CORTEX 46 (2010) 1317–1329

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

No evidence for a prolonged attentional blink in developmental dyslexia

Gregor M.T. McLean [a,*], Anne Castles [a], Veronika Coltheart [a] and Geoffrey W. Stuart [b]

[a] Macquarie Centre for Cognitive Science, Macquarie University, Australia
[b] School of Psychological Science, La Trobe University, Australia

ARTICLE INFO

Article history:
Received 13 October 2008
Reviewed 25 March 2009
Revised 14 May 2009
Accepted 14 October 2009
Published online 4 August 2010

Keywords:
Attentional blink
Dyslexia
Reading development

ABSTRACT

When two targets are presented within 500 msec of each other in rapid serial visual presentation (RSVP), the accuracy of second target identification is significantly reduced; a phenomenon termed the *attentional blink*. Recent studies have reported that children and adults with dyslexia exhibit deficits tied to the attentional blink; however, some ambiguity remains as to the nature of these impairments and how they relate to reading difficulties. The current study aimed to address these issues by examining attentional blink deficits in relation to orthographic, phonological, and fluency aspects of reading impairment. Twenty-two children with dyslexia were compared to 22 children with normally developing reading skills on an attentional blink task with results indicating the dyslexia group exhibited impaired performance regardless of the temporal lag between targets. These deficits appeared tied to general RSVP performance rather than a prolonged attentional blink and differences between groups fell below significance when the influence of general performance factors were controlled for.

1. Introduction

In recent years, research on developmental dyslexia has predominantly focussed on phonological processing deficits, such as impairments in phonological awareness and in the acquisition of grapheme–phoneme rules (see Snowling, 2000 for a review). Such deficits are prevalent in a substantial proportion of children with reading difficulties. However, not all poor readers exhibit phonological difficulties, suggesting that reading disorders may be heterogeneous with a variety of different causes (Castles and Coltheart, 1996). As such, a second body of research has explored the possibility that other, non-phonological deficits may be present in cases of dyslexia, and particularly has focussed on the possible existence of subtle perceptual and attentional processing deficits in some poor readers. In this vein, developmental dyslexia has been associated with deficits in a range of aspects of visual attention (see Valdois et al., 2004 for a review) as well as with impairments in temporal processing across several sensory modalities (see Farmer and Klein, 1995 for a review).

More recently, a number of studies have specifically explored temporal aspects of visual attention in dyslexia. These studies have primarily examined visual temporal attentional processing using dual-target rapid serial visual presentation (RSVP) paradigms and investigating a phenomenon known as the *attentional blink*. In this paper, we will review the evidence for an abnormal attentional blink in individuals with dyslexia, and will report on a study in which

* *Corresponding author*. Macquarie Centre for Cognitive Science, Macquarie University, North Ryde, NSW 2109, Australia.
E-mail address: greg.mclean@dsto.defence.gov.au (G.M.T. McLean).
0010-9452/$ – see front matter © 2010 Elsevier Srl. All rights reserved.
doi:10.1016/j.cortex.2010.06.010

we examined different aspects of performance on attentional blink tasks in the context of different reading subprocesses.

1.1. *The attentional blink and attentional dwell time*

In an attentional blink paradigm, participants attempt to identify two targets embedded amongst a series of distractors within an RSVP stream typically shown at rates of ten items per second. The first target (T1) is usually identified correctly with relative ease, but identification of the second target (T2) is noticeably impaired in direct proportion to the stimulus onset asynchrony (SOA) or *lag* between the first and second targets (Raymond et al., 1992). The attentional blink refers to this temporal period or *blink* in which T2 accuracy is temporarily impaired.

Theoretical accounts of the attentional blink propose that inferior T2 performance is a direct consequence of attention to T1 and is a result of the limited capacity of temporal attentional processing mechanisms (Chun and Potter, 1995; Shapiro et al., 1997). A representative example is the two-stage model of Chun and Potter (1995), which outlines two sequential processes required for correct target identification. Initially, a rapid detection stage (Stage-1) processes the features of incoming stimuli in order to identify potential targets from distractors. This processing is fast and efficient, but stimulus representations at this stage are relatively short-lived and vulnerable to decay or over-writing by subsequent distractor stimuli. Thus, a second, capacity-limited, processing stage (Stage-2) is required to establish target representation in short-term memory for conscious report. This Stage-2 processing phase can only be applied serially to individual stimuli and requires the rapid access to and sufficient activation of an individual's stored cognitive representations of the relevant targets (i.e., the letters, numbers or shapes used as target stimuli) to allow for the conscious report. Consequently, if T2 is presented before Stage-2 processing of T1 can be finalised, insufficient resources remain available and leave T2 vulnerable to decay or over-writing (Chun and Potter, 1995). From this account, T2 accuracy improves as the lag between T1 and T2 increases due to the likelihood that T1 processing will be complete by the time T2 is presented. The implication of this theory is that the duration of an individual's attentional blink provides an estimate of their *attentional dwell time* for T1, that is, how long attention must be devoted to a target in order for its representation to be encoded for conscious report.

1.2. *Studies of the attentional blink in dyslexia*

Attentional blink differences in dyslexia were first explored by Hari et al. (1999) in a study comparing dual-target search by a group of adults with a pre-existing diagnosis of dyslexia with a group of adults with normal reading skills. Hari et al. (1999) reported that while both groups exhibited a significant attentional blink, the adults with dyslexia exhibited a prolonged attentional dwell time (700 msec) compared to the normal readers (540 msec). However, a potential problem with the design of the Hari et al. (1999) study is that alphabetic stimuli (i.e., letters) were used as targets and differences in letter recognition ability may have been responsible for the inferior performance by individuals with dyslexia. Visser et al. (2004) addressed this problem by using a task with non-alphabetic stimuli (i.e., shapes) in a study comparing the attentional blink of a sample of children with dyslexia with that of a group with normally developing reading skills. The findings were broadly consistent with those of Hari et al. (1999).

There have since been further reports of attentional blink abnormalities, of various kinds, both in dyslexia (Buchholz and Davies, 2007; Facoetti et al., 2008) and in the related disorder of specific language impairment (SLI) (Lum et al., 2007). There is also some evidence for associations between performance on attentional blink tasks and reading ability in children and adults with normal-range reading skills (La Rocque and Visser, 2009; McLean et al., 2009).

Yet despite the proliferation of research interest, significant questions remain concerning the precise nature of these reported attentional blink abnormalities and, more importantly, how they might relate to reading impairment. Indeed the attentional blink task is a complex and multifaceted one, and the aberrant performance on this task by individuals with dyslexia may be attributable to a number of different factors, some not specifically associated with visual temporal attention (Badcock et al., 2008). Therefore, before proceeding with further consideration of possible associations with reading ability, it is instructive to clarify exactly the kinds of abnormalities individuals may exhibit on dual-target RSVP tasks; and more importantly, the type of processing impairments these abnormalities reveal.

1.3. *Patterns of abnormal performance on the attentional blink task*

Fig. 1 represents four possible ways in which performance on a dual-target RSVP task might be abnormal. In attentional blink research, typically only trials in which T1 has been correctly identified (T2|T1) are examined as the source of error on T2 identification is unknown across incorrect T1 trials. In each of these figures, the solid lines indicate typical dual-target RSVP performance indicative of an attentional blink. That is, these lines represent impaired T2|T1 accuracy at relatively short lags (200 msec and 400 msec) along with gradual improvement to levels similar to single-target detection at later lags (600 msec and 800 msec). The broken lines indicate abnormal performance of various forms.

In Fig. 1a, the broken line illustrates a pattern of performance across lags that would be consistent with an abnormally *prolonged* attentional blink: performance levels are similarly low at 200 msec and 400 msec, but T2|T1 identification remains significantly impaired at 600 msec and does not rise to single-target detection levels until 800 msec. As discussed above, a prolonged attentional blink is indicative of an increased attentional dwell time, whereby individuals appear to need to devote attentional resources for a longer period of time than is usual in order to correctly identify a target.

The broken line in Fig. 1b indicates a different kind of abnormality, which we will refer to as an abnormality in *depth* of attentional blink. Here, it can be seen that attentional dwell time is of normal duration in that T2|T1 performance has recovered by 600 msec, yet performance is significantly *more* impaired than normal during the attentional blink phase