Published in final edited form as:

New Dir Child Adolesc Dev. 2019 May ; 2019(165): 5–10. doi:10.1002/cad.20287.

Introduction to Special Issue Models for Innovation: Advancing Approaches to Higher-Risk and Higher-Impact Learning Disabilities Science

Lynn S. Fuchs and Donald L. Compton

Vanderbilt University and Florida State University

The central focus of this special issue is increasing understanding of and identifying effective treatments for students with learning disabilities (LDs), who represent a vulnerable subset of the population. The most common LDs are reading LDs and mathematics LDs. However, concurrent (comorbid) difficulties are also common across reading and mathematics or involving reading or mathematics LD with concurrent writing LDs, attention disorders, and other developmental disabilities.

Reading achievement and math achievement are strong predictors of quality of life, financial security, and life expectancy (Batty, Kivimäki, & Deary, 2010; Ritchie & Bates, 2013). Word reading skill is foundational to reading comprehension, and limited reading comprehension decreases access to content knowledge and undermines learning during (Catts, Hogan, & Deary, 2005; Fuchs et al., 2015). In parallel fashion, calculation skill is foundational to higher-level math, such as fractions, algebra, and word problems (Fuchs et al., 2006; Jordan et al., 2013). Additionally, developmental trajectories in reading and mathematics are established early and remain stable over time (Duncan, Dowsett, & Classens, et al., 2007; Fuchs, Geary, Fuchs, Compton, & Hamlett, 2016). This is also the case for comorbid LDs across reading and math, with half of children with poor performance in one area also evidencing poor performance in the other domain (Koponen et al., 2018). It is therefore important to note that students with comorbid LD experience worse outcomes than do peers with difficulty in one domain (Cirino, Fuchs, Elias, Powell, & Schumacher, 2015). and is associated with less adequate response to generally effective intervention (Fuchs, Fuchs, & Prentice, 2004).

For these reasons, increasing understanding of and identifying effective treatments for reading LDs, mathematics LDs, comorbid reading and math LDs, as well as comorbid difficulty in other academic, adaptive, and psychosocial forms of performance, is a critical focus within child and adolescent psychology. Researchers and practitioners in these and related fields need be informed about important scientific advances designed to deepen understanding about definitional issues surrounding LDs, designed to expand insight into how individual differences in cognitive processes contribute to the development of reading, mathematics, and comorbid LDs, and designed to extend understanding about co-occurring LDs.

The *Eunice Kennedy Shriver* National Institute for Child Health and Human Development (NICHD) within the National Institutes of Health has supported programmatic lines of research to advance scientific knowledge about LDs and their treatment and/or prevention. These LD Research Centers and LD Innovation Hubs bring together transdisciplinary groups of researchers to work in a highly collaborative milieu with the goal of advancing understanding about high-impact, innovative LD topics. The proposed special issue provides scientific updates on the work and future directions being pursued within the present round of six NICHD LD Centers and Hubs, with implications for understanding LDs that occur during childhood and adolescence and for deepening insight into the nature of and effective treatment of reading LDs or mathematics LDs, with or without comorbid disorders.

Each of the six contributions comprising this special issue contributes to this central focus, while addressing the interests of a broad audience of developmental scholars. The first article, authored by Richard Wagner, Ashley Edwards, Antje Malkowski, Chris Schatschneider, Rachel Joyner, Sarah Wood, and Fotena Zirps who represent the Florida State University LD Research Center, addresses methodological innovations for understanding and predicting reading LDs, specifically dyslexia. Despite decades of research, consensus on a definition of common LDs such as dyslexia has been difficult to achieve, and this represents a fundamental problem for the field. The authors discuss how the absence of consensus stems in part from an inconsistent empirical literature, comprising relatively small-scale correlational studies that suffer from error surrounding point estimates. It also results from a sole focus on conceptual integration of studies, rather than systematic and quantitative synthesis. Wagner et al. thus argued that model-based meta-analyses and Bayesian models framed in terms of informative priors for dyslexia are needed to produce a more stable and well-supported conceptualization of reading LD. The authors illustrated a new approach for doing so based on the known distribution of the difference between correlated variables and used this distribution to estimate the proportion of students whose poor reading is unexpected and likely due to dyslexia.

In the second article, Jessica Church-Lang, Paul Cirino, Jeremy Miciak, Jenifer Juranek, Sharon Vaughn, and Jack Fletcher, of the Texas Center for Learning Disabilities, focus on the role of executive functions (EFs) in the reading process and reading LDs. The authors reviewed findings from cognitive, intervention, and neuroimaging perspectives regarding the role of EFs in several types of reading performance, and they integrate findings across studies conducted with a range of struggling and typical readers. The goal is to clarify the role of EFs in the reading process and in those with reading difficulties at grades 3-5. In a series of behavioral studies, they found that a bi-factor structure best represented a comprehensive assessment of EF. They documented that cognitive and behavioral measures of EF relate independently to math and reading and that EF relates to reading, above and beyond other variables, even though EF training component did not improve intervention response and pretest EF abilities did not relate to intervention response. In neuroimaging studies, they found that the EF task evoked control activity, but did not reveal differences between struggling and typical readers. Further, EF activity during pretest reading was related to intervention response. Across studies, they conclude that EF appears involved in the reading process, but general EF does not appear to predict or improve intervention outcomes.

In the third paper, Donald Compton, Laura Steacy, Yaacov Petscher, Jay Rueckl, Nicole Landi, Steve Frost, and Ken Pugh, who represent the LD Hub at Florida State University, Haskins Laboratory, and the University of Connecticut, focus on linking computational and behavioral theories of individual word-reading development approaches with the challenges of learning to read a quasi-regular orthography, such as English. The goals are not only to enrich understanding of the processes that influence individual differences in word-reading development in dyslexic as well as typically-developing children but also to inform issues of practice, including curriculum, instruction, diagnosis, and intervention. After describing the rationale for this approach and explaining behavioral and computational modeling methods for examining the experiential (exogenous) and child-specific (endogenous) factors that determine acquisition of orthographic-phonological knowledge at different subword granularities, they summarize findings from initial studies in the Hub's program of research.

The final three articles address issues of comorbidity of reading LDs, math LDs, and disorders related to other forms of academic and psychosocial performance. The methodological approaches, conceptual frameworks, and substantive findings from these three papers focused on the topic of comorbidity have broad applicability in the field of child and adolescent psychology, because so many individuals experience concurrent difficulty across multiple forms of performance. In the special issue, we sequence these three articles by addressing issues of LD comorbidity in terms of the number of domains concurrently investigated.

Lynn Fuchs, Douglas Fuchs, Pamela Seethaler, Laurie Cutting, and Jeannette Mancilla-Martinez, who represent the Vanderbilt University LD Hub, focused on connections between LDs that concurrently occur between reading comprehension and mathematics word-problem solving. They explain how a growing literature suggests connections between word-problem solving and text comprehension via oral language competence, which in turn indicates an important role for oral language and text comprehension instruction in the remediation of word-problem solving difficulties. They consider the potential promise of a theoretically coordinated approach for simultaneously improving performance across text comprehension and word-problem solving. The specific nature of findings that connect word-problem solving and text comprehension via oral language is highly relevant to other child and adolescent developmental issues, given the role oral language plays in learning.

Erik Willcutt, Robin Peterson, Lauren McGrath, Bruce Pennington, Jan Keenan, Marie Banich, John DeFries, Sally Wadsworth, and Richard Olson, of the Colorado Learning Disabilities Research Center, explain how their interdisciplinary, multisite research program uses converging levels of analysis not only to deepen understanding of the genetic and environmental etiology, neuropsychology, and developmental outcomes of LDs in reading (RLD), math (MLD), and writing, but also to provide important insights into the comorbidity between these LDs. They report findings from their latest twin study, which show how shared genetic influences contribute to the significant covariance between all aspects of reading (word reading, reading fluency, and reading comprehension) and math (calculations, math fluency, and word problems), while elucidating how distinct genetic or environmental influences contribute to weaknesses in each specific academic domain. Moreover, findings reveal that RLD and MLD are associated with a range of negative

outcomes on measures of current functioning and outcomes five years after the twins were first assessed. Finally, they describe how the Center continues to expand on this work with a comprehensive battery including measures of all dimensions of academic achievement described in current definitions of LD and with new neuroimaging and molecular genetic studies.

Finally, Elena Grigorenko, Lesley Hart, Sascha Hein, Julia Kovalenko, and Oxana Naumova, represent the Houston LD Hub. These researchers provide an overview of the nearly 100-year-old literature showing connections between juvenile delinquency with learning difficulties and LDs, another form of comorbidity. The authors describe low academic achievement - delinquency connections, while noting the many still unanswered questions regarding the strength, direction, stability, and causality of those associations. Grigorenko and her colleagues used this literature to contextualize the research being conducted at their Hub. They focused on previous studies that provide rationale for their Hub's scientific approach, in which they study reading LDs among students with juvenile delinquency and address some of the key lingering questions in the literature.

Acknowledgments

This research was supported by 2 P20HD075443 and Core Grant HD15052 from the Eunice Kennedy Shriver National Institute of Child Health & Human Development to Vanderbilt University and by Grant P20HD091013 to Florida State University to Florida State University by Eunice Kennedy Shriver National Institute of Child Health and Human. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institute of Child Health & Human Development or the National Institutes of Health.

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