Research Report

CHANGING FACES: A Detection Advantage in the Flicker Paradigm

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Abstract—*Observers seem surprisingly poor at detecting changes in images following a large transient or flicker. In this study, we compared this* change blindness *phenomenon between human faces and other common objects (e.g., clothes). We found that changes were detected far more rapidly and accurately in faces than in other objects. This advantage for faces, however, was found only for upright faces in multiple-object arrays, and was completely eliminated when displays showed one photograph only or when the pictures were inverted. These results suggest a special role for faces in competition for visual attention, and provide support for previous claims that human faces are processed differently than stimuli that may be of less biological significance.*

Faces are meaningful stimuli, of great social and biological importance. Indeed, single-cell recordings (e.g., Perrett, Hietanen, Oram, & Benson, 1992), neuroimaging studies (e.g., Kanwisher, McDermott, & Chun, 1997), and neuropsychology (e.g., De Renzi, 1986) have pointed to brain areas selectively activated by faces. Such evidence has led to proposals that face processing may be subserved by a specialized module that results in automatic and mandatory processing of faces (Farah, 1995). However, despite this neural evidence that face processing may be special, there is little behavioral evidence for this claim.

Although some studies have demonstrated unique sensitivity of face perception to configural information (Tanaka & Farah, 1993), other studies have shown that objects other than faces can acquire similar configural sensitivity after extensive training (Gauthier & Tarr, 1997). In addition, although facial expressions and gaze direction seem to have a special capacity to attract attention (Driver et al., 1999; Friesen & Kingstone, 1998; Langton & Bruce, 1999; Mack & Rock, 1998), neutral faces typically require serial search, which implies that their perception is not automatic, but rather requires attention (Brown, Huey, & Findlay, 1997; Kuehn & Jolicoeur, 1994; Nothdurft, 1993; Suzuki & Cavanagh, 1995).

These visual search studies, however, have used fairly artificial experimental situations. For instance, most of these studies have used inverted or scrambled faces for nontarget stimuli, and schematic face drawings that do not convey all the information real faces convey have been used as targets. It remains possible, then, that faces would draw more attention than other objects if all stimuli in the array were photographic images of real objects. Moreover, even if face perception is not automatic but rather depends on attention, faces may still have a special capacity to attract attention for further processing. This attention-capturing property of faces should become apparent, however, only in situations in which real face stimuli are competing with other real objects for attention. This was the hypothesis of the present study. To investigate it, we employed a recent paradigm that has been used to investigate visual attention in more lifelike settings.

Rensink, O'Regan, and Clark (1997) demonstrated that subjects are sometimes remarkably poor at detecting changes between two images of real-life scenes when the images are separated by a large transient, so that they appear to flicker. This phenomenon is termed *change blindness* (for reviews, see Simons, 2000; Simons & Levin, 1997). For example, subjects failed to detect that an airplane engine was removed between scenes. Attention seems to play an important role in change detection, as subjects are more likely to detect a change when attention is precued to the object of change. From our hypothesis about the special attention-capturing quality of faces, we reasoned that attention would be spontaneously cued to a face even in the absence of any instruction (cf. Levin & Simons, 1997). Thus, we predicted that any changes concerning faces would be noticed more readily than changes concerning other competing objects. We tested this prediction in two experiments.

EXPERIMENT 1

Figure 1 depicts the sequence of events in each trial in Experiment 1. Photographs of six objects from six different categories (faces, food, clothes, musical instruments, appliances, and plants) were presented on each display, with the center of each object placed 5° from fixation. Six instances (e.g., six different faces, six different appliances) from each category were used throughout the experiment. Apart from the faces, the objects selected for each category were chosen to be maximally different from one another in terms of their overall shape, (e.g., a rectangular toaster and a round fan were included in the appliance category). All the faces used, however, had a similar overall shape and were of the same sex (female). We selected the stimuli in this way to minimize low-level visual differences between the changing faces and to maximize such differences for the changing objects in the other categories, so that any advantage for faces in change detection could not be attributed to the faces being less visually similar than the objects in the other categories. (We also addressed this issue directly in Experiment 2.)

Each trial cycled through two displays (533 ms each) separated by a blank interval (83 ms) until a response was made or 20 s elapsed. On half of the trials, the displays were identical to one another (no-change condition). In the other half (change condition), between displays one of the objects changed to another object of the same category (e.g., a face changing to another face). Twelve subjects were asked to make a speeded forced-choice response to indicate the presence or absence of a change between displays. After this speeded response, subjects were asked to report which, if any, of the six categories had changed. A total of 144 trials was run after a short block of practice.

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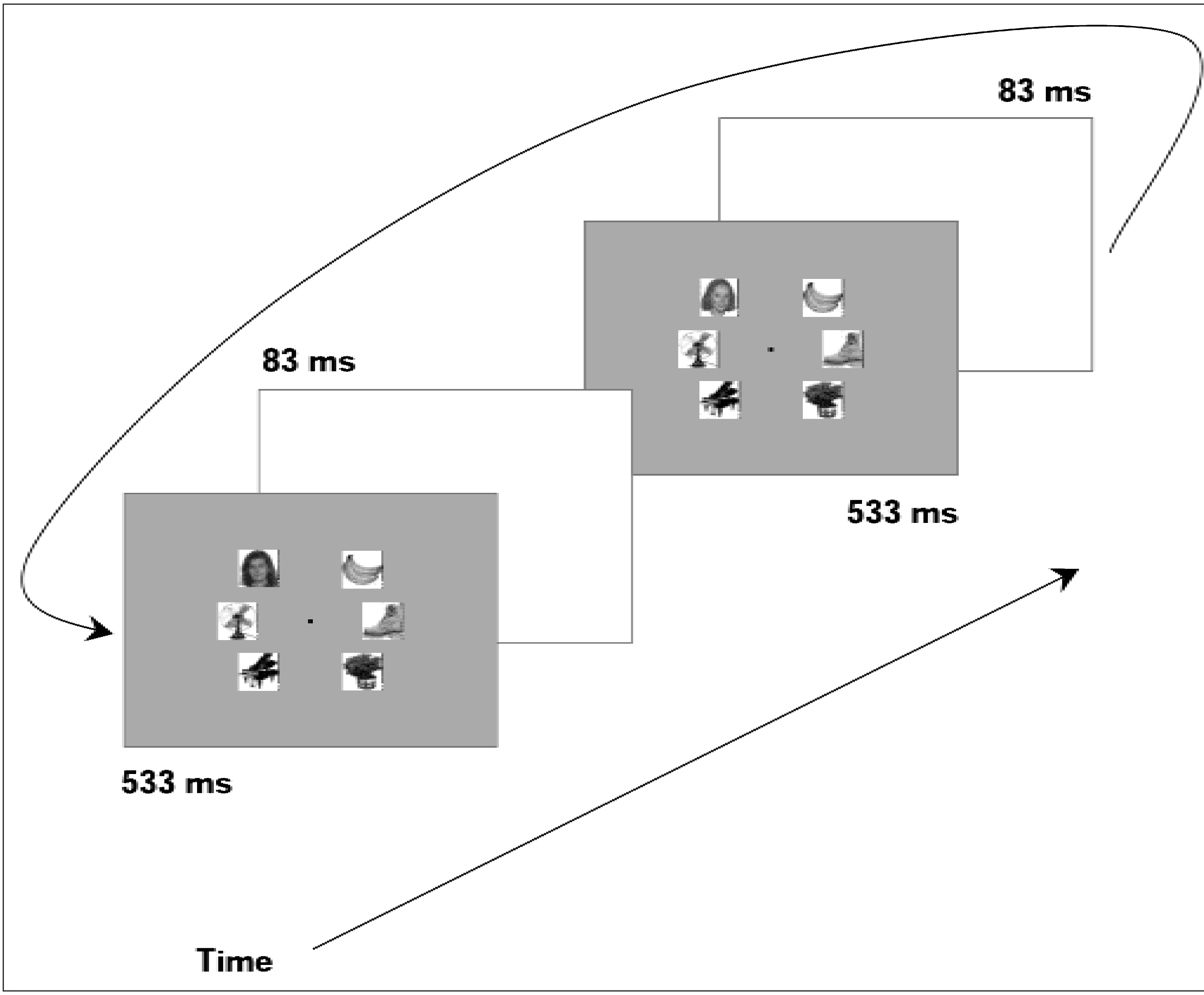

Fig. 1. Example of the events for a typical trial in Experiment 1. Following an intertrial interval of fixation for 2,000 ms, the first frame of object items appeared for 533 ms. A transient (blank white screen) was then presented for 83 ms, followed by the presentation of the second frame of objects for another 533 ms. Another transient was then presented, and this sequence repeated until the subject responded, or 20 s had elapsed. Six objects, one from each of six different categories (faces, food, clothes, musical instruments, appliances, and plants), were presented in each display, and the center of each object was placed 5° from fixation. Across trials, six instances from each category were used.

Figure 2 shows the mean detection response time (RT) and error rate for each category in change-present trials.[1] One-way analyses of variance (ANOVAs) on these RTs and error rates showed a significant main effect of category for both: $F(5, 55) = 5.35$, $p < .001$, for RTs; $F(5, 55) = 5.73$, $p < .001$, for error rates.[2] More important, as can be seen in Figure 2, this effect of category could be attributed to change detection being reliably faster and more accurate for faces than for any other category: $F(1, 11) = 8.42$, $p < .02$, for RTs; $F(1, 11) = 13.46$, $p < .01$, for error rates.

At the end of the experiment, we also asked subjects to rate the difficulty of change detection for each category on a scale from 1 (*most easy*) to 6 (*most difficult*; see the line graphed in Fig. 2). Although change detection was superior for faces compared with any of the other objects, subjects nonetheless judged the faces to be the second-hardest category for perceiving these changes!

Thus, Experiment 1 demonstrated a clear advantage in change detection for faces versus the other categories. This effect, however, did not appear to have any conscious influence on subjects' difficulty ratings, as these showed a clear discrepancy with performance as far

1. Note that no-change trials cannot be broken down by category. The mean RT for the no-change trials was 4,931 ms.

2. The analysis of errors was based on misses, as most errors in Experiment 1 (133 of 138 errors in total) were due to misses rather than false positives. The accuracy for reporting which object changed was 99%.

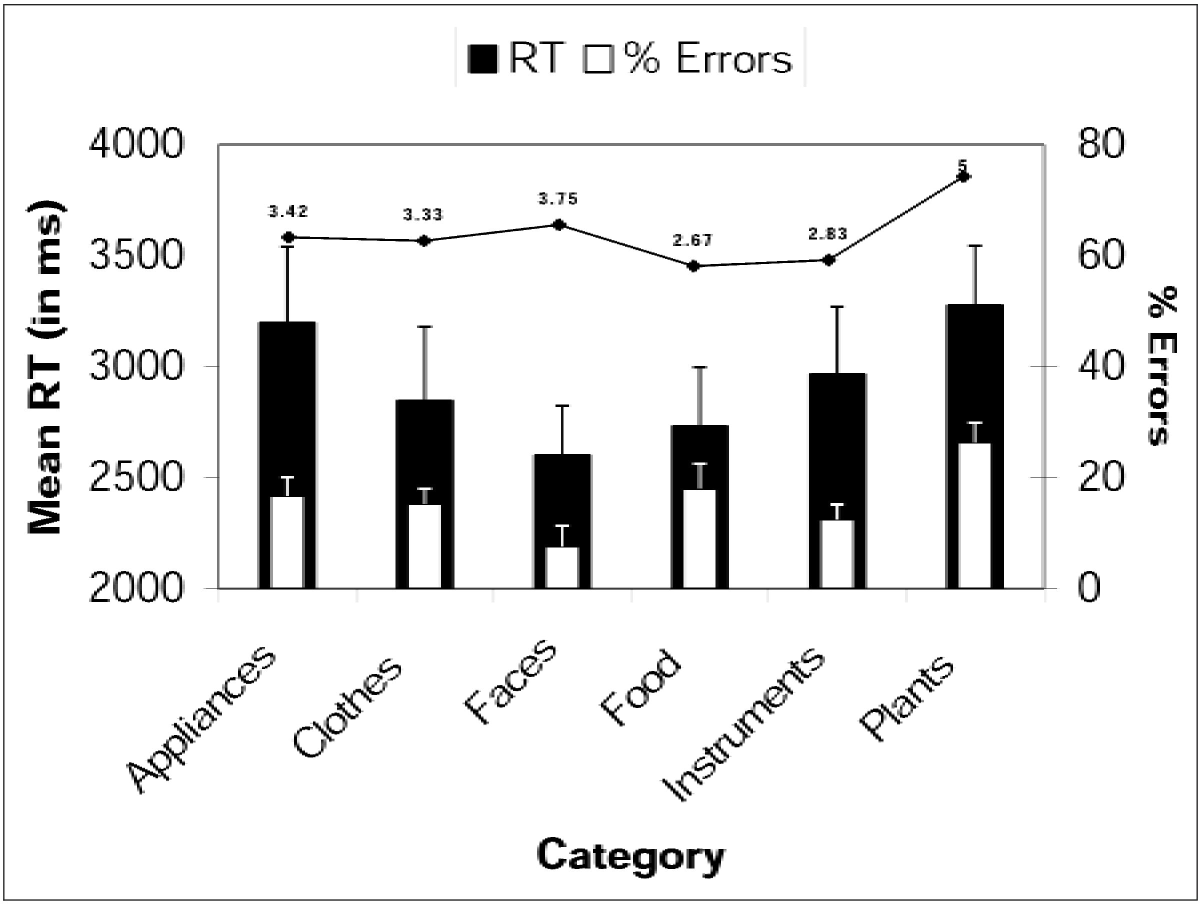

Fig. 2. Mean response times (RTs) and percentage errors for change detection in each category in change-present trials of Experiment 1. The line above the bars shows the mean difficulty ratings for the categories (1 = *most easy*, 6 = *most difficult*). Error bars represent 1 *SE*.

as faces were concerned.[3] We return to this discrepancy after discussing Experiment 2.

EXPERIMENT 2

Experiment 2, which consisted of two subexperiments, was conducted to determine whether the advantage for faces in change detection, as measured in Experiment 1, could be explained by factors other than attention, such as low-level image properties.

Experiment 2a

In Experiment 2a, we presented just one (changing or unchanging) object in every display, thus eliminating any need for one object to compete for attention with other objects. In such a situation, attention can be fully allocated to the single object, and change detection should therefore be mainly determined by visual similarity of the changing objects. If the detection advantage for faces observed in the previous experiment was indeed due to the faces winning over other objects in competition for attention, then no such advantage should be found when competition for attention is eliminated.

As before, one object changed to another object from the same category in a random 50% of the trials. The single object was presented in any of the six positions used in Experiment 1. The duration of the displays was reduced to 100 ms to speed up the flickering, thereby compensating for the reduced difficulty and emphasizing low-level feature changes. The duration of the transient was 83 ms, as before. Twelve new subjects participated in this experiment.

One-way ANOVAs demonstrated a significant effect of category on change-detection RTs, $F(5, 55) = 3.03$, $p < .02$, and a nonsignificant trend in the error rates ($p > .10$). As can be seen in Figure 3a, and unlike in Experiment 1, change-detection RTs were significantly slower for faces than for any of the other categories, $F(1, 11) = 6.11$, $p < .05$. Figure 3b shows a similar pattern for the no-change trials, namely, a significant difference in RTs between the categories, $F(5, 55) = 3.76$, $p < .01$, mainly due to slower RTs in trials with faces than in trials with other objects, $F(1, 11) = 6.18$, $p < .05$. This suggests

3. There was a better correspondence between ratings and actual performance for the other categories (apart from instruments, the order of difficulty was the same in the ratings and detection RTs). This suggests that subjects' ratings were likely based on the difficulty of change detection rather than on some other impression, such as the difficulty of stimulus identification (this possibility is also unlikely considering that identification accuracy in reporting which object changed was 99%). It might be argued that the impression that it is difficult to detect a change in faces actually led to a strategy of focusing attention on the faces. However, analyses on trials in which change detection occurred within 1.5 cycles showed that faces were still the fastest and least missed category. This makes it unlikely that the face advantage was strategic.

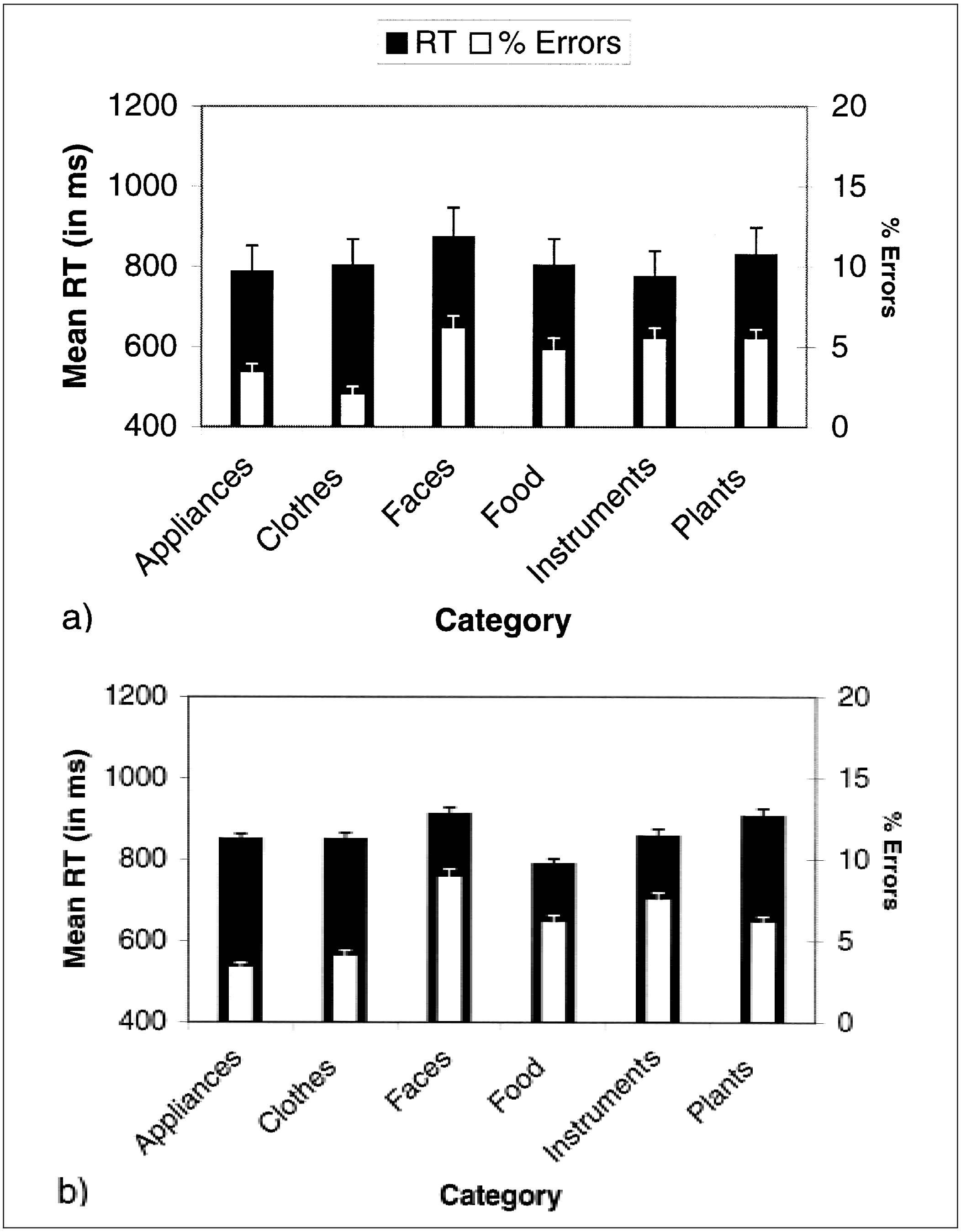

Fig. 3. Mean response times (RTs) and percentage errors for change detection in Experiment 2a. Results for the change trials (a) and no-change trials (b) are shown separately. Error bars represent 1 *SE*.

that the faces used were indeed more similar to one another than the different objects within the other categories, as expected from the way we selected our stimuli.[4]

4. Interestingly, the order of difficulty in detection RTs in Experiment 2a closely matched the order of the ratings of difficulty in Experiment 1 for all the categories (apart from instruments, just as the order of the difficulty rating for instruments did not match the order of the RT for instruments in Experiment 1). This further confirms that the ratings were based on the subjective difficulty of change detection, an impression that seems to have been based on the visual similarity between the changing objects, rather than on their ability to capture attention.

Experiment 2b

Experiment 2b was run to further rule out a low-level image-based account of the competition advantage for faces in Experiment 1. For example, the attentional advantage for faces among other objects in

Experiment 1 could have been caused by a greater image salience of the faces. Thus, Experiment 2b used the multiple-object setting of Experiment 1 (and the same timing: 533 ms for each display and 83 ms for the transient), but with all the objects inverted.[5] It has been shown that inversion impairs recognition of faces more than recognition of other objects (Yin, 1969). If the face advantage measured in Experiment 1 was low-level image driven, it would be found again in this experiment. However, if the face advantage is dependent on the semantic processing of faces, it would not be found for inverted faces.

Unlike in the other experiments, there was no main effect of object category for RTs in this experiment, $F(5, 55) = 2.02$, $p = .09$. Detecting a change between inverted faces was not faster or more accurate than detecting changes between other objects. The mean RTs across the 12 new subjects were 1,842, 1,869, 1,883, 1,966, 1,972, and 2,013, for the food, musical instrument, clothes, face, appliance, and plant categories, respectively. Although there was a main effect of object category in the error rates, $F(5, 55) = 2.20$, $p < .025$, unlike in Experiment 1 the face category did not have the least proportion of errors. The mean error rates across subjects were 15.1, 18.8, 20.3, 24.5, 29.2, and 32.3% for the food, face, clothes, musical instrument, appliance, and plant categories, respectively. Notice that the overall RTs were faster in this experiment than in Experiment 1, but error rates were overall higher (average error rate on change and no-change trials combined was 22% in Experiment 2b vs. 9% in Experiment 1). The greater tendency for a general speed-accuracy trade-off in this experiment may indicate reduced processing for the inverted objects, resulting in performing the task on the basis of a more speedy and error-prone low-level detection of feature changes.

DISCUSSION

Our study shows that faces play a special role in attention (Experiment 1), and that a low-level feature-based account cannot explain their special status (Experiments 2a, 2b). A change-detection advantage for faces was found only when faces competed with other objects for attention (Experiment 1), but was eliminated when inverted objects were presented (Experiment 2b) and was even reversed when just a single object was presented in each display (Experiment 2a). Thus, a situation of high perceptual load, which results in competition for attention, seems crucial for revealing the observed face advantage. These findings imply a special status for faces in competition for selective attention, and are consistent with recent findings that facial expressions have a unique capacity to draw attention (Mack & Rock, 1998).

The results clearly demonstrate that change detection is not determined simply by factors of low-level salience or instruction (e.g., Levin & Simons, 1997). All previous change-blindness experiments compared change detection between objects that varied in their perceptual quality (e.g., their overall salience, retinal position). Our study involved a control for these factors, because we varied orientation and attentional load, and could therefore clearly attribute differences in change detection to attentional factors rather than salience. Furthermore, our study shows that face perception need not be special in a general sense (e.g., Gauthier & Tarr, 1997), but rather that any face advantage crucially depends on a situation of competition for attention.

Notice that our findings of preferential attention to faces do not imply that face processing is automatic, in the sense that it is capacity-free and therefore independent of attention. Rather, as discussed in the introduction, faces may depend on attention for their processing (as demonstrated by the previous visual search studies, e.g., Kuehn & Jolicoeur, 1994), but benefit from having a higher priority in receiving and engaging attention, compared with other objects that may be of less significance to the observer. We note that because a change occurred on 50% of the trials, and was equally likely in any of six categories, the probability of a face change was only 8%. Such a low probability makes it unlikely that the face advantage in our task was strategic.

Moreover, subjects' ratings of difficulty revealed that they were unaware of the face advantage (despite a close match between difficulty ratings and detection RTs for most nonface objects). Perhaps the attentional advantage of faces is involuntary and not open to subjects' awareness (see Kramer, Hahn, Irwin, & Theeuwes, 1999; Theeuwes, Kramer, Hahn, & Irwin, 1998, for a demonstration of attentional capture in the absence of awareness).

Although our studies may not allow us to decide on the exact role of conscious awareness in change detection, or in the preferential allocation of attention to faces, they clearly indicate that the detection advantage for faces is independent of awareness. We conclude that human faces constitute a special stimulus for attention, and for change detection. Although it is presently unclear why faces summon attention, future studies should indicate the necessary conditions for revealing theses effects, and thus provide clues as to what is special about faces.

5. We thank Ron Rensink for suggesting this experiment. By using the same stimuli (apart from the inversion of the objects) and procedures as in Experiment 1, we intended to rule out alternative accounts of why there was no advantage for faces in Experiment 2a. For example, there may have been more eye movements to the single objects in the displays in Experiment 2a than to the multiple objects in the displays of Experiment 1, and this might have caused the difference in results for these two experiments. We thank Allison Sekuler for raising this possibility.

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