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.

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 & Rock, 1998) and changes to be missed if they do not capture attention *(change blindness;* Simons & Levin, 1998). Classic demonstrations have shown that a gorilla may pass through a scene unnoticed if attention is occupied elsewhere in the scene (Simons & Chabris, 1999) and a change in the identity of a conversational partner may be missed if attention is distracted (Simons & 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 & 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 & 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 (1999), 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, Amlani, & Rensink, 2008; Kuhn & Tatler, 2005; Kuhn, Tatler, Findlay, & Cole, 2008). 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 & Tatler, 2005; Kuhn, Tatler, et al., 2008). Failure to detect changes to object features has also been shown during an interactive task in virtual reality (Triesch, Ballard, Hayhoe, & Sullivan, 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 utilize highly 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. 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; MovieS1), 50p to old 10p (Figure 2-Middle Row; MovieS2), and US Quarter to Kennedy Half Dollar (Figure 2-Bottom Row; MovieS3).

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 (Figure 1, A and C).

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 (21 participants) they were asked directly if they had noticed the coins change. Most participants 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 (Figure 1; B and D).

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 (e.g. shape or color) than others (e.g. 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 & 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 & Levin, 1998) or saccades to mask the change (Henderson & Hollingworth, 2003), as the occlusion used in this study was very brief (~325ms on average) and the eyes fixated the location of the coin throughout this period, removing any extended demands on transaccadic or working memory. Our results confirm prior reports of change blindness during object pursuit in complex naturalistic and virtual environments (Kuhn & Tatler, 2005; Kuhn, Tatler, et al., 2008; Memmert, 2006; Triesch, et al., 2003) and extend it to simpler naturalistic dynamic scenes in which competition for attention is minimized.

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.

Acknowledgments

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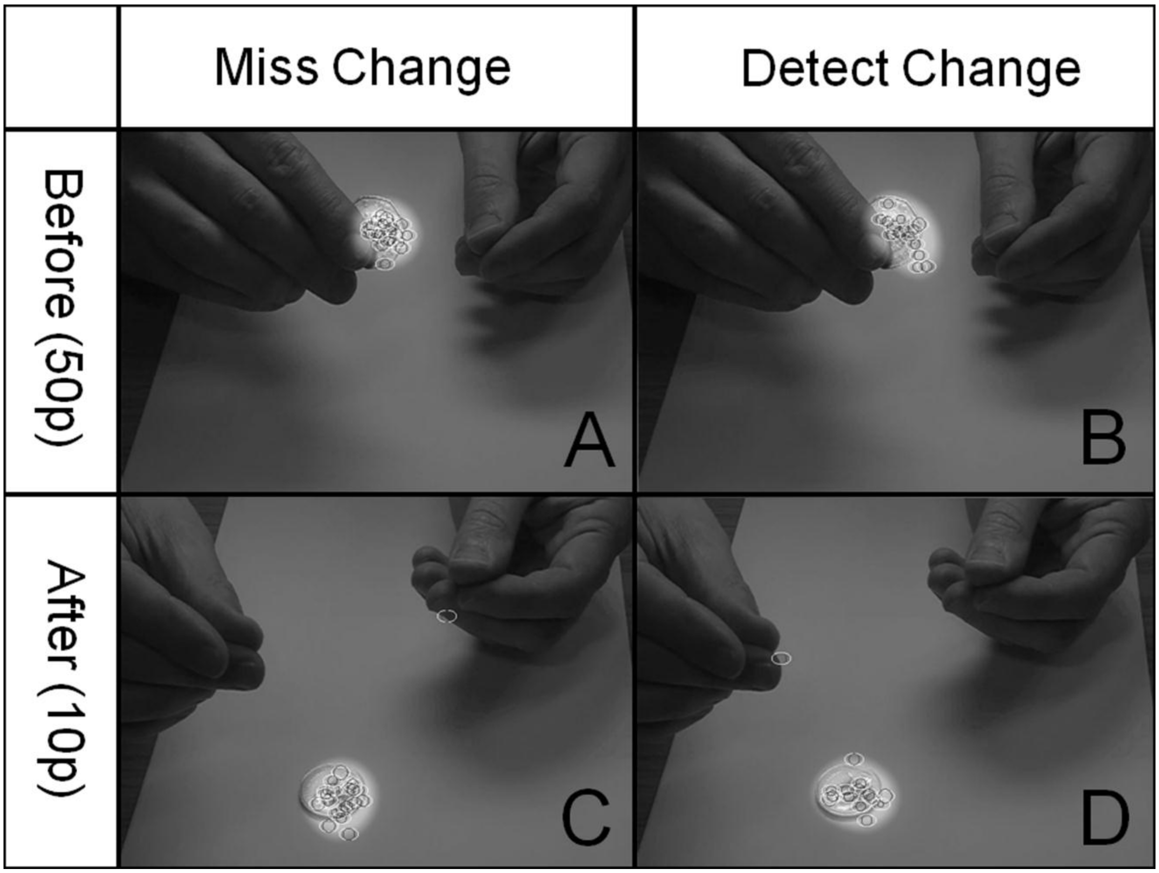

Figure 1: Participants guessed whether the coin would land Head or a Tail. The coin begins as a 50p (A and B) and was switched with a 10p as it passed between the hands (C and D). A and C represent the gaze of 23 participants (out of 26) who failed to detect the coin change during the first viewing. B and D represent the gaze of the 19 participants (21 total) who detected the coin change during the final viewing. Videos were presented in color during experiment.

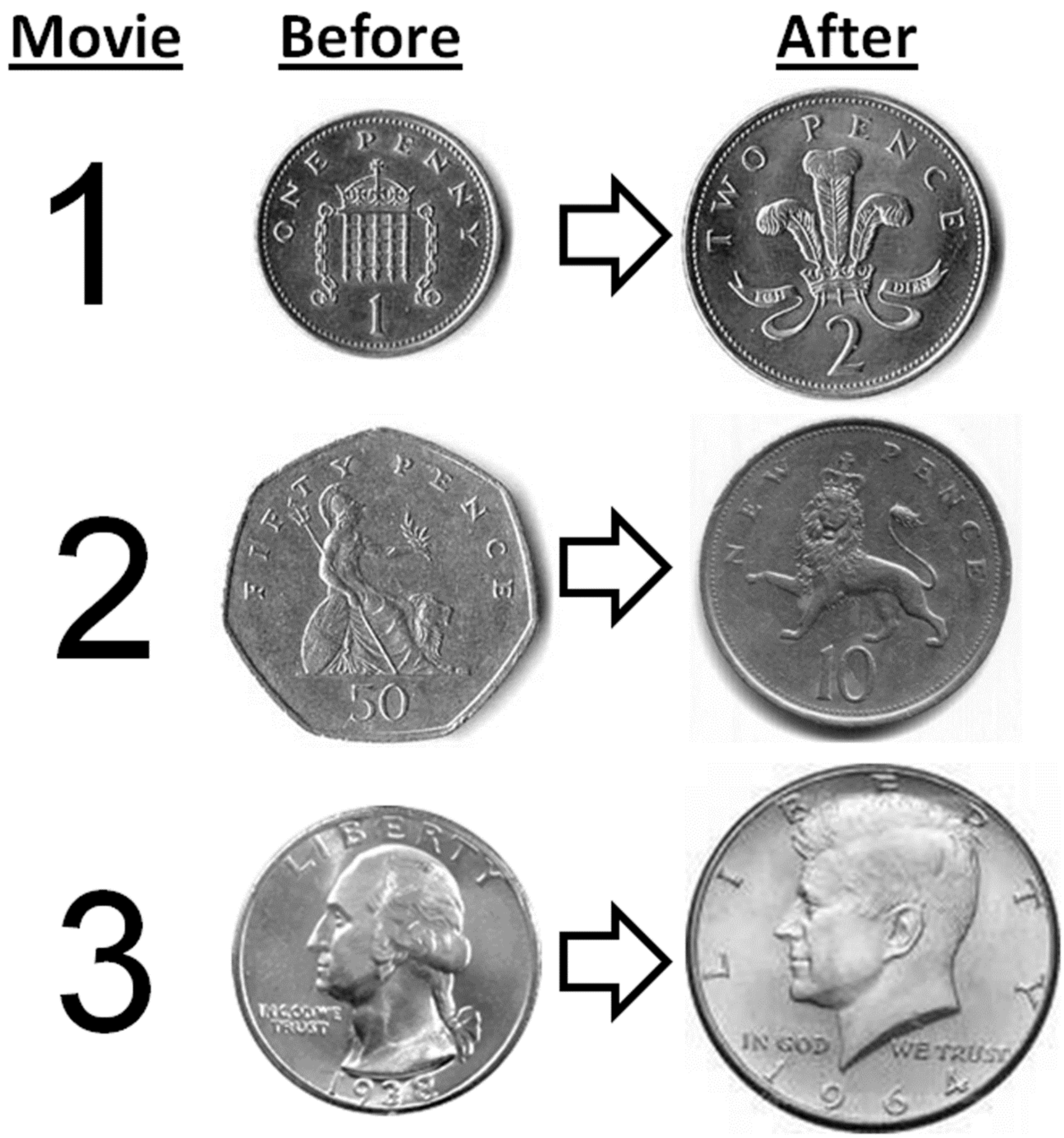

Figure 2: The coins used in the three movies (MovieS1-3). The British 1p and 2p were copper and the rest of the coins were silver.

Supporting Online Material for

The penny drops: Change blindness at fixation.

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This PDF file includes:

Materials and Methods

Captions for Movies S1 to S5

Other Supporting Online Material for this manuscript includes the following:

Movies S1 to S5

Materials and Methods

Participants

Twenty six participants (3 male; mean age=22.6yrs) were recruited from the University of Edinburgh undergraduate population and paid £6 for their time. The experiment was approved by the University of Edinburgh Ethics committee according to the British Psychological Society ethical guidelines.

Materials

Stimuli consisted of three 44 second full-color videos (720x576, 25fps, XVID codec) depicting a pair of hands in close-up manipulating a series of coins against a white tabletop. Each coin was passed between the hands a few times then dropped on the table. At the beginning of each video, the coin was clearly displayed to the camera. After the coin drop, the coin remained visible for a few seconds. Each video consisted of four coin drops: Video 1= UK 1p, UK Old Half Crown, UK 1p, US Silver Dollar; Video 2= US Quarter, UK Old Half Crown, UK 50p, US Silver Dollar; Video 3= UK Old 10p, UK 50p, US Quarter, UK Old Half Crown. During the third coin drop in each video the coin was secretly switched for another coin during a brief occlusion by the hand (see Video): Video 1=UK 1p to UK 2p (e.g. small to large); Video 2= UK 50p to UK Old 10p (e.g. pentagon to circle); Video 3= US Quarter to US Silver Dollar (e.g. small to large).

Procedure

Participants were instructed that they would be shown three videos depicting a pair of hands manipulating a series of coins. The coins would be dropped on the table and their task was to shout out whether they thought it would land heads or tails up before the coin was dropped. Before the experiment began the eyetracker (Eyelink 1000, SR research; tower mount, monocular mode with a forehead rest) was calibrated using a nine point calibration and participants were instructed not to move from the forehead rest. Between each video a central fixation cross was used to re-center participant gaze and check calibration accuracy.

After all three videos had been shown once, participants were asked whether they “had seen anything else". They were then instructed to watch the videos again without guessing heads or tails. After the second presentations they were again asked if they had seen anything else. If they did not report seeing any of the coin changes they were explicitly asked if they had seen the coin change and then shown the videos for a third time.

Analysis

Raw gaze data from the eyetracker was parsed for blinks (lost data) and saccades (eye velocity >30°/s and acceleration >9000°/s^2) then converted into frame-based gaze coordinates for each video and participant. Gaze of multiple participants was visualized on top of the original video and a fixation density heatmap created by spreading a circular gaussian (2° standard deviation) around each fixation (Mital, Smith, Hill, & Henderson, 2011). Hotter colors indicate a greater concentration of gaze (see Figure 1).

Movie S1

Original Video 1.

Movie S2

Original Video 2.

Movie S3

Original Video 3.

Movie S4

Video 2 with overlaid gaze positions of 23 participants (out of 26) who failed to detect the 50p to 10p change during first viewing.

Movie S5

Video 2 with overlaid gaze positions of 19 participants (out of 21) who detected the 50p to 10p change during the third viewing.