Research Report

Psychological Science
21(11) 1611–1615

DOI: 10.1177/0956797610385952
http://pss.sagepub.com

Does Facial Processing Prioritize Change Detection? Change Blindness Illustrates Costs and Benefits of Holistic Processing

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Abstract

There is broad consensus among researchers both that faces are processed more holistically than other objects and that this type of processing is beneficial. We predicted that holistic processing of faces also involves a cost, namely, a diminished ability to localize change. This study (*N* = 150) utilized a modified change-blindness paradigm in which some trials involved a change in one feature of an image (nose, chin, mouth, hair, or eyes for faces; chimney, porch, window, roof, or door for houses), whereas other trials involved no change. People were better able to detect the occurrence of a change for faces than for houses, but were better able to localize which feature had changed for houses than for faces. Half the trials used inverted images, a manipulation that disrupts holistic processing. With inverted images, the critical interaction between image type (faces vs. houses) and task (change detection vs. change localization) disappeared. The results suggest that holistic processing reduces change-localization abilities.

Keywords

face perception, object recognition, facial features, perception

Received 2/14/10; Revision accepted 5/26/10

Tom shaved off the moustache he had worn for years. Person after person noticed something had changed, but very few could identify what had changed. Some guessed he had a different haircut or new glasses; others thought he had lost weight. This seems to be a common experience for many people when someone changes his or her facial appearance; they detect the change, but cannot identify specifically what changed. In this report, we refer to this experience as the *change-detection/change-localization problem*.

There is a large research literature on the differences between how people process faces versus how they process other objects. This research has led to rather broad (albeit not unanimous) agreement that people primarily process human faces on a holistic or configural level, rather than on a featural level (e.g., Rossion, 2009; Tanaka & Farah, 1993). Although the terms holistic and configural have been used interchangeably, causing some confusion in the literature, they have different meanings (see McKone & Yovel, 2009). *Configural* refers to the spacing between features, and *holistic* refers to the integration of featural and spacing information in a unified representation. For our purposes, we refer to face processing as holistic, by which we mean that the face is processed largely as an undecomposed whole. In this article, we report an experiment in which we tested the hypothesis that holistic processing facilitates overall change detection but impedes localization of change.

It is not our purpose to tackle the question of whether the differences in the processing of faces versus the processing of other objects are due to a special cognitive mechanism for faces or result from an expertise in processing faces (e.g., Diamond & Carey, 1986; Gauthier & Tarr, 1997; Wong, Palmeri, & Gauthier, 2009). We merely adopt the generally accepted view of theorists that people typically do not process faces on a feature-by-feature basis, but instead tend to process the "whole" face largely intact (Macrae & Lewis, 2002; Perfect, Dennis, & Snell, 2007). A staple form of evidence that faces are processed differently than other objects is that inversion impairs face recognition more than it impairs the recognition of other objects—a finding termed the face-inversion effect (Anaki & Moscovitch, 2007; Leder & Bruce, 1998, 2000; Murray, 2004; Rhodes, Brake, & Atkinson, 1993; Tanaka & Sengco, 1997; Yin, 1969; Yovel & Kanwisher, 2008).

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Studies of face processing that bear on the holistic-versus-featural issue have used a variety of tasks, such as flicker tasks (Davies & Hoffman, 2002; Favelle & Burke, 2007), recognition memory tasks, distinctiveness ratings, bizarreness ratings, odd-one-out tasks, sequential matching tasks, and sequential same/different tasks (McKone & Yovel, 2009). In our study, we used a modified change-blindness task (Rensink, O'Regan, & Clark, 2000; Simons & Ambinder, 2005; Simons & Rensink, 2005), which is similar to sequential same/different tasks, but we included two conditions for testing our change-detection/change-localization hypothesis. In one condition, participants were asked whether or not a change occurred—a task similar to the sequential same/different task. In the other, more novel condition, the test object always changed, and participants were asked what changed. This new condition was critical for testing our proposition that holistic processing facilitates change detection but impedes change localization.

We compared participants' performance in responding to faces with their performance in responding to houses. This comparison required us to largely ignore any main effects of the difference in image type and focus instead on interaction effects. Consider, for example, the images in Figure 1. It would prove nothing to show that people could see change in the face (notice the change in the jaw) better than they could see change in the house (notice the change in the porch) or vice versa. Accordingly, the paradigm we developed relies on the presence or absence of critical interactions (ignoring any main effects) between the type of image (faces vs. houses) and the type of task (detecting change vs. localizing the change).

We propose that holistic processing has the advantage of being sensitive to detecting changes that might occur at one of many possible feature locations in an object. We further propose, however, that this type of processing also has a cost, namely, a relatively poor ability to localize what specific characteristic of the overall image changed. Feature-based processing should be less sensitive to detecting small changes that might occur at one of many possible locations in an object unless the observer happens to be focusing on that particular location. However, when a

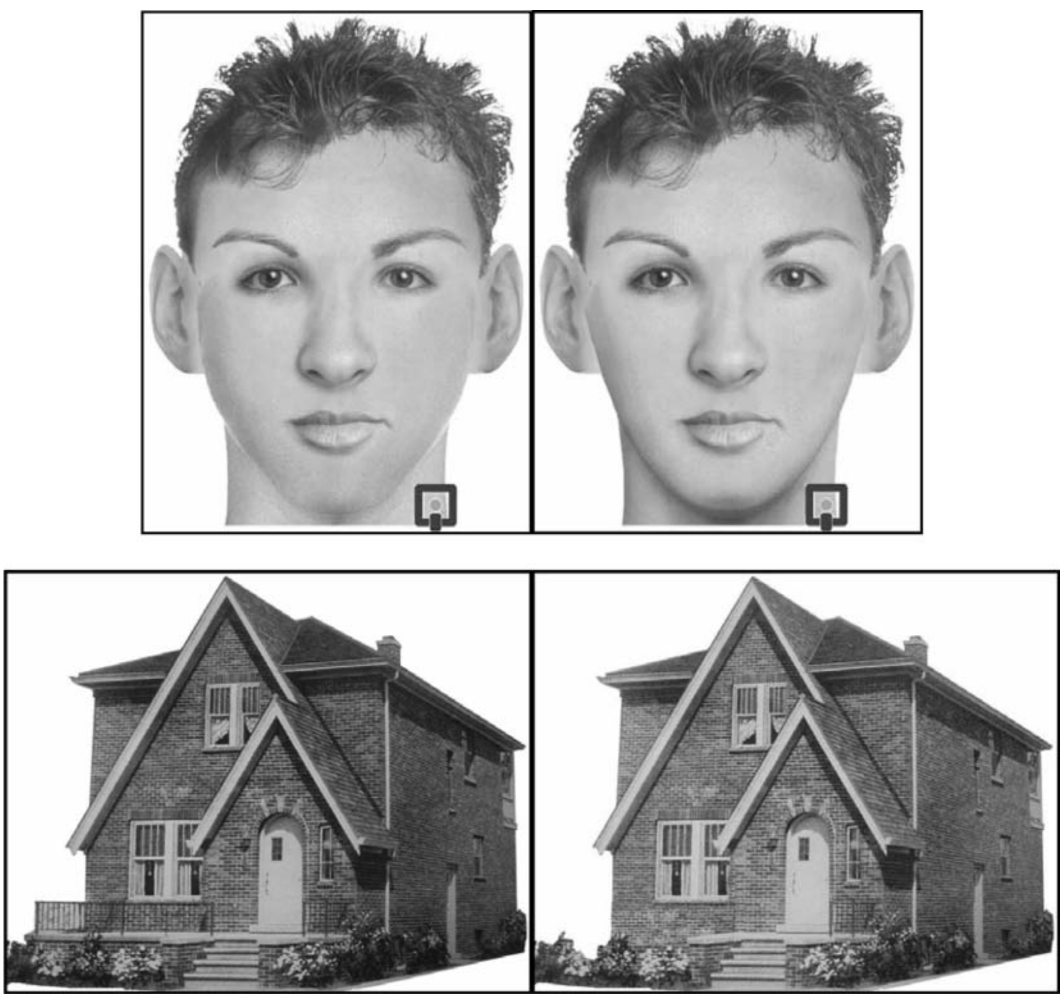

Fig. 1. Examples of the face and house stimuli used in the experiment. The images on the left are the unaltered, original versions; the images on the right illustrate how the images were altered. In these examples, the jaw of the face was changed, and the porch on the house was changed. The symbol appearing on the bottom of each face picture is a trademark of the Faces™ software (IQ Biometrix, Inc., http://www.iqbiometrix.com/products_faces_40.html) and appeared on all the face images.

change is detected in feature-based processing, the person will be able to localize what has changed easily. Hence, our experiment used specially prepared faces and houses in which one feature had changed. Our prediction was that people would be better at detecting the occurrence of a change in faces than in houses, but better at identifying what changed in houses than in faces. Moreover, if our hypothesis is correct, then this interaction between image type (faces vs. houses) and task (change detection vs. change localization) would largely disappear when the house and face images were inverted.

Method

Participants

One hundred fifty undergraduate students (n = 75 for each task) from Iowa State University participated in this experiment for course research credit.

Materials

Ninety-six images were created for this study.[1] These included eight original faces and eight original houses. We created five variations of each face and of each house by changing one of five features at a time (for faces: hair, nose, eyes, mouth, or chin; for houses: roof, chimney, window, door, or porch). The faces were created and manipulated utilizing Faces™ software (IQ Biometrix, Inc., http://www.iqbiometrix.com/products_faces_40.html). The houses were manipulated with Adobe Photoshop. The images were divided randomly into two sets, each consisting of four faces (original images and their altered versions) and four houses (original images and their altered versions). Half of the participants were tested with one set, and half with the other set (through random assignment). We created two sets of stimulus materials to increase generalizability of our results.

Design

We used a 2 (task: change detection vs. change localization) × 2 (image type: faces vs. houses) × 2 (image orientation: upright vs. inverted) mixed-factorial design. Task was manipulated between subjects, whereas image type and orientation were manipulated within subjects. Image type was blocked; participants were randomly assigned to perform the task with houses first or faces first. Participants in the change-localization condition completed 80 trials; each of four original faces and four original houses was tested twice with each of its variations, once in an upright orientation and once upside down. Both images in a given trial were displayed in the same orientation. Participants in the change-detection condition completed 160 trials: 80 trials in which the original image changed and 80 trials (randomly intermixed with change trials) in which the original image did not change. Each image was shown an equal number of times upright and inverted, and the inverted and upright images were randomly intermixed.

Procedure

Each trial presented an original image (1.5 s), a blank mask (0.3 s), and then a test image (1.5 s), followed by an instruction screen. Past research indicates that people can deliberately process faces in a featural manner if given sufficient time (Wells & Hryciw, 1984). We reasoned that quick displays should evoke whatever natural or automatic processing tendencies people have for the stimulus in question. In the change-localization condition, the instruction screen read, "Please identify what change you believe could have occurred." The five possibilities were listed, and participants used a mouse to click on the chosen feature. In the change-detection condition, the screen read, "Did a change occur in the face [house] you were originally presented?" Participants used a mouse to click the "yes" or "no" option.

Results

We calculated accuracy in the change-detection task as the sum of the percentages of hits and correct rejections. Accuracy for the change-localization task was simply the percentage of trials on which participants correctly picked the feature that changed. We then corrected each participant's accuracy score for chance using the following formula: (% correct – % chance) ÷ (100% – % chance). The resulting score represents an estimate of the percentage of trials on which the participant knew the correct answer and did not simply happen to guess correctly. This correction was needed because chance performance was quite different for the change-detection task (50%) and the change-localization task (20%). All analyses were performed using the corrected scores.

Our primary interest was in the predicted three-way interaction among task, image orientation, and image type, which was statistically significant, $F(1, 141) = 11.24$, $p < .001$. The pattern of results followed our prediction (see Fig. 2). For upright images, the change-detection scores were better for faces than for houses, whereas the change-localization scores were better for houses than for faces; the interaction of task and image type was significant, $F(1, 141) = 24.03$, $p < .001$. For inverted images, in contrast, task did not differentially moderate performance on houses versus faces, and the interaction of task and image type was not significant, $F(1, 141) = 1.00$, $p = .76$. Hence, the three-way interaction is easily described as a two-way interaction between task and image type for upright images that disappears for inverted images.[2]

Pair-wise contrasts for upright images showed that accuracy for faces was significantly greater than accuracy for houses in the change-detection task, $t(74) = 2.29$, $p = .025$, $d = 0.26$, whereas accuracy for faces was significantly lower than accuracy for houses in the change-localization task, $t(74) = 4.83$, $p < .001$, $d = 0.56$. When the images were inverted, however, performance was significantly better for houses than for faces on both the change-detection task and the change-localization task, $t(74) = 3.85$, $p < .001$, $d = 0.44$, and $t(74) = 4.35$, $p < .001$, $d = 0.50$, respectively.

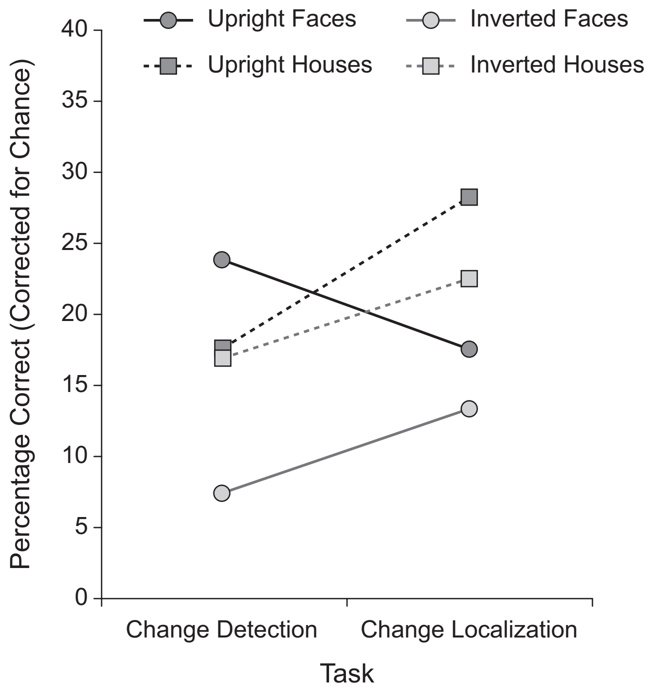

Fig. 2. Percentage correct as a function of task (change detection vs. change localization), image type (faces vs. houses), and image orientation (upright vs. inverted).

Although participants tended to perform best on faces when changes were made to the eyes and best on houses when changes were made to chimneys, and tended to perform worse when changes were made to noses and windows, the patterns reported were stable across all features. Specifically, the same interaction between task and image type was found at the level of each individual feature (e.g., nose, roof, chin, porch). Hence, the critical Task × Image Type interaction was not due to a subset of features driving the effect.

Discussion

We hypothesized that the tendency for people to process faces in a holistic manner and houses in a feature-based manner would result in better detection of changes in faces than in houses. In contrast, holistic processing should be less able to localize change than more feature-based processing is, so change-localization performance should be better for houses than for faces. We found this predicted interaction and, thus, support for the change-detection/change-localization hypothesis. Moreover, we found that when the houses and faces were inverted, this critical interaction disappeared.

Some readers might be puzzled about how performance on the change-localization task could be better than performance on the change-detection task for houses (upright and inverted) and for inverted faces. How can people know what changed and yet be unaware whether there was change? They cannot, and these data should not be interpreted that way. The two tasks were qualitatively different. Participants in the change-detection condition were asked whether there was change under conditions in which there was a change on half of the trials and no change on the other half. Participants in the change-localization condition, in contrast, decided what changed under conditions in which something always changed. For that reason, the two tasks are not directly comparable, and we again remind readers that the interpretable results are contained in the interaction between task and image type. For this same reason, we are not concerned that the change-detection task included twice as many trials as the change-localization task. Main effects and simple effect differences between these counterbalanced tasks have no explanatory power for the interactions, which are the focus of this work.

The results of this experiment might help explain why face composite systems (such as the Faces™ software utilized to create the face images for this study) yield such poor results with eyewitnesses (see Wells & Hasel, 2007). Face composite systems require eyewitnesses to select facial features from a large number of possible features, and the selected features are assembled to create a face image. The standard interpretation of the poor likenesses that are created through this procedure is that memories for faces are stored holistically, whereas composite systems require a more decomposed, featural representation. We agree with that interpretation, but the current results lead us to add a related observation. Specifically, when witnesses finish a composite, they are typically asked to look at the overall result (the whole created face) and are free to change any features. Our findings suggest that witnesses are likely to detect that the composite is not a good representation of their memory, but they cannot discern which feature or features are different from their memory, which prevents them from making effective corrections.

We began with the curious observation that when people make changes to their facial appearance, their close acquaintances seem to detect the changes but often cannot locate them. The propensity to process faces holistically seems to be a likely explanation given the pattern of results found in the current experiment. We believe that these results also have broader implications for the distinction between holistic and featural processing because they suggest that there is no overall advantage for holistic processing over featural processing, but instead that each has advantages or disadvantages depending on the nature of the task.

Acknowledgments

We thank Jason C.K. Chan, Frederick O. Lorenz, Eric E. Cooper, and Shana K. Carpenter at Iowa State University for their help in this project.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

This research was supported by National Science Foundation Grant 0850401 to the second author.

Notes

1. All 96 images developed for this research (i.e., the 8 original faces and all of their variations plus the 8 original houses and all of their variations) can be obtained from the authors at no cost upon request.
2. We tested whether the order in which the image types were presented and the set of images used moderated the critical three-way interaction by performing a 2 (task: change detection vs. change localization) × 2 (image type: faces vs. houses) × 2 (image orientation: upright vs. inverted) × 2 (set: A vs. B) × 2 (order: faces first vs. houses first) mixed analysis of variance (task, order, and set were between-subjects factors; image type and orientation were within-subjects factors). There was a significant four-way interaction among image type, task, image orientation, and set, $F(1, 141) = 4.56$, $p = .034$. However, the pattern in Figure 2 still held for both sets, and the four-way interaction appears to be due to the pattern being somewhat more dramatic for one set than for the other.

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