Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/brainres

Brain Research

Research Report

# Neural correlates of reward-driven attentional capture in visual search

Senqing Qi[a,b], Qinghong Zeng[a], Cody Ding[a,c], Hong Li[a,b,*]

[a]Key Laboratory of Cognition and Personality, Ministry of Education, Department of Psychology, Southwest University, Chongqing 400715, China

[b]Research Center for Psychological Development and Education, Liaoning Normal University, Liaoning 116029, China

[c]University of Missouri, St. Louis, USA

ARTICLE INFO

*Article history:*
Accepted 25 July 2013
Available online 2 August 2013

*Keywords:*
Reward
Visual search
Attentional capture
N2pc
Distracter positivity (Pd)

ABSTRACT

Event-related potentials (ERPs) were used to investigate whether a physically non-salient and task-irrelevant stimulus feature previously associated with reward can capture attention. In the training phase, participants implicitly associated a certain color with reward. In the subsequent test phase, participants searched for a uniquely shaped singleton among non-target shapes, with color completely irrelevant to the current task demand. Response time was delayed on trials wherein the target was simultaneously presented with an associated distracter, compared with trials without one. In ERPs, a lateralized reward-associated distracter elicited an N2pc component when a concurrent target was presented on the vertical meridian. The control experiment discounted the possibility that this N2pc was caused by familiarity of the reward-associated distracter. Presenting both the target and reward-associated distracter on the opposite side elicited N2pc, with the reward-associated distracter-elicited N2pc preceding the target-elicited N2pc, albeit only in trials with slow responses. These results show that the participants shifted their attention to the target only after noticing the task-irrelevant reward-associated distracter in slow trials. Therefore, task-irrelevant reward-driven salience can capture attention. Distracter positivity was observed in fast distracter-present trials presenting both a lateral distracter and a midline target. Thus, the reward-associated distracter should be actively suppressed to efficiently select the task-relevant target. Lastly, the distracter-elicited N2pc was negatively correlated with individual differences in reward drive score. This correlation may provide insight into reward sensitivity problems.

© 2013 Elsevier B.V. All rights reserved.

## 1. Introduction

Given the limited processing capacity of the sensory systems of the human brain, selective attention systems must choose a subset of goal-relevant or physically salient stimuli and bring it to conscious awareness for further processing (Anderson et al., 2011; Corbetta and Shulman, 2002). Two major attentional mechanisms are related to attentional priority during such selection processes: a bottom-up, stimulus-driven mechanism (Theeuwes, 2010) and a top-down, goal-oriented

*Correspondence to: Key Laboratory of Cognition and Personality, Ministry of Education, Southwest University, Beibei, Chongqing 400715, China. Fax: +86 23 6825 2309.
*E-mail address:* lihong@lnnu.edu.cn (H. Li).

0006-8993/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.brainres.2013.07.044

control mechanism (Folk et al., 1992; Müller et al., 2003; Wolfe et al., 2003). Bottom-up selection is primarily driven by the physical salience of the stimulus. A stimulus that is salient relative to its neighbors evokes strong salience signals that are prioritized in the human perceptual system (Hickey et al., 2006; Theeuwes, 2010). By contrast, the top-down selection depends on the goals, knowledge, and expectations of a person (Eimer and Kiss, 2008; Folk et al., 1992; Wykowska and Schubö, 2010).

Complex visual stimuli that are physically non-salient but biologically significant to the organism, such as reward and emotional stimuli, also draw attention (Hodsoll et al., 2011; Kiss et al., 2009; Öhman and Mineka, 2001; Schacht et al., 2012). For instance, the reward magnitude of targets affects the efficiency of target selection, as reflected by an earlier and larger electrophysiological marker of visual selection for high-reward targets than for low-reward ones (Kiss et al., 2009). Thus, the value of a stimulus strongly modulates the allocation of voluntary attention. However, whether a physically non-salient task-irrelevant stimulus associated with value through reward learning can capture attention remains unclear.

Several studies have explored such possibility (Rutherford et al., 2010; Anderson et al., 2011). Rutherford et al. (2010) found that task-irrelevant faces associated with reward delay visual orientation to the target. Anderson et al. (2011) observed a delayed response time (RT) to the target when a non-salient and task-irrelevant stimulus feature previously associated with reward was simultaneously presented with the target. Eye movement studies have also examined the nature of the reward-driven inference effects described by Anderson et al. (2011). Theeuwes and Belopolsky (2012) found that a stimulus associated with high reward facilitates more significant oculomotor capture than that associated with low reward. However, Anderson and Yantis (2012) observed that a learned value (i.e., whether a distracter is associated with a high or low reward) does not affect the amount of oculomotor capture.

Whether the RT cost caused by a reward-associated distracter (Anderson et al., 2011) results from reward-driven attentional capture or from only a non-specific filtering cost should further be investigated. Non-specific filtering cost arises from the competition between distracter and target. Such competition prolongs pre-attentive processing and thus delays the shift of attention to target stimuli (Becker, 2007; Kiss et al., 2012). If the hypothesis of non-specific filtering cost is valid, attention does not shift to a reward-associated distracter. Given that behavioral measures cannot isolate the relevant attentional processes in reward-driven effects, whether the reward-driven RT cost results from early misguided attention to the reward-associated distracter is difficult to determine. Visual attention can also be covertly shifted to objects and locations without eye movements, which can provide only a link to study the allocation of overt attention to visual stimuli. Given these limitations in determining whether non-salient stimuli imbued with value via associative learning can capture attention, this study addressed this question by utilizing the high temporal resolution of event-related potentials (ERPs), focusing on the N2pc component. The N2pc component reflects the focusing of covert attention on a potential target item and the filtering of surrounding distracter items (Luck and Hillyard, 1994; Eimer, 1996; Mazza et al., 2009). N2pc is typically elicited at lateral parieto-occipital electrode sites contralateral to the location of an attended stimulus between 200 and 300 ms after the onset of a certain stimulus, such as a singleton target (Eimer, 1996; Luck and Hillyard, 1994; Woodman and Luck, 1999) or a physically salient distracter (Hickey et al., 2006) in a visual search task.

The N2pc component has been used as a neural marker to investigate the capability of physically salient yet task-irrelevant stimuli to capture attention (e.g., Hickey et al., 2006; Wykowska and Schubö, 2010; Kiss et al., 2012; Töllner et al., 2012). Hickey et al. (2006) used the additional-singleton paradigm to investigate whether a salient but task-irrelevant color singleton captures attention. Observers searched for a uniquely shaped singleton; a salient color singleton was included in several trials. A reliable N2pc component was triggered by color singleton distracters on trials with the target on the vertical meridian. Thus, these distracters captured attention although they were known to be task-irrelevant. In trials with the targets and distracters on the opposite side, a small distracter N2pc preceded the target N2pc, suggesting that attention was initially drawn to the distracter before it was reallocated to the target. These patterns confirm the bottom-up nature of attentional capture by salient visual events and refute the hypothesis that attentional capture is always under top-down control. However, attentional capture by color singletons depends on the task set (Eimer and Kiss, 2008; Wykowska and Schubö, 2010; Töllner et al., 2012).

By measuring the N2pc for the reward-associated distracter, we can further examine whether attention shifts to this distracter. The distracter used in our study significantly differs from those in prior studies (Hickey et al., 2006; Wykowska and Schubö, 2010; Kiss et al., 2012; Töllner et al., 2012) because the task-irrelevant distracter in our study is associated with reward but is physically non-salient. In our study, participants implicitly associated high reward with a specific color through reward learning in the training phase. In the subsequent test phase, participants were asked to search for a shape-singleton target; thus, color was irrelevant to the task. On half the trials, one of the non-target items was rendered in a formerly rewarded color. Based on the attentional capture hypothesis, we hypothesized that if the reward-associated distracter captures attention, it elicits N2pc in trials presenting both a lateral distracter and a midline target. Placing the target on the vertical meridian and the distracter on a lateral location makes the distracter for all N2pc components because stimuli on the vertical meridian do not elicit N2pc (Woodman and Luck, 1999; Hickey et al., 2006). If attention is first captured by the reward-associated distracter when both the target and reward-associated distracter are on the opposite side, the corresponding N2pc of the target exhibits an "inverse polarity." That is, a less negative N2pc to the target at the contralateral electrode sites relative to the ipsilateral electrode sites flips to a more negative one (Hickey et al., 2006). Nevertheless, the non-spatial filtering costs hypothesis indicates that no N2pc is elicited by the distracter in any experimental conditions.

Given that the ability to resist distraction constantly fluctuates (Leber, 2010), we compared "fast" and "slow" distracter trials under given conditions (as defined by an RT median

Download English Version:

https://daneshyari.com/en/article/6263507

Download Persian Version:

https://daneshyari.com/article/6263507

Daneshyari.com