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RESEARCH ARTICLE

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is noninformative with regard to the location of the subsequent target. It captures attention exogenously to the peripheral location, and its function is therefore usually

role, and consequently T2 would beneWt less from this rTPJ activation. A central cue, in contrast, would activate the dorsal network to signal top–down control and to facilitate target processing at the cued location. This positive signal would compensate for the inhibitory signal within the dorsal network. Presumably, target processing could beneWt from this relatively constant compensation both inside and outside the AB, in contrast to the transient circuit-breaker eVect induced by a peripheral cue.

As argued by Ghorashi et al. (2009), however, temporal integration between a target and its mask due to visual persistence (Di Lollo et al. 1994) might be a problem for exogenous cueing. Temporal integration is the phenomenon that a target and its mask are perceived as a single compound stimulus, because the blank interval between the target and the mask (i.e., inter-stimuli interval, ISI) is not long enough. In Experiment 4 of Nieuwenstein et al. (2005), the negligible exogenous cueing eVect outside the AB might be due to a ceiling eVect; that is, the T2 performance is degraded by the temporal integration and is limited to a certain level. To minimize the possible impact of temporal integration, Ghorashi et al. (2009), following Experiment 4 of Nieuwenstein et al. (2005), presented targets for a brief duration (13.3 ms). Between T2 and its mask, a critical ISI was inserted, with the duration of this ISI being varied dynamically and individually for each participant by parameter estimation sequential testing (PEST; Taylor and Creelman 1967), resulting in a level of 70% T2 accuracy. Using the dynamic ISI as the index of T2 performance, the authors found that exogenous cueing shortened the duration of the ISI, but this cueing eVect did not vary with T1–T2 lag. The authors concluded that spatial cueing and the AB have independent mechanisms.

Nevertheless, the PEST procedure, which measures target performance in terms of ISI, is not commonly used for studying the AB and has little comparability with previous studies measuring target report accuracy. To collect convergent evidence for the dissociation between exogenous and endogenous cueing in the AB, the present study directly compares both types of cueing in more conventional RSVP paradigm, using essentially the same task, stimuli, and procedure. In two experiments, exogenous and endogenous cues were used respectively, and two colored targets were embedded in triple, simultaneous RSVP streams of letters (Fig. 1; cf. Peterson and Juola 2000).

After T1 appeared in one of the streams, an exogenous cue (the sudden appearance of a frame at the location of one of the remaining streams; Experiment 1) or an endogenous cue (an arrow presented at the central Wxation position; Experiment 2) was presented, in half of the trials, to indicate the location where T2 would be presented. The cue was 100% valid with regard to the target location. The SOA between T1 and T2 (TOA) could be short (i.e., 376 ms; T2 inside the AB period) or long (752 ms; T2 outside the AB period), and the SOA between the cue and T2 (CTOA) could also be short (188 ms) or long (282 ms). To avoid the problems of ceiling eVect and temporal integration, a varying inter-stimulus interval (consisting of a blank screen) was inserted between consecutive frames in the RSVP display. While the SOA between frames was constant, the actual duration of each frame was determined for each participant by a pre-test, in which only one target was presented among a stream of distractors. The proper duration of each item was determined using a criterion of 70% target accuracy (cf. Shulman et al. 2003).

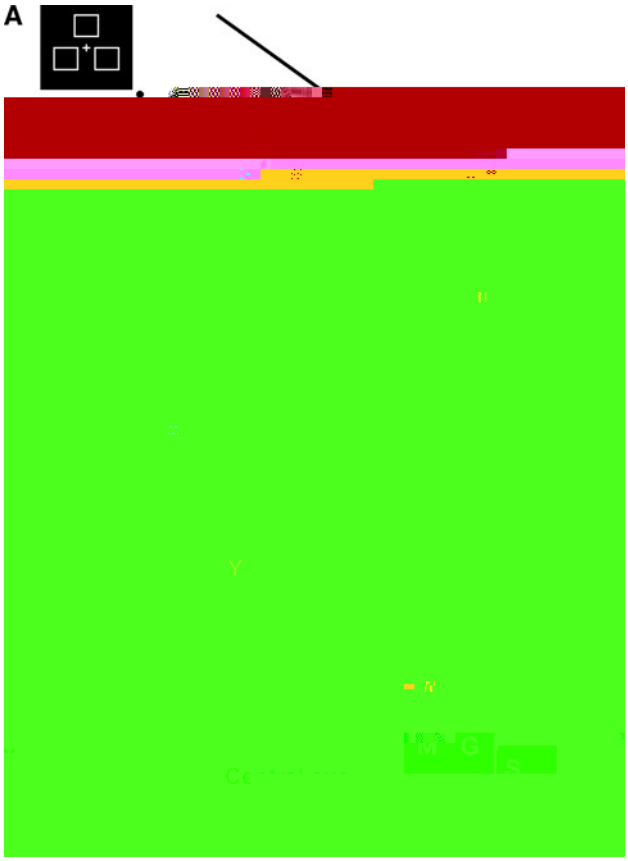

Fig. 1 Schematic representation of RSVP for Experiments 1 (**a**) and 2 (**b**), respectively. In both experiments, a trial started with a display consisting of a central Wxation and three frames indicating the positions of the upcoming RSVP streams. Subsequently, these frames were replaced by three RSVP streams while the central Wxation remained present. The RSVP streams consisted of , with serving as targets. Cues were inserted between the Wrst and second targets. A encircling a served as the peripheral cue in Experiment 1 (see **a**) and an replacing the central Wxation served as the central cue in Experiment 2 (see **b**)

Method

Participants

Forty right-handed students from Peking University were recruited in return for monetary compensation. Their ages ranged between 19 and 26 years, with a mean of 21 2.4 years. All the participants reported having normal color vision and normal or corrected-to-normal eyesight. They were randomly assigned to either Experiment 1 or Experiment 2.

Design

Experiments 1 and 2 adopted essentially the same within-subject design. The onset asynchrony between targets (TOA) had 2 levels, 376 and 752 ms (i.e., T2 presented at lag 4 or 8 following T1). A cue was present in 50% of the trials. In these cued trials, the onset asynchrony between the cue and T2 (CTOA) was either short (188 ms) or long (282 ms); that is, the cue was presented in the second or the third frame before T2.

Apparatus and stimuli

The experiments were run in a sound attenuated, dimly illuminated room, with stimuli presented on a 17″ CRT monitor running at a resolution of 1,024 768 pixels

processing and consolidation of T2 suVers from the limited resources depleted by T1 or from the bottleneck of post-perceptual processing of T1. However, the notion of a bottleneck or depletion of resources is incongruent with the present results. According to Jonides (1981), endogenous orienting elicited by a central cue is resource- and time-consuming; an increase in memory load or a decrease in the processing time of the cue would reduce the size of the cueing eVect. If during the AB period there are only limited resources available for processing the central cue, we would expect the cueing eVect to be smaller than when the

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that the endogenous orienting counteracts the inhibitory top–down signals during an AB. On average, the net benefit may be the same for both TOAs. In fact, it has been reported that when the processing of an endogenous cue is not deteriorated by the AB, e.g., a cue indicating TOA presented before each trial, endogenous attentional modulation of T2 performance is larger inside than outside the AB (Martens and Johnson 2005). To test the validity of this alterative account, more research is needed in which the stages of endogenous cueing are investigated separately.

In summary, although the dynamics of attentional selection in the spatial and the temporal domains have been extensively investigated along separate research lines, little is known about how spatial and temporal attentional selection might interact. The present study suggests that spatial exogenous and endogenous cueing may function via different mechanisms in interacting with attentional selection processes in the temporal domain.

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