What can change blindness tell us about the visual processing of complex objects?

Simone Keane
University of Wollongong

Stephen A. Palmisano
University of Wollongong, stephenp@uow.edu.au

Publication Details
What can change blindness tell us about the visual processing of complex objects?

Abstract
Processing visual information about objects in our environment is an essential and widely used skill. However, recent research in change blindness suggests that humans are remarkably poor at detecting certain types of changes to objects. In particular, changes to the configuration of an object's parts are detected quicker and more accurately than changes to the shape of the parts or a switching of parts. The implication of this finding is that information regarding the layout or configuration of an object is better encoded than finer details, like part shape. The aim of the current study was to determine whether this configural advantage in change detection is a consequence of the type or simply the amount of information involved in a change. Specifically, we kept change type constant while manipulating the complexity (number of parts) of the stimulus objects. Results showed that changes to the configuration of parts were detected quickly and most accurately, regardless of object complexity. The detection of part shape and switch changes, however, was influenced by object complexity. Importantly, these results suggest that the nature of the configural change rather than its relative magnitude is critical for successful change detection.

Keywords
objects, change, tell, us, about, visual, processing, can, complex, blindness

Disciplines
Arts and Humanities | Life Sciences | Medicine and Health Sciences | Social and Behavioral Sciences

Publication Details

This conference paper is available at Research Online: http://ro.uow.edu.au/hbpsapers/939
What can change blindness tell us about the visual processing of complex objects?

Simone K. Keane (skeane@uow.edu.au)
Stephen Palmisano (stephenp@uow.edu.au)
Department of Psychology
University of Wollongong, Sydney NSW 2522 Australia

Abstract

Processing visual information about objects in our environment is an essential and widely used skill. However, recent research in change blindness suggests that humans are remarkably poor at detecting certain types of changes to objects. In particular, changes to the configuration of an object’s parts are detected quicker and more accurately than changes to the shape of the parts or a switching of parts. The implication of this finding is that information regarding the layout or configuration of an object is better encoded than finer details, like part shape. The aim of the current study was to determine whether this configural advantage in change detection is a consequence of the type or simply the amount of information involved in a change. Specifically, we kept change type constant while manipulating the complexity (number of parts) of the stimulus objects. Results showed that changes to the configuration of parts were detected quickly and most accurately, regardless of object complexity. The detection of part shape and switch changes, however, was influenced by object complexity. Importantly, these results suggest that the nature of the configural change rather than its relative magnitude is critical for successful change detection.

Introduction

Processing visual information about objects in the world around us is an important skill useful in everyday life. Not only is this a skill we use often, it seems effortless. We can look around our environment and experience a richly detailed visual world of colour, texture, shape and motion. However, despite the apparent ease with which we view the world around us, recent research in change blindness suggests that humans are remarkably poor at detecting sometimes quite large changes to their visual environment (see Simons & Levin, 1997; Rensink, 2002 for reviews). Change blindness has been found for different types of object change even when only a single object is present (Keane, Hayward, & Burke, 2003; Williams & Simons, 2000). Keane et al. (2003) investigated the ability to detect three kinds of change to novel 3D objects: (i) changes to the spatial configuration of an object’s parts, where one object part moved to another unoccupied position on the object, (ii) changes to the shape of those parts, where one part was replaced with a new part and (iii) changes to the relative arrangement of object parts, where two parts switched positions. Using a one-shot change detection task, they found that observers detected changes to the configuration of an object’s parts quicker and more accurately than changes to the shape of the parts or a switching of parts. The rationale behind using the change blindness paradigm to study vision is that the changes that are detected reflect the types of information that are encoded by the visual system. Thus, Keane et al.’s results suggest that information regarding the global configuration of parts is better encoded than more local details, such as part shape. This finding is in line with coarse-to-fine (e.g., Ginsburg, 1986) and global-to-local (see Kimchi, 1992 for a review) accounts of visual object processing that suggest that visual processing begins with coarse global information and proceeds to finer detail information.

However, the above study always used object stimuli that each consisted of 4 parts. Because configural, shape and switch changes involve different numbers of parts, it is difficult to determine whether configural information has a processing advantage over other types of information or whether previous results are merely a consequence of configural changes being somehow larger or more salient than shape or switch changes. It is impossible to equate the magnitude of the different changes in terms of the amount of visual information involved (although some attempt has been made, see Keane et al., 2003). However, one way around this problem is to keep the change types constant and manipulate the magnitude or complexity of the objects. We have defined object complexity as the number of parts of which an object is composed.

The current study investigated the same three types of property change as Keane et al (2003); configural, shape and switch changes, in objects of differing complexity (5, 6, and 7 parts). These different changes involved either one (configuration and shape) or two parts (switch), regardless of the total number of parts an object has. For example, a configural change only ever involves one part of a 5-, 6- or 7-part object (irrespective of the object’s complexity). Thus, a configural change in a 5-part object alters a larger proportion of the object than a configural change in a 7-part object. The same is true for shape and switch changes. If superior detection of configural change is found regardless of object complexity, it can be argued that it is not the proportion of local visual information changing that drives change detection; rather it is the qualitative nature of the changes themselves (e.g., global versus local information) that are important factors in the ability to detect change.
Method

Participants

A total of 31 undergraduate students of the University of Wollongong participated and were tested individually. All subjects had normal or corrected to normal vision. Participants received course credit for participating.

Materials

Stimuli were rendered images of 3D novel objects (see Figure 1, for example). The stimuli were generated using the Strata StrataVision 3D software package, a 3D modeling, scene composition and rendering program. This software allows for the rendering of 3D objects using both specified (e.g., cubes, cones, spheres) and created (e.g., horns, prisms) geometric primitives. Constructive-solid-geometry operations such as unions and intersections allowed for the construction of multi-part 3D objects. Textured and coloured “skins” could be mapped to the surface of these multipart objects. All object stimuli in this experiment were rendered in the same colour and texture. There were three “base” objects at each of the 5-, 6-, and 7-part complexity level with three change types made to three different parts resulting in a total of ninety different object exemplars. The mask used in this experiment was 425 by 312 pixels in area. The experiment was controlled by RSVP software (Williams & Tarr, no date) on Macintosh computers.

Procedure

The experiment consisted of 326 randomly ordered trials. Each trial began with a fixation cross appearing for 0.5 s at the centre of the screen, followed by the first object for 2 s, immediately followed by a mask appearing on the screen for 1.5 s, and finally another object which remained on the screen until the participant responded. The second object was either identical to the first or different in one of three ways: (1) part shape; (2) a switching of parts; or (3) spatial configuration. Responses for each trial timed out after 5 s. The next trial began 1 s after the participant made a response or the trial timed out. If no response was made, the trial timed out 5 s after presentation of the second stimulus. Stimulus location was jittered by 25 pixels, that is, randomly placed at a position 25 pixels in any direction from the centre of the screen. Participants were asked to indicate whether the two objects presented to them were the “same” or “different” by pressing corresponding keys on a keyboard. Half of the trials were “same” trials and the other half “different” trials. The different trials were split equally into the three change type conditions.

The instructions given to subjects at the beginning of the experiment were as follows: “On each trial in this experiment, you will be asked to judge whether two objects are the same or different. On each trial, a fixation cross will be followed by a briefly displayed object. This will be followed by a “mask” (a patterned screen), then the second object. Try to ignore the mask and judge whether the two objects are the same or different. Sometimes you may find this to be a relatively easy task, and sometimes you may find it to be difficult. Respond as accurately and as fast as you can. You will hear a beep every time you get a trial wrong. Remember, you should respond SAME if you see two views of the same object and DIFFERENT if you see two different objects.”

Results and Discussion

A 3x4 repeated measures ANOVA including number of parts (5, 6 and 7) and change type (configuration, switch, shape and same) was used to analyse accuracy data. A significant variation in performance based on the number of parts of the object $F(2,60) = 78.73, p < .01, MSE = 0.47$ was found. The linear contrast was found to be significant indicating that change detection accuracy decreased as object complexity increased ($p < .05$). A significant main effect of change type was found, $F(3,90) = 23.44, p < .01, MSE = 0.42$. Bonferroni-adjusted post hoc contrasts showed that shape changes were detected significantly less accurately than all other change types (all $p < .005$). Configuration changes were detected with significantly greater accuracy than shape or switch changes (both $p < .001$), but were not different to making a same detection ($p = 0.18$). There was a significant interaction found between number of object parts and change type, $F(6,180) = 10.33, p < .01, MSE = 0.09$. From Figure 2a, it can be seen that the greater the number of parts, the less accurate subjects were at detecting shape and switch changes. Interestingly, performance for configural change detection and making a same decision does not appear to be influenced by object complexity.

Data analysis of RT was conducted using accurate responses. A 3x4 repeated measures ANOVA including number of parts (5, 6 and 7) and change type (configuration, switch, shape and same) was used to analyse RT data. A significant difference in RT
In order to determine whether the configural advantage for change detection is consequence of the type or simply the amount of information involved in the change, it is necessary to investigate change quantitatively. Because it is difficult to equate the size of changes involving different types of object information, we kept the change type constant while manipulating the complexity of the objects within which the changes occur. Results show that participants were quickest and most accurate at detecting changes to the configuration of parts, regardless of the complexity of the object involved. That is, the type of change influenced change detection performance despite the amount of information involved in the change. Specifically, regardless of whether the proportion of the object involved in a change was small or large, configural changes were detected more often than shape or switch changes. The detection of part shape and switch changes, however, was influenced by the relative amount of change. As complexity increased, detection of shape and switch changes became more difficult.

A speed-accuracy trade-off could explain these results: with increasing object complexity, participants may sacrifice speed for accuracy in processing the information needed to detect switch changes. However, the detection of part switches may place greater processing demands on the visual system than the detection of configural or shape changes. In the case of switch detection, the shape of an object's parts as well as the relative locations of those parts needs to be processed in order to successfully detect a switch. There may be some minimum amount of time needed for this kind of processing to occur regardless of the complexity of the object.

Importantly, overall these results suggest that it is the change to the global spatial layout of the object as a whole rather than the amount or proportion of raw, local visual information changing, which accounts for the configural advantage found by Keane et al. (2003). It appears that regardless of the complexity of an object, information about the global configuration of parts is processed quickly and utilised accurately. Further, there is a relative time and accuracy cost associated with the processing of the shape or arrangement of object parts, particularly as the proportionate amount of object information involved in the shape or switch change decreases.

**Acknowledgements**

The authors would like to thank William Hayward and Darren Burke for helpful comments and suggestions.
References


