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Cognitive inhibition in students with and without dyslexia and dyscalculia

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ABSTRACT

The present study presents a comparison of the cognitive inhibition abilities of dyslexic, dyscalculic, and control students. The participants were 45 dyslexic students, 45 dyscalculic students, and 45 age-, gender-, and IQ-matched control students. The major evaluation tools included six cognitive inhibition tasks which were restructured during principal component analysis into three categories: graph inhibition, number inhibition, and word inhibition. Comparisons of the 3 groups of students revealed that in graph inhibition, dyscalculic students performed worst of the 3 groups, with dyslexic students also performing worse than control students in this category. For number inhibition, the control students' performances were equal to those of dyslexic students, with both groups performing better than dyscalculic students. For word inhibition, control students' performances were equal to those of dyscalculic students; both groups had shorter response times and lower incorrect rates than dyslexic students. These results suggest the complexity of the different cognitive inhibition abilities displayed by dyslexic, dyscalculic, and control students. However, some regular patterns occurred.
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1. Introduction

The most recent working definition of developmental dyslexia and dyscalculia describes dyslexia as a specific deficit in the acquisition of reading (especially word recognition and decoding) and dyscalculia as a specific deficit in the acquisition of arithmetic skills (especially number fact knowledge). Prevalence rates for academic failure in these domains show wide variation, depending on the definitional criteria (Landerl, Fussenegger, & Willburger, 2009).

Persons with dyslexia and dyscalculia have deficits in several mental processing abilities, including inhibition (van der Sluis, de Jong, & van der Leij, 2007), with deficiencies in reading and arithmetic skills demonstrating as the outcomes of these deficits. Inhibition is a central component of executive function (EF) and generally focuses on the ability to actively inhibit or delay a dominant response to achieve a goal (Blaye & Chevalier, 2011). Several recent studies have investigated the inhibition abilities of dyslexic and dyscalculic students (Altemeier, Abbott, & Berninger, 2008; Borella, Carretti, & Pelegrina, 2010; Borella, Ghisletta, & de Ribaupierre, 2011; Cain, 2006; Landerl et al., 2009; van der Sluis, de Jong, & van der Leij, 2004; Willburger, Fussenegger, Moll, Wood, & Landerl, 2008). However, the results of these studies were not always consistent. Several possible reasons could explain these inconsistencies, with differences in measurement tools the most likely. The present study, therefore, used the tasks applied in several of these previous studies to evaluate the inhibition abilities of students with and without dyslexia and dyscalculia.

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1.1. Inhibition

Investigators have described that inhibition is the primary executive function, and precedes and allows the development of other executive functions (Barkley, 1997; Carlson & Moses, 2001). According to Barkley (2003), to engage in conscious, reflective problem solving, one first needs to inhibit automatic responses to engage strategic processes in favor of a long-term goal. Inhibition delays a prepotent (automatic, overlearned) response to achieve a goal and can, thus, protect that delay even in the presence of interference (Barkley, 2003). When prepotent responses are inhibited, a temporal pause occurs that allows for development or implementation of self-directed or self-regulatory actions. Inhibition first appears in development at the age of 3 or 4, continuing to develop through adolescence. The development of other self-regulatory functions occurs after the appearance of inhibition during development (Altemeier et al., 2008).

Inhibition is not a stable mental process; it is variable. In developmental psychology, inhibitory control is most often defined as the capacity to suppress the behavioral or cognitive processes that can cause interference (Carlson, Moses, & Hix, 1998). Inhibition can, therefore, occur at the behavioral level (response control) or at the cognitive level (attentional inertia). Cognitive disinhibition often leads to behavioral disinhibition. At a cognitive level, lack of inhibition leads to representational inflexibility rather than a response control problem (Diamond, 2002). Harnishfeger and Pope (1996) defined cognitive inhibition as the active suppression of a previously activated cognitive representation, such as the ability to clear incorrect inferences from memory. Barkley (1997), however, defined cognitive inhibition as involving the following components: (a) inhibition of prepotent (learned) responses, creating a delay in responding to an event; (b) interruption of ongoing responses because of performance feedback; (c) protection of this delay in responding (the ability to maintain the delay in responding that was created by inhibiting the response).

Some academics do not agree with this definition. Harnishfeger (1995), for example, argued that behavioral inhibition and cognitive inhibition are distinct. In contrast, Nigg (2000), similar to Barkley (1997), suggested that control of interference should be distinguished from cognitive inhibition because it applies to the protection of working memory. This seems to have merit because tasks purported to measure working memory tend to identify a dyslexic weakness (Engelhardt, Nigg, Carr, & Ferreira, 2008; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005).

Inhibition is an important process in daily life and during school learning. According to the definition of Carlson et al. (1998), cognitive inhibition is more important than behavioral inhibition, especially in academic learning. It is, therefore, not surprising that previous studies concerning the inhibition of dyslexic and dyscalculic students all addressed cognitive inhibition (Altemeier et al., 2008; Borella et al., 2010, 2011; Cain, 2006; Golden & Golden, 2002; Landerl et al., 2009; Rubinsten & Henik, 2006; van der Sluis et al., 2004; Willburger et al., 2008).

Several of the previous studies that compared cognitive inhibition abilities in dyslexic and dyscalculic students provided inconsistent findings (Landerl et al., 2009; Rubinsten & Henik, 2006; van der Sluis et al., 2004; Willburger et al., 2008). The present study, therefore, expands on this research by evaluating cognitive inhibition in students with and without dyslexia and dyscalculia.

1.2. Tasks for measuring cognitive inhibition

Generally, previous studies on dyslexic or dyscalculic students' inhibition did not focus exclusively on inhibition; several dependant variables often existed in one study. For example, Brosnan et al. (2002) examined digit span, inhibition, verbal fluency, planning, sequencing, and organization. Landerl et al. (2009) evaluated phonological awareness, phonological and visual–spatial short-term and working memory, naming speed (including inhibition and shifting), and basic number processing skills. Rubinsten and Henik (2006) assessed inhibition, reading comprehension, reading production, and phonological awareness. Golden and Golden (2002) examined selective attention and inhibition, van der Sluis et al. (2004) examined inhibition and shifting, and van der Sluis et al. (2007) investigated inhibition, shifting, and updating abilities. The study performed by Willburger et al. (2008) evaluated rapid naming, inhibition, and shifting in dyslexia and dyscalculia. These studies used 1 or 2 tasks to measure inhibition in participants. This led to the problem of tasks for measuring inhibition not being extensive enough to accurately identify characteristics in dyslexic and dyscalculic students, and might explain the inconsistencies in results from comparisons of inhibition abilities in students with dyslexia and dyscalculia.

The different inhibition measuring tasks may also test other abilities. For example, the study of Brosnan et al. (2002) used the group embedded figures test (GEFT) to evaluate inhibition in dyslexic students. However, this test may also relate to visual–spatial abilities. Golden and Golden (2002) used the Stroop task to measure inhibition in students with dyslexia and ADHD. The studies of Landerl et al. (2009) and Rubinsten and Henik (2006) used size number inhibition to measure inhibition in dyslexic and dyscalculic students; this test may be related to number fact knowledge. Rubinsten and Henik (2006) used the Navon figures test to measure inhibition in dyslexic and dyscalculic students; however, phonological awareness can also be indicated by this test. The studies of van der Sluis et al. (2004) and Willburger et al. (2008) used object inhibition and quantity inhibition tests in dyslexic and dyscalculic students. The object inhibition test may indicate students' visual–spatial abilities; the quantity inhibition test may also be related to counting and number fact knowledge.

The present study, therefore, used the object inhibition, quantity inhibition, Stroop inhibition, size number inhibition, Navon figures, and group embedded figures tests to evaluate inhibition in students with and without dyslexia and dyscalculia. The analyses included the integration and restructuring of the results of the different inhibition measures.

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