University of Haifa — جامعة حيفا
THE FACULTY OF EDUCATION

Edmond J. Safra Brain Research Center For the Study of Learning Disabilities
UNIVERSITY OF HAIFA, ISRAEL

INCREASED RELIANCE ON TOP-DOWN INFORMATION TO COMPENSATE FOR REDUCED BOTTOM-UP USAGE OF ACOUSTIC CUES IN DYSLEXIA

Hadeer Derawi,[1,2] Eva Reinisch[3] and Yafit Gabay[1,2]

1Department of Special Education, University of Haifa, Haifa, Israel
2Edmond J. Safra Brain Research Center for the Study of Learning Disabilities
3Acoustics Research Institute, Austrian Academy of Sciences, Vienna, Austria

INTRODUCTION

- Speech recognition in real world environments involves the use of low-level acoustic as well as higher-level lexical information.
- Ganong Effect (lexical bias): listeners prefer to interpret an acoustically ambiguous segment such that a phonological string forms a real word rather than a nonword.
- People with developmental dyslexia (DD) show speech perception impairments when required to categorize sounds based on acoustic cues (Noordenbos & Serniclaes, 2015) and use lexical cues more than neurotypicals (Reed, 1989).
- The ability to use low-level sensory cues is more effortful for those with DD ➡ compensatory mechanisms such as reliance high-level top-down knowledge.
- Test whether a process is effortful (resource demanding): dual task setting ➡ participants perform primary and secondary tasks simultaneously (Navon & Gopher, 1980).
- Ganong effect in dual task settings ➡ greater reliance on top-down information (i.e., greater Ganong effect) (Mattys, Barden, & Samuel, 2014; Mattys & Wiget, 2011).
- If greater use of top-down information in speech under cognitive load arises as a consequence of impoverished sensory analysis ➡ increased reliance on that information when sensory analysis is hindered, as in the case of DD.

METHODOLOGY

Participants. Individuals with DD, N=24 (M=26.04) and typically developing (TD) readers, N=21 (M=25.09) matched for cognitive abilities and age. Native speakers of Hebrew.
Stimuli. 11-step /s/ - /ʃ/ continuum on 10 words where /s/ and 10 words where /ʃ/ forms a real words.
Procedure. Phonetic categorization of /s/ or /ʃ/ with lexical bias (i.e., Ganong task) under low and high cognitive load (CL); order of CL conditions counterbalanced across participants.
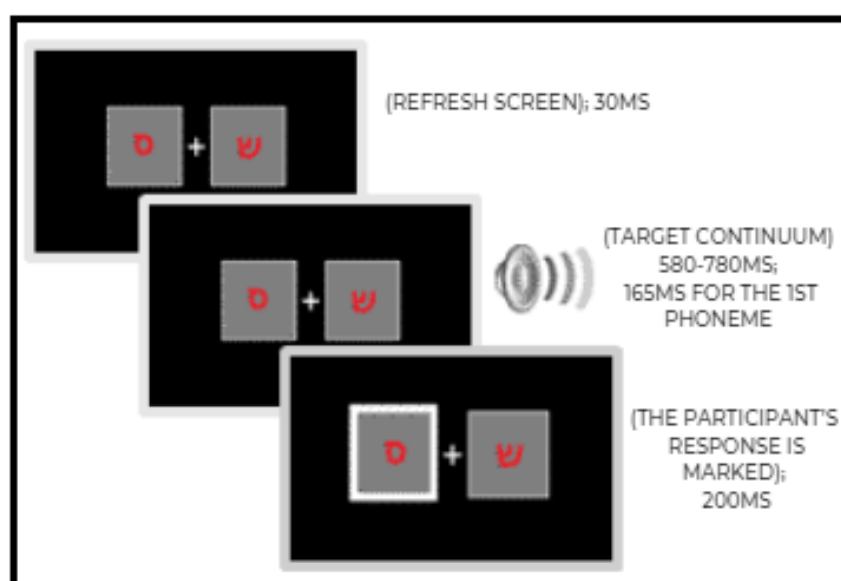
Phonetic categorization task- Is the first sound /s/ or /ʃ/?

A. Low cognitive load   B. High cognitive load
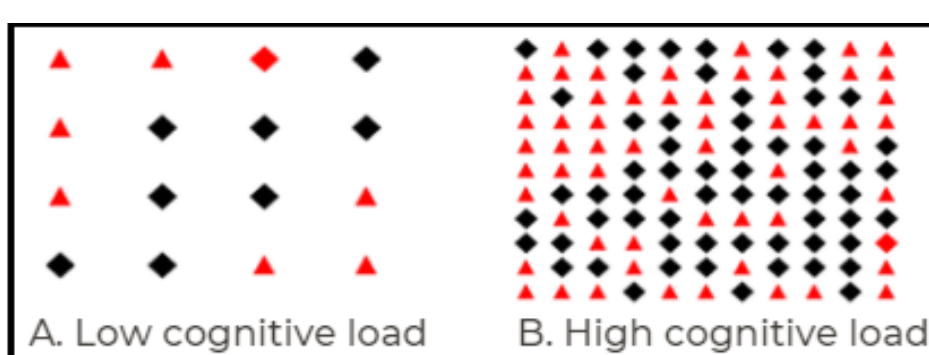
Secondary task - Visual search task: Is there a red rhombus?

Individuals with Developmental Dyslexia

show increased reliance on top-down lexically-mediated perception processes, likely as a compensatory mechanism for reduced efficiency in bottom-up usage of acoustic cues.

RESEARCH HYPOTHESIS

If speech recognition is more effortful for those with DD, they could be expected to exhibit a greater modulation of the Ganong effect by cognitive load compared to TD readers.

RESULTS

- **Visual task:** Poorer performance on a demanding compared to less demanding visual search task ➡ no difference between groups.
- **Phonetic categorization task:** three-way interaction between Lexical bias, Group, and Cognitive Load [b(lexical bias:group:cognitive load) = 0.75, SE = 0.16, z = 4.53, p < .000]. A Greater modulation of the Ganong effect (i.e., lexical-bias effect) by load in the DD group compared with the TD group.
- Three-way interaction between Continuum, Group, and Cognitive Load [b(continuum:group:cognitive load) = -0.32, SE = 0.05, z = -5.94, p < .000]. Shallower categorization functions of the continuum in the high than low load condition ➡ effect larger in the TD than in the DD group.
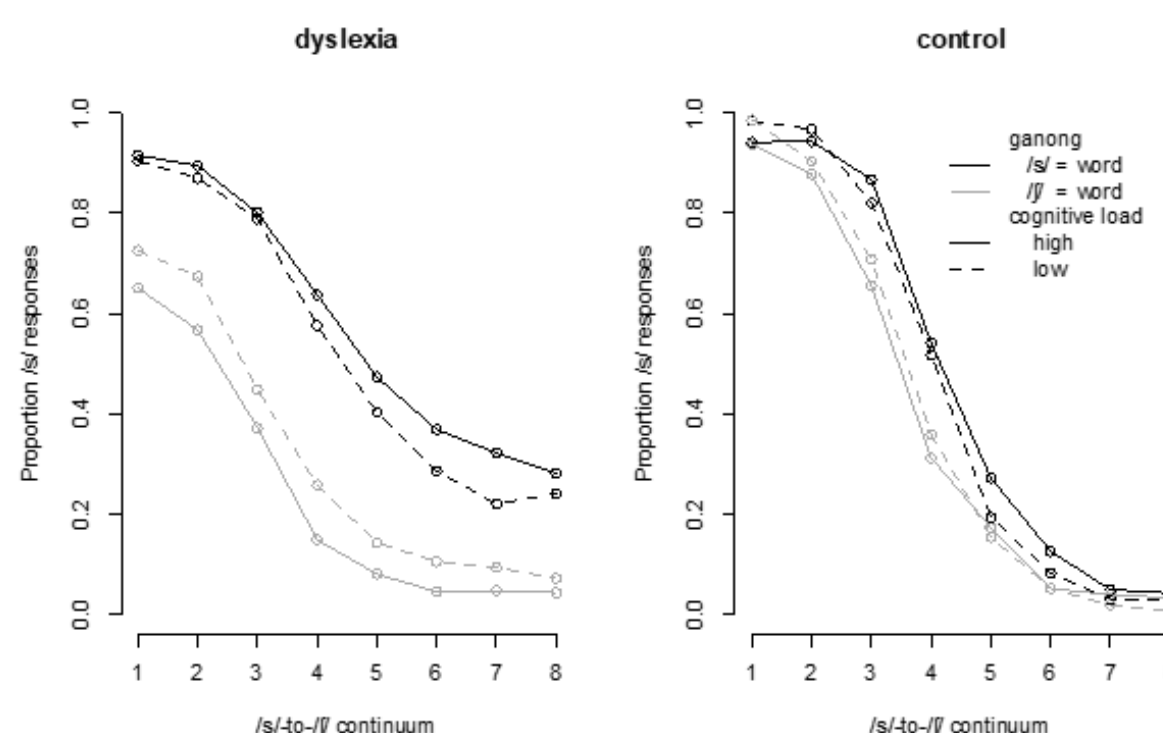
CONCLUSION

- Greater reliance on top-down information in the dyslexia group as cognitive load increases. Shallower identification curve in the dyslexia group relative to TD readers.
- This could be a compensatory mechanism due to impaired low-level perceptual processes in DD.
- Greater performance modulation by CL in dyslexia can be accounted by impaired automaticity view of dyslexia (Nicolson & Fawcett, 1990, 2019; Nicolson, Fawcett, & Dean, 2001; Ullman et al., 2020).
- Low-level perceptual learning might limit the ability to form precise phonological representations ➡ speech recognition skills based on low-level cues less robust (Gabay & Holt, 2015).

RELATED LITERATURE

- Gabay, Y., & Holt, L. L. (2015). Incidental learning of sound categories is impaired in developmental dyslexia. *cortex, 73*, 131-143.
- Mattys, S. L., Barden, K., & Samuel, A. G. (2014). Extrinsic cognitive load impairs low-level speech perception. *Psychonomic bulletin & review, 21*(3), 748-754.
- Mattys, S. L., & Wiget, L. (2011). Effects of cognitive load on speech recognition. *Journal of Memory and Language, 65*(2), 145-160.
- Navon, D., & Gopher, D. (1980). Task difficulty, resources, and dual-task performance. *Attention and performance VIII*, 297-315.
- Nicolson, R. I., & Fawcett, A. J. (1990). Automaticity: A new framework for dyslexia research? Cognition, 35(2), 159-182.
- Nicolson, R. I., & Fawcett, A. J. (2019). Development of dyslexia: The delayed neural commitment framework. *Frontiers in behavioral neuroscience, 13*, 112.
- Nicolson, R. I., Fawcett, A. J., & Dean, P. (2001). Developmental dyslexia: the cerebellar deficit hypothesis. *Trends in neurosciences, 24*(9), 508-511.
- Noordenbos, M. W., & Serniclaes, W. (2015). The categorical perception deficit in dyslexia: A meta-analysis. *Scientific Studies of Reading, 19*(5), 340-359.
- Reed, M. A. (1989). Speech perception and the discrimination of brief auditory cues in reading disabled children. *Journal of experimental child psychology, 48*(2), 270-292.
- Ullman, M. T., Earle, F. S., Walenski, M., & Janacsek, K. (2020). The neurocognition of developmental disorders of language. *Annual review of psychology, 71*, 389-417.

B(LEXICAL BIAS:GROUP) = 1.29, SE = 0.41, Z = 3.19, P < .001

B(CONTINUUM:GROUP:COGNITIVE LOAD) =-0.32, SE = 0.05, Z =-5.94, P < .000

EMAIL: HADEER.115@GMAIL.COM