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High familiarity enhances visual change detection for face stimuli

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Does high familiarity with a face enable particularly efficient visual processing? In three experiments, we presented briefly and successively two pairs of faces (either famous or recently learned), masking each presentation. Between the first and the second presentations, one face changed, and the task was to locate this change. Performance was significantly better when the change involved a famous face. This *superfamiliarity effect* was found only for changes occurring in the left visual field and was abolished by inverting the faces. Extended prior study of the recently learned faces did not improve performance with these stimuli. The results suggest that superfamiliarity promotes highly efficient visual processing and may especially activate a configural mode of analysis.

It is well established that familiarity with a visual image has significant consequences for its subsequent processing. For example, prior exposure increases naming speed (e.g., Bar & Biederman, 1998), enhances preference (Monahan, Murphy, & Zajonc, 2000), promotes view-invariant recognition (Jolicœur, 1985, 1990), and can mitigate the effects of image degradation (James, Humphrey, Gati, Menon, & Goodale, 2000). Although the effect of prior exposure versus novelty has been well explored, in only a few experimental studies have the perceptual consequences of very high familiarity versus mere familiarity or recent learning been investigated (Arnell, Shapiro, & Sorensen, 1999; Shapiro, Caldwell, & Sorensen, 1997; Tong & Nakayama, 1999). Generally, these studies have suggested that high familiarity promotes speeded or more efficient processing.

Using a visual search procedure, Tong and Nakayama (1999) showed that one's own face could be detected more rapidly than a stranger's face with which one had become familiar among a heterogeneous spatial array of other recently learned strangers' faces, even when the stimuli were inverted or the viewpoints varied. Another study (Raymond, Shapiro, & Arnell, 1992), in which the attentional blink (AB) paradigm was used, required detection of people's names as the second of two successive targets imbedded in a rapid serial presentation of distractor words (Shapiro et al., 1997). In a typical AB experiment, the second target is poorly detected if it is presented within about 500 msec of the first target and both items are masked (Raymond et al., 1992). Shapiro et al.'s (1997) study showed that although expected AB effects were found with other people's names, no AB was found when the second target was the participant's own name. The AB effect is thought to reflect temporal limitations in the ability to reallocate attention to a second target after a first has been processed. Without attention, it is thought that efficient processing of a second target is either weakened by interference from prior images (Shapiro et al., 1997) or delayed (Chun & Potter, 1995), so that a durable representation of it cannot be created before the next image (mask) appears, resulting in reduced detection of the second target. Not finding an AB effect for one's own name suggests that it can be processed more efficiently than other names, by virtue of its high familiarity or personal relevance. This interpretation is consistent with Tong and Nakayama's view of why one's own face is so much easier to spot in a crowded array than a recently learned stranger's face. Both of their experiments indicated that the processing needed for explicit recognition of highly familiar or personally relevant stimuli may be faster than that for similar but less familiar or less socially salient images.

Similarly, Mack and Rock (1998) found that one's own name was successfully detected under conditions of inattentional blindness, and Arnell et al. (1999) showed reduced repetition blindness for one's own name relative to other names. Note that in all these studies, explicit recognition of the familiar target was required. It is, therefore, unclear whether the benefits of high familiarity seen in these studies resulted from facilitation of processes involving explicit recognition or from enhanced perceptual processing. To address this issue, we devised a change detection task using famous and recently learned faces that did not require explicit recognition of stimuli but merely the detection of an image change. We presented two successive displays of different pairs of faces, each pair being briefly presented and then masked in order to limit processing. One face was common to each pair and was presented at the same location both times, whereas the other face changed. The task was to locate the changed

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image and, hence, unlike the tasks in previous studies, did not require explicit recognition or naming.

Although this would seem to be an easy task, detection of seemingly obvious changes is difficult with brief masked presentations if attention has not been allocated sufficiently to the changing aspect of the image (Rensink, O'Regan, & Clark, 1997). They are obvious, however, if the changing image is attended, because change detection depends on creating durable representations in the time available—that is, before masking stimuli disrupt processing. Attention probably aids change detection by speeding durable encoding. We reasoned that if high familiarity also speeds processing, as the studies in which visual search and AB paradigms have been used suggest, detection of changes involving famous versus recently learned faces should be facilitated. To lower overall performance in our task, thus rendering the potential effects of familiarity on processing speed more observable, we diffused attention spatially by requiring participants to report the gender of the left and right faces (gender never changed between successive presentations), in addition to locating the face that changed. We also diffused attention temporally by adjusting the timing of our displays to maximize AB effects for the second presentation. Because performance on a change detection task requires processing of two successive targets, as in an AB procedure, high familiarity in one of the changing faces—particularly, the second—was predicted to improve performance if familiarity assists rapid perceptual processing. (In this way, our experiment is akin to Shapiro et al.'s, 1997, own-name study.) If, on the other hand, familiarity assists access to long-term memory after initial perceptual representations are made available to working memory, change detection might not be facilitated when famous faces are used.

Familiarity aside, face perception may be accomplished by using two different modes of processing (Bartlett & Searcy, 1993; Moscovitch, Winocur, & Behrmann, 1997; Rhodes, Brake, & Atkinson, 1993). One is *featural*, relying on analysis of facial features, such as eyes, ears, and so forth, to identify individuals. The other is *configural*, integrating information from the whole face and matching it to an internal template (e.g., Farah, Wilson, Drain, & Tanaka, 1998). The latter process seems necessary because faces form a very homogeneous class of stimuli, in which single features do not uniquely specify each member. Moreover, recognition of previously encountered faces is remarkably good despite variations in viewpoint, lighting, face expression, makeup, hairstyle, facial hair, and so forth, which alter the visual information in a face. Support for the notion that both processes are important in face recognition comes from neuropsychological research showing a double dissociation for featural and configural deficits (Farah, Wilson, Drain, & Tanaka, 1995; Moscovitch et al., 1997; Postma, Izendoom, & De Haan, 1998). Additional support comes from studies in which face stimuli were manipulated in a way that disrupted configural processes but left local feature information intact. Such manipulations included inverting face stimuli (Valentine & Bruce, 1988; Yin, 1969), scrambling (Tanaka & Farah, 1993), "exploding" (Farah, Tanaka, & Drain, 1995), and misaligning parts of the image in two-dimensional (Moscovitch et al., 1997) or three-dimensional (Nakayama, Shimojo, & Silverman, 1989) space. In general, such manipulations disrupt face recognition performance but leave recognition of facial features intact. On the other hand, simple alterations to one or two facial features, leaving the configural image generally intact, can also impair face identification (Sinha & Poggio, 1996).

How might familiarity with a face affect either or both processes? Common sense suggests that if visual learning under natural circumstances were to aid face processing, it might preferentially speed configural, as opposed to featural, processing, because multiple different exposures to a face would provide greater consistency for configural than for featural characteristics. For example, experience in seeing a person who wore glasses only occasionally would promote perceptual discounting of his or her glasses as an identifying feature; recognition would be better served by a configural strategy. Indirect support for a possible preference for configural processing with increasing familiarity can be found in studies that have reported that different perceptual strategies appear to underlie recognition of recently introduced faces versus familiar faces. Research has indicated that recently learned faces are primarily recognized by external features (e.g., hair), whereas recognition of familiar faces relies on internal details as much as or even more than on external features (Ellis, Shepherd, & Davies, 1979; Haig, 1986; Nachson, Moscovitch, & Umiltà, 1995; Ross & Turkewitz, 1982; Young, Hay, McWeeny, Flude, & Ellis, 1985). The use of internal face information is generally associated with configural processing, because the face inversion effect (reduced recognition with inversion) is more pronounced when only internal features are available (Moscovitch & Moscovitch, 2000). Because face inversion is thought specifically to cripple configural face processing (Moscovitch & Moscovitch, 2000; Moscovitch et al., 1997), this suggests that relying on internal face features for face recognition, as occurs with increasing familiarity, may be associated with reliance on a configural face-processing strategy. If this were the case, any advantages gained by using famous faces in our change detection task should be minimized or eliminated by face inversion, a manipulation used in our second experiment.

To anticipate, in Experiment 1 we found better performance in the change detection task when famous faces, rather than merely familiar faces, were used. These effects were eliminated by face inversion (Experiment 2) and could not be easily induced for the merely familiar faces by providing an elaborated prior study period (Experiment 3). The results are consistent with the notion that high familiarity speeds face processing by promoting configural modes of perceptual processing.

METHOD

Participants

Forty-seven British undergraduates (41 females and 6 males), ranging in age from 18 to 49 years, volunteered to participate in exchange for course credit. Forty-one were right-handed, and 6 were left-handed. All reported normal or corrected-to-normal vision and were naive as to the purpose of the experiment. Informed consent was obtained prior to participation. In Experiment 1, 26 participants were tested: 10 using Face Set A and 16 using Face Set B. In Experiments 2 and 3, 10 and 11 different people participated in the experiments, respectively.

Apparatus and Stimuli

The experiment was programmed in PsyScope (v.1.2.2), and run on an 8600/200 Power PC Macintosh computer. Stimuli were displayed on a 13-in. (33-cm) color (75-Hz) monitor. Responses were recorded via the computer keyboard. A chinrest was used to stabilize head position 97 cm from the computer monitor. Testing was conducted in a small room with low ambient illumination.

Face stimuli were rectangular grayscale digital photographs subtending 5.6° × 4.1°. The center of each face was positioned 3.2° along the horizontal meridian to the left and right of a small central black fixation cross. Two different sets of stimuli were presented in Experiment 1 (Sets A and B), but only Set A was used in Experiments 2 and 3. Each set comprised eight faces: four nonfamous (two males and two females) and four famous (two males and two females). Within each face set, the contrast and clarity of each image and the face size were adjusted to a roughly similar level. Set A faces were "natural" portraits that included hair, neck, some shoulders, and some variation in background gray level. In Set B, the faces were isolated and presented with hair, but without neck or shoulders, on the same uniform gray background. These images had more contrast than did those in Set A. All the faces were frontal views, with both eyes and the other internal and external facial features clearly visible. All the faces were smiling, except one famous male and one nonfamous male in each set, who bore a neutral expression.

Nonfamous faces were randomly selected from a North American high school yearbook and from business Web sites depicting employees. The famous faces selected were highly familiar to British undergraduates at the time the study was conducted. Set A contained Diana, Princess of Wales (P.D., who had died 1.5 years prior to the study), Prince Charles (P.C.), whose image was often present in the news, Leonardo DiCaprio (L.D.C.), who starred in the film *Titanic*, which was at cinemas at the time of the study, and Jennifer Aniston (J.A.), who starred in the television series "Friends" and in shampoo advertisements (both being aired at the time of the study). Set B contained Tony Blair (T.B.), U.K. prime minister at the time, William Hague (W.H.), U.K. leader of the opposition at the time (both appearing often in news clips), Carol Vorderman (C.V.), a U.K. television personality, and Cher (C.), a pop star, both experiencing popularity at the time of the study.

The pattern mask used in all the experiments was a scrambled collage of upright face parts taken from images similar in detail to the faces used in the study.

Procedure

A typical trial is illustrated in Figure 1. Each trial commenced with a 1,000-msec presentation of the fixation stimulus. Four 100-msec displays were then presented successively (without any interstimulus intervals), creating a sequence lasting 400 msec. In order of presentation, these displays were the first pair of faces, a pair of scrambled face masks (presented over each face), the second pair of faces, and another pair of pattern masks. On every trial, one face was common to both pairs and was presented at the same location. The other face changed between the first and the second presentations. Female faces changed only into other female faces, and male faces changed only into other male faces. The face that changed is called the *target*, and the face that remained unchanged is called the *distractor*.

The participants' task was to report the change location (left or right), using a keypress. They then reported the gender of both faces by pressing one of two keys for the left image and one from a different pair of keys for the right image. The gender task prevented the participants from attending to only half the display. Trials were self-paced, with at least 1.5-sec intervals. The participants completed 20 practice trials at the beginning of the session, using nonfamous faces that were not part of either Face Set A or B. Each session took 45 min to complete.

A test session consisted of 384 trials presented in a pseudorandom order, so that equal numbers of trials were presented for each condition and all necessary counterbalancing was maintained.

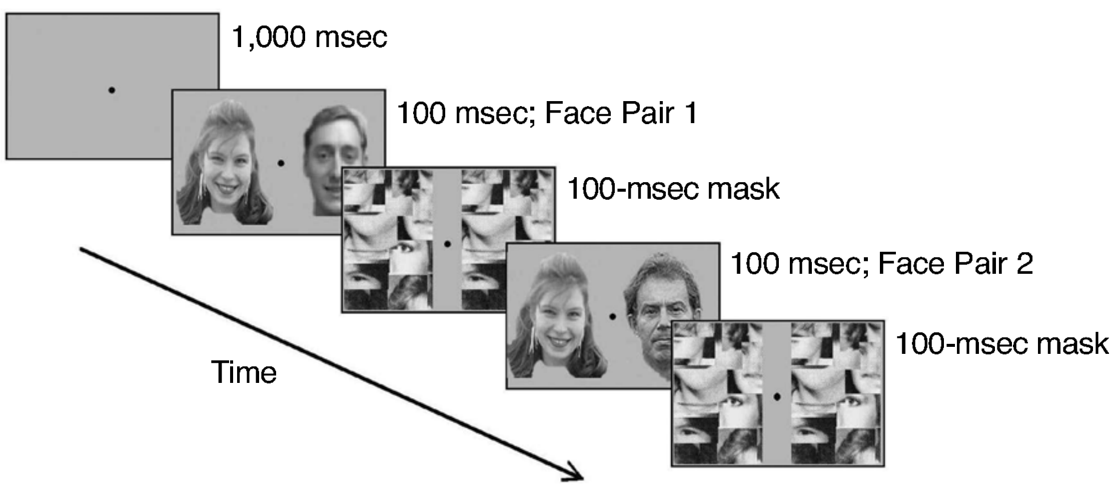

Figure 1. An example trial. After a fixation stimulus, a pair of faces, a scrambled face mask, a second pair of faces, and another mask were presented sequentially. In the second pair, one face was changed to a different face of the same gender. The participants reported the gender of the left and right faces and the location of the changed face.

Within each face set and gender group, each face was changed into each of the other faces an equal number of times. Moreover, each face was presented an equal number of times, and the attributes (e.g., fame or gender) of the faces in the first presentation could not be used to predict the location of the change contained in the second presentation.

Each experiment had four change conditions: a famous face changing into another famous face (FF), a nonfamous face changing into another nonfamous (NN) face, a famous face becoming a nonfamous face (FN), and a nonfamous face becoming a famous face (NF). On half of the trials, the distractor face was famous, and on the remainder it was nonfamous. Changes occurred on the left on half the trials and on the right on the remaining trials. In addition, changes occurred half of the time to female faces and half of the time to male faces. Simultaneously presented face pairs were matched for gender on half of the trials and were mismatched on the remaining trials.

In Experiment 1, all the faces were presented upright, and the participants performed the task with either Face Set A or Face Set B. In Experiment 2, all the stimuli (including the masks) were presented inverted, and Face Set A was used exclusively. In all other respects, Experiment 2 was the same as Experiment 1. Experiment 3 (upright faces) was also similar to Experiment 1, except that only Face Set A was used and a period of study of all the faces was provided prior to testing. This is described in more detail below.

EXPERIMENT 1

Results

Gender task. On average, the participants correctly named the gender of the left and the right faces on 83% of the trials ($SE = 6.8\%$). All the participants scored 70% or better on this task. The difference in performance for Set A and Set B was nonsignificant. More important, gender judgment accuracy was the same for famous and nonfamous faces, indicating that for this task, high familiarity provided no advantage. An analysis of variance (ANOVA) on these data was conducted to determine the effect of visual field (left or right), change condition (NN, FF, NF, or FN), and distractor (famous or nonfamous). The results revealed that no main effect or interaction was significant. This finding indicates that the presence or absence of high familiarity in the display did not differentially tax the processes needed to perform the gender task. Thus, any effects of familiarity in the change detection task cannot be easily accounted for by hypothesizing differential resource availability remaining from the gender judgment task.

Change detection performance. For this and all the subsequent experiments, only trials in which both gender judgments were correct were analyzed for changed detection performance. In this and the subsequent experiments, gender of the changing faces had a nonsignificant effect on change location performance and will not be discussed further. Within the experimental session, there were 24 trials for each condition per observer (i.e., change type, side of change, and distractor type combination). Excluding trials on which the gender task was incorrect, this means that each data point for each participant was based on 20 trials on average.

The important finding of the first experiment can be seen in Figure 2, which plots the mean percentage correct for change localization for each of the four change conditions separately for the visual field in which the change occurred. There are two points to note. First, accurately locating the changing face was more likely when the change involved at least one famous face. Sec-

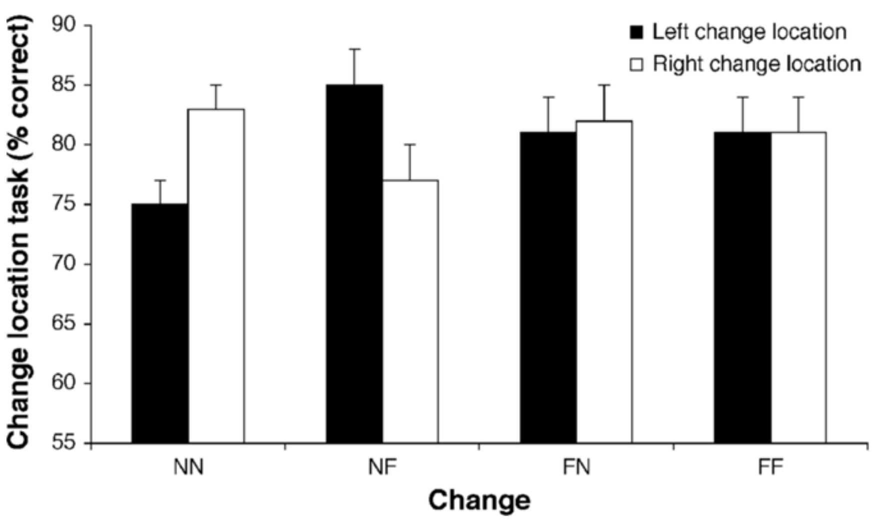

Figure 2. The group mean percentages of correct change localizations are plotted for each of the four change conditions used in Experiment 1 (upright faces). The first letter in the condition label ("Change") refers to the nature of the face before it changed (famous [F] or nonfamous [N]), and the second letter refers to its replacement image. For example, NF refers to the conditions in which a nonfamous face changed into a famous face. Black and white bars represent data for changes presented to the left or the right visual field, respectively. Vertical lines indicate ±1 *SE*.

ond, this effect of familiarity was present only for images presented to the left visual field.

An ANOVA on the percentage of correct localization responses for the change detection task was conducted using one between factor (face set, A or B) and three within factors (visual field, left or right; nonchanging distractor, famous or nonfamous; and change condition, NN, FF, FN, or NF). The main effects of face set (A or B), visual field (left or right), and nonchanging distractor (famous or nonfamous) were nonsignificant. The nonsignificance of the main effect for face set and the lack of any interaction effects for this factor are important because they indicate that any effects of change condition are unlikely to be due to specific aspects of the particular famous and nonfamous faces chosen for the study.

This ANOVA also revealed a significant main effect for change condition [$F(3,72) = 7.991$, $p < .01$] and, as can be seen in Figure 2, a significant interaction of change condition and visual field [$F(3,72) = 5.422$, $p < .01$]. Interestingly, when the changing faces appeared in the right visual field, group mean performance was uniformly good (83%), although not at ceiling, regardless of the presence or absence of a famous face in the changing display. A separate ANOVA of just the right-field data revealed a nonsignificant effect of change condition. However, when a face change occurred in the left visual field, familiarity in the images had a clear effect [$F(24,72) = 11.891$, $p < .01$]. With high familiarity in at least one image, detection of left field changes was as good as that for right-field changes. However, without any famous faces involved, changes in the left field were more poorly detected, performance here being 7.0 percentage points lower than that for all other left-field conditions. Bonferroni-corrected post hoc comparisons for the left visual field means indicate that performance in the NN condition was significantly ($p < .05$) worse than performance in all the conditions with a changing famous face. Note also that performance in the NF (famous face second) condition was significantly, albeit modestly, better (by 2.4 percentage points) than that for the FN (famous face first) condition ($p < .05$). Although small in magnitude, this benefit is important theoretically because it suggests that high familiarity in a face may mitigate AB effects, a point discussed in more detail in the General Discussion section. Also of note is that two famous faces in the changing display did not enhance performance over that seen with only one famous face.

Effect of session. A question that arises from this experiment concerns the effect of repeatedly viewing the same nonfamous faces. Although the faces were novel on the first few trials, familiarity must have developed during the course of the session. To analyze for this effect, the trials were divided into quartiles, and a three-way repeated measures ANOVA (change condition × quartile × visual field) was conducted. Importantly, not only was the quartile main effect nonsignificant, the triple interaction with quartile, change condition, and visual field was also nonsignificant [$F(9,225) = 1.103$, $p > .05$], meaning that the visual superfamiliarity effect described above was present throughout the session. Superfamiliarity, as used here, refers to a stimulus that, through extensive exposure and personal relevance, has formed robust representations beyond that associated with mere frequent viewing. These superfamiliar stimuli can be of an iconic nature, such as famous portraits (as presented here), or they may be close friends' or relatives' faces.

EXPERIMENT 2

Experiment 1 demonstrated that change detection was significantly better when a famous face was part of the changing display than when only recently learned nonfamous faces were viewed. Since the effect was found for two different sets of faces, its seems unlikely that this effect can be accounted for by specific "quirks" in features of the famous faces that made change detection particularly easy and were, by accident, not present in the features of the nonfamous faces. However, to rule out this possibility, we conducted the same experiment with the images inverted. With inversion, the same local features would still be available to signal change detection, and if these accounted for the superfamiliarity effect, the pattern of data should be the same as that observed in Experiment 1. (Recall that the participants only had to locate the image change and were not required to identify the faces, beyond specifying gender.) This manipulation also allowed us to examine whether configural processes in face perception underlie the superfamiliarity effect. Since face inversion is thought specifically to disrupt configural processing (e.g., Leder & Bruce, 2000; Moscovitch et al., 1997), it should eliminate the superfamiliarity effect if speeded configural processing accounts for the pattern of results in Experiment 1.

Results

Gender task. On average, the participants were correct on this task on 71% of the trials ($SE = 3\%$), a level of performance statistically lower by 11 percentage points than that obtained using Face Set A in Experiment 1 [$F(1,18) = 5.194$, $p < .05$]. As in Experiment 1, an ANOVA using visual field, change condition, and distractor condition as factors revealed that all main effects and interactions were nonsignificant.

Change detection. Group mean performance on the change detection task with inverted faces (conditionalized on correct gender responses) is plotted in Figure 3. An ANOVA on these data, using three within factors (visual field, left or right; distractor, famous or nonfamous; and change condition, NN, FF, FN, or NF), revealed that all main effects and interactions were nonsignificant. Although there was a difference in overall performance in the left and the right visual fields (11%), this did not reach statistical significance [$F(1,10) = 1.37$, $p > .05$]. Importantly, the effect of change condition was also nonsignificant. A similar analysis, using just those partici-

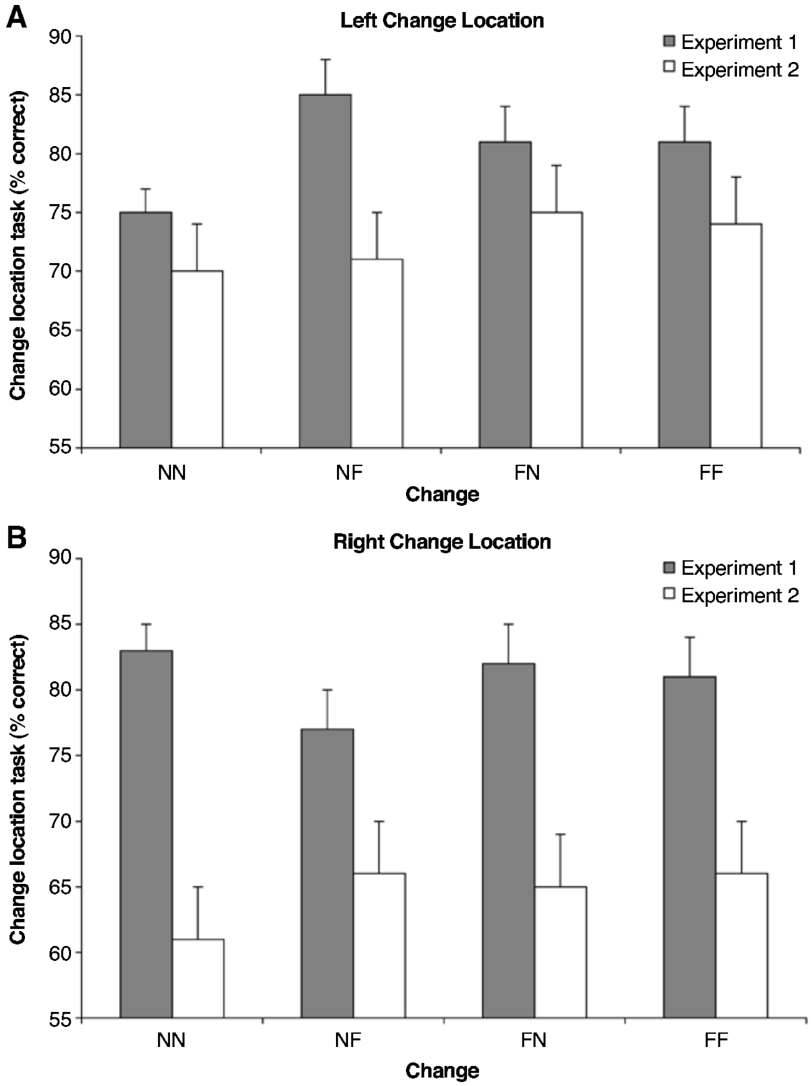

Figure 3. Group mean percentages of correct change localizations for trials in which upright (Experiment 1) or inverted (Experiment 2) faces changed in the left (panel A) or the right (panel B) visual field for each change condition. The first letter in the condition label ("Change") refers to the nature of the face before it changed (famous [F] or nonfamous [N]), and the second letter refers to its replacement image. Vertical bars indicate ±1 *SE*.

pants who viewed Set A stimuli in Experiment 1 (upright faces), revealed a very different pattern. There, both the main effect of condition [$F(3,27) = 4.977$, $p < .01$] and the interaction of change and visual field [$F(3,27) = 3.094$, $p < .05$] were significant, and the overall pattern of results was similar to that shown in Figure 2.

A between-experiments ANOVA comparing the left-field data of Experiment 1 (Set A, faces only) and Experiment 2, using change condition as a within factor, was then conducted. This analysis failed to reveal a significant main effect of experiment, but the interaction of experiment and condition was marginally significant [$F(3,57) = 2.38$, $p < .08$]. As can be seen in Figure 3, the critical improvement with upright famous images for left-field performance seen in Experiment 1 (Set A) was clearly absent in Experiment 2.

EXPERIMENT 3

The purpose of this experiment was to determine whether the superfamiliarity effect in the first experiment could be eliminated by allowing the participants to gain greater familiarity with the nonfamous faces before the test session. It is possible that access to semantic information (e.g., a name) contributed to the superfamiliarity effect in Experiment 1, since this was available only for the famous faces. To test this, in Experiment 3, 10 different observers were given the face, the name, and an 80-word biographical sketch for each of the faces. Accurate statements about the famous faces were made along with fictitious but interesting statements for the nonfamous faces. The participants studied the information (on average, for 8 min) until they felt able to identify each face. Prior to the change detection test, each face was presented to the participant, who was required to name the person and supply one other piece of information about him or her. All the participants were 100% correct and so proceeded to the experimental test session, which was identical to that conducted for Experiment 1, except that only Face Set A was used.

Results

Gender task. On average, the participants were correct on naming the gender correctly for the left and the right images on 89% of the trials ($SE = 1.1\%$), a value not statistically different from that measured for Face Set A in Experiment 1. As before, an ANOVA on the percent correct data, using visual field, image change, and distractor, revealed no significant main effects or interactions.

Change detection. Group mean performance on change detection for changes occurring in the left and the right visual fields and for each of the four change conditions are shown in Figure 4. As can be seen in the figure, high familiarity clearly aided change detection, as it did in Experiment 1—that is, changes were more likely to be correctly localized when they involved a famous face and occurred on the left. An ANOVA on the percentage of correct change location responses was conducted using three within factors (visual field, left or right; distractor, famous or nonfamous; and change condition, NN, FF, FN, or NF). As in Experiment 1, a significant main effect for change condition [$F(3,27) = 3.38$] and a significant interaction of change condition and visual field [$F(3,27) = 3.73$, $p < .05$] were found.

As in Experiment 1, performance was uniformly good when changes were located in the right visual field. For the left visual field, changes involving a famous face achieved levels comparable to those for the right visual field, whereas nonfamous changes (NN) were at a disadvantage, performance here being 10 percentage points lower than that for all the other left-field conditions. Post hoc mean comparisons showed that differences between the NN condition and the NF and FF conditions were statistically significant ($p < .05$).

Distractor effects. Unlike in Experiment 1, there was a significant main effect for distractor type [famous or nonfamous; $F(3,27) = 15.5$, $p < .01$]. When the nonchanging face in the display was a famous face, mean performance was 81% correct, as compared with only 73% correct when the static distractor was a nonfamous image. Note that all other interactions involving this factor were nonsignificant, indicating that the effect of distractor, not seen in Experiment 1 or 2, was independent of the effect of change condition and visual field. To compare these results with those obtained using Face Set A in Experiment 1, a between-experiments ANOVA was conducted using visual field, distractor, and change condition as within factors. This revealed a significant experiment × distractor interaction [$F(1,18) = 5.8$, $p < .05$]. Other interactions of the experiment were nonsignificant. This effect is shown in Figure 5. Performance was the same for both groups when a nonfamous distractor was present, but when a famous distractor was used, accuracy was six percentage points higher with preexposure to all the faces (Experiment 3) than without such prior experience (Experiment 1).

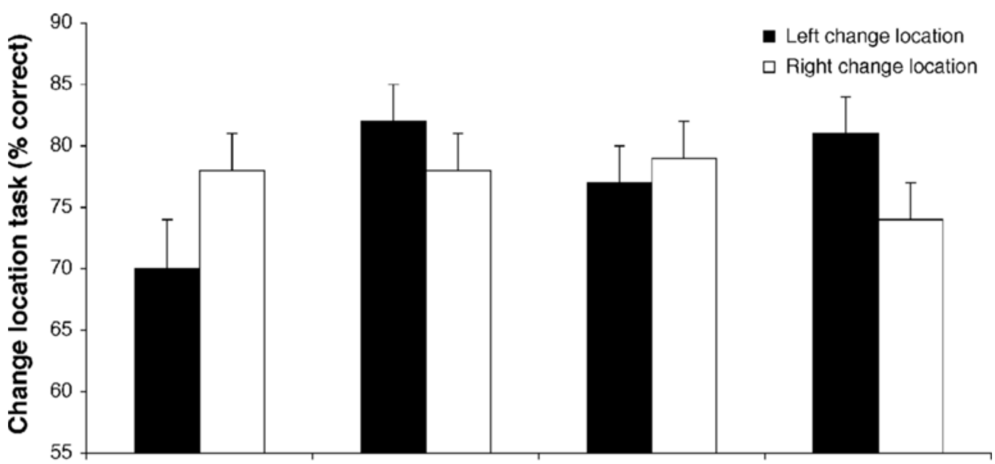

Figure 4. Group mean percentages of correct change localizations for upright faces for each change condition measured after a period of prior study (Experiment 3). Vertical lines indicate ±1 *SE*.

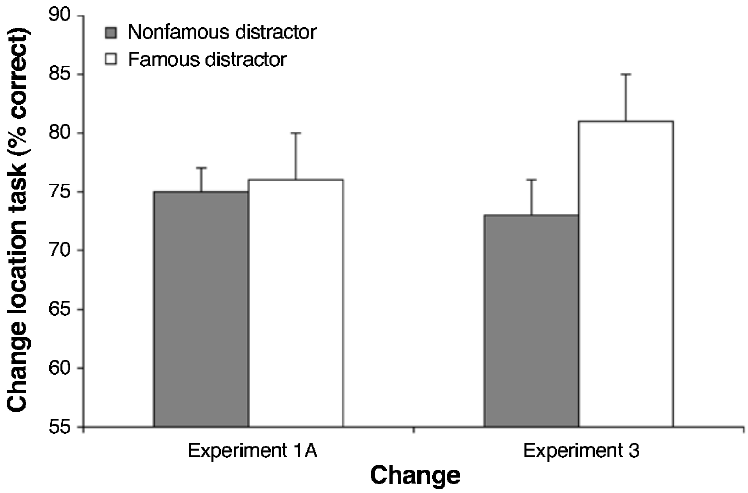

Figure 5. Group mean percentages of correct change localizations for famous and nonfamous nonchanging distractors. Vertical bars indicate ±1 *SE*.

GENERAL DISCUSSION

In three studies, the perceptual consequences of viewing famous versus recently learned nonfamous faces were assessed using a change detection task. Experiment 1 showed that when a brief masked bilateral display of two faces was followed by a similar display with one of the two faces being replaced by another, observers were more likely to detect the change in the display if a famous face was involved in the alteration. This visual superfamiliarity effect was found only for stimuli presented to the left visual field and was not present for changes presented to the right visual field stimuli. When, in Experiment 2, the study was repeated with inverted faces, the visual superfamiliarity effect vanished. In Experiment 3, upright faces were again used, but this time the participants were given an opportunity for focused study of the faces prior to testing. The pattern of results and the size of the visual superfamiliarity effect was similar to that in Experiment 1, replicating the effect and showing that perceptual effects of high familiarity are not easily or quickly induced. Unlike the results of Experiments 1 and 2, famous nonchanging images significantly facilitated performance in Experiment 3.

Three questions arise from these experiments. First, why were changes easier to detect when famous faces were involved, and second, why was the superfamiliarity effect lateralized to the left visual field? A third but more minor issue concerns the advantage for famous nonchanging distractors shown in Experiment 3.

Superfamiliarity Effects

Because each successive image in our display was immediately masked by a scrambled face image, locating the image change cannot have been based on detection of local transients in luminance or edge information, which were scattered over the entire display. Rather, change localization in this task probably requires a poststimulus comparison of relatively high level mental representations of the first and second pairs of faces. Detecting face changes probably involves the same mechanisms as those engaged during other successive dual tasks using rapid sequential visual displays, such as during AB tasks. Studies of the AB effect—that is, a deficit in detecting a second visual target after successfully identifying a previous target when the two targets appear within a half second of each other (Raymond et al., 1992)—indicate that there is a severe temporal bottleneck for the development of task-relevant high-level representations in sequential displays such as those used here (Luck, Vogel, & Shapiro, 1996). The general explanation for the AB effect is that creating a new, durable object representation for the first target image uses up available attentional resources for a lengthy period (Raymond, 2003). This leaves fewer resources for processing the second target image, resulting in a representation too weak (Shapiro, Raymond, & Arnell, 1994) or too transient (Chun & Potter, 1995; Seiffert & Di Lollo, 1997) to control report. However, if the second image requires few processing resources to begin with, perception of it could be unimpaired by attending to a prior visual target, and it might "survive" the AB bottleneck. Perhaps this is the basis for the superfamiliarity effect observed here. Tong and Nakayama (1999) proposed that high familiarity can cause faces to be processed faster or more efficiently than when recently learned and that they require fewer attentional resources. If so, the famous faces in our study may have needed fewer resources to produce durable representations, thus facilitating change localization performance. High familiarity might be particularly advantageous in the second face pair, which is presented during the blink, when the strains of rapid sequential visual processing are most pronounced. Our finding that NF type changes (when the famous face appeared in the second display) produced better performance than FN type changes also supports this possibility. This finding is also consistent with data from a conventional AB study showing that one's own name, but not others' names, "survives" the AB (Shapiro et al., 1997).

Although our data suggest that famous faces require fewer attentional resources than do recently learned faces, they do not speak to why this might occur. On the basis of their study of the perceptual processing advantages of highly familiar faces, Tong and Nakayama (1999) proposed that extensive experience with an image leads to the development of particularly efficient neural codes for processing it (Barlow, 1961). They suggested that experience leads to a reduction in the otherwise redundant neural encoding used when stimuli are initially encountered. This increased efficiency in the coding of results in faster processing and demands less attentional control, thus streamlining perceptual processing. Our study suggests that when temporal pressure on visual processing is exerted, the benefits of efficient coding become apparent.

In contrast to the efficient coding view, Leveroni et al. (2000) showed that, overall, greater brain activation (as measured with functional magnetic resonance imaging) is produced during famous face recognition than during recognition of newly learned faces. This suggests that rather than a leaner neural response to highly familiar stimuli, a larger, more generalized response is generated. However, in Leveroni et al.'s study, recently learned faces had been previously exposed only once, and the specific famous face images used during scanning had not been seen before. The greater response to the famous faces may have been due to elaborated emotional and semantic responses to these images. In our third experiment, which allowed prior study of the face images and semantic and emotional information about them, these types of elaborated memorial responses should have been generated for both famous and recently learned faces. Even so, famous faces still had a selective effect on performance, suggesting that activating semantic and emotional memories cannot easily account for processing advantages gained through extensive experience. Indeed, our third experiment, showing that superfamiliarity effects cannot be induced for recently learned faces despite an opportunity to elaborate semantic and emotional knowledge associated with a face, supports Tong and Nakayama's (1999) contention that extensive visual experiences (as in thousands of exposures, not hundreds) is needed to induce efficient coding.

More efficient processing of highly familiar faces could also explain why famous static distractors selectively aided performance in Experiment 3 but had no effect in Experiment 1. In Experiment 3, the effect of this prior study was better change detection performance when famous, but not recently learned, faces were the nonchanging distractor faces. One explanation for this is that prior exposure may have primed highly familiar faces more effectively than the recently learned faces by activating the efficient codes available to process the famous faces. Begleiter, Porjesz, and Wang (1995) showed a greater reduction in visual memory potentials for primed familiar faces versus primed unfamiliar faces, indicating that familiarity interacts with priming effects. In Experiment 3, priming may have preferentially speeded the processing of famous faces, allowing the participants to more readily determine when a famous face remained unchanged during the trial—thus, by default, aiding identification of the correct change location. Because the effect of famous static distractors did not interact with the effect of change type, it appears that the effects of familiarity on priming may be independent of other processing advantages bestowed by highly familiar images.

Visual Field Effect

The superfamiliarity effects reported in Experiments 1 and 3 were localized to the left visual field. This finding indicates that information initially available to the right cerebral hemisphere is able to access information that differentiates a famous from a nonfamous face, even though this information is not required for the task. When changes occurred in the right visual field, performance was unaffected by familiarity in the changing faces, indicating that the left hemisphere detected changes by using a somewhat different mechanism, for which familiarity was irrelevant. A left-field superfamiliarity effect is consistent with neuropsychological reports indicating that damage to the right, and not to the left, anterior temporal area of the cortex results in selective impairment in semantic recognition of famous faces (Tranel, Damasio, & Damasio, 1997) and difficulties in familiarity and personal relevance perception more generally (van Lancker, 1997). It is also partially consistent with Leveroni et al.'s (2000) imaging study, in which brain activation levels when participants made *old/new* judgments for famous and novel faces were compared with those for the same judgments for recently learned and novel faces. They found greater right activation differences in the anterior inferior parietal cortex, the inferior frontal gyri, the anterior cingulate, and the parahippocampal gyrus. However, they also found greater left-hemifield activations for the extrastriate cortex and the left hippocampus.

Suppose that a key difference in the processing of highly familiar versus recently learned faces is that the former is achieved through greater use of configural or holistic processes, whereas the latter relies more on local facial features. This shift from featural processing to configural processing with increased experience makes sense from a practical point of view. Repeated experience in seeing a person is typically associated with observing them with different hairstyles, expressions, and other transient features, such as glasses, makeup, and facial hair, making reliance on facial features for recognition impractical. Support for the possibility that high familiarity is associated with using configural face-processing modes can be found in Experiment 2. Here, we showed that inverting the faces abolished the superfamiliarity effect. Because inversion of faces is thought to disrupt configural processing preferentially (Leder & Bruce, 2000) and to lead to slower encoding (Freire, Lee, & Symons, 2000), not finding any superfamiliarity effect when faces were inverted suggests that in Experiments 1 and 3 (when the faces were upright), the famous faces were processed with a configural strategy.

A left-field bias in the superfamiliarity effect suggests, then, that the right hemisphere is biased for configural processing. This is broadly consistent with notions of hemispheric asymmetries in spatial image processing (see Ivry & Robertson, 1998, for a review). Although both hemispheres are activated eventually by information seen in either hemifield, due to extensive interhemispheric connections via the corpus callosum, and both appear to be equally sensitive to a wide range of spatial frequencies (Kitterle, Christman, & Hellige, 1990), asymmetries in processing can be observed when similar stimuli are presented bilaterally and both must be attended (Ivry & Robertson, 1998), as in the present experiments. With such stimulation, the right hemisphere appears to adopt a more global mode of processing, whereas the left hemisphere appears to preferentially analyze local information. This is analogous to configural and featural processing of faces, respectively, and findings from face perception research generally support this lateralization of processing mode (Gilbert & Bakan, 1973; Levine, Banich, & Koch-Weser, 1988; Luh, 1998; Sergent, 1985). Our finding a left-field bias in the superfamiliarity effect is thus consistent with the supposition that configural processing is associated with enhanced familiarity.

In three experiments, we used a change detection task (that did not require explicit image recognition) to demonstrate that highly familiar faces can be perceptually processed more efficiently and can demand fewer attentional resources than do recently learned images. The pattern of results supports the general claim that extensive experience with a face promotes an emphasis on a configural, as opposed to a featural, mode of face processing. It remains unclear how perceptual efficiency gained from high familiarity is achieved and whether such gains are restricted to face stimuli.

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