The Effect of Conceptual Tasks on Change Blindness

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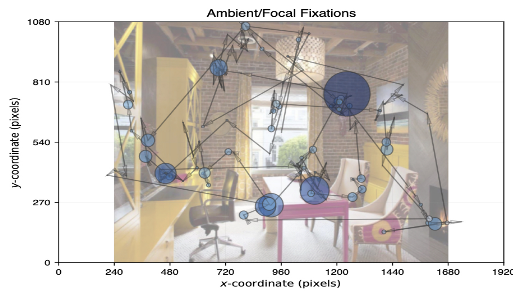
(a) participant searches for a change in the image



(b) sample scanpath

ABSTRACT

The human inability to notice significant changes to an object or scene is known as change blindness. Various studies have revealed this phenomenon's presence in various contexts, going so far as to show that objects under fixation can undergo unnoticed changes. While it is still not entirely clear why change blindness occurs, such observational lapses call into question the assumption that a detailed visual representation of a scene is stored by the brain. As such, investigating what makes changes in a scene more noticeable can shed light upon how the brain processes and stores visual information. This study seeks to examine whether observational tasks can guide attention effectively enough to better identify changes in a scene that may otherwise be missed. Results, while inconclusive, suggest trends of greater attention to semantic detail when participants were given an observational task. A follow-up study with greater power is suggested in order to determine if these trends are generally present.

KEYWORDS

eye tracking, visual attention, change blindness

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1 INTRODUCTION

It may seem that when we perceive the world visually, we are good at keeping track of a rich and detailed model of our field of view. However, the phenomenon known as "change blindness" calls this assumption into question. Broadly speaking, change blindness refers to the inability of people to notice a visual change in a scene or object. Myriad studies have suggested that if an object or part of a scene is not being paid any specific attention, it can change dramatically and go unnoticed by an observer.

Rensink et al. [1997] conducted one of the earliest studies to focus specifically on change blindness of more natural visual stimuli. Based on this work, Rensink postulated that visual changes which occur during visual disruption will go unnoticed unless the observer is paying attention to the area that changes. Further work showed that even while an object was fixated, it could undergo changes that would go unnoticed [O'Regan et al. 2000]. Findings such as these suggest that it is insufficient for an observer to merely look at an object; one must be actively paying attention to and comparing an object to memory in order to overcome change blindness.

This study seeks to demonstrate whether a broad perceptual task can influence the ability of an observer to locate specific changes in a scene. The hypothesis is that despite the added cognitive load of a task, its addition can help guide an observer's attention to specific objects in the scene, making it easier for them to detect changes later that they may have otherwise missed.

2 BACKGROUND

The very earliest work on change blindness generally involved subjects' eye movements during reading. For example, Rayner [1975] showed that the ability to distinguish words changing to nonword strings diminished as the change occurred further from a fixation. A study by Grimes [1996] popularized change blindness research by using images, rather than text, as stimuli. Subjects would regularly fail to notice hats or faces switched around, significant changes to the skylines of cities, and people resized and moved around a scene. Rather than a failure of the mind to process textual information, change blindness could now be interpreted to be a fundamental gap in visual perception.

From there, researchers worked to discover other contexts in which change blindness is present. Whereas Grimes's study involved saccades, changes went unnoticed if they occurred during blinks [O'Regan et al. 2000] or while briefly blanking out the display (flicker task) [Rensink et al. 1997]. "Mudsplashes", visual artefacts that do not cover the changing object, could still contribute to missed changes [O'Regan et al. 1999]. Levin and Simons [1997] conducted a study that revealed change blindness between cuts of a movie, and flicker tasks were shown to cause changes to go unnoticed in video as well [Wallis and Bulthoff 2000]. Clearly, there is an entire suite of conditions under which observers fail to perceive what would otherwise be obvious.

With the phenomenon cropping up in such diverse environments, the body of work began to shift towards attempting to understand why changes could so often slip by. An early prevailing theory was that those who failed to detect a change overwrote their memory of the object that changed. Levin et al. [2002] showed that those who notice the change of a conversation partner could recognize both individuals more consistently than those who did not notice the change, suggesting that the latter group discarded the memory of their former conversation partner. While this theory seemed to hold water, the prevailing idea today is that change blindness stems, at least in part, from a failure in the comparison of pre- and post-change stimuli. For example, Simons et al. [2002] held a conversation with subjects wherein he discarded a ball halfway through. Many of the subjects did not notice the change until prompted, upon which they realized that the experimenter had been previously holding a ball. Results such as these show that the pre-change stimulus is still remembered, but not always actively compared.

Finally, it is important to note that a task can have significant effects on the impact of change blindness. It has long been understood that the semantic importance, or how "interesting" a changing object is to an observer, has influence upon how effectively they can notice it changing [Rensink et al. 1997]. As such, tasks that assign semantic importance to an object may make it easier for an observer to notice it changing. For example, warning observers ahead of time that the change will be to the color of an object made it easier for them to detect the change [Aginsky et al. 2000]. However, the same did not hold for changes involving the position or presence of an object [Aginsky et al. 2000]. These findings suggest that color is a surface-level property of objects that is associated with them individually, whereas their presence or position within a scene is not unless they are inherently objects of interest within the scene.

3 HYPOTHESIS

With no cueing regarding the nature of the changing object, the subject would generally behave as predicted by Rensink et al. [1997]. In particular, their fixations would eventually gravitate towards areas of intrinsic semantic interest, and they may have a hard time detecting changes in objects of marginal interest. Participants given broad, conceptual cues would have shorter fixations that are less likely to overlap as they scan the scene to extract conceptual information from more objects. As such, they would have an easier time noticing changes as they have attended to more objects in the scene.

4 METHODOLOGY

4.1 Participants

A sample of 6 current and formaer Clemson University students (2 females) aged 21-26 volunteered to participate in this study.

4.2 Apparatus

Eye position data were sampled using a Gazepoint GP3 eye tracker. The system sampled at a rate of 60 Hz with a 1° visual angle accuracy. Participants sat 25 inches away from a 1920x1080 monitor, under which the eye tracker was mounted.

Figure 1: A pair of stimulus images. Note the missing keyboard on the desk in the left image.

4.3 Stimulus

The stimuli used were pairs of similar images with a single detail altered between them. These image pairs were taken from an image database designed for change blindness studies, as described by Sareen et al. [2016]. These image pairs change only objects determined to be of marginal interest, so they should not draw attention naturally.

4.4 Experimental Design

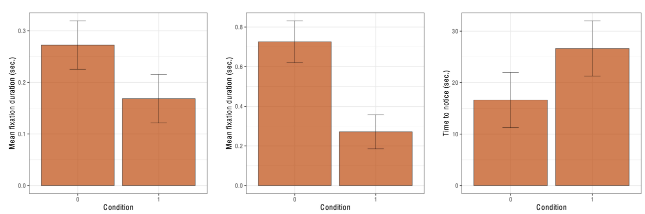
The study was conducted using a between-subjects design with two groups. Each group was tasked with noticing and identifying a change between pairs of stimulus images. In each pair, the images are displayed alternatively, using a brief blank image in between to avoid pop-out effects. After the change is identified or a certain time passes, the subject is asked a broad, conceptual question about the images (for example, "What time period was the scene from?"). The change in the images in each case is related to the concept from the question. The control group is given no information before each trial, and is simply tasked with identifying the difference between the images. The participants in the second group are informed of the question they will be asked ahead of time. For each subject, the order of the stimuli pairs was randomized.

4.5 Procedure

Each participant was seated 25 cm away from the monitor. After signing a consent form, they were informed that their task would be to identify changes in pairs of similar images, and then answer a question about the contents of the image. It was made clear that they should indicate the change as soon as they notice it, even if they feel as though they will not be able to accurately answer the question. Then, they completed a demographics questionnaire and eye tracker calibration procedure, and finally moved on to the trials.

In all trials, the first image in the pair is displayed for 800ms. Afterwards, a blank gray image is displayed for 120ms. Then, the second image is displayed for 800ms, followed by the gray image for 120ms. This entire process repeats until the end of the trial. A trial ends after 48 seconds (40 back and forth image swaps) or after the participant indicates the difference in the images. A participant indicates the location of the difference by fixating upon it for at least 150ms, then pressing any button on the keyboard. Even if the participant is incorrect, the trial ends, upon which they are asked a conceptual question about the scene. Participants in the experimental group are informed of this question before the start of the trial.

5 RESULTS



(a) fixation duration vs condition (b) AOI fixation duration vs condition (c) trial time vs condition

Figure 2: Graphs showing the effect of condition. Condition 1 is control.

Overall, results from this study were mostly inconclusive. Most importantly, the effect of informing participants of the question before each trial was found to have no significant effect ($F(1, 4) = 1.74$, $p = .257$, *n.s.*). Furthermore, this information also did not affect fixation duration ($F(1, 4) = 2.45$, $p = .192$, *n.s.*) or saccade amplitude ($F(1, 4) = 6.77$, $p = .060$, *n.s.*).

However, condition did show a significant effect on the duration of fixations on the object in the scene that changed ($F(1, 3) = 11.9$, $p = .044$, $p < .05$). Additionally, the interaction between condition and stimulus image was also significant ($F(4, 12) = 4.72$, $p = .016$, $p < .05$).

6 DISCUSSION

It was expected that providing participants with information before each trial would affect how they would observe the images, leading to shorter fixations as they scan for specific information in the scene. This theorized more focused scanning, then, may have lead to more quickly noticing the change between the images, due to the increased number of attended objects in the scene.

While there was no significant interaction between fixations or saccades as a whole with the experimental condition, the data does show some trends. In particular, saccade amplitudes were generally slightly lower in the control condition, and fixations were markedly shorter in the control condition. These trends may suggest that when given a task to search for specific information, participants spent longer looking at specific objects in the scene in order to probe for this information. Once attention was moved elsewhere, it tended to be moved further away, potentially suggesting that participants looking for specific information did not settle on the closest object while scanning, but were willing to look further for an object of greater semantic interest.

These theories are supported by the significantly greater fixation durations on the areas of change (AOIs) in the experimental condition. The questions were designed to make the AOIs areas of high semantic interest, so that participants would be more likely to attend those objects. While those with no information merely glanced at the object that changes, informed participants attended them for much longer, potentially absorbing more information. This increased attention to the object that changed may be partially responsible for the trend of faster trials for informed participants, potentially indicating that those who studied the object more carefully were more likely to have noticed when it changed.

7 LIMITATIONS & FUTURE WORK

The biggest limitation on this study was the small sample size. The power of the tests was greatly hindered by only having 6 participants. While none of the results of interest were significant, some of the data did show potential trends (see 2). A follow-up study using a larger sample size may reveal significant effects that this study failed to capture.

An additional factor to reconsider in the case of a follow-up study would be stimulus selection. The image used was just barely not found to have a significant effect on how quickly participants noticed a change ($F(1.63, 6.52)$, $p = .051$, *n.s.*). If a study is conducted with more participants, the effect of the image may come to overshadow the effect of the condition. As such, more careful selection of stimulus images may be necessary for future studies.

8 CONCLUSION

While the results of this study were inconclusive, trends in the data show potential for the discovery of significant effects in a future study. Particularly, significantly longer fixations on AOIs in the informed condition may be indicative of such a trend on a broader scale. A follow-up study with higher power and more careful stimulus selection may reveal insight into understanding or overcoming change blindness. The study of change blindness will continue to hold the possibility of presenting novel insights into how humans perceive the world and integrate scene information.

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