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Cognitive flexibility deficits in children with specific reading comprehension difficulties

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ABSTRACT

Substantial research indicates decoding difficulties are a primary contributor to reading comprehension problems. Yet, far less is known about sources of reading comprehension problems when readers' decoding abilities are appropriate for grade level (i.e., specific reading comprehension difficulties; RCD). Executive functioning contributes uniquely to RCD beyond traditional predictors, such as decoding ability and vocabulary. However, of the three core executive functions, working memory and inhibition have received relatively more research attention than cognitive flexibility, even though readers with RCD typically focus inflexibly on decoding processes without attention to meaning. Two studies assessed the contribution of cognitive flexibility to RCD. Study 1 employed a matched sampling approach to examine general and reading-specific cognitive flexibility in 24 readers with RCD and 24 typically developing readers (from a pool of 140 students) at the end of 1st and 2nd grades. Readers with RCD were significantly lower in reading-specific cognitive flexibility than typically developing peers, even when decoding, verbal ability, nonverbal matrix reasoning ability, and vocabulary were controlled; a similar, though not significant, difference emerged for general, color-shape cognitive flexibility. Study 2 revealed a teacher-delivered cognitive flexibility intervention produced significant improvements in reading comprehension for students with RCD ($n = 18$) who had not shown significant growth prior to intervention; after intervention, their reading comprehension growth was comparable to typically developing controls ($n = 21$).

1. Introduction

Reading comprehension problems affect a significant number of elementary school children. According to the National Assessment of Educational Progress, one third of fourth grade students in the United States (US) cannot comprehend text at the basic level, which requires simple inference making and information extraction from texts, and two thirds of US fourth grade students cannot comprehend text at the proficient level, which reflects abilities to integrate information, draw conclusions, and evaluate texts (Institute of Education Sciences, 2013). The Progress in International Reading Literacy Study (PIRLS) revealed similar achievement patterns for international fourth grade students (including US students) on analogous achievement benchmarks, indicating that the development of successful reading comprehension is also a substantial international concern (Thompson et al., 2012). These data are troubling and indicate that we have much more to learn about reading comprehension difficulties.

Although much research has investigated the contribution of decoding difficulties to reading comprehension problems (see García & Cain, 2014, for a review), far less is known about reading comprehension problems when decoding skills are appropriate for grade level (see Duke, Cartwright, & Hilden, 2014, for a review). Recently, executive functioning has emerged as a significant predictor of reading comprehension problems in children who show specific reading comprehension difficulties (RCD) in the absence of decoding difficulties. Executive functioning is an umbrella term that refers to the cognitive control processes necessary to engage in goal-directed behavior, such as inhibition, monitoring, planning, and working memory. Processes included in definitions of executive functioning vary widely in the literature (Goldstein, Naglieri, Princiotta, & Otero, 2014). However, consensus is emerging that there are three interrelated but distinct core executive functions, cognitive flexibility, inhibition, and working memory, which underlie more complex

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functions, such as planning and monitoring (Diamond, 2013; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Peterson & Welsh, 2014). This is the perspective we take in the current paper. Past research indicates two of the three core executive functions, inhibition and working memory, contribute to RCD (e.g., Cain, 2006; see review of this research in section 1.2, below). However, no work has examined the role of cognitive flexibility, the third core executive function, to RCD. Thus, the studies reported in this paper were designed to explore the role of cognitive flexibility in RCD.

1.1. Specific reading comprehension difficulties (RCD)

Readers with RCD show a discrepancy in reading-related skills, such that their reading comprehension is significantly lower than would be expected in comparison to their average or above average decoding and cognitive abilities (e.g., Cain, 2006; Locascio, Mahone, Eason, & Cutting, 2010; Sesma, Mahone, Levine, Eason, & Cutting, 2009). These students exist in countries around the globe, such as in Canada (Lesaux, Lipka, & Siegel, 2006), Finland (Torppa et al., 2007), France (Megherbi & Ehrlich, 2005), Israel (Kasperski & Katzir, 2013), Italy (Levorato, Roch, & Nesi, 2007), the Netherlands (van der Schoot, Reijntjes, & van Lieshout, 2012), the United Kingdom (Cain & Oakhill, 2007), and the United States (Buly & Valencia, 2002). Furthermore, children with RCD comprise 10% to 30% of samples of struggling readers in elementary classrooms (Applegate, Applegate, & Modla, 2009; Buly & Valencia, 2002; Catts, Compton, Tomblin, & Bridges, 2012; Catts, Hogan, & Fey, 2003; Torppa et al., 2007).

Despite the prevalence of students with RCD, teachers and parents often overlook these students' problems because their fluent word reading abilities mask their comprehension difficulties (e.g., Applegate et al., 2009). In short, they sound like good readers. However, these students seem unable to focus on meaning because of an inflexible focus on word-level features of print (Dewitz & Dewitz, 2003; Nation, Clarke, & Snowling, 2002; Yuill & Oakhill, 1991). Once students with RCD reach the upper elementary grades and reading comprehension becomes the focus of both language arts and content area curricula, their difficulties become apparent. In fact, nearly half of children with late-emerging reading disabilities have RCD (Catts et al., 2012), though longitudinal data indicate some of these students' undetected difficulties with language comprehension may have been present from an earlier age (Nation, Cocksey, Taylor, & Bishop, 2010).

Traditionally, conceptions of reading comprehension difficulties have been guided by the view that reading comprehension is the product of decoding skill and linguistic comprehension (i.e., the simple view of reading; Gough & Tunmer, 1986; Hoover & Gough, 1990). Thus, according to this perspective, children with reading comprehension problems either have decoding difficulties, language comprehension difficulties, or difficulties with both skills (Gough & Tunmer, 1986; Tunmer & Hoover, 1992). Consistent with this perspective, despite their adequate decoding skill, students with RCD have been found to have substantial difficulty with language comprehension (Nation et al., 2010; Nation & Snowling, 2004; Stothard & Hulme, 1992) as well as skills related to language comprehension, such as sensitivity to semantic relations among words (Nation & Snowling, 1999), the ability to infer word meanings from context (Oakhill, 1983), vocabulary growth over time (Cain & Oakhill, 2011), syntactic awareness (Nation & Snowling, 2000), grammatical understanding (Nation et al., 2010), the ability to make inferences from text and prior knowledge (Bowyer-Crane & Snowling, 2005; Cain & Oakhill, 1999), the ability to resolve ambiguity in language (Oakhill & Yuill, 1986; Yuill & Oakhill, 1988), and understanding and awareness of narrative structure (Cain, 2003; Cain & Oakhill, 1996).

However, not all children with comprehension problems fit the profiles predicted by the simple view. In one study, for example, 15%, 13.8%, and 23.6% of second, fourth, and eighth grade students with poor reading comprehension, respectively, did not exhibit problems with either decoding or linguistic comprehension (Catts, Hogan, & Adlof, 2005). In fact, studies of student profiles of reading difficulty have consistently found subsets of students who do not fit the profiles predicted by the traditional, simple view (Aaron, Joshi, & Williams, 1999; Buly & Valencia, 2002; Catts et al., 2003; Hock et al., 2009; Leach, Scarborough, & Rescorla, 2003; Torppa et al., 2007). Data like these suggest additional processes may be involved in reading comprehension and have prompted calls for, and the development of, expanded conceptions of reading comprehension that better reflect the complexities involved in comprehension processes (Cartwright, 2007, 2008; Cromley & Azevedo, 2007; Duke et al., 2014; McNamara & Magliano, 2009; Oakhill & Cain, 2007; Pressley et al., 2009; RAND Reading Study Group, 2002).

1.2. The importance of executive functions for reading comprehension

In particular, recent neurocognitive research suggests executive functions may be an important addition to conceptualizations of reading comprehension. Executive functions are cognitive processes that enable individuals to manage and direct their thinking toward particular goals. As noted previously, although wide variation exists regarding the array of processes included in definitions of executive functioning (Goldstein et al., 2014), consensus is emerging that three interrelated but distinct core processes, working memory, inhibition, and cognitive flexibility, underlie other, more complex executive functions (Best & Miller, 2010; Davidson, Amso, Anderson, & Diamond, 2006; Dawson & Guare, 2010; Diamond, 2013; Miyake et al., 2000; Peterson & Welsh, 2014). Given that reading comprehension requires management of multiple complex, simultaneous sub-processes (Cartwright, 2009; Oakhill & Cain, 2012; Perfetti, 1985; Pressley et al., 2009), executive functions may play an important role in successful reading comprehension. Indeed, recent work indicates executive functions contribute to reading comprehension processes beyond other traditionally studied predictors of reading comprehension, such as decoding ability and verbal comprehension (Cartwright, 2002, 2007; Cartwright, Marshall, Dandy, & Isaac, 2010; Conners, 2009; Kieffer, Vukovic, & Berry, 2013; Sesma et al., 2009). Furthermore, students with RCD exhibit deficits in executive functions, such as working memory (Cain, Oakhill, & Bryant, 2004; Pimperton & Nation, 2014; Yuill, Oakhill, & Parkin, 1989) and inhibition (Borella, Carretti, & Pelegrina, 2010; Cain, 2006; Pimperton & Nation, 2010), in comparison to typically developing peers, making executive functions a likely target of intervention for these students. However, much work remains to be done in this area.

First, although the role of working memory in reading comprehension has been studied extensively (e.g., Cain et al., 2004; Carretti, Borella, Cornoldi, & De Beni, 2009; Carretti, Cornoldi, De Beni, & Romanó, 2005; Daneman & Carpenter, 1980, 1983; Oakhill, Hartt, & Samols, 2005; Oakhill, Yuill, & Parkin, 1986; Pimperton & Nation, 2014; Sesma et al., 2009; Stothard & Hulme, 1992; Yuill et al., 1989), and the role of inhibition in reading comprehension has received a good deal of attention as well (e.g., Borella et al., 2010; Cain, 2006; De Beni & Palladino, 2000; De Beni, Palladino, Pazzaglia, & Cornoldi, 1998; Henderson, Snowling, & Clarke, 2013; Kieffer et al., 2013; Palladino, Cornoldi, De Beni, & Pazzaglia, 2001; Pimperton & Nation, 2010), cognitive flexibility has received comparatively little research attention. Thus, our first study examines cognitive flexibility in children with and without RCD. Furthermore, the majority of work on executive functions and reading comprehension has focused on whether and how executive functions contribute to comprehension processes. However, far fewer studies have examined executive skill interventions that target reading comprehension, and even fewer have put executive skill interventions into the hands of teachers in