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Domain-specific Rapid Automatized Naming deficits in children at risk for learning disabilities

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ABSTRACT

Performance in Rapid Automatized Naming (RAN) tasks with different materials (dice, digits, letters, objects) and key precursor skills of reading and arithmetic were assessed in kindergarten children ($n = 541$) in their last year before entering elementary school. Based on their precursor skills, three groups of children were identified, i.e. children at risk for reading problems ($n = 31$), children at risk for arithmetic problems ($n = 39$), and children at risk for problems in both domains ($n = 34$). These at-risk children were compared to a control group ($n = 343$) regarding their performance in the different RAN tasks. Results revealed domain-specific deficits in both groups of children with a single risk: While children at risk for problems in reading exhibited deficits in the RAN of letters and objects, children at risk for problems in arithmetic showed deficits in the RAN of dice and digits. The group of children at risk for problems in both domains displayed additive, domain-general deficits. Findings are discussed in the context of behavioral and neurocognitive research on reading and mathematical disabilities.

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1. Introduction

Rapid Automatized Naming (RAN) labels a simple task: it refers to children's ability to name sequentially presented stimuli such as letters, digits, quantities, objects, or colors as quickly and accurately as possible. Typically, accuracy rate is high even in young children. Denckla and Rudel (1976a,b,c) were the first to start a series of studies exploring RAN and its connection to reading performance, showing that children with a reading disability performed significantly lower in these tasks. Subsequently, RAN has been investigated intensively in both cross-sectional as well as longitudinal studies over the last 30 years and its close relation to reading acquisition has been demonstrated reliably (Denckla & Cutting, 1999). A multitude of studies confirmed the finding that RAN represents a mechanism that differs between reading impaired and normally developed readers (van den Bos, 1998; Di Filippo et al., 2005; de Jong & van der Leij, 1999, 2003; Shanahan et al., 2006; Wimmer, 1993; Wimmer, Mayringer, & Landerl, 1998; Wolf, Bally, & Morris, 1986; Wolf & Bowers, 1999). RAN has also been proven to be a good predictor for later reading achievement even when controlling for intelligence (Badian, 1993; Bowers, Steffy, & Tate, 1988), short-term memory (Parilla, Kirby, & McQuarrier, 2004), prior reading achievement (Badian, 1993), cognitive processing speed (Denckla & Cutting, 1999), or letter knowledge (Lepola, Poskiparta, Laakkonen, & Niemi, 2005). An ongoing matter of debate concerns the question whether deficits in RAN and phonological deficits are two separate sources of reading dysfunction. Some researchers argue that RAN deficits can be traced back to a phonological core deficit in dyslexia (e.g. Vellutino, Fletcher, Snowling, & Scanlon, 2004), whereas others consider RAN to be largely unrelated to phonological deficits and assume that it contributes independently to reading impairment (double-deficit hypothesis, e.g. López-Escribano & Katzir, 2008; Wolf & Bowers, 1999). This debate continues even on a more comprehensive level. In a recent meta-analysis, Vukovic and Siegel (2006) state that evidence so far does not strengthen the proposition of a single RAN deficit in dyslexics. They argue that it is difficult to separate the influence of RAN and phonological processing on reading performance measures as they found them to be significantly correlated throughout literature. On the contrary, Swanson, Trainin, Necoechea, and Hammill (2003) reported in their meta-analysis RAN and phonological awareness to be only weakly interrelated and to load on two different factors.

The connection between RAN and mathematical performance has also been explored recently (Chard et al., 2005; Krajewski & Schneider, 2009; Landerl, Bevan, & Butterworth, 2004; van der Sluis, de Jong, & van der Leij, 2004; Swanson & Jerman, 2006). For example, van der Sluis et al. (2004) were able to demonstrate that RAN performance differs between children with arithmetic problems and normally developing children. This finding could also be confirmed in a selective meta-analysis by Swanson and Jerman (2006). In addition, RAN has been shown to substantially contribute to the prediction of individual differences in the development of mathematical skills. For example, Chard et al. (2005) found that RAN performance in a number naming task, measured in kindergarten, significantly predicted mathematical skills at the beginning of the first grade.

The underlying cognitive mechanisms that account for individual differences in RAN performance and make it a good predictor for reading as well as for arithmetic achievement are largely unknown. Furthermore, it is unclear whether those mechanisms are the same for both domains. It has been argued that the predictive power of RAN tasks for the two domains may depend on the different materials used. Landerl et al. (2004), for example, showed that number naming speed was lower in dyslexics compared to controls, while Krajewski and Schneider (2009) demonstrated that RAN of numbers in kindergarten predicted mathematical performance in fourth grade. However, as only RAN of numbers was applied in both studies, the question of possible domain-specific contributions of particular RAN tasks to mathematical achievement has not been in the center of attention. Nevertheless, questions about domain specificity of RAN tasks for both reading as well as arithmetic achievement have been in the focus of two studies. Van der Sluis et al. (2004) examined RAN of objects, digits, letters, and quantities in reading-disabled, arithmetic-disabled, and comorbid disabled children at a mean age of 10.75 years. Compared to a control group, arithmetic-disabled children were slower in naming digits and quantities, while reading-disabled children were slower in naming digits and letters. Moreover, children in the comorbid group showed deficits in all four RAN tasks. They displayed a combination of the respective deficits of the reading-disabled and arithmetic-disabled groups. This

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