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14. ABSTRACT
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Self-Induced Attentional Blink: A Cause of Errors in Multiple-Target Visual Search

Stephen H. Adamo, Matthew S. Cain, & Stephen R. Mitroff

Abstract

Multiple-target visual searches, wherein more than one target can be present simultaneously, are especially error-prone with a decrease in second target accuracy after a first has already been found in a display. This phenomenon, known as Satisfaction of Search (SOS), presents a dangerous problem for many real-world searches, yet much is unknown about its cognitive underpinnings. We examined SOS errors in relation to another phenomenon that has been extensively studied: the Attentional Blink (AB). Surprisingly, despite obvious paradigm differences (e.g., self-paced vs. experimentally-timed) we found that an attentional blink can underlie SOS errors.

Summary

Visual search, looking for a target amongst distractors, is key to everyday activities (e.g., finding your car keys) and is a core skill for many life-saving professions (e.g., radiology). While searching for a single target is common in laboratory studies, many real world searches can contain multiple targets. Unfortunately, multiple target searches are curiously error prone, such that after a first target has been found subsequent targets are less likely to be detected. This pervasive form of error is referred to as *Satisfaction of Search* (SOS; Tuddenham, 1962), and is thought to account for one-third of radiological misses (Berbaum et al., 2010). Much remains to be learned about the causes of SOS but it is clear that there are many cognitive factors at play. For example, it is not the case that searchers are simply failing to look at the second target, as they may fixate a missed second target (Samuel et al., 1995), even up to 50% of the time (Cain et al., 2012). The current study assessed multiple-target search performance in light of a related cognitive phenomenon, the Attentional Blink (AB; Raymond et al., 1992), with the goal of simultaneously informing the study of both SOS and AB.

In an AB paradigm, items are typically presented in a Rapid Serial Visual Presentation (RSVP) stream at a rate of about 100ms per item. That is, items (often letters and/or numbers) are shown one at a time in the center of a screen at a rate of 10 items per second and observers report how many pre-defined targets were present in the stream. An AB refers to a decrease in second target accuracy when the second target is presented approximately 200 to 300ms after a detected first target. While there are obvious differences between SOS and AB paradigms, they are both fundamentally focused on the same phenomenon—the failure to detect a second target after having found a first target. As such, it is interesting to explore whether they may be mechanistically related and whether an AB-like effect can, at least partially, underlie SOS errors. In this experiment, we employed eye tracking to investigate fixation patterns to see whether an AB could cause a decrease in second target accuracy in a self-guided and self-paced multiple-target visual search.

Methods

Participants

28 members of Duke University (17 females; mean age of 19.5 years) participated for course credit or payment.

Stimuli and Procedure

Participants completed a visual search task for target "T" shapes amongst distractor "L" shapes on a white background. Targets were either of high salience (57–65% black) or low salience (22–45%) while the majority of distractors were low salience (Figure 1A). There were 25 items (1.3° × 1.3°) in each display with either one or two targets present per trial. Ten percent of the trials had a single, high-salience target, 10% had a single, low-salience target, and 80% had both a high- and low-salience target. Participants were instructed that they had 15 seconds to search and there was always going to be one, or two targets per trial. There were 25 practice trials where feedback was provided on misses and false alarms, and 250 experimental trials with no feedback. Participants' eye movements were tracked using a Tobi 1750, 50 Hz IR-illuminated video eye tracker.

We focused the AB-related analyses to accuracy for low-salience targets ("T2" in the AB terminology) on dual target trials where the high-salience target ("T1") was found first. Low salience target fixations were divided into temporal bins ("lags"). The lags were defined by the average time between successive distractor item fixations (i.e., the sum of the time fixating the item [~210ms] and the time to saccade to the next item [~60ms]) after fixating the high salient target. Thus, each 270ms lag approximated one item fixation. The first lag was half the length of the others (135ms) to ensure that we were specifically examining the first fixation after the high-salience target was detected.

Results

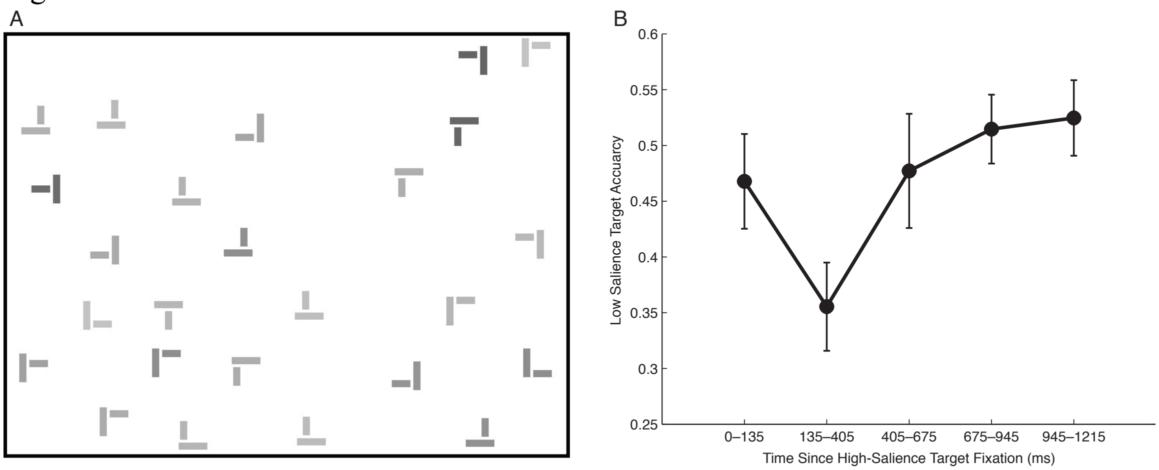
In a paired t-test between Lag 1 and 2, there was significant Lag 1 sparing ($t(27)=2.16$, $p=0.040$) where participants had higher second-target accuracy up to 135ms after fixating the first target compared to when they fixated from 135ms to 405ms (Figure 1B). More importantly, participants demonstrated a prototypical AB effect, with worse accuracy at Lag 2 (135–405ms) compared to Lag 5 (945–1215ms; $t(27)=3.30$ $p=0.003$).

Discussion

The AB-style blink found here reveals that an attentional blink can be self-induced and not tied to an RSVP stream (participants searched at their own pace). To our knowledge this is the first evidence of a self-generated AB. There are obvious paradigm differences between the SOS and AB tasks (e.g., self-paced vs. experimentally-timed, simultaneous spatial presentation vs. serial temporal presentation), which leaves more work to be done to determine whether the effects found here stem from a common underlying mechanism or from separate, but related, mechanisms. Regardless, the discovery of a self-induced attentional blink can inform existing theories of AB. Likewise, the current data shed new light on SOS research, demonstrating that search accuracy is negatively impacted for approximately 400ms after first target fixations. This link is exciting as it suggests that further insight from the AB literature can guide SOS research.

An AB in multiple-target search has implications for both cognitive psychology and applied realms. For the study of cognitive psychology, the existence of self-induced attentional blinks offers new avenues of research that can further refine AB and SOS theories. For applied realms, knowing that a self-induced attentional blink could possibly underlie real-world search errors can direct research to improve performance in real-world multiple-target searches where finding targets may be a matter of life-or-death.

Figure 1



A. Typical stimulus display. Participants were instructed to search for perfect T shapes amongst pseudo-L distractor items (2 present here).
B. Results. Low-salience target accuracy as a function of when it was fixated relative to when the high-salience target was most recently fixated.

References

Berbaum, K. S., Franklin, E. A. J., Caldwell, R. T., & Schartz, K. M. (2010). Satisfaction of search in traditional radiographic imaging. In E. Samei & E. Krupinski (Eds.), *The handbook of medical image perception and techniques* (pp. 107–138). Cambridge, England: Cambridge University Press.

Cain, M. S., Adamo, S. H., & Mitroff, S. R. (2012, May), What eye-tracking can tell us about multiple-target visual search. Vision Science Society, Naples, FL.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an rsvp task: An attentional blink? *Journal of Experimental Psychology: Human Perception & Performance, 18,* 849–860.

Samuel, S., Kundel, H. L., Nodine, C. F., & Toto, L. C. (1995). Mechanism of satisfaction of search: Eye position recordings in the reading of chest radiographs. *Radiology, 194,* 895–902.

Tuddenham, W. J. (1962). Visual search, image organization, and reader error in roentgen diagnosis: Studies of the psycho-physiology of roentgen image perception. *Radiology, 78,* 694–704.