AUDITORY PROCESSING AND READING DISABILITY: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background

- Auditory processing frequently linked to language-based learning difficulties
- Past systematic reviews, meta-analyses: broad deficits[1-3]
- Nature of deficit unclear – not causal
- Heterogeneous tasks, disorders, and range of study quality
- Focus on reading disability (RD), four task categories
  - Frequency, duration, and intensity discrimination as well as gap detection

Research Questions

1. How large are behavioral auditory discrimination deficits in RD?
2. What is the quality of the extant literature?
3. Is there publication bias?

Methodological Highlights:

- Registered Report Format, In Principle Acceptance at *Scientific Studies of Reading*
- PRISMA[4] systematic review and meta-analysis

Search Strategy

- Search references and citations of included papers from Hämäläinen et al., 2013
- Searched newly identified studies' references and citations
- SnowGlobe Application (snowglobe.soc.northwestern.edu)

Inclusion Criteria:

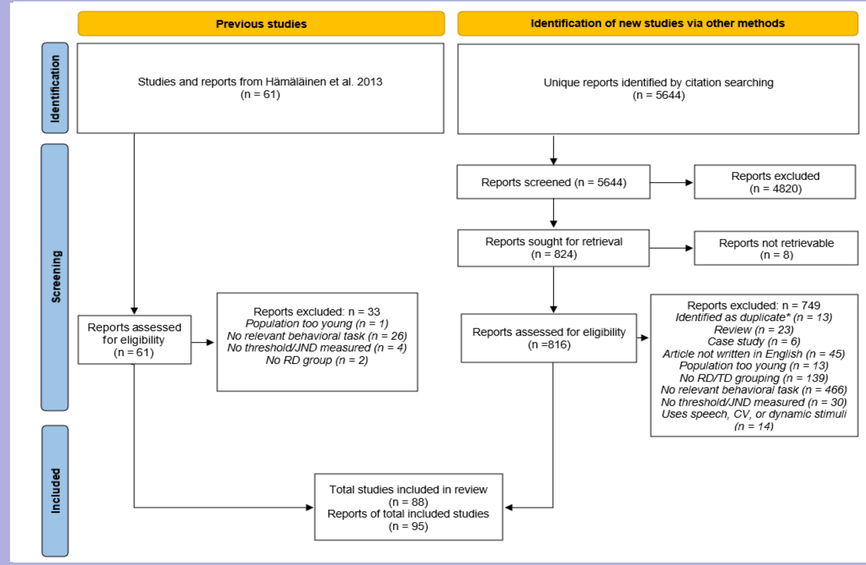
- ➢ Group of individuals with RD and control group
- ➢ Relevant auditory processing task
  - ➢ Behavioral threshold for any of the four task categories
- ➢ Reported means and SDs to calculate standardized mean difference (SMD; e.g., *d* and *g*)

Sample Characteristics

- N = 63 samples, n = 3,545 participants
  - n = 2,206 children, n = 1,045 n = 253 adolescents
  - n = 2,003 English L1, n = 558 Hebrew L1

Analysis Plan

- Robust variance estimation (RVE) meta-analysis models
  - Allows modeling of multiple effect sizes in same sample



Research Question 1: How large are behavioral auditory discrimination deficits in RD?

Model	*N*	*k*	*d*	*t*	95% CI
Task Category					
Frequency	30	55	**.79**	7.56	[.58 1.01]
Duration	14	22	**.80**	6.12	[.52 1.08]
Intensity	24	34	**.60**	7.65	[.44 .76]
Gap Detection [a]	16	23	**.80**	4.89	[.45 1.15]

N = number of samples/studies; k = number of effect sizes
All models were significant at $p < .001$.
a – model is presented with an extreme outlier excluded

Research Question 2: What is the quality of the extant literature?

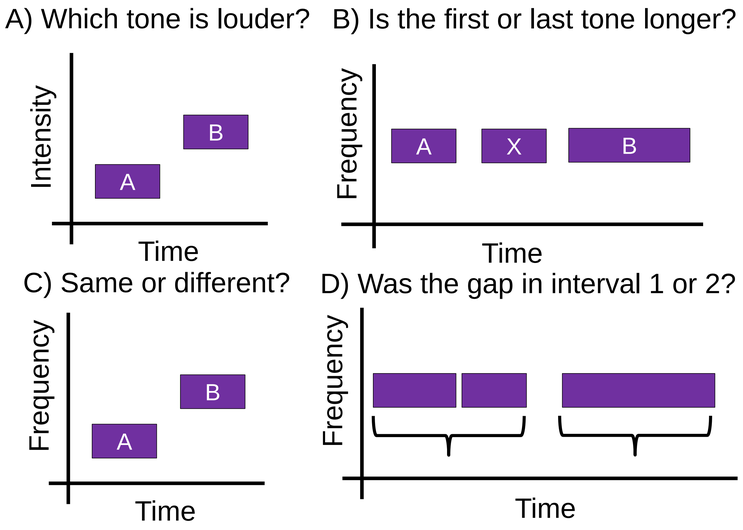
- *Measure*: NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies
- 43 studies identified as fair, 4 identified as good, and 16 identified as poor.

Research Question 2a: What improvements are needed?

- No study calculated and reported statistical power
- Only 3 studies calculated or reported reliability for non-standardized auditory processing measures
- Improved reporting on comorbid disorder inclusion

Research Question 3: Is there publication bias?

- **Yes.** There was a significant effect of sampling bias (i.e., SE) on effect sizes $t(2.84) = 2.85$, $p = .03$)



Example psychophysical task designs and categories
A) 2-alternative forced choice (2AFC) intensity discrimination
B) AXB duration discrimination. X is always the same duration.
C) Same or different frequency discrimination
D) 2-interval, 2-alternative forced choice (2I-2AFC) gap detection

Conclusions

- Large deficits in cross-domain basic auditory discrimination
- Documents a significant intensity discrimination deficit for first time
  - Often used as a "control task"
- High risk of bias in literature
  - Effects of low power, unknown reliability

Future Directions

- Increase scope of task categories (e.g., rise time)
- Cross-domain correlations (duration and frequency?)
- Correlations with prereading variables (rapid naming, phonological awareness

References

1. Hämäläinen et al. (2013). *J Learning Disabilities*, 46(5), 413–427.
2. Gu & Bi (2020). *Neuroscience & Biobehavioral Reviews*, *116*, 396–405.
3. Witton et al. (2020). *Dyslexia: Intl Journal of Research and Practice*, 26(1), 36–51.
4. Page et al. (2021). BMJ, 372, n71.

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NeuroMusic, 2022

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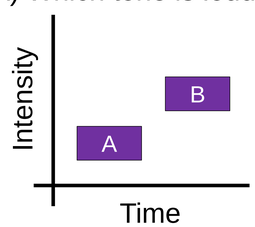
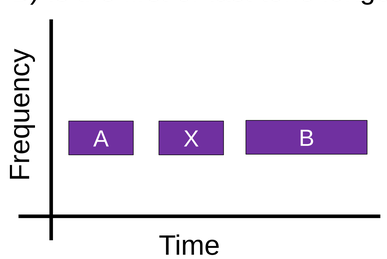
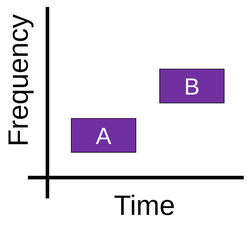
A) Which tone is louder?



B) Is the first or last tone longer?



C) Same or different?



D) Was the gap in interval 1 or 2?