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Note

The visual attention span deficit in dyslexia is visual and not verbal

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ABSTRACT

The visual attention (VA) span deficit hypothesis of dyslexia posits that letter string deficits are a consequence of impaired visual processing. Alternatively, some have interpreted this deficit as resulting from a visual-to-phonology code mapping impairment. This study aims to disambiguate between the two interpretations by investigating performance in a non-verbal character string visual categorization task with verbal and non-verbal stimuli. Results show that VA span ability predicts performance for the non-verbal visual processing task in normal reading children. Furthermore, VA span impaired dyslexic children are also impaired for the categorization task independently of stimuli type. This supports the hypothesis that the underlying impairment responsible for the VA span deficit is visual, not verbal.

1. Introduction

Developmental dyslexia is characterized by a severe reading acquisition impairment in children of normal intelligence, free of any neurological or psychiatric condition. It is widely admitted that dyslexia is a consequence of a phonological deficit (Vellutino et al., 2004; Ziegler and Goswami, 2005). Nevertheless, as a significant proportion of dyslexic children exhibit no phonological impairment (Bosse et al., 2007; White et al., 2006), such a deficit cannot account for the full spectrum of the disorder. Concurrently, visual processing performance has been shown to contribute to reading performance in typical readers (Kevan and Pammer, 2008; Kwon et al., 2007; Pammer et al., 2005). Moreover, visuo-spatial attention (Facoetti et al., 2008, 2006) and low level visual processing (Boden and Giaschi, 2007) have been found to be impaired in dyslexic readers. Multifactorial accounts of dyslexia (Menghini et al., 2010) have opened new perspectives such as the existence of a visual rather than phonological system impairment (Vidyasagar and Pammer, 2010).

Several studies have explored multi-element visual processing in dyslexic children using whole and partial report tasks (Bosse et al., 2007; Valdois et al., 2003). Impaired performance on these tasks was interpreted as evidence for a deficit in the number of individual visual elements that can be processed simultaneously, namely a visual attention (VA) span disorder.

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Research has shown that a subset of dyslexic children exhibits such a deficit (Bosse et al., 2007). Within the framework of the Multi Trace Memory (MTM) model of reading (Ans et al., 1998), a VA span deficit can explain impaired reading acquisition by preventing simultaneous processing of the constituent letters of relevant orthographic units. The relevance of the VA span to reading is highlighted behaviourally by the fact that VA span performance is a reliable predictor of reading performance independently of phonological processing in typically developing (Bosse and Valdois, 2009) and dyslexic children (Bosse et al., 2007).

Even though the VA span disorder's definition encompasses all types of visual elements, behaviourally its hallmark is impaired performance on letter-report tasks. These tasks have two potential caveats: they necessitate a verbal response and use verbal stimuli. Consequently it has been claimed (Hawelka and Wimmer, 2008; Ziegler et al., 2010) that the impairment does not follow from a visual processing deficit but from impaired visual to phonological code mapping in line with the phonological theory of dyslexia. In order to disambiguate from these two interpretations, it is necessary to confront predictions of both hypotheses on available data of tasks requiring verbal report and/or multi-element processing.

String visual processing has been studied extensively in dyslexia, albeit with many different types of paradigms which have led to contrasting results. Because of these numerous paradigms, it is crucial to identify those that do, in fact, investigate *multi-element parallel* visual processing. Not only do appropriate tasks need to involve processing of several elements, but paradigms also need to ensure that visual processing is parallel. Indeed studies that do not constrain stimulus presentation time (Hawelka and Wimmer, 2008; Pitchford et al., 2009) are not relevant for the VA span hypothesis.

Performance of parallel visual processing can be assessed independently of phonological ability by using tasks that require no verbal report, tasks that use non-verbal stimuli or, ideally, tasks that combine both. Poor performance for dyslexic readers in tasks involving parallel processing of verbal stimuli but no verbal response has previously been reported (Rutkowski et al., 2003; Ziegler et al., 2010). While this data is in line with the hypothesis of a purely visual processing deficit in dyslexia, it is not sufficient to sideline an underlying phonological cause insofar as the use of verbal material might automatically involve phonological recoding and yield a phonologically-constrained performance.

In order to completely disambiguate the role of visual and phonological processing in dyslexia, visual processing has been investigated using change detection tasks with non-verbal material. Not only were dyslexic readers impaired (Jones et al., 2008; Pammer et al., 2004), but task performance predicted reading performance in both children and adults (Pammer et al., 2005, 2004). These results cannot be accounted for by a phonological account of dyslexia, but are in line with predictions of the VA span deficit hypothesis.

However, another symbol processing task has yielded opposite results (Ziegler et al., 2010). Based on data from a partial report identification task, the authors argued against a visual deficit in dyslexia as the task yielded a deficit with letters and digits but not with symbols.

The main goal of this study is to disambiguate which of a parallel visual processing deficit or a phonological coding deficit is the proximal cause of the VA span deficit in dyslexia. We will investigate parallel visual processing in normal and dyslexic children using non-verbal categorization and verbal and non-verbal stimuli. Since we aim to specify the nature of the VA span deficit, all dyslexic participants will exhibit such a deficit. We aim to show (1) that performance on this non-verbal task relates to VA span performance in a large group of typically developing children and (2) that VA span impaired dyslexic children are impaired on this non-verbal task, regardless of character type.

2. Methods

2.1. Population

One hundred and nine typically-developing children and 14 dyslexic children took part in the experiment. The typical

Table 1 – Mean scores (SD) of age (chronological and reading) and reading performance for typically developing (TYP), dyslexic (DYS) and control (CTRL) children.

	TYP ($N = 105$)	DYS ($N = 14$)	CRTL ($N = 14$)	t or Z
Chronological age	106.4 (14.6)	128.9 (14.6)	128.2 (11.1)	$t(26) = .13$, *n.s.*
Reading age	109.5 (21.5)	86.0 (5.9)	135.9 (18.7)	$t(15.6) = 9.54^{***}$
Reading				
Regular word				
Accuracy/20	17.0 (2.3)	13.1 (3.8)	19.4 (.73)	$Z = -4.34^{***}$
Speed (wds/min)	51.6 (22.7)	22.3 (8.4)	79.9 (20.7)	$t(17.1) = -9.65^{***}$
Exception words				
Accuracy/20	10.9 (4.9)	7.9 (4.7)	16.1 (3.5)	$Z = -3.69^{***}$
Speed (wds/min)	44.2 (20.4)	21.0 (10.5)	71.1 (18.9)	$t(20.3) = -8.67^{***}$
Pseudo-words				
Accuracy/20	15.7 (2.7)	10.6 (4.1)	17.5 (2.0)	$Z = -3.90^{***}$
Speed (wds/min)	39.7 (14.3)	19.7 (5.4)	56.8 (14.2)	$t(16.6) = -9.14^{***}$
VA span				
Global report	80.7 (10.9)	64.0 (7.7)	89.6 (7.0)	$t(26) = -9.22^{***}$

*** $p < .001$.