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Hold the future, let the past go: Attention prefers the features of future targets

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ABSTRACT

Previous studies have shown that attention can be captured by task-irrelevant distractors under the guidance of attentional control settings. However, it is unknown whether people can establish an attentional control setting (ACS) for a sequence of distinct events. The present study tested that question by asking observers to expect a sequence of two colored targets in a specific order. The results show that irrelevant distractors that matched either the color of the first expected target or that of the second target captured attention. Thus observers are unable to temporarily suppress the color of the future target in their ACS. However, the temporal order of targets is still useful for guiding attention: Observers were able to abandon the color of the first target and maintain an ACS for the second one as long as there was a sufficient time interval between the two targets.

1. Introduction

Attentional selection makes people highly adaptive in a complicated environment and thus is critical for our survival. Attentional selection based on a unique feature of a target is one of the most important ways through which attention works. Studies have shown that people can selectively attend to objects that match a target-defining feature such as color and luminance (Du & Abrams, 2008, 2010; Folk, Remington, & Johnston, 1992; Folk, Remington, & Wright, 1994; Motter, 1994a; Motter, 1994b), orientation (Du & Abrams, 2012; Haenny, Maunsell, & Schiller, 1988; Haenny & Schiller, 1988; Maunsell, Sclar, Nealey, & DePriest, 1991), size (Becker, 2010), or motion direction (Maunsell & Treue, 2006; Serences & Boynton, 2007; Treue & Martinez-Trujillo, 1999), and sometimes even complicated figures (Chelazzi, Duncan, Miller & Desimone, 1998).

More interestingly, the effect of feature-based attention just described is able to override location-based selection. For example, Motter (1994a, 1994b) showed that prior knowledge of target color can enhance the neural response of many V4 cells which selectively respond to the target color and whose receptive-fields are spread across the whole visual field. Consistent with this line of physiological evidence, many behavioral studies revealed similar dominance of feature-based attention over location-based attention. For example, stimuli that match the color we are seeking can capture our attention even when they appear outside of the area of interest (Du & Abrams, 2008, 2010, 2012; Folk, Leber, & Egeth, 2002; Serences et al., 2005). This involuntary capture of attention is referred to as contingent capture because it is contingent upon the feature match between the target and the irrelevant distractors (Folk et al., 1992). As Folk and colleagues proposed, our attention is guided by our behavioral goals, with this type of guidance also known as an attentional control setting (ACS).

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Initially, Folk et al. (1994) found that when the target-defining feature was color, neither onset nor motion captured attention. When the target-defining feature was motion, both motion and onset but not color captured attention. Thus they proposed that ACSs could only be set to broad categories such as dynamic discontinuities (dynamic events such as the onset or movement) or static discontinuities (static features such as color or shape singletons). However, more and more converging evidence has shown that attentional control settings are highly flexible and can change according to specific task demands (Bacon & Egeth, 1994). For example, people can either precisely tune the ACS to a specific target color (Folk & Remington, 1998; Folk et al., 2002) or maintain multiple colors in their attentional control setting (Irons, Folk, & Remington, 2012). In addition to categorical information or specific feature values, recent studies showed that attentional control settings also maintain relational information of how the target differs from irrelevant distractors. Thus attention can be guided by the relationship between the target and distractors. For example, when the target (orange) is always redder than the yellow distractors, attention is captured by any distractor that is redder than yellow. As a result, both red and orange distractors capture attention (Becker, 2010; Becker, Folk, & Remington, 2010).

Only a few studies have ever examined whether our attentional control setting can integrate multiple features into one unified control setting. For example, one study showed that participants can simultaneously maintain separate attentional control settings at distinct spatial locations (Adamo, Pun, Pratt, & Ferber, 2008). It is tempting to conclude that people can integrate a unique color and a specific location into a conjunctive control set of attention (eg. red-left). However, a follow-up electrophysiological study showed that the selection of location occurred irrespective of attentional selection based on a color-match between cue and target. Thus the authors suggested that color-based and location-based selection of attention work in parallel and the attentional facilitation contingent upon a color-match occurred after spatial attention had been allocated to the cued location (Adamo, Pun, & Ferber, 2010).

To survive in the real world, observers might desire to change their attentional control settings often to adapt to a rapidly changing environment. Thus it is very important to know more about the temporal dynamics of changing ACSs. However, few studies have examined the temporal features of attentional control settings for multiple targets. Of interest in the present study is how observers represent the temporal order of multiple targets in ACSs. In order to test whether people can integrate a specific temporal order of targets with colors of multiple targets, we presented two colored targets in a RSVP stream at the center of the display, and some irrelevant distractors in the periphery. If observers can use the temporal order of multiple targets in attentional control settings perfectly, attention will only be captured by irrelevant distractors that match the current target. In addition, if observers can combine the temporal order with multiple target colors, it is unknown how long it takes observers to switch from one color to another in ACSs. We examined that question also.

2. Experiment 1

The present experiment was designed to examine how observers represent the temporal order of multiple targets in ACSs. A previous study showed that observers could make quick switches between multiple attentional control settings when the target color changed across trials (Lien, Ruthruff, & Johnston, 2010). But it is unknown whether observers can switch from one color to another in ACSs when they have to identify multiple targets in a single trial. In real life, people often have to deal with multiple events continuously rather than facing one event at a time. Thus it is important to test whether observers can combine the temporal order of multiple targets into their ACS when they have to monitor multiple targets in an RSVP stream of letters with multiple colors.

In the present study, observers were required to identify two specifically colored targets embedded in a RSVP stream of letters at the center of the display. If observers are perfectly efficient, a peripheral color singleton that matches the color of the first target (T1) should capture attention only when it appears before T1, and a peripheral color singleton that matches the color of the second target (T2) should capture attention only if it appears after T1 but before T2.

2.1. Methods

2.1.1. Participants

Twenty undergraduate students at Washington University participated in an hour-long experiment for course credit. All had normal or corrected-to-normal visual acuity. No participants had experience in similar experiments.

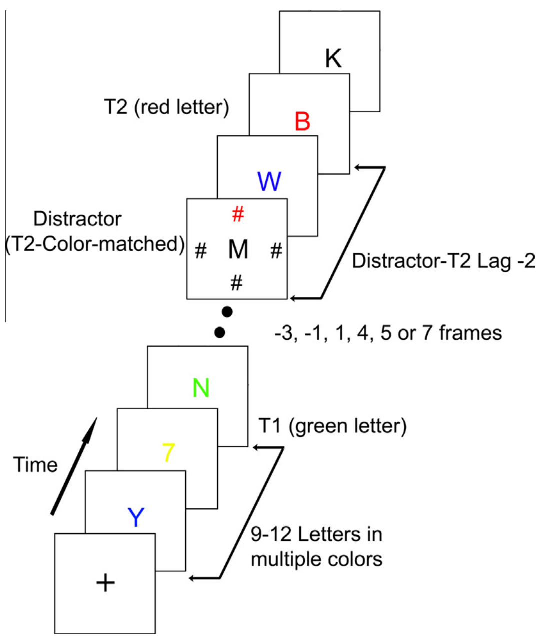

Fig. 1. A schematic representation of the procedure in Experiment 1. Each frame was presented for 40 ms, and followed by a blank interval of 40 ms.