A Computational Model of Implicit Memory Captures Dyslexics' Perceptual Deficits

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Jaffe-Dax, Sagi, Raviv Ofri, Jacoby Nori, Loewenstein Yonatan, and Ahissar Merav. 2015.

Abstract:

Dyslexics are diagnosed for their poor reading skills, yet they characteristically also suffer from poor verbal memory and often from poor auditory skills. To date, this combined profile has been accounted for in broad cognitive terms. Here we hypothesize that the perceptual deficits associated with dyslexia can be understood computationally as a deficit in integrating prior information with noisy observations. To test this hypothesis we analyzed the performance of human participants in an auditory discrimination task using a two-parameter computational model. One parameter captures the internal noise in representing the current event, and the other captures the impact of recently acquired prior information. Our findings show that dyslexics' perceptual deficit can be accounted for by inadequate adjustment of these components; namely, low weighting of their implicit memory of past trials relative to their internal noise. Underweighting the stimulus statistics decreased dyslexics' ability to compensate for noisy observations. ERP measurements (P2 component) while participants watched a silent movie indicated that dyslexics' perceptual deficiency may stem from poor automatic integration of stimulus statistics. This study provides the first description of a specific computational deficit associated with dyslexia.

SIGNIFICANCE STATEMENT This study presents the first attempt to specify the mechanisms underlying dyslexics' perceptual difficulties computationally by applying a specific model, inspired by the Bayesian framework. This model dissociates between the contribution of sensory noise and that of the prior statistics in an auditory perceptual decision task. We show that dyslexics cannot compensate for their perceptual noise by incorporating prior information. By contrast, adequately reading controls' usage of previous information is often close to optimal. We used ERP measurements to assess the neuronal stage of this deficit. We found that unlike their peers, dyslexics' ERP responses are not sensitive to the relations between the current observation and the prior observation, indicating that they cannot establish a reliable prior.

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