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Research Report

Greater attentional blink magnitude is associated with higher levels of anticipatory attention as measured by alpha event-related desynchronization (ERD)

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ABSTRACT

Accuracy for a second target (T2) is reduced when it is presented within 500 ms of a first target (T1) in a rapid serial visual presentation (RSVP)—an attentional blink (AB). Reducing the amount of attentional investment with an additional task or instructing the use of a more relaxed cognitive approach has been found to reduce the magnitude of the AB. As well, personality and affective traits, as well as affective states, associated with a more diffused or flexible cognitive approach have been found to predict smaller AB magnitudes. In the current study, event-related desynchronization in the alpha range was used to investigate whether the degree of attentional investment in anticipation of a RSVP trial was related to the behavioral outcome of that trial. As hypothesized, greater alpha ERD before the RSVP trial, indicating greater anticipatory attentional investment, was observed on short lag trials where an AB was present (inaccurate T2 performance) compared to short lag trials where an AB did not occur. However, on trials where T2 was presented after a longer period relative to T1, greater alpha ERD before the RSVP trial was found on trials with accurate T2 performance. Results support models of the AB that propose that greater attentional investment underlies the AB, and furthermore that this attentional investment is prepared in anticipation before each RSVP trial.

1. Introduction

When two to-be-attended targets are presented in a rapid serial visual presentation (RSVP) stream, accuracy for the second target (T2) is reduced when it is presented within 500 ms of the first target (T1), relative to longer T1–T2 separations—a phenomenon known as the attentional blink (AB; Raymond et al., 1992). The AB has been interpreted as reflecting attentional limitations where attentional processing of T1 interferes with and/or delays the allocation of attention to T2 if T2 is presented before T1 processing has been completed (Shapiro et al., 1997).

1.1. Models of the AB

Traditional models of the AB tend to characterize the AB in terms of bottlenecks on information processing (e.g., Chun and Potter, 1995; Jolicoeur, 1998). For example, in the two-

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Abbreviations: AB, attentional blink; ERD, event-related desynchronization; RSVP, rapid serial visual presentation; T1, first target; T2, second target

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stage model of the AB (Chun and Potter, 1995), it is proposed that there are two stages to target processing. At the first stage, multiple stimuli can be processed in parallel and temporary fragile representations of the stimuli are created. In the second stage of processing, the fragile and temporary representations are encoding into more durable working memory representations that can be used for later report. Stage two processing is time and attention demanding such that a bottleneck is created at stage two processing if T2 is presented while T1 is still undergoing stage two processing, or if RSVP distractors are currently competing for stage two processing resources. Until that bottleneck is resolved, the encoding of any subsequent targets is delayed leaving their perceptual representations vulnerable to decay and reducing the probability that they will be accurately reported. Thus, any unnecessary investment of stage 2 processing resources in T1 would be expected to exacerbate the AB.

More recently, there have been models of the AB suggesting that some feature of cognitive control is responsible for the pattern of attentional investment that results in the failure to accurately report T2 at short target separations. For example, in the Temporary Loss of Control model (TLC; Di Lollo et al., 2005), it is suggested that cognitive control initially optimizes an input filter in favor of T1. When attention is needed to process the T1 stimulus, less attention is available to control the input filter and the filter falls under bottom-up control. If T2 is presented before cognitive control of the input filter is restored, this loss of cognitive control impairs selection of T2, resulting in the AB. Therefore, the TLC model implies that a lack of top-down cognitive control following T1 is responsible for the AB.

In the Boost-and-Bounce model (Olivers and Meeter, 2008), it is proposed that the T1 item elicits an excitatory "boost" that lasts long enough to also boost the distracter item that immediately follows T1 into working memory. Cognitive control then responds to the presence of this distracter with an inhibitory "bounce" that prevents subsequent items, including T2, from entering working memory. According to this model, poor cognitive control over the "bounce" response (i.e., an inability to prevent the "bounce") seems to initiate the context necessary for an AB.

The Threaded Cognition model (Taatgen et al., 2009) also suggests that a memory function initiated by T1 prevents the further detection of targets. Taatgen et al. (2009) characterize this memory function as an overexertion of control, and suggest that when this control function is not engaged, the probability of accurate T2 performance is increased.

In their Overinvestment Hypothesis, Olivers and Nieuwenhuis (2005, 2006) propose that the AB results from the unrestrained investment of attentional resources extending to all RSVP items such that distractors become effective competitors for entrance into working memory. When T2 appears soon after T1, it is particularly vulnerable to this interference given the additional attention required for encoding T1, resulting in the AB. However, Olivers and Nieuwenhuis (2005, 2006) suggest that if investment of attention was reduced to a level just sufficient to encode the targets, then interference would be reduced and the probability of accurate T2 performance would increase, particularly at short target separations.

In all of the above models, limited attentional resources and inappropriate application of attention underlie the AB. Cognitive control models further suggest that this is a result of maladaptive management of attentional resources by top-down cognitive control. If more or less adaptive cognitive control and the resultant investment of attentional resources could influence the magnitude of the AB, then that would imply that the AB does not reflect a fundamental attentional processing limitation. Instead, the AB would be conceptualized as resulting from a particular attentional style, where its magnitude is influenced by the kind of cognitive control or attentional investment of attentional resources with which an individual approaches the RSVP task.

Recent evidence where researchers have manipulated or measured the level of cognitive control and/or attentional investment supports this conceptualization of the AB—specifically the possibility that overly stringent cognitive control and inappropriate attentional investment contribute to the AB. For example, when participants engaged in concurrent task such as detecting yells in music or performing a match to sample task, Olivers and Nieuwenhuis (2005, 2006)[1] found that the AB was reduced relative to control conditions where participants performed only the AB task. Similarly, the AB has been reduced when task instructions emphasized a more passive target search strategy where you let the targets jump out at you (Olivers and Nieuwenhuis, 2005), and when AB task instructions emphasized reporting the two targets as a combination or pair (Ferlazzo et al., 2007). Olivers and Nieuwenhuis (2006) also observed a reduced AB when participants were exposed to positive affective pictures, relative to negative or neutral pictures. This result has implications for models of the AB given that positive affect is associated with an open and flexible cognitive processing style and diffused attention (e.g., Fredrickson, 2001) while negative affect is associated with heightened focusing of attention (e.g., Kramer et al., 1990).

Individual differences in trait affect (MacLean et al., 2010) and state affect (MacLean and Arnell, 2010) have been shown to predict AB magnitude where greater positive affect is associated with reduced AB magnitudes and greater negative affect is associated with increased AB magnitudes. Personality dimensions related to attentional investment and focus have also been shown to predict the magnitude of the AB where higher scores on extraversion and openness to experience predicted smaller AB magnitudes, and higher scores on neuroticism predicted larger AB magnitudes (MacLean and Arnell, 2010). Individual differences in the degree of global versus local processing also predict AB magnitude, where an individual's tendency to focus on the local information as opposed to seeing the global overall picture was positively associated with larger AB magnitudes (Dale and Arnell, 2010). Individual differences in the ability to effectively inhibit or ignore RSVP distractors have been shown to relate to the AB where greater inhibition of irrelevant RSVP distractors was

[1] Olivers and Nieuwenhuis indicated that the effect of music played concurrently with the RSVP stream on AB magnitude could not be consistently replicated (Olivers and Nieuwenhuis, 2006, Footnote 1).