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Title
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Permalink
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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 28(28)

ISSN
1069-7977

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Publication Date
2006

Peer reviewed

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The Effect of Personal Familiarity on the Speed of Face Recognition

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Abstract

While previous studies have explored the effects of familiarity on various kinds of visual face judgments, the role of familiarity in face processing is not fully understood. Here, we examine the effect of real-world personal familiarity in three simple delayed-match-to-sample tasks in which subjects were required to match faces on the basis of orientation (upright v. inverted), gender and identity. We find that subjects had a significant speed advantage with familiar faces in all three tasks, with the advantage for familiarity in the orientation case being markedly smaller than the other conditions. This indicates that real-world experience with a face exerts a powerful influence on face processing in tasks where identity information is irrelevant, even in tasks that could in principle be solved via low-level cues. These results underscore the importance of experience in shaping visual recognition processes.

Introduction

The human visual system effortlessly and automatically extracts a wealth of information from face stimuli, including identity, gender, expression, race, age, and a host of other properties. For the most part, the ability to extract such information from a given face does not require extensive exposure to that particular face, and judgments of properties such as gender or race are performed with high accuracy even on completely novel faces. Even so, humans tend to encounter a relatively small number of faces repeatedly, and it is not surprising that these familiar faces may enjoy some processing advantages relative to unfamiliar faces. (Ge, Luo, Nishimuira, & Lee, 2003; O'Donnell & Bruce, 2001; Bruce, Henderson, Newman, & Burton, 2001; Hancock, Bruce, & Burton, 2000). However, it is not clear *a priori* that all face judgments should necessarily benefit from familiarity, nor is there any reason to believe that various kinds of judgment should benefit equally from familiarity. Variation in the advantage conferred by familiarity across tasks could provide important clues to the nature of face representations.

The conceptual orthogonality of many face judgments (e.g. the expression of a face is independent of its gender) has led to the powerful, early idea that various face recognition tasks might be executed by parallel, non-overlapping "modules" (Bruce & Young, 1986). Since face familiarity ostensibly depends on the identity of a face, it has been suggested that under such a model, face familiarity should not affect other tasks, such as gender judgments, because "identity" and "gender" would be processed by separate, non-interacting modules. Along these lines, there are some results that indicate familiarity does not appear to affect gender recognition (Bruce, 1986) or expression classification (Young, McWeeny, Hay, & Ellis, 1986).

More recently, substantial evidence has emerged that familiarity does influence other "orthogonal" face judgments. Using images that were parametrically morphed along a continuum between trained ("familiar") and untrained ("unfamiliar") faces, Rossion demonstrated significantly faster response times (RTs) for sex classification of the familiar stimuli compared to the unfamiliar images (Rossion, 2002). Likewise, other researchers have pointed out cases where it appears that there are interactions between the familiarity of a face and the processing of race (Bruyer, Leclere, & Quinet, 2004), expression (Gallegos & Tranel, 2005; Kaufmann & Schweinberger, 2004), and even speech (Walker, Bruce, & O'Malley, 1995). Taken together, these studies suggest that experience with faces might exert a strong influence on tasks beyond those that are explicitly related to identity.

In the present study, we sought to extend what is known about facial familiarity in three simple delayed-match-to-sample tasks in which subjects were required to match faces on the basis of orientation (upright or inverted), gender, or identity. We assess the extent to which familiarity with a face lowers the response time for accurate classification across our three judgments. There are several reasons why we believe this experiment fills important gaps in our understanding of familiar face processing. First, the use of a matching task minimizes the memory and training requirements necessary to carry out our three recognition tasks. Also, regardless of whether the subject is matching a face according to gender, identity, orientation (or any other attribute we might choose), the nature of the response (a

left/right choice) is equated across tasks. This makes comparisons across tasks more justifiable than when a binary choice (male/female) is required in one task and a multiple-category choice (expression or identity) is required in another. Second, the use of personally familiar faces obviates the need for training on novel images (which may not lead to complete "familiarity") or the use of celebrity faces (which may be more distinctive than typical faces). There is also reason to believe that personal acquaintances should give rise to the strongest familiarity effects (Clutterbuck & Johnston, 2002). Finally, by asking subjects to perform a very easy matching task, we avoid the possibility of a speed-accuracy trade-off by looking for variations in RT while all subjects are performing highly accurately.

Methods

Subjects

Twenty-four subjects (four men and twenty women, aged 18-25) participated in this study. Twelve of these subjects were highly familiar with a subset of the individuals depicted in the face database used here. The other twelve subjects were gender-matched controls with no acquaintances among the individuals in the database. All subjects were compensated for their participation in this study.

Stimuli

We used a database of faces depicting residents and affiliates of an undergraduate dorm at MIT. The full image set contains 190 unique individuals, half men and half women. Each individual is pictured in left and right profile, left and right ¾ view, and in two different frontal images. The pictures were initially full-color and 640x480 pixels in size.

For presentation, the images were resized to 128x96 pixels, and reduced to grayscale so that broad color cues could not facilitate recognition of targets. To make the matching tasks less trivial, target faces were also Gaussian-blurred in Adobe Photoshop to approximately 6 cycles across the face. Blurring was intended to discourage subjects from performing matching based on small-scale details like moles or blemishes on the face.

Cue images were generated for the "Gender" and "Orientation" tasks by creating facial morphs of the images in our database using MorphMan. The orientation cue image was the result of morphing together all faces in the database. For the "Gender" task, male and female cue images were created by morphing together all the men and women in the database respectively.

Procedure

Subjects were seated approximately 0.5 m from a computer monitor with no restrictions on head position. Before beginning, subjects in the experimental group were shown the entire set of individuals in the database and asked to select 9 individuals familiar to them, 5 of which were to be of their gender. They were then asked to select an additional 9 individuals (5 gender matched) who they had never seen before, or seen only infrequently (meaning once or twice). Each gender-matched control was shown the faces selected by their experimental group counterpart and asked if they recognized anyone. Volunteers for the control group who indicated that they did recognize individuals in the array were asked to participate in a different experiment not related to the present study.

Each subject participated in the "Orientation", "Gender," and "Identity" tasks, with task order balanced across subjects. In each task, a trial began with the presentation of a cue image for 500ms in the center of the screen. After a 500ms pause, the subject was then presented with two images (left and right), one that matched the cue image with regard to the current task and another that did not. Subjects were asked to indicate which stimulus matched the cue via button presses as quickly and accurately as possible. Target images remained on screen until the subject made a response. Location of the target was randomized across trials. (Figure 1)

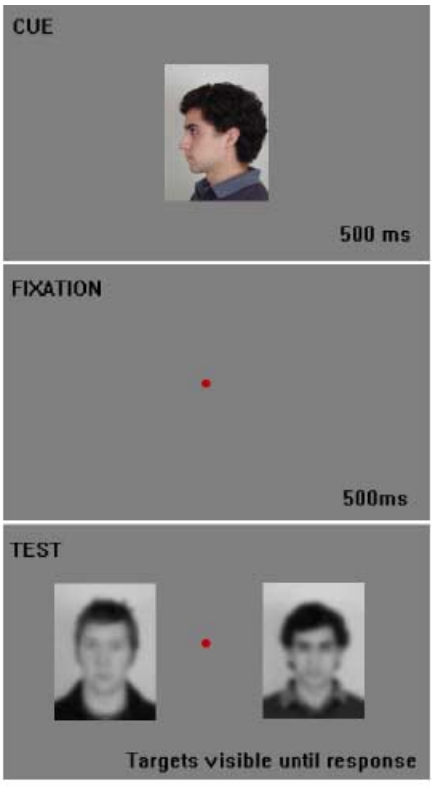

Figure 1: An illustration of the cued 2AFC task used in all three tasks. An "Identity" trial is depicted here, with the correct answer being the right-most image.

In the "Orientation" task, the cue stimulus was always the grand average morph described previously, presented upright, unblurred and in full-color. Test images were

blurred, grayscale frontal images of one individual, one presented upside-down and the other presented upright. Each individual was used 4 times in this experiment, for a grand total of 36 "familiar" trials and 36 "unfamiliar" trials per subject.

In the "Gender" task, the cue image was either the average female or average male morph described previously. The cue was presented upright, unblurred and in full-color followed by blurred, grayscale test images. Test images always displayed one male and female, both drawn from the "Familiar" pool or the "Unfamiliar" pool for the subject in question. Each possible pair of differently gendered faces of the same familiarity was used twice, once with the male image as a cue, once with the female image as a cue, for a grand total of 40 trials per condition. To limit subjects' ability to utilize "pictorial information" (Bruce, 1983) to perform the task, the particular view used for each pair of test images was rotated through the two unique frontal views and the two ¾ views available for each person.

Finally, in the "Identity" task, subjects were cued with unblurred, upright, full-color profile images of the individuals in their stimulus set. Test images were blurred, grayscale images and also matched at test for familiarity as described above. Each individual was used as a cue 4 times, for a grand total of 36 trials per condition. As in the "Gender" task, the view selected for the test images was rotated through the frontal and ¾ views for each individual.

All stimulus presentation parameters and response collection were carried out with the use of the Matlab Psychophysics Toolbox (Brainard, 1997; Pelli, 1997).

Results

We expect that if facial familiarity can affect any of the recognition processes recruited to complete the three tasks described here, we shall see evidence of reduced response time for correct judgments of orientation, gender, or identity matching in the experimental group. Given that the tasks we present are very easy, we do not expect to see any variation in accuracy across subjects or tasks. If the relevant cognitive processes are truly independent of familiarity, we expect that responses to "Familiar" faces should be no faster than those to "Unfamiliar" faces. To control for the fact that some faces may be easier than others to classify according to gender (or orientation and identity), we shall also directly compare the speed advantage for "Familiar" v. "Unfamiliar" faces in our experimental group to that derived from the control group. In doing so, we are able to rule out any effects of potentially confusing images that are only accurately classified if one has personal knowledge of the individual depicted.

Accuracy

Average performance for all subjects across all three tasks exceeded 95% correct. A two-way ANOVA with subject group and task as factors yielded no significant main effects or interactions ($F < 1$ in all cases). As we expected, all subjects found the three implementations of this matching task very easy.

Response Time

To examine the effects of facial familiarity on response time, we take advantage of the fact that each subject was required to perform both familiar and unfamiliar recognition within the same matching task. This allows us to consider paired differences between "Familiar" and "Unfamiliar" faces for each subject, enabling us to factor out inter-subject RT variability. For each subject, we compute the mean RT for all correct "Familiar" and "Unfamiliar" trials within a task. Our dependent variable is then simply the "Familiar" mean subtracted from the "Unfamiliar" mean. If personal familiarity does indeed give rise to faster recognition, we shall primarily see positive values of this difference score in the experimental group that significantly exceed those obtained from the control group. If there is no effect, we expect to see scores that are not significantly different from those of controls.

A two-way ANOVA was carried out with task and subject group as factors. A significant main effect of subject group (Experimental > Control) was observed ($p < 0.0001$), but there was only a marginally significant effect of task ($p = 0.07$). A significant interaction between subject group and task was also observed ($p < 0.05$). Post-hoc Tukey's tests revealed that this interaction was due to a significant difference between subject groups for both the "Gender" and "Identity" tasks ($p < 0.01$), while the difference between subject groups for the "Orientation" task was not significant. Bar graphs of the difference scores obtained from both groups are displayed in Figures 2 and 3.

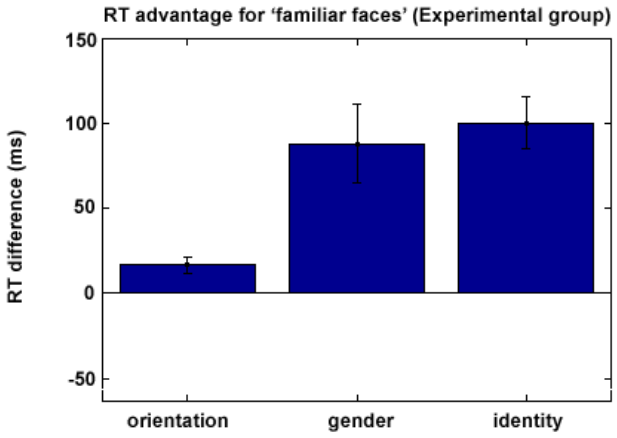

Figure 2: The average RT advantage for familiarity in the experimental group. Error bars represent +/- 1 S.E. of the mean. Each difference is significantly greater than zero.

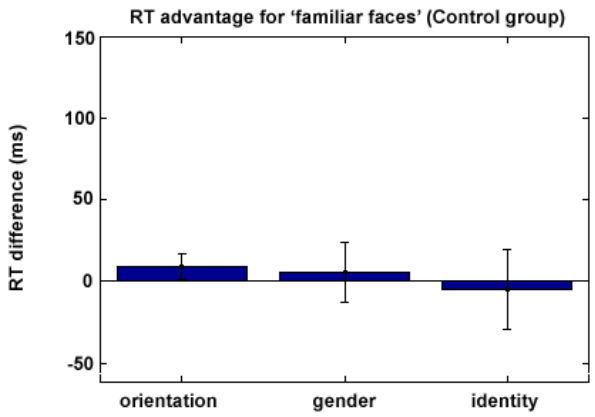

Figure 3: The average RT advantage in the Control group for the personal acquaintances selected by subjects in the Experimental group. Error bars represent +/- 1 S.E. of the mean. We note that the speed advantage for the Gender and Identity tasks is significantly less than that seen in the experimental group and is also not significantly different from zero. This indicates that the faces selected as 'Familiar' by our Experimental group were not simply easier to classify according to gender or identity. The Orientation speed advantage for this group is not significantly greater than zero, but is also not significantly smaller than the speed advantage seen in the Experimental group.

Further examination of the difference scores obtained from the "Orientation" tasks reveals a potentially interesting, but inconclusive result. A one-sample t-test on the difference scores obtained from the Experimental group reveals that the mean difference between "Unfamiliar" and "Familiar" RT is larger than zero to a highly significant level ($p < 0.005$). The same statistic calculated for the Control group yields a non-significant difference ($p > 0.4$).

While it is premature to conclude from this that personal familiarity is definitely able to affect such a low-level visual judgment as face orientation, we find the consistency within the experimental group with regard to this speed difference to be compelling. Moreover, the comparison to the control group may be less crucial in this condition than for gender or identity matching. A particular face may be difficult to assign gender to, or to recognize from a new view, making it crucial to compare experimental group performance to that of controls. However it seems difficult to imagine how a face could appear "more upside down" than another (as opposed to more feminine or more masculine), weakening the argument that the speed advantage for familiar faces we observe in the experimental group for the orientation task is a function of the particular faces displayed therein. We must point out however, that the RT difference between familiar and unfamiliar faces in this task is much smaller than that found for gender or identity matching, however (approximately 15 ms compared to approximately 100ms) indicating that even if this effect is real there may be some important difference between how familiarity affects this "low-level" task and how it impacts more complex judgments.

It is also interesting that the magnitude of the speed advantage is so similar across the Gender and Identity tasks. This is particularly compelling given the RT difference for processing of unfamiliar faces across these two tasks. In Figure 4 for example, we see that for subjects in the experimental group, familiar faces were matched to the cue image in the Identity task in as much time as it took to determine the orientation of the same faces. This is remarkable, considering that judging facial orientation is an extremely low-level task whereas matching identity across views is far more difficult computationally. By contrast, even though there is much more room for improvement in the RT for gender matching, it does not undergo a similarly dramatic increase, but rather decreases by approximately the same absolute amount. This may suggest a wide-spread mechanism by which familiarity affects many different recognition processes in the same way, a topic we shall discuss in more detail.

Finally, it is somewhat surprising that gender matching appears to take a good bit longer than identity matching. This may be an artifact of the blurring manipulation applied to our target images, but gender differences between male and female faces are generally expressed in coarse, high-contrast features (Russell, 2003). Thus, gender should not be disproportionately difficult to recover from blurred images.

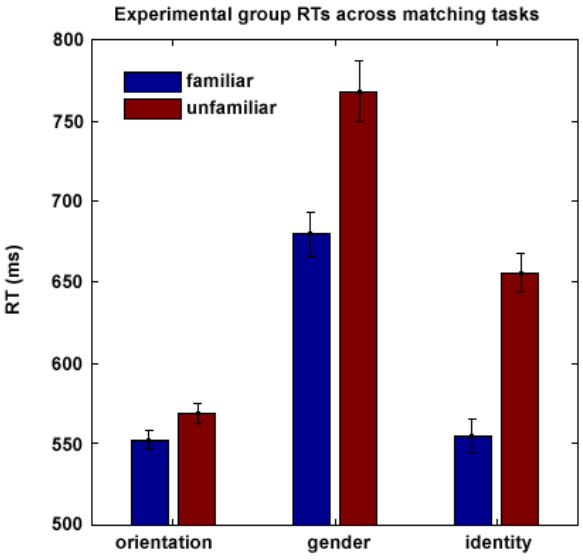

Figure 4: Average RT for matching across task for experimental group subjects. We display the data in this form to point out the large differences in mean RT for "unfamiliar" gender and identity matching that are nonetheless reduced by the same amount when "familiar" faces are presented to the experimental group. It is interesting that the Gender task does not benefit more from familiarity, and may suggest a unified mechanism by which familiarity influences both processes.

Discussion

We have found that personal familiarity with faces increases the speed with which gender matching and identity matching across views can be performed. This suggests that facial familiarity, sex, and identity are not independent cognitive processes, but rather interact with one another. Moreover, by inspecting Figure 2 we can see that the speed advantage obtained for performing gender matching is more or less of the same magnitude as that obtained for identity matching across views. Finally, our experimental group showed a very small familiar-face advantage for matching face orientation. This difference was not significantly different from that of the control group, but was significantly larger than zero. This effect may mean that familiarity with a face can affect very simple low-level judgments, although not to the same degree as it affects more complex visual tasks.

An interesting theoretical question resulting from these findings is how one should revise a model such as Bruce and Young's (1986) to incorporate an interaction between facial familiarity and other recognition processes. That is to say, what is the mechanism by which familiarity with a face results in faster judgments of gender and identity?

One possibility is that there may be no single mechanism of familiarity that cuts across all of the tasks described here. Familiarity may interface with gender and identity matching in fundamentally different ways, for example. Though both of these processes were evaluated in the context of matching tasks with the same structure, this does not mean that the recognition problems in question are actually the same. In particular, the identity matching task requires the subject to generalize an object label across a pose change, while the gender task does not. Thus, it could be the case that familiarity enhances performance in these tasks in substantially different ways. For the identity matching task, it could be the case that familiar faces are simply represented across a wider range of views than unfamiliar faces. In the case of the gender task, we would need to determine another aspect of the relevant recognition process that was similarly affected, as it is difficult to describe this task in terms of view invariance.

We note however, that Troje and Kersten (1999) suggest that there is no such difference in the use of object-centered vs. view-centered representations across familiar and unfamiliar faces. This gives us good reason to suspect that the problems being solved in these two matching tasks may be more similar to one another than we might initially expect. Still, how might familiarity with a face effect performance in this matching task?

One possibility is that familiarity induces a change in processing strategy. Subjects may pay attention to different parts of unfamiliar faces, for example. When confronted with an unfamiliar face, it may be that subjects rely on relevant image cues that are highly reliable across the population but more difficult to extract. If a face is confirmed as familiar, different features that can be extracted and evaluated faster may be given priority. We know, for example, that as faces become familiar, subjects shift from using primarily external face features for recognition to relying more heavily on internal features (Young et al.,1985). It seems unlikely that extracting internal features from blurred images such as those we have used here would be more accurate or efficient for gender or identity matching, but a similar change in the information used to perform the task may be driving the effects we see here. Some experimental evidence suggests we should rule out the well-known "configural/featural" distinction as a candidate (see Collishaw & Hole, 2000), but that does not exclude other changes in how features are weighted relative to face familiarity. Classification images could be a useful tool for exploring the possibility that the information used to perform various tasks changes with familiarity. In particular, the "Bubbles" paradigm may be a good vehicle for understanding how different visual information may be used for matching familiar and unfamiliar faces (Gosselin & Schyns, 2001; Schyns, Bonnar, & Gosselin, 2002). For example, comparisons of "bubbles" images obtained from performing matching tasks on familiar and unfamiliar faces could indicate if image information is used differently as faces become familiar.

Another unified mechanism by which familiarity could impact many distinct facial recognition processes is through a change in criterion. This would imply that there are no real changes in the initial selection of image features, or the efficiency of feature extraction and evaluation. Rather, the speed advantage for familiarity would be the result of lowering the threshold necessary for familiar faces to be accurately classified. In this model, facial familiarity (old/new face) would be processed rapidly, and used to determine how much evidence is required before all other processes return a value for their respective judgments. Old faces would receive low thresholds, meaning that very little evidence could give rise to successful classification. For new faces, the model would adopt a more conservative criterion, requiring more information (and thus more time) before accepting an output. This global criterion shift would predict relatively uniform speed advantages across tasks given the same level of familiarity. Comparing the size of RT differences across a wider range of tasks than presented here would provide some initial support for this model, as would disconfirming the hypothesis that subjects use different image features to process familiar faces.

Finally, what should we make (if anything) of the small RT advantage found for orientation matching in the experimental group? One way to think about this "low-level" task is as a baseline measure of how much previous exposure with a face makes any subsequent processing easier. Having seen a face before may simply prime all pathways in the visual stream that deal with that face, "clearing a path" for future recognition. To the extent that such a global priming effect might exist, the result from the orientation task suggests that for any visual judgment regarding a familiar face, a small (~15ms) RT advantage may be observed. However, given that this RT difference

was only significantly different from zero (not from controls), further work examining the robustness of the effect is necessary before any firm conclusions should be drawn. At present, however, we find the possibility that familiarity with a face can affect such a simple task for which identity is completely irrelevant intriguing.

We suggest that the current results demonstrate that familiarity can powerfully affect a range of visual judgments in face recognition, including identity, gender, and possibly the assessment of low-level image properties. Our results, combined with those from other laboratories, highlight the need for alternate cognitive models of face recognition that incorporate these interactions. Further work elucidating what changes in processing occur as a face becomes familiar may also prove enlightening.

Conclusions

Facial familiarity was shown to reduce the RT necessary for accurate gender and identity matching by roughly the same amount. Judgments of facial orientation may also benefit weakly from facial familiarity, but this effect is smaller and less robust. Facial familiarity was shown to affect a range of face recognition tasks in an extremely simple matching task using images of personal acquaintances.

Acknowledgements

The authors would like to thank Pawan Sinha for his support of this work. Also, we thank Richard Russell for the use of his face database, as well as the residents of MIT's Senior Haus for posing for the photos. BJB and DC were supported by National Defense Science and Engineering Graduate Fellowships.

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