Change Blindness

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Most people have a strong belief in the accuracy and completeness of their visual experience. Indeed, it is often said that "seeing is believing", indicating that visual perception is considered to be one of the most trustworthy means of obtaining information about the world, distorting little and missing less.

In spite of our strong impressions, however, research has shown that visual perception does not capture as much of the world as we think. For example, a driver might believe that simply by looking around they would always be able to see an oncoming car, always notice the sudden veering of a nearby child on a bicycle, and always see the sudden appearance of an animal that ran in front of their car. But they would be wrong. Even if viewing conditions were excellent, they could still miss such events, for example, if they talking on a cell phone.

Much of this concern is based on the existence of *change blindness*, the inability to notice large changes that occur in clear view of an observer. This effect is extremely robust and can be produced under many different conditions, including when the changes are repeatedly made and the observer knows that they will occur. Consequently, change blindness is believed to reflect limitations on the way we see, limitations with important consequences for how much of the world we actually perceive in everyday life.

Basic effect

Change blindness can be produced in a variety of ways. One of these is shown in Figure 1. Here, a picture of a real-world scene is presented for a half second or so, followed by the same picture changed in some way—for example, an object changed in color or size, or removed altogether. These two pictures then alternate, with a blank field appearing for a fraction of a second before each appearance of each picture. Observers are asked to watch this flickering display and find the change.

Although observers generally believe that they could easily see any change that was large enough, experimental results paint a very different story. Under these "flicker" conditions, even large changes can remain unseen for long stretches of time, with observers sometimes requiring 10 or 20 seconds (20 or 40 alternations) before they notice the change, even when that change is extremely easy to see once noticed.

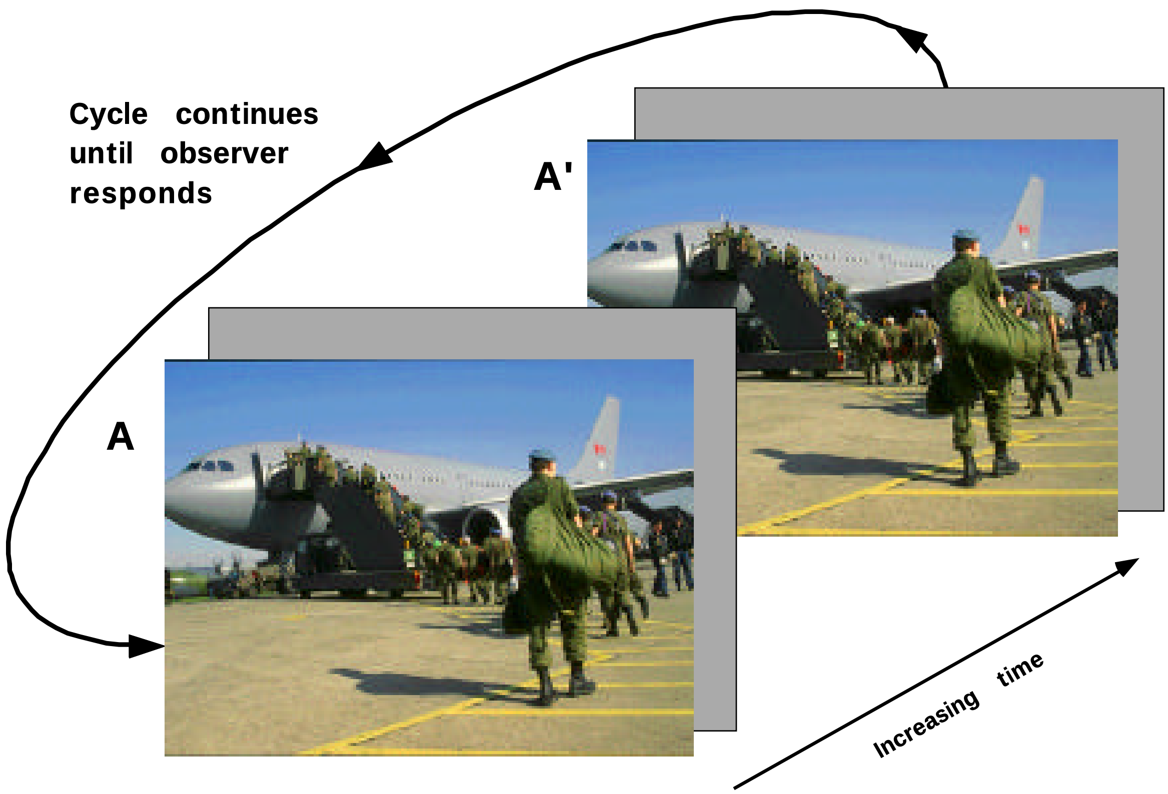

Fig. 1. Flicker technique. Here, the observer views a continual cycling of images between original picture A and altered picture A', with blank fields briefly appearing between them. Each image is typically on for about half a second, while the blanks are on for a quarter second or so. (The strength of the effect does not depend greatly upon the exact durations used.) The images alternate until the observer responds that they see the change that is occurring. In this example, the change is the appearance/disappearance of the airplane engine.

Why do these conditions create change blindness? The key factor is believed to be the appearance of the blank fields. Normally, a change produces a motion signal at its location. But when a blank field appears it produces motion signals throughout the display. If these global signals are strong enough they will overwhelm the local signals, and make changes more difficult to notice.

Extent of the effect

Although the flicker conditions of Figure 1 seem somewhat artificial, counterparts can be found in everyday life. An interesting example occurs in motion pictures. Here, changes are often accidentally introduced during cuts between scenes—such as a sudden close-up or switch of viewpoint—owing to changes that may occur while the lighting and camera are being set up for the new view. (For example, cigarettes keep burning.) A cut in a film acts like flicker in that it swamps any local motion signals arising from any such change, making it difficult to notice. Consequently, viewers can miss large changes in the position of actors, changes to their clothing, and sometimes even changes of the actors themselves if these are made during a cut.

This can also happen if the change is made during an eye movement or an eye blink. Under these conditions, the local motion signals accompanying the change are again swamped by global signals due to the movement of the eye or due to the blink. Such techniques were used by film directors decades ago to deliberately make unnoticed changes in the middle of a scene. For example, a change might be made at the moment a major character appeared at the side of the screen, and thus, at the moment the audience moved their eyes. A change might also be made during a sudden loud noise (such as a gunshot), which would cause the audience to blink their eyes.

Change blindness can also occur if the change is made while the changing item is occluded by another object. Again, this condition is such that the local motion signals accompanying the change are lost. Occlusion is not limited to laboratory studies, and so change blindness created this way can be found in the real world. For example, observers often fail to notice changes to other people in real life situations (including changes of conversation partner!) if the change is made at the moment a panel passes in front of the observed person, or when they briefly duck behind a tall counter.

Visual attention

The key factor in causing change blindness appears to be the effective removal of the local changes that accompany a change, either by being overwhelmed by global motion signals, or else by hiding them altogether. But why should this be? The prevailing explanation is that *visual attention is needed to see change*. Under normal conditions, the local motion signal created by a change automatically draws attention, allowing it to be seen. But if this signal is lost (for example, being swamped by global signals), attention will no longer be automatically drawn to the change. Instead, the viewer must send their attention around the scene on an item-by-item basis, until it reaches the item that is changing. Until this occurs, they will be unable to see the change, no matter how much time goes by.

This proposal has major implications for our understanding of visual attention. Previously, attention was believed to integrate information only across space—for example, creating the percept of an object from a set of disconnected lines in an image. But it now appears that attention also integrates information across time, allowing that object to be seen to move or change in a dynamic way. Importantly, the large size of these effects also allows change blindness (using carefully controlled images) to be used as a tool to explore the nature of attention. Among other things, it has been discovered that no more than four or five items can be attended at a time, with only a few properties (e.g., color or shape) of each.

This account can also explain many of the effects created by magicians, in which objects suddenly appear, disappear, or are transformed in ways that seem to defy the laws of physics. But a careful examination shows that many of these effects rely critically on a manipulation of attention. Although many things are in play during a performance, only a few can be attended at any one time. The only events *seen* to occur are therefore those to which the magician has directed attention; all others pass by unnoticed.

Scene perception

If the perception of change requires attention, and if attention is limited to just four or five items, our representation of events in the world cannot be very complete. Why then do we have such a strong impression of seeing everything in a scene?

One possibility is that scene perception is based on a "just-in-time" system in which detailed representations of objects and events are created only when requested (Figure 2). If the allocation of attention were well managed, the appropriate representation would always be ready, and so appearing to higher levels as if all representations were present simultaneously. This scheme is somewhat like that used in lighting a refrigerator: if the light is always on when needed (i.e, when the door is open), it will appear as if the light is on all the time.

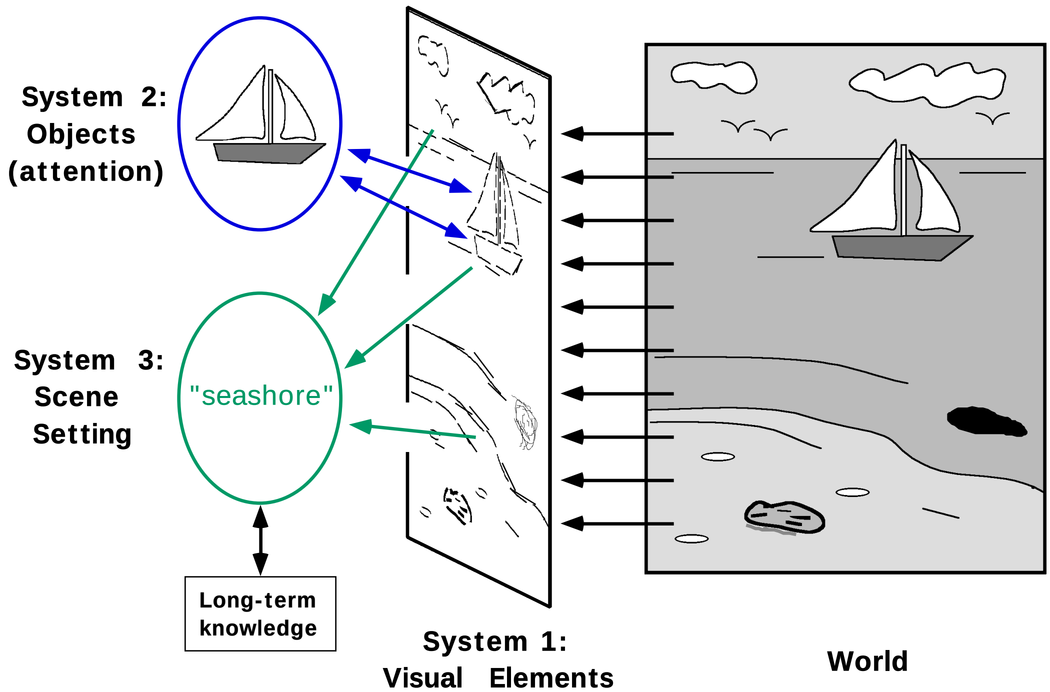

Fig. 2. "Just-in-time" scene representation. (1) An initial system analyzes visual input into a set of simple visual elements. These elements are very short-lived, and are continually regenerated as long as light continues to enter the eyes. (2) Visual attention "grabs" a subset of these elements and enters them into a more coherent object representation that allows changes to be tracked. At most only a few such representations exist at any time. After attention releases them, the "held" items return to their original short-lived state. (3) At the same time as objects are being formed, other aspects of the scene are rapidly computed without attention, based directly on the visual elements. Together with knowledge in long-term memory, this forms a "setting" capable of guiding attention to those items relevant for task at hand.

In this account, the representation of a scene may be much sparser and more dynamic than previously believed, with only a few objects and events represented in detail at any time. Since the choice of which objects and events to represent in detail depends on the goal and the knowledge of the observer, different people could literally see the same scene in different ways. Indeed, studies have shown that experts can perceive a situation differently than novices, and that differences can exist between observers from different cultures.

Future research

Although change blindness has already provided us with a great deal of information about how people see, considerably more can still be done. For example, the relative ease in detecting a change in an object indicates how quickly attention is sent to that object, and thus, how important it is to the viewer. Mapping out the relative ease in detecting changes in the objects in a scene can therefore provide information about how any individual perceives the world, and how this depends on factors such as emotional state or task.

Change blindness can also be used to explore those aspects of perception that are not accessible to conscious awareness. For example, the eyes of an observer can track an object and respond to changes in its position, even when these changes are undetected at a conscious level. Recent studies suggest that observers may do better than chance at guessing the existence of changes that they do not consciously see. In addition, some observers are able to sense changes before they can see them, which may partly explain the common belief in a sixth sense. Further research of this kind is likely to provide new insights into the nature of perception, and perhaps even the nature of consciousness.

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Web sites:

Change Detection Database
http://viscog.beckman.uiuc.edu/change/

The Need for Attention to See Change
http://www.psych.ubc.ca/~rensink/flicker

Symposium on Mack and Rock's Inattentional Blindness
http://psyche.cs.monash.edu.au/psyche-index-v6.html