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Research Report

The fate of object memory traces under change detection and change blindness

Niko A. Busch[a,b,*]

[a]Institute of Medical Psychology, Charité–Universitätsmedizin, Berlin, Germany
[b]Berlin School of Mind and Brain, Humboldt Universität zu, Berlin, Germany

ARTICLE INFO

Article history:
Accepted 8 May 2013
Available online 15 May 2013

Keywords:
EEG
Long-term memory (LTM)
Short-term memory (STM)
Attention
Inattentional blindness
Awareness
Consciousness

ABSTRACT

Observers often fail to detect substantial changes in a visual scene. This so-called change blindness is often taken as evidence that visual representations are sparse and volatile. This notion rests on the assumption that the failure to detect a change implies that representations of the changing objects are lost all together. However, recent evidence suggests that under change blindness, object memory representations may be formed and stored, but not retrieved. This study investigated the fate of object memory representations when changes go unnoticed. Participants were presented with scenes consisting of real world objects, one of which changed on each trial, while recording event-related potentials (ERPs). Participants were first asked to localize where the change had occurred. In an additional recognition task, participants then discriminated old objects, either from the pre-change or the post-change scene, from entirely new objects. Neural traces of object memories were studied by comparing ERPs for old and novel objects. Participants performed poorly in the detection task and often failed to recognize objects from the scene, especially pre-change objects. However, a robust old/novel effect was observed in the ERP, even when participants were change blind and did not recognize the old object. This implicit memory trace was found both for pre-change and post-change objects. These findings suggest that object memories are stored even under change blindness. Thus, visual representations may not be as sparse and volatile as previously thought. Rather, change blindness may point to a failure to retrieve and use these representations for change detection.

1. Introduction

Subjective visual experience suggests that we have access to a rich and stable representation of a visual scene. However, this intuition has been challenged by results obtained with the "change blindness" paradigm (see Rensink, 2002; Simons and Rensink, 2005, for reviews). This line of research has demonstrated that observers are often unable to detect large changes in a scene when the change occurs simultaneously with a brief visual disruption, be it a saccade (McConkie and Currie, 1996; Hayhoe et al., 1998), an eye blink (O'Regan et al., 2000), a flicker (Rensink et al., 1997), or a distracting stimulus

*Correspondence address: Charité Universitätsmedizin, Institut für Medizinische Psychologie, Luisenstr. 57, 10117 Berlin, Germany. Fax: +49 30 450 529 990.
E-mail address: niko.busch@charite.de

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http://dx.doi.org/10.1016/j.brainres.2013.05.014

(O'Regan et al., 1999). Under these conditions, a change cannot be detected directly by detecting the motion or contrast transient. Instead, change detection depends on preserving and comparing object representations of pre-change and post-change objects. Change blindness obviously points to a limit in our ability to represent, process, and maintain visual scenes. But which of the numerous perceptual processes involved in change detection is subject to this limit?

In order to detect a change, an observer has to process and represent visual information through a number of stages. First, the pre-change display must be encoded, and the representation of the pre-change display must be maintained in short-term or long-term memory, or both. Second, the post-change display must be encoded and maintained. Third, pre-change and post-change information must be compared, based on either information currently active in short-term memory or on information retrieved from long-term memory. Finally, the observer needs to make a decision as to whether a change has or has not occurred.

Several authors have argued that change blindness results from a limitation at the encoding stage (O'Regan, 1992; Blackmore et al., 1995). Proponents of this view argue that the capacity to represent visual information is strongly limited and suggest that we represent no more than the semantic and structural gist of a scene plus a small portion of the scene's details, which are currently attended. A strong interpretation of the change blindness phenomenon is that our every-day intuition is wrong—visual representations may be, in fact, more sparse than we believe. An alternative account argues that change blindness can result from a failure to form a stable representation in short-term or long-term memory. Thus, as long as the scene is in view, visual representations may be rich, in line with our phenomenology of a rich experience. However, these representations are volatile and are easily overwritten once the original scene disappears and the modified scene is presented (Becker and Pashler, 2002; Landman et al., 2003; Beck and Levin, 2003). Another cause for change blindness has been demonstrated by Mitroff et al. (2004) who found that sometimes observers are able to recognize both pre-change and post-change objects in a subsequent memory test even when they were blind to the changes made to these objects, indicating that change blindness can result as well from a failure to compare existing representations of pre- and post-change information. Recently, a number of behavioral studies have investigated the role of long-term memory in change detection. Performance on memory tasks, that require recognition of the changing objects, is often better than change detection performance, suggesting that object memory traces for the changing object are formed, but are not used in the change detection task (Varakin and Levin, 2006; Hollingworth, 2005; Hollingworth and Henderson, 2002; Beck et al., 2007). Other authors have demonstrated that cues presented after the change has occured improve change detection performance by facilitating retrieval of object information from long-term memory (Hollingworth, 2003; Beck and van Lamsweerde, 2011). In sum, these studies have found that change blindness can as well result from a failure to retrieve object representations from long-term memory, in spite of existing memory representations.

The present study investigated the fate of object representations in long-term memory under change blindness. To my knowledge, this is the first study combining a change detection paradigm with a subsequent recognition memory task that investigates neural markers of memory representations under change blindness. Participants were presented with scenes consisting of familiar, nameable objects, one of which changed on each trial, while recording event-related potentials (ERPs). Participants were asked to detect changes and report their location. In an additional recognition task, participants were to discriminate old objects, either from the pre-change or the post-change scene, from entirely new objects. The analysis focused on the ERP-difference between old and new items presented in the recognition task. If change blindness was only due to a capacity limit during encoding or maintenance, or due to overwriting, the visual system should not be able to recognize the changing objects as old under change blindness, and no ERP old/new effect should ensue. If, however, change blindness can result from a failure to retrieve object representations from memory during detection, it might be possible to observe a memory effect (i.e. old/new ERP differences) in the subsequent recognition task even when the change detection task had failed. Indeed, I found a robust ERP difference between old and novel objects in spite of change blindness, indicating that traces of object memories persisted even when changes to these objects were not noticed. Importantly, this effect was found even when both localization and recognition failed. This finding suggests that in addition to limited capacity for encoding and overwriting, change blindness can also occur when the visual system fails to retrieve object representations from memory.

2. Results

2.1. Behavioral results

Participants correctly localized the change on 48% of all trials (see Table 1).

Table 1 – Behavioral performance in the change localization task and the old/new recognition task. The table gives average proportion correct (and standard error of the mean) relative to the number of pre-change and post-change trials.

	Pre-change		Post-change	
	Loc. correct	Loc. incorrect	Loc. correct	Loc. incorrect
Rec. correct	0.30 (0.02)	0.28 (0.02)	0.46 (0.03)	0.30 (0.02)
Rec. incorrect	0.17 (0.01)	0.24 (0.01)	0.03 (0.01)	0.21 (0.02)