and Swets, 1974).
- Hit rate (H) and false alarm rate (F) calculated for each participant for both tasks.
- d’ determined for each participants using the formula:
  \[ d' = z(H) - z(F) \]

<table>
<thead>
<tr>
<th>Δf</th>
<th>TD</th>
<th>APD</th>
<th>SLI</th>
<th>BOTH</th>
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<tbody>
<tr>
<td></td>
<td>M  SD  SE</td>
<td>M  SD  SE</td>
<td>M  SD  SE</td>
<td>M  SD  SE</td>
</tr>
<tr>
<td>Small</td>
<td>1.94 1 (.28)</td>
<td>1.24 1.07 (.54)</td>
<td>0.89 1.17 (.58)</td>
<td>0.9 0.95 (.28)</td>
</tr>
<tr>
<td>Medium</td>
<td>3.1 1.03 (.29)</td>
<td>2.05 1.43 (.72)</td>
<td>1.96 .68 (.34)</td>
<td>1.6 1.08 (.36)</td>
</tr>
<tr>
<td>Large</td>
<td>3.85 79 (.22)</td>
<td>3.28 1.25 (.63)</td>
<td>2.63 .84 (.42)</td>
<td>2.17 1.25 (.42)</td>
</tr>
</tbody>
</table>

Rota-Donahue et al., JAAA, 2016.
Δƒ detection in children with APD or SLI
Electrophysiology

- Examples (Rota-Donahue, 2010)

- Method:
  - Population: 8-11 year-old children screened for hearing, attention and neurological deficits; tested for non verbal intelligence, language and auditory processing.
  - Procedure: EEG recording time locked to the frequency change, P1-N1-P2 measures.
  - Stimuli: continuous tones.
Comparison $\Delta f$ thresholds Non TD vs. TD

P1-N1-P2 in children with APD or SLI

Rota-Donahue, 2014
T complex at T7 and T8 for the four groups of participants.

T-Complex

Average amplitude in µVolts of Tα at T7 and T8 sites
Suprathreshold frequency discrimination

- Related to everyday perception.
- Rarely reported, as $\Delta f$ thresholds studies prevail.
- Clinical profiles affect frequency discrimination differently, (Rota-Donahue et al., 2016).
Brain Basis of APD and SLI

Atrophy in the periSylvian fissure reported by Boscariol et al., 2011
Clinical Case – Jane, 10 year-old girl

- Questionnaire: neurological deficits ruled out, unremarkable medical history.
- Hearing screening: pass bilaterally between 500Hz and 4000Hz.
- Checklist to rule out AD(H)D based on the Connors’ checklist: pass.
- Test of non-verbal intelligence. TONI score of 96.
- CELF Core Language Standard Score of 55.
- Referred for APD evaluation due to lack of progress in speech language therapy.

Tests of Auditory Processing:

- LiSN-S: below norms
- DDT: 54%, AD, 44% AS
- GIN: 20ms AU
- SCAN3-C – A/F ground subtest scaled score: 8

Overall:
- Client has both APD and SLI
Differential Processing Training Program
by Kerry Winget (LinguiSystem)

**Book 1 Acoustic Tasks**
- Dichotic Listening
- Temporal Patterning
- Auditory Discrimination

**Book 2 Acoustic-Linguistic Tasks**
- Phonemic Manipulation
- Phonic Manipulation

**Book 3 Linguistic Tasks**
- Word Relationships
- Prosodic Interpretation
- Language Organization

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After 2 months of Auditory Training

SOAP notes from the SLP:
- Jane is more attentive during sessions.
- The mother is more motivated.
- Jane is able to follow 3 steps commands (> 80% after 2 months of auditory training), compare to 1 step commands before training.
- However, Jane’s language comprehension and her reading skills are still very poor.
- CTOPP, phonological memory (memory for digits and non word repetition), score: 88.
- Future goals include working on word relationships and semantics.
Overall - $\Delta f$ in children

**Typically developing children:**
- Behavioral $\Delta f$ thresholds similar to adults’, in the order of 1% of the base frequency.
- Electrophysiologically, $\Delta f$ thresholds also in the order of 1% of the base frequency.

**Clinical groups:**
- Elevated behavioral $\Delta f$ thresholds.
- Reduced EEG response at T7 and T8.
- Reduced MMN amplitude.
- Compounding effect of having 2 disorders vs. one.
- Suprathreshold $\Delta f$ detection also affected.
- Importance of identifying APD to provide auditory training.

**Conclusion**

- APD and SLI
- Spectral processing and language learning
- Threshold and suprathreshold detection
- The assessment of $\Delta f$ detection
- Remediation plans
References


Thank you

Questions?