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Priming effects under correct change detection and change blindness

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ABSTRACT

In three experiments, we investigated the priming effects induced by an image change on a successive animate/inanimate decision task. We studied both perceptual (Experiments 1 and 2) and conceptual (Experiment 3) priming effects, under correct change detection and change blindness (CB). Under correct change detection, we found larger positive priming effects on congruent trials for probes representing animate entities than for probes representing artifactual objects. Under CB, we found performance impairment relative to a “no-change” baseline condition. This inhibition effect induced by CB was modulated by the semantic congruency between the changed item and the probe in the case of probe images, but not for probe words. We discuss our results in the context of the literature on the negative priming effect.

1. Introduction

Observers often fail to notice substantial changes in a visual scene, when such changes coincide with other events that disrupts the motion signal normally associated with the changes (Simons & Rensink, 2005).[1] In the present investigation, we will consider the priming effects that are induced by detected changes and by undetected changes.

1.1. Change blindness

Change blindness (CB) has been studied with two different approaches: the “one-shot” task and the “flicker task” (for a review, see Jensen, Yao, Street, & Simons, 2011). In the “one-shot” task, participants are shown an original display, a blank, and then the changed display (Simons, 1996). In the “flicker task”, an original and changed image alternate back and forth, separated by a brief blank screen (Rensink, O’Regan, & Clark, 1997).

The extent to which observers show CB depends on several factors. The likelihood of CB is higher if the pre-change items are represented in memory with low fidelity (Hollingworth & Henderson, 2002), for objects that are not of central interest within a scene (Rensink et al., 1997), for items that had not been foveated (Henderson & Hollingworth, 1999), under conditions of high perceptual load (Lavie, 2006), and when fewer resources are available for encoding (McCarley et al., 2004). CB can occur with artificial stimuli and in the real world (Simons & Levin, 1998).

Several mechanisms have been proposed to explain why changes to images can go undetected. CB can reflect a representation failure (the post-change stimulus could disrupt access to the pre-change stimulus), a comparison failure (the pre-change representation might not have been encoded into memory, or the comparison between the pre-change and the post-change stimulus is not possible), or both (*e.g.*, Hollingworth, 2003; Rensink et al., 1997; Noë, Pessoa, & Thompson, 2000).

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[1] Failures of awareness have also been studied with other paradigms, such as the attentional blink (Raymond, Shapiro, & Arnell, 1992), repetition blindness (Kanwisher, 1987), and object masking (Boynton & Kandel, 1957).

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1.2. Priming under change blindness

An important research question is to determine what information, if any, is preserved under CB. The failure to consciously perceive a change, in fact, does not necessarily imply the absence of processing and encoding of the changes to an object or scene. Information from a stimulus change (hereafter called the "prime") might persist, even though it is not consciously available, and it might affect the processing of the subsequent stimulus (hereafter the "probe"). In order to address this question, researchers have asked whether an unattended scene or stimulus change is capable of priming.

Under correct change detection focused attention is given to the part of the visual scene being changed; the change is encoded in memory, and the pre-change information is compared to the post-change information. In these circumstances, *positive compatibility effects* (PCE) are observed, that is, response facilitation in compatible trials (*i.e.*, prime-probe pairs requiring the same response) and response hindering in incompatible trials (*i.e.*, prime-probe pairs requiring different responses) (*e.g.*, Silverman & Mack, 2006; Yeh & Yang, 2009).

But does stimulus information persist under CB? And is such information capable of priming? And, if priming is observed, do these priming effects involve access to abstract semantic representations, or do they occur at a more peripheral structural/perceptual processing level? The evidence for answering these questions is not conclusive. In the present research, we will examine these questions by considering the possible effects of an unperceived change on an immediately successive semantic categorization task.

1.3. Three hypotheses

Priming effects under CB are well documented when an image change is followed by a perceptual task (Fernandez-Duque & Thornton, 2000; Fernandez-Duque & Thornton, 2003; Laloyaux, Devue, Doyena, David, & Cleeremans, 2008; Laloyaux, Destrebecqz, & Cleeremans, 2006; Thornton & Fernandez-Duque, 2000). What has been less studied is whether CB can elicit priming effects on performance in a semantic task performed immediately after the image change (*e.g.*, word-picture matching, picture categorization, word categorization).[2] Three hypotheses can be derived from the literature.

1. The more extreme hypothesis is that, under CB, semantic priming does not occur at all: "in the face of change blindness, the change itself is not represented and can exert no influence on behavior" (Mitroff, Simons, & Franconeri, 2002, p. 814).
2. A second hypothesis is that non-perceived changes can still produce positive compatibility effects (PCE) on an immediately successive semantic response (*i.e.*, performance benefits on compatible prime-probe pairs and performance costs on incompatible prime-probe pairs).
3. A third hypothesis is that non-perceived changes produce negative compatibility effects (NCE) on an immediately successive semantic response (*i.e.*, performance costs on compatible prime-probe pairs).

Even though it is counter-intuitive, the third hypothesis is supported by several lines of evidence. Evidence of negative priming for ignored objects comes from the study of briefly-presented natural scenes. For example, in an experiment by VanRullen and Koch (2003) observers were asked to recall the objects within a visual scene that was shown for 250 ms and then masked. In a word-picture go/no-go matching task performed immediately after, VanRullen and Koch found that the objects that had been previously explicitly recognized elicited a positive priming effect, whereas the "ignored" objects (those that did not enter visual awareness) elicited a reliable negative priming effect (see also Gordon, 2006).

Support for the third hypothesis also comes from the masked priming literature, where it has been shown that the sign of the priming effect depends on the visibility of the prime (Eimer & Schlaghecken, 2003; Sumner, 2007; Sumner, Tsai, Yu, & Nachev, 2006). For example, Frings and Wentura (2005) asked participants to perform a naming task for a probe word preceded by a masked prime. They found a PCE in participants who were aware of the prime and a NCE in participants who were unaware of the prime.

A neural habituation priming model has been proposed to explain the change from positive to negative priming in masked priming experiments (Huber, 2008; Huber, Shiffrin, Quach, & Lyle, 2002; Huber, Shiffrin, Lyle, & Quach, 2002; Rieth & Huber, 2010; Weidemann, Huber, & Shiffrin, 2005). In their ROUSE model, Huber and collaborators argued that prime and probe stimuli give rise to noisy representations that are subject to source confusion. In order to recognize the probe, participants must "discount" from the decision about the probe the feature activity that is associated with the prime. The positive priming effects arise from the fact that the prime-related activity is not completely removed from decision about the probe (facilitation). But, under some circumstances, the prime-related activity is overestimated and the discounting mechanism introduces a bias against the features in the prime, producing a performance cost for probe stimuli that have the same features as the prime stimuli. This over-discounting of the activation of the features of the prime thus results in a

[2] There is a long-standing debate about the amount of processing of sensory input that occurs before conscious perception (*e.g.*, Hannula, Simons, & Cohen, 2005). Early-selection models postulate that semantic content is available only after attention selection and, therefore, it is necessarily associated with awareness (*e.g.*, Broadbent, 1987). According to such models, therefore, the processing of unattended information may only be limited to the earliest stages of perceptual analysis.