Change blindness in a dynamic scene due to endogenous override of exogenous attentional cues

Citation for published version:
Smith, TJ, Lamont, P & Henderson, JM 2013, 'Change blindness in a dynamic scene due to endogenous override of exogenous attentional cues' Perception, vol 42, no. 8, pp. 884-886., 10.1068/p7377

Digital Object Identifier (DOI):
10.1068/p7377

Published In:
Perception

Perception, 2013, volume 42, pages 884–886

doi:10.1068/p7377

SHORT AND SWEET

Change blindness in a dynamic scene due to endogenous override of exogenous attentional cues

Tim J Smith[1], Peter Lamont[2], John M Henderson[3]
[1] Department of Psychological Sciences, Birkbeck, University of London, Malet Street, London WC1E 7HX, UK; e-mail: tj.smith@bbk.ac.uk; [2] Psychology, University of Edinburgh; [3] Institute for Mind and Brain, University of South Carolina
Received 13 September 2012, in revised form 5 June 2013

Abstract. Change blindness is a failure to detect changes if the change occurs during a mask or distraction. Without distraction, it is assumed that the visual transients associated with the change will automatically capture attention (*exogenous* control), leading to detection. However, visual transients are a defining feature of naturalistic dynamic scenes. Are artificial distractions needed to hide changes to a dynamic scene? Do the temporal demands of the scene instead lead to greater *endogenous* control that may result in viewers missing a change in plain sight? In the present study we pitted endogenous and exogenous factors against each other during a card trick. Complete change blindness was demonstrated even when a salient highlight was inserted coincident with the change. These results indicate strong endogenous control of attention during dynamic scene viewing and its ability to override exogenous influences even when it is to the detriment of accurate scene representation.

Keywords: dynamic scene, change blindness, eye movements, visual attention, magic, cuing

What we remember of a visual scene is a result of where we attend and which details of attended locations we encode in memory. One of the most striking demonstrations of the interaction between attention and memory is *change blindness*. Change blindness is the failure to detect an obvious change to a scene if the change occurs during a flicker, an eye movement, or another onset such as a mudsplash. For example, Rensink and colleagues (1997) demonstrated that a disappearing plane engine was hard to identify if flickers were inserted between altered versions of the photograph. The flicker masks the visual transients associated with the change that would otherwise automatically (ie *exogenously*) capture attention and lead to detection.

Masks or brief periods of occlusion have also been used to hide changes in dynamic scenes (eg Levin and Simons 1997). A coin can be switched with another coin whilst the viewer fixates it as long as the viewer is attending to whether the coin is a head or tail and the change happens during a brief occlusion by the hands (Smith et al 2012). However, dynamic scenes, by definition, contain natural visual transients. Are artificial distractions necessary to hide a change in a dynamic scene? Whilst watching a dynamic scene, viewers must decide on how to distribute attention in space and time in order to optimise information uptake. This *endogenous* control of attention must coordinate the viewer's expectations about what is relevant with the demands of the stimulus. Endogenous control has been shown to limit capture by stimulus features in simple displays (Folk et al 1992). Does a similar tempering of exogenous control occur during dynamic scenes, and can it be used to hide a change in plain sight?

In the present study we asked whether viewers can be made blind to a change in a dynamic scene through endogenous control and whether this can be overridden by exogenous capture of attention. In our study viewers watched a video of a simple card-counting task (supplementary video 1). (We encourage readers to view the video now before reading on.) The video depicted a man's hands as he unpacked a deck of blue-backed cards and then dealt them face up on the table. The audio narration instructed viewers to "count exactly how many red cards are dealt."

In the reveal the backs of all of the cards were shown to have changed colour from blue to red. It is only at this point that participants realise they have been watching a card trick. The secret behind the colour change was simple: only the first few cards had blue backs, all the rest had red backs, and it is these that the dealer turns over at the end (figure 1). The critical feature (the change from blue to red; figures 1a and 1b) was in clear view, was task-relevant (participants were counting 'red'-faced cards), and was only 3.4 deg from the attended cards.

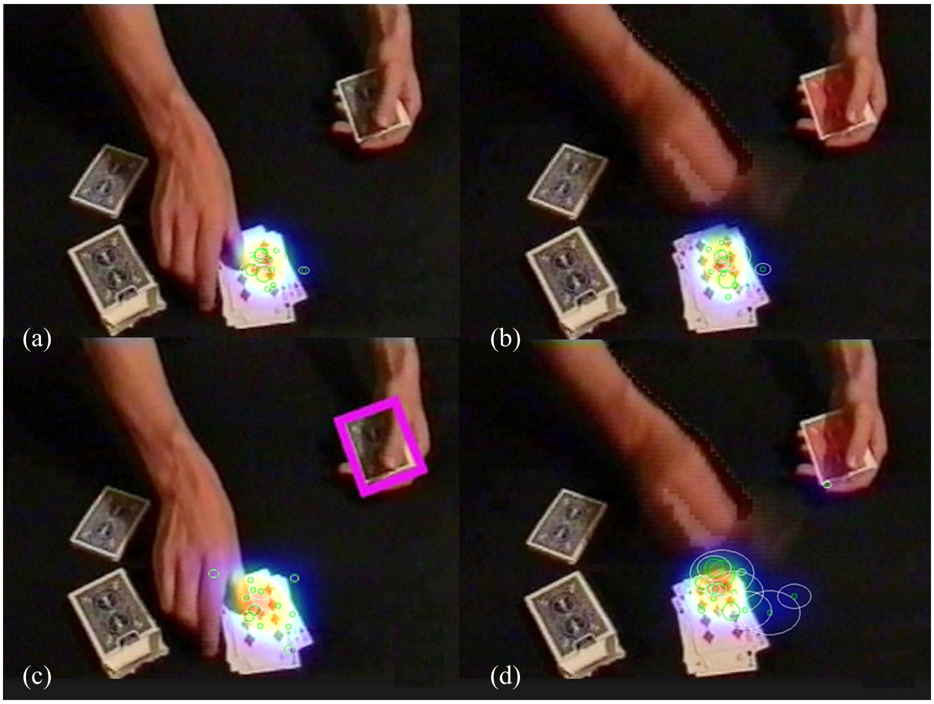

Figure 1. [In colour online, see http://dx.doi.org/10.1068/p7377] Screen shots from the video used in all experiments. Ellipses represent gaze locations of fifteen participants from each experiment. Diameter of ellipse indicates fixation duration, and heatmap indicates degree of gaze clustering (more clustered = hotter colour). (a) Experiment 1: 480 ms preceding the change of the backs of the cards from blue to red; (b) Experiment 1: 240 ms following the colour change; (c) Experiment 3: the pink outline of the cards in the dealer's hand presented in experiments 2 and 3; (d) Experiment 3: following the onset and 240 ms after the colour change.

In experiment 1 we showed fifteen participants the video whilst their eye movements were recorded (with an Eyelink 1000). After the video, participants were asked if they had seen when the card backs had changed colour. Various fanciful guesses were offered, but none of the fifteen participants reported seeing the cards change colour. Eye-tracking data collected during the video showed that all participants fixated the faces of the cards (see supplementary video 2). Participants were shown the video a second time and instructed not to count the cards. During this second presentation of the video most participants (13 out of 15) looked at the backs of the cards (supplementary video 3), and reported seeing the colour change after the video finished. This increase in detection across presentations was significant (McNemar exact binomial $\text{test}_1 = 10.083$, $p < 0.001$).

How robust is participant belief that only the card faces are relevant (ie their endogenous control of attention)? Can attention be exogenously drawn to the location of the change? To investigate this question, we replicated the experiment with a new set of fifteen viewers. In experiment 2 a sudden colour onset (a 240 ms bright pink outline to the deck of cards) was used to try to 'pull' attention to the deck of cards just before the colour change. Similar unexpected onsets have increased change detection in static flicker paradigms (Scholl 2000).

Even in this condition, eye-tracking revealed that viewers continued to fixate the card faces, ignoring the visual transient (supplementary video 4). Once again, none of the fifteen viewers reported seeing the card backs change colour. As in the first experiment, most of the viewers (12 out of 15) noticed the changing colour during second viewing and looked directly at the card backs (a significant increase from the first viewing; McNemar exact binomial $test_1 = 11.077$, $p < 0.001$).

Owing to the dynamic nature of the stimuli and the predictable trajectory of the cards as they are dealt, it is possible that participants selectively filter out irrelevant transients such as the salient outline. In experiment 3 we endeavoured to remove this filter by instructing participants both to count the number of red cards and to report a 'pink flash' via button press. Nine of the fifteen participants reported seeing the flash, with four participants even saccading towards the deck of cards in response to the onset (supplementary video 5). Nevertheless, none of the participants noticed the colour change. All fifteen participants noticed the change during second viewing (a significant increase from the first viewing; McNemar exact binomial $test_1 = 13.067$, $p < 0.001$).

In summary, 45 out of 45 participants failed to notice a colour change that took place close to fixation during first viewing. The majority of participants (40 out of 45) were able to detect the change during a second viewing (no significant difference across experiments; Fisher's Exact $\chi^2_2 = 3.120$, $p = 0.343$, ns). Our results demonstrate that expectations about the relevant features and locations within a dynamic scene can override stimulus factors competing for attention and even limit detection of an otherwise salient visual change near fixation. This study extends previous findings of failure to detect changes in an edited dynamic scene (Levin and Simons 1997), the presence of an object in a dynamic scene [ie *inattentional blindness* (eg Simons and Chabris 1999)], and the use of misdirection to hide small changes, such as a dropped cigarette (Kuhn and Tatler 2005), by demonstrating that large changes to a scene do not need to be artificially masked or hidden within a complex event if the viewer chooses to look away from the change. Control of attention during dynamic visual scenes is much more complex than observed in static scenes and closely related to our spatiotemporal expectations about the events depicted.

Acknowledgments. This project was funded by the Leverhulme Trust (Ref F/00-158/BZ) awarded to JMH and a University of London starter grant awarded to TJS. Thanks to Rachael Bedford for statistical advice and Parag K Mital for use of CARPE for dynamic heatmap generation. The trick was created by Peter Lamont and Richard Wiseman, as part of a "Psychology of magic" project funded by the Wellcome Trust in 2001, and subsequently published in MAGIC magazine (2003 "The deja vu colour changing deck" *MAGIC* **11** 87–88).

References

Folk C L, Remington R W, Johnstone J C, 1992 "Involuntary covert orienting is contingent on attentional control settings" *Journal of Experimental Psychology: Human Perception and Performance* **18** 1030–1044

Kuhn G, Tatler B W, 2005 "Magic and fixation: Now you don't see it, now you do" *Perception* **34** 1153–1161

Levin D T, Simons D J, 1997 "Failure to detect changes to attended objects in motion pictures" *Psychonomic Bulletin & Review* **4** 501–506

Rensink R A, O'Regan J K, Clark J J, 1997 "To see or not to see: the need for attention to perceive changes in scenes" *Psychological Science* **8** 368–373

Scholl B J, 2000 "Attenuated change blindness for exogenously attended items in a flicker paradigm" V*isual Cognition* **7** 377–396

Simons D J, Chabris C F, 1999 "Gorillas in our midst: sustained inattentional blindness for dynamic events" *Perception* **28** 1059–1074

Smith T J, Lamont P, Henderson J M, 2012 "The penny drops: Change blindness at fixation" *Perception* **41** 489–492