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Advancing School Professionals' Dyslexia Knowledge Through Neuroscience: Bridging the Science-Education Gap Through Developmental Psychology

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This review presents a summary of the research on advancing dyslexia knowledge among school professionals. It contributes to the literature with a proposed solution for professional development and teacher training through the field of developmental psychology. The article outlines what has been done to address the science-education gap owing to misunderstandings about dyslexia, proposing a solution to advance school professionals' knowledge of dyslexia through developmental psychology coursework aimed at the neuroscience of dyslexia, including basic and cognitive neuroscience concepts. The review outlines the legislative and research support for this proposal as well as the candidate knowledge focused on the neuroscience of dyslexia to address gaps in professional knowledge and practice. The review includes a discussion section with implications for research and practice.

Keywords: teacher preparation, professional development, dyslexia knowledge, training and development, neuroscience (psychology), neuromyths, dyslexia myths

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INTRODUCTION

This brief review focuses on advancing school professionals' dyslexia knowledge through neuroscience, reflecting the longstanding need for bridge-building and -sustaining between reading science and education fields. It adds to the literature and moves it forward through a proposal for professional development research and practice aimed at improving dyslexia knowledge and practice. Researchers have identified educational psychology as having the potential to bridge the gap between reading science and education fields (Macdonald et al., 2017; Seidenberg, 2013). This proposal is especially promising since relevant and high-quality science is often conducted within educational psychology programs in schools of education. This article outlines what has been done to address this science-education gap owing to misunderstandings about dyslexia, proposing a solution to advance school professionals' knowledge of dyslexia through developmental psychology coursework aimed at the neuroscience of dyslexia.

The Dyslexia Myth

Dyslexia is the most prevalent specific learning disability and among the most prevalent childhood disorders (Cortiella and Horowitz, 2014; Wagner et al., 2020). Dyslexia is defined by inaccurate and/or dysfluent word recognition and underlying phonological difficulties that result in word reading deficits (Lyon et al., 2003). Despite this consensus definition about the neurobiological basis of

dyslexia, educators and the general public adhere to the dyslexia myth of seeing letters or words backwards, or "backwards reading" (Macdonald et al., 2017; White et al., 2020). While this dyslexia myth is the most widespread misconception of dyslexia, other identified misunderstandings about dyslexia also require attention (e.g., Washburn et al., 2014; White et al., 2020). Misunderstanding of dyslexia's causes can prevent access to evidence-based reading interventions (Castles et al., 2018), while pursuing ineffective visual interventions (American Academy of Pediatrics, 2009; American Academy of Pediatrics, 2014; Fletcher and Currie, 2011; Knight, 2018; Pennington, 2011). In other words, widespread misconception of dyslexia interferes with providing best practices for identification and intervention (e.g., delayed identification because a student who is not reversing letters is not suspected of having dyslexia).

The Dyslexia Myth and Other Neuromyths

Dyslexia's most persistent misconception may be related to misunderstandings about the brain and learning known as "neuromyths" (Lilienfeld et al., 2010). Over the past decade, research has identified educators' misconceptions about the brain and learning, focusing on how these myths arise and why they persist (Howard-Jones, 2014). For example, Macdonald et al. (2017) found a clustering of "classic" neuromyths (items related to learning styles, dyslexia, the Mozart effect, the impact of sugar on attention, right-brain/left-brain learners, and using 10% of the brain), such that the dyslexia myth was often endorsed by the same individuals who endorsed other neuromyths. This clustering of misconceptions raises the question of whether addressing these misconceptions through neuroscience may address the dyslexia myth, among other brain-behavior misunderstandings.

Seidenberg's (2013) two-culture hypothesis for the research to practice gap in reading is similar to Howard-Jones' (2014), who contends the most persistent neuromyths endorsed across PK12 through higher education are due to "cultural distance" between neuroscience and education, tracing persistent myths about the brain and learning as germinating from "seeds of confusion", "cultural conditions", and biased distortions of scientific data (pp. 817–819). Pasquinelli (2012) identifies three processes about neuromyths' origins as 1) distortions of scientific facts, 2) obsolete offspring of scientific hypotheses, or 3) outgrowths from misinterpretations of experimental results. In the case of the dyslexia myth, its origins can be found in obsolete ideas stemming from previously held scientific hypotheses, which have been debunked by 40 years of reading research. Unfortunately, approaches that bridge reading research and education fields featuring updated models of dyslexia with prominent contributions from neuroscience are not typically accessible to preservice educators or school professionals (Anderson et al., 2020; Riley, 2020).

WHAT HAS BEEN DONE TO ADVANCE PROFESSIONALS' DYSLEXIA KNOWLEDGE?

Over the past decade, researchers have identified lacking professional development on dyslexia as stemming from "The Peter Effect" (i.e., "One cannot teach what they do not know", Applegate and Applegate, 2004, as cited in Binks-Cantrell et al., 2012). Reportedly, the dyslexia myth is prevalent among higher education instructors at similar rates as preservice and in-service educators (Betts et al., 2019). Research on improving school professionals' dyslexia knowledge has identified this pervasive misconception among pre-service and school professionals (Washburn et al., 2011, Washburn et al., 2014, Washburn et al., 2017; White et al., 2020). White et al. (2020) found no significant differences in dyslexia knowledge within education majors (e.g., elementary v. special education v. school psychology), or between education and non-education majors. This research underscores the expressed need for explicit, intensive professional development to address the persistent misconception of dyslexia among teacher candidates and school professionals. The question remains in *how* to change the persistent misconception of dyslexia, as the effect of knowledge transmission approaches remains an open question since "debunking" messages are not always effective in countering misinformation (Chan et al., 2017).

Researchers have identified this gap in school professional development, calling for a neuroscience primer that addresses the neurobiology of dyslexia (Anderson et al., 2020; Kearns et al., 2019). Neuroscience in education research has the potential to address this need. For example, the neuroscience concept of synaptic plasticity establishes why individuals with dyslexia require intensive practice to learn to read since axonal pathways differ from typically developing readers and individuals with dyslexia require more synapses trained to successfully associate phonemes with graphemes, to recognize words, and to associate meanings with words (Gabrieli, 2009; Klingberg et al., 2000).

While the neuroscience of reading has been identified as candidate knowledge for filling the conceptual gap in teacher-education related to dyslexia (e.g., Kearns et al., 2019; Seidenberg, 2013), little research exists on teacher education programs or standalone professional development models that provide such training. A few research studies have been aimed at improving school professionals' knowledge of dyslexia through educational neuroscience training programs or interventions (Anderson et al., 2020). A recent study using conceptual change theory found that preservice teachers' dyslexia knowledge could improve through reading refutation text as compared to control text on dyslexia (Peltier et al., 2020); however, it is unknown whether the researchers grounded their text explanations in the neuroscience of dyslexia. Moreover, it is unknown whether conceptual change evident from text reading translated to educators' improved understanding of reading development and how dyslexia occurs in individuals, as well as how interventions influence reading development. Such scientifically based understandings would be more likely to adhere through bidirectional and ongoing coursework on basic neuroscience, including neurocognitive and linguistic processes involved in reading development, as has been identified by advocates in the field (e.g., Consortium on Reading Excellence in Education [CORE], International Dyslexia Association).

Legislation Supporting School Professionals' Dyslexia Knowledge

Since 2016, United States (U.S.) federal and state policies have been passed for the inclusion of dyslexia content in teacher preparation programs and professional development programs (Washburn et al., 2017). To date, 43 U.S. states have dyslexia laws, and a growing number of states have initiatives and resolutions to promote dyslexia awareness in K12 settings (National Center on Improving Literacy, 2019), including dyslexia screening (Youman and Mather, 2018). Most U.S. states have laws governing dyslexia screening, intervention, or professional development; however, no research exists on connections between these initiatives and improved dyslexia identification or intervention outcomes (Phillips and Odegard, 2017; Odegard et al., 2020).

Improving School Professionals' Dyslexia Knowledge Through the Science of Reading

Most reading scientists agree that over 40 years of research from neuroscience and psychology owes to the science of reading, with consensus on how reading develops and how reading problems present in individuals across cultures and languages (see review by Pennington, 2008). Seidenberg (2013) terms the science of reading supporting reading instruction and intervention as the "Modern Synthesis", noting that educators lack access to the science of reading due to a cultural divide between science and education fields. Currently, the science of reading is highlighted as a fundamental cornerstone of higher education instructional pedagogy in educational leadership consortiums such as Deans for Impact (Riley, 2020) as well as among leading reading and dyslexia advocacy organizations (e.g., CORE, IDA, The Reading League). These advocacy efforts outline knowledge based on reading research for teachers, school administrators, and caregivers alike. Less clear is how teacher-training programs in institutions of higher education address the need for teaching in the interdisciplinary science of reading development to teacher candidates. Current programs for school professionals are intentionally focused on translating research on the science of reading into practice in terms of explicit systematic phonics approaches (Kilpatrick, 2015). However, this information is not typically taught in connection with the underlying neuroscience principles of the reading process (see Willingham, 2017 for a discussion). For example, the neuroscience concept of synaptic plasticity could support educators to understand why individuals with dyslexia require intensive practice and support to learn to read.

Additionally, it is unknown to what extent this information, including professional development efforts lead to changes in teachers' dyslexia knowledge or practice. To address this research-to-practice gap through developmental psychology, it is important to look at the sources of the dyslexia myth as well as ways that researchers have tried to address professional development in dyslexia knowledge; these topics could be addressed through developmental psychology courses.

ADVANCING PROFESSIONAL DYSLEXIA KNOWLEDGE THROUGH DEVELOPMENTAL PSYCHOLOGY COURSEWORK

This review of the efforts to advance school professionals' dyslexia knowledge highlights a need for improved access to the basic neuroscience concepts of dyslexia, which could debunk the dyslexia myth of backwards reading as well as support improved understanding of reading development and its disruptions. There is a clear role for the presentation of interdisciplinary scientific information on reading development and evidence-based reading practices for dyslexia across education, neuroscience, and psychology fields. Advancing previous research (Anderson et al., 2020; Anderson et al., in review), the proposed topics are aligned with the science of reading and hold potential to deeply address and mitigate school professionals' endorsement of the dyslexia myth and to advance knowledge of dyslexia interventions.

The Reading Network

The reading network refers to brain areas associated with reading development and includes information about the relationships between brain regions and their implications in reading development and disorders. In order to improve dyslexia knowledge, neuroscience topics such as the interactivity and development of brain regions associated with reading skill acquisition (e.g., reading network involving tempo-parietal junction and visual word form area, see Norton et al., 2015 for a discussion) support an increasingly comprehensive understanding of reading development and disorders such as dyslexia.

The Reading Brain and Its Disruptions in Dyslexia

Neuroscience content that is focused on the reading brain and its disruptions in dyslexia supports improved understanding of the basis for dyslexia. For example, helping educators to understand that disruptions are in regions implicated in language and complex cognition, and not basic visual processes, could correct the widespread misunderstanding that dyslexia is based on reading backwards. This topic could include intervention response findings that show structural and functional brain alterations in individuals with dyslexia.

Neuroscience Concepts and Principles

Educators and school professionals are not likely to have prior knowledge or experience in basic neuroscience topics, which makes a scaffolded learning environment even more critical to understanding and retaining knowledge about dyslexia's neurocognitive and linguistic basis. Preliminary research findings from an online training intervention aimed at improving school professionals' dyslexia knowledge through educational neuroscience indicated that participants struggled with integrating disciplinary vocabulary (e.g. tempo-parietal

junction, visual word form area, etc.) with their current understandings of reading development, dyslexia and its characteristics (Anderson et al., in review). Neuroscience concepts including neuroanatomy, neuroplasticity, working memory, and processing speed could support educators' improved understanding of dyslexia within the context of modularity and interactivity of brain regions, as well as brain-behavior relationships in language and reading development.

DISCUSSION

This review adds to the literature on the dyslexia myth and moves it forward with a comprehensive approach to increasing school professionals' dyslexia knowledge. This approach includes a bidirectional primer on neuroscience concepts underlying reading development, which could also address general neuromyths (e.g., those related to brain laterality, auditory and visual learning modalities). Developmental psychology programs could play a prominent role in promoting educational neuroscience knowledge among faculty and instructors (see Betts et al., 2019) as well as among school professionals. Schools of education and developmental psychology departments/programs could provide educational neuroscience instruction at undergraduate and graduate levels so that incoming school professionals possess a basis for evaluating pedagogical approaches purportedly based in educational neuroscience. This could also address the proliferation of "brain-based learning" educational claims by ensuring that educators have foundational skills to evaluate them. This introductory content could be provided by discussing common misconceptions about the brain and learning (i.e., the dyslexia myth and other neuromyths), their origins and practices that are outgrowths of these misconceptions. This topic could serve as a foundation for conveying the complexity of the brain and learning and fit into existing educational psychology courses. This is an especially important implication as the endorsement of neuromyths, and particularly the dyslexia myth of backwards reading, continues to be a persistent misunderstanding among educators and the general public across cultures. Educational psychology has the potential to bridge the knowledge gap between the neuroscience of dyslexia and education, given the field's interdisciplinary training across neuroscience, educational psychology, and academic skill development.

AUTHOR CONTRIBUTIONS

AA conducted the research, prepared the manuscript for submission, and responded to all drafts of the manuscript with feedback from Frontiers Review Team.

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