The penny drops: change blindness at fixation

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SHORT AND SWEET

The penny drops: Change blindness at fixation

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Abstract. Our perception of the visual world is fallible. Unattended objects may change without us noticing as long as the change does not capture attention (*change blindness*). However, it is often assumed that changes to a fixated object will be noticed if it is attended. In this experiment we demonstrate that participants fail to detect a change in identity of a coin during a magic trick even though eyetracking indicates that the coin is tracked by the eyes throughout the trick. The change is subsequently detected when participants are instructed to look for it. These results suggest that during naturalistic viewing, attention can be focused on an object at fixation without including all of its features.

Keywords: magic, change blindness, eye movements, attention, object perception

Our perception of a visual scene is incomplete and constructed over time from attended details. The selective nature of attention allows objects to pass by unnoticed, if they are irrelevant to the viewing task (*inattentional blindness*—Mack and Rock 1998) and changes to be missed, if they do not capture attention (*change blindness*—Simons and Levin 1998). Classic demonstrations have shown that a gorilla may pass through a scene unnoticed, if attention is occupied elsewhere in the scene (Simons and Chabris 1999) and a change in the identity of a conversational partner may be missed, if attention is distracted (Simons and Levin 1998). It is typically assumed that changes to a fixated object will be noticed, unless spatial attention is focused on another part of the scene (Mack and Rock 1998).

However, several earlier studies have suggested that change blindness may also exist at fixation. While viewing an edited sequence depicting motion of a character, participants failed to detect a change in identity of the actor across a cut (Levin and Simons 1997). The actor's face was assumed to be the centre of attention in the scene, although participants were not eyetracked so this could not be confirmed. In a replication of the Simons and Chabris inattentional blindness study, Memmert (2006) showed that the fixation location of children did not predict their likelihood of detecting the unexpected gorilla. Similar evidence of object detection without fixation has been shown by Kuhn and colleagues across a series of studies using magic tricks (Kuhn and Tatler 2005; Kuhn et al 2008a, 2008b). Recording eye fixation during live and pre-recorded magic tricks revealed no effect of eccentricity of gaze on detection of the event critical to the trick (Kuhn and Tatler 2005; Kuhn et al 2008b). Failure to detect changes to object features has also been shown during an interactive task in virtual reality (Triesch et al 2003).

All of the studies cited above suggest that awareness of objects, events, and features may not be guaranteed by fixation. However, these demonstrations all utilise highly

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complex scenes, distraction, or interactive tasks that may have encouraged attention to survey the scene independent of fixation. The objective of the present study was to investigate whether change blindness can occur at fixation in simpler naturalistic scenes in which attention and fixation are coupled.

In this study we constructed a series of videos in which an object was attended while it changed. An appendix to this paper as well as movie files are available online at http://dx.doi.org/10.1068/p7092. The videos depicted a pair of hands passing a coin and then dropping it on the table (figure 1). The participant's task was to guess whether the coin would land with heads or tails facing up. During a critical trial the coin was secretly switched as it was briefly occluded by the hand. Three blocks of videos were presented, each consisting of four coin drops. The third coin drop always contained the coin change. Across the three blocks, the coin changed from a UK 1p to 2p (figure 2—top row; movie S1), 50p to old 10p (figure 2—middle row; movie S2), and US quarter to Kennedy half dollar (figure 2—bottom row; movie S3).

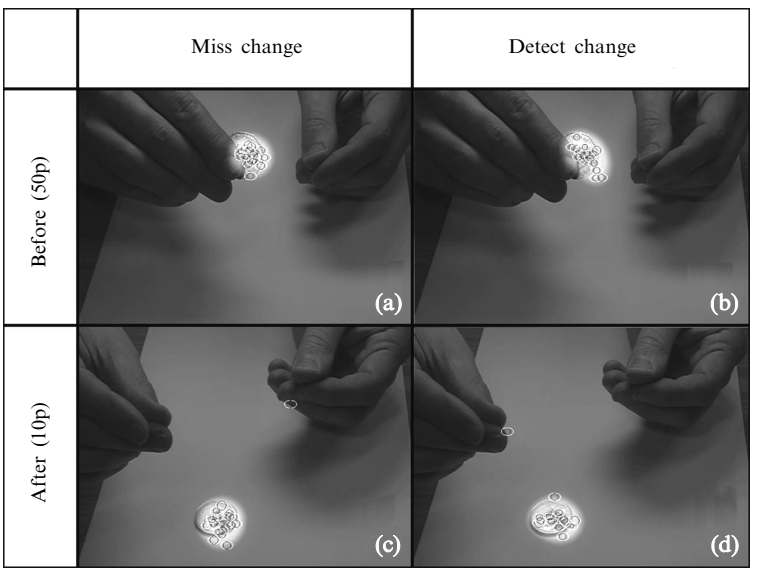

Figure 1. Participants guessed whether the coin would land head or a tail. The coin begins as a 50p (a and b) and was switched with a 10p as it passed between the hands [(c) and (d)]. (a) and (c) represent the gaze of twenty-three participants (out of twenty-six) who failed to detect the coin change during the first viewing. (b) and (d) represent the gaze of the nineteen participants (twenty-one total) who detected the coin change during the final viewing. Videos were presented in colour during experiment.

Twenty-six participants viewed the videos while their eye movements were recorded. After the first presentation of all three videos, participants were asked if they noticed "anything else". None of the participants reported seeing the 1p to 2p change, 88.5% of participants failed to report the 50p to 10p change and 96.1% missed the quarter to half dollar change. The eye-movement recordings confirmed that all participants were fixating the coin during its entire time on screen (figures 1a and 1c).

All participants were shown the videos again without having to guess heads or tails. After the second viewing, 80.8% of participants missed the 1p to 2p change, 53.8% failed to report the 50p to 10p change, and 53.8% missed the quarter to half dollar change. Participants were again seen to fixate the coin during its entire time on screen.

Finally, if participants had failed to report all of the coin changes (twenty-one participants) they were asked directly if they had noticed the coins change. Most participants

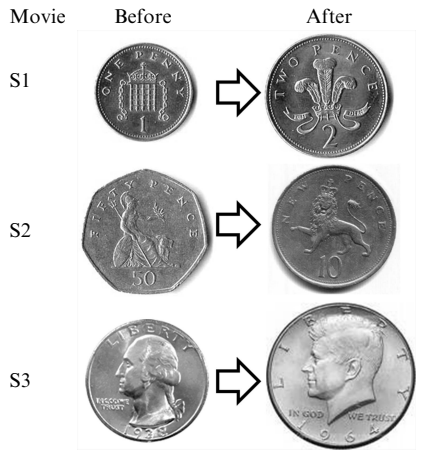

Figure 2. The coins used in the three movies (movie S1 – S3). The British 1p and 2p were copper and the rest of the coins were silver.

expressed shock that the coin had changed without them noticing. They were shown the videos a third time and asked to explicitly detect the coin change. 57.1% (12/21) of participants noticed the 1p to 2p change, and virtually all of the participants (90.5%) noticed the 50p to 10p change and the quarter to half dollar change (90.5%). Eye tracking confirmed that, as in the previous two presentations, participants were fixating the coin during its entire time on screen (figures 1b and 1d).

These results demonstrate that fixating an object during a dynamic naturalistic task and attending to features that are indicative of its identity does not guarantee that a change in identity will be noticed. Both subtle changes, such as the size difference between 1p and 2p, and the large changes, such as the shape difference between 50p and 10p, were perceivable by the majority of participants but only when instructed to look for them. The different detection rates suggest that viewers may be more sensitive to some features (eg shape or colour) than others (eg size). Further experiments are required to investigate whether there is a default hierarchy of features represented during naturalistic viewing, or whether the tracked features rely on relevance to viewing task.

These findings differ from previous evidence of inattentional blindness at fixation (Mack and Rock 1998) as attention was not shifted away from fixation or to an overlapping but irrelevant object when the change was missed. They are also distinct from studies that have used prolonged occlusion (Simons and Levin 1998) or saccades to mask the change (Henderson and Hollingworth 2003), as the occlusion used in this study was very brief ($\sim$325 ms on average) and the eyes fixated the location of the coin throughout this period, removing any extended demands on transsaccadic or working memory. Our results confirm prior reports of change blindness during object pursuit in complex naturalistic and virtual environments (Kuhn and Tatler 2005; Kuhn et al 2008b; Memmert 2006; Triesch et al 2003) and extend it to simpler naturalistic dynamic scenes in which competition for attention is minimised.

Our results suggest that, during naturalistic dynamic events, attention may be focused on an object without including its constituent features including the object's identity. An object can change right before our eyes without us even noticing.

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