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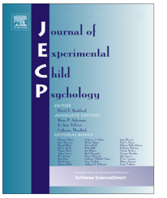

Developmental changes in feature detection across time: Evidence from the attentional blink

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ABSTRACT

The ability to select targets from an ongoing stream of visual information is critical to the successful management of visual attention. The attentional blink (AB), a phenomenon elicited using rapid serial visual presentation, allows for the assessment of the limits of the temporal visual system, and is reflected in a decrease in accuracy in the detection of the second of two targets when it occurs within 200–500 ms of a first target. Evidence regarding the development of the AB is mixed and appears to be dependent on the task demands. Here we present data examining the AB across middle childhood, early adolescence, and adulthood using a feature binding task. Participants were asked to detect and report the identity of two purple letters presented in a stream of black letters at a rate of 135 ms/item. On this feature binding task, the depth of the AB was invariant across development but AB recovery occurred earlier with increasing age. Furthermore, the error data suggested important developments in temporal binding that were reflected both in a decrease in the number of swaps (where participants reverse the order of the targets but identify them correctly) and in the spread of temporal binding errors with age. These findings suggest that the characteristics of the AB and its development are task dependent and also suggest that the development of binding abilities in visual search tasks mirrors the time course of multisensory binding effects, perhaps suggesting a common mechanism.

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Introduction

The development and fine-tuning of the visual system during maturation presumably allows for increases in our ability to parse, encode, and process incoming information across both the spatial and temporal domains to make sense of our constantly changing visual world. These developmental changes provide an important means to answer questions about visual cognition that are not otherwise easy to address. For example, if a phenomenon observed in adults is thought to reflect a limitation of the system, that phenomenon should be more pronounced in a less-developed visual system. On the other hand, if that phenomenon is thought to reflect a useful mechanism or is the result of learning, it should be less pronounced in a less-developed visual system. This article builds on previous efforts (Russo, Kates, Shea, LeBlanc, & Wyble, 2016) to better understand developmental changes in how the visual system processes information across time by studying phenomena related to sequential processing that includes the attentional blink (AB) and different types of errors made under temporal pressures.

Rapid serial visual presentation (RSVP) is an experimental technique that measures the ability of the visual system to rapidly attend to and consolidate information distributed in the temporal domain. In RSVP, stimuli are presented rapidly, around 10 per second, and targets must be selected from among distractors (Forster, 1970; Potter, 1984) that can consist of characters, words, or even natural images. These targets can be specified in multiple ways such as by feature (e.g., colors), by category (e.g., letters), and by some combination (Potter, 1976). RSVP tasks are designed to explore the temporal limitations of attentional selection, a central aspect of the successful management of visual attention in daily functioning.

One well-studied phenomenon that arose from RSVP studies is the attentional blink. The AB occurs in RSVP tasks where participants must detect two targets and is reflected in a dip in accuracy when the second target occurs between 200 and 500 ms of the first target (Broadbent & Broadbent, 1987; Raymond, Shapiro, & Arnell, 1992). This AB, which is not a physical blink but rather a metaphorical blink, is thought to reflect a mechanism that limits the amount of information that is being attended to and, thus, can be used as an index of the time course of processing a given target (Dux & Marois, 2009; Martens & Wyble, 2010). That is, if participants are asked to attend to a stream of visual information and look for targets, and when they detect one, their attention becomes focused on that target so that they can process it, identify it, and store it in memory. During this time, attention is diverted away from the main stream of information to allow for deeper processing of the target, which takes around 200–500 ms. If a second target appears during that time frame, it is often missed and is reflected in a drop in accuracy for the second target. In the first computational AB models, the depth of the AB, measured in decreased accuracy for the second target (conditionalized on accurate report of the first target), reflected the "amount" of resources required for target processing. Thus, it would logically follow that the deeper the blink, the greater the amount of attentional processing required. Given that children are generally less efficient at processing information, it was expected that the AB would get shallower with age, which has been substantiated in some, but not all, articles on the topic.

Developmental studies of the AB

Developmental studies of the AB have been conducted, with varying results. Some studies have shown that the AB gets shallower with increasing age (Dye & Bavelier, 2010; Garrad-Cole, Shapiro, & Thierry, 2011; Heim, Benasich, Wirth, & Keil, 2015), whereas others have shown that the AB gets deeper with age (Russo et al., 2016). This juxtaposition can be explained, in part, by task demands. For example, both Dye and Bavelier (2010) and Garrad-Cole et al. (2011) had their participants detect a red triangle (T1), oriented left or right, and then detect a blue triangle (T2), oriented up or down, among distractors of different shapes and colors (e.g., green triangles, blue circles, and yellow squares). Participants needed to report the orientation of both the red and blue triangles at the end of each trial. Thus, participants needed to shift their mental set between the detection of the first