Change Blindness

Change blindness is the inability to recognize changes to objects in the environment after interruption, i.e. an object in the environment changes while an individual is looking away, but he or she does not notice the change upon looking back. As an example, the right mirror of the van in *Inception* is broken in one shot, and the left mirror is broken in the following shot, but most viewers, including the author, did not notice these changes.

Whatever its cause, most people are susceptible to change blindness.[1] Based on the current body of research and results from three featured studies, this paper will attempt to explain the causes of change blindness by answering two key questions. First, do people have a visual representation of unattended parts of the visual field? Second, what are the cognitive mechanisms for change blindness?

Most cognitive psychologists remain divided on the cognitive mechanisms for change blindness. Proponents of the *representation failure* theory believe that people do not encode a visual representation of unattended parts of their visual field. Thus, changes to unattended objects simply "write over" the previous visual representation in the visuospatial sketchpad. For example, *representation failure* proponents would argue that viewers never remembered the right mirror of the van in *Inception* was broken, so the second shot did not seem to be different from the first one.

The *representation failure* theory is based on research from both pattern recognition and attention. Current pattern recognition research shows that people schematize the visual field by adding or removing objects to their mental representation. For example, an individual might remember seeing a stethoscope in a doctor's examination room but forget that there were photos on the wall. Other pattern recognition research shows that people only encode a minimal representation, or the most common view, of most objects. For example, since a lamp is usually

[1] Autistic individuals have lower propensity to change blindness (Smith & Milne, 2009).

viewed from the side, most people only encode a lateral view of a lamp and must mentally rotate their minimal representation when they see a lamp from any other angle.

Current attention research shows that people are only capable of attending to a limited number of objects at one time. For example, if the reader is attending to this paper, he or she will not be able to attend to an open book, someone talking in another room, or the computer screen on the desk.

Drawing from the current body of research, the *representation failure* theory states that mental representations are easily altered because of a propensity towards schematization of visual information and failure to encode unattended parts of the environment.

Representation failure can be further classified as either *global* or *circumscribed representation failure*. *Global representation failure* results from a complete lack of awareness about an object's existence, while *circumscribed representation failure* results from a mental representation of some but not all of an object's characteristics. For example, in *Inception*, Ariadne's gloves falls through a crack in the ground in one shot and reappear in another shot. *Global representation failure* suggests that viewers did not notice the gloves at all, while *circumscribed representation failure* suggests that viewers knew the gloves were in the general vicinity but could not remember whether they had fallen through the crack (Rensink, O'Regan, & Clark, 1997; Varakin, Levin, & Collins, 2007; Weisberg & Reeves, 2011).

Another explanation for change blindness is the *comparison failure* theory. Proponents of this theory believe that the visuospatial cortex is capable of processing complex visual stimuli simultaneously and that working memory may retain a mental representation of virtually all objects in the visual field. They argue that change blindness results from neglecting to compare the original mental representation to the new visual representation. Thus, people will recognize changes to objects if prompted.

The *comparison failure* theory is based on attention research that shows people have an adaptive bias to assume the environment will not change. Usually, if an individual looks away from his or her original field of view, the environment will not spontaneously change. Thus, assuming the environment is exactly the same as when one looked away is usually advantageous. However, when the environment does change, an individual may fail to compare the new visual representation to the original mental representation based on this assumption (Simons, Chabris, Schnur, & Levin, 2002; Varakin et al., 2007; Weisberg & Reeves, 2011).

Although both the *representation failure* and *comparison failure* theories are supported by multiple studies, neither can wholly explain change blindness in absence of the other since both are based on acknowledged theories in pattern recognition, attention, and memory. In some instances, *representation failure* causes change blindness, and, in others, *comparison failure* is the cause.

All three featured studies appear to support a combination of the two change blindness theories. In the first study, Rensink et al. (1997) conducted three experiments using what they termed a “flicker” technique; the researchers showed participants an image, a blank filler, the same image, another blank, a changed image, another blank, the changed image, and another blank in a loop until they recognized the difference between the two images. The changed image contained a presence/absence, location, or color difference in either central objects, such as a helicopter in the sky, or marginal objects, such as a cloud in the background.

In all experiments, participants were asked to press a key as soon as they detected the change and verbally describe the change. Only correct descriptions were included in the results, but the identification error rate was low (1.2%).

Each series of four images and four blanks was considered one alternation. In the first experiment, participants were shown the standard alternation, which consisted of 240ms of each image and 80ms of each blank. They were also shown alternations with no blanks as a control. Participants required significantly more alternations to identify changes in the “flicker” condition versus the control and in marginal objects versus central objects. These results indicate that change blindness exists when attention is broken, i.e. when an individual looks away from the original field of view. They also suggest that attention is limited to central objects, since it takes longer to identify changes to marginal objects.

In the second experiment, participants were shown alternations which consisted of 540ms of the first image, an 80ms blank, 540ms of the changed image, and another 80ms blank for a total of two images and two blanks. Participants did not require significantly fewer alternations to identify changes relative to the original “flicker” condition. These results indicate that change blindness does not result from processing limitations because additional processing time did not improve performance.

In the third experiment, participants were shown the standard alternation with an additional 3s visual cue at the beginning of the experiment that indicated the changed object. The visual cues were correct 100%, 50%, or 0% of the time. Valid cues in either the completely- or partially-valid conditions significantly reduced the number of alternations needed to identify changes relative to the original “flicker” condition. However, the number of alternations needed was still significantly greater than in the control condition. Invalid cues did not increase the number of alternations required significantly. The improved performance from valid cues suggests that the number of alternations needed in experiment one did not result from visual limitations; the cues would not have helped participants see something they could not see.

Resink et al. (1997) concluded that participants suffered from *representation failure*, but *representation failure* alone does not explain the improvement in performance with valid visual cues. If participants did not encode a mental representation of the original object, they would not be able to identify what had changed even with visual cues. However, the fact that participants required more alternations in the cued condition than in the control condition suggests that any mental representation of the original object was only partial, making comparison more difficult.

As a whole, these three experiments suggest that change blindness results both from having only a partial mental representation (*representation failure*) and from failing to compare the relevant objects in the mental representation to those in the visual field (*comparison failure*).

Since participants failed to identify presence/absence of objects as well as changes in location and color, the experiments also distinguished between *global* and *circumscribed representation failure* (Resink et al.,1997).

In the second study, Simons et al. (2002) conducted three similar experiments in a natural setting. In the first two experiments, a researcher asked a consenting participant for directions. After the participant began talking, a group of confederates walked between the participant and researcher and either took a basketball the researcher had been holding or provided her with a ball if she had not been holding one. Afterwards, the participant was asked to answer open-ended questions that led up to a question about the basketball. In the second experiment, the participant was asked to describe the basketball.

Experiment one was intended as a pilot study to determine if the stimulus (basketball) was noticeable. Three participants (27%) recognized the change spontaneously after only a few questions, and another three participants (27%) recognized the change when cued. Since the majority of participants identified the change, the stimulus appeared to be noticeable. Experiment two confirmed these results; five participants (19%) recognized the change spontaneously, and fourteen participants (54%) recognized the change when cued.

In the third experiment, a researcher started out holding two objects that were either consistent or inconsistent, e.g. flowers and a “Get Well” balloon versus flowers and a soccer ball, while another researcher asked for directions. The group of confederates would remove one of the items. Afterwards, the participant was asked to answer open-ended questions that led up to a question about the item that had been removed. The participant received both verbal and visual cues, i.e. the researcher would mime holding the removed object. Then, the participant was asked to describe the item.

Experiment three confirmed the results from experiments one and two. Ten participants (20%) recognized the removal spontaneously, and twenty-two participants (45%) recognized the change when cued. No significant difference was shown between the consistent and inconsistent conditions, but participants in the inconsistent condition were more likely to incorrectly describe the removed object.

The results from all three experiments suggest that some participants encoded a mental representation of their original visual field, while others did not seem to have a mental representation for reference. Those who spontaneously identified changes did not have change blindness, those who needed to be cued suffered from *comparison failure*, and those who could not identify changes at all suffered from *representation failure*. The incorrect descriptions in the inconsistent condition are an example of *circumscribed representation failure* (Simons et al., 2002).

In the third study, Varakin et al. (2007) conducted two experiments in a similar setting. In the first experiment, a researcher asked a consenting participant to participate in a distractor experiment related to a word in a binder, while a confederate took notes nearby. Participants were asked to close their eyes and visualize the word in the binder, while the confederate and researcher quietly traded binders so that the new binder was a different color. Afterwards, participants were asked a series of open-ended questions that led to a question about the binder. Participants who knew the binder had been switched were known as “hitters” while those who did not were known as “missers.”

All participants were shown a series of binders and asked to identify the original binder color and font for the distractor word in the “line-up” as well as provide confidence ratings for their responses. Missers were significantly less accurate than hitters, and low-confidence missers were significantly less accurate than high-confidence missers at identifying the original binder color. Hitters, low-confidence missers, and high-confidence missers did not differ significantly on the font identification task.

Experiment two was conducted in the same way as experiment one, except participants were asked to identify both the original binder and the second binder in the “line-up.” Missers with high confidence of both pre- and post-color identification were considered high-confidence missers, and the rest were considered low-confidence missers. Again, high-confidence missers were significantly better at the color identification task than low-confidence missers. This showed that the discrepancy between high-confidence and low-confidence misser performance was not due to a first-impressions bias, i.e. remembering only the original binder's color and neglecting to compare it to the new binder.

These experiments demonstrated that both *representation failure* and *comparison failure* cause change blindness. The discrepancy between hitter and misser performance on the color identification task points to *circumscribed representation failure*. However, high-confidence missers perform significantly better because they have a mental representation of the original binder. They suffer from *comparison failure*, while low-confidence missers suffer from *representation failure* since they simply do not remember the original binder as clearly (Varakin et al., 2007).

Ultimately, the current body of research and featured studies suggest that change blindness is caused by both *representation failure* and *comparison failure*. People only encode a partial mental representation of both attended and unattended parts of the visual field. Although attended objects are encoded more clearly, people have the capacity to compare a mental representation of even unattended objects with their current visual field. However, due to an adaptive bias to assume the environment will not change, people often neglect to make that comparison.

In some instances, change blindness occurs because of a failure to encode parts of the visual field (*representation failure*). In other instances, change blindness occurs because of a failure to compare an encoded mental representation to the visual representation (*comparison failure*). Neither theory can singlehandedly explain change blindness in its entirety.

References

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