Reducing the Other-Race Effect through Caricatures

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Abstract

We recognize faces from our own race better than those from another race. Although the relative contribution of different mechanisms (e.g. contact vs. attention) remains elusive, it is generally agreed that the other-race effect results from the fact that discriminatory facial features are race-dependent. Previous research has also shown that facial recognition improves when viewers are first familiarized with faces whose most distinctive features have been caricaturized. In this study, we sought to determine the extent to which familiarization with caricaturized faces could also be used to reduce other-race effects. Using an old/new face recognition paradigm, Caucasian subjects were first familiarized with a set of faces from multiple races, and then asked to recognize those faces among a set of confounders. Participants who were familiarized with and then asked to recognize veridical versions of the faces showed a significant other-race effect on Indian faces. In contrast, participants who were familiarized with caricaturized versions of the same faces, and then asked to recognize their veridical versions, showed no other-race effects on Indian faces. This result suggests that caricaturization may be used to help individuals focus their attention to features that are useful for recognition of other-race faces.

1. Introduction

Studies have shown that subjects tend to recognize faces of their own race better than faces from another race [1-5]. This observation, also known as the *own-race bias* or *other-race effect*, reflects differences in perceptual expertise [2]. In a study by Valentine and Endo [1], British and Japanese subjects were asked to rate the distinctiveness of faces from their own race and from the other race. Correlations between the distinctiveness rating of British subjects and Japanese subjects were 0.82 on British faces and 0.65 on Japanese faces. According to the authors, these results suggest that the perception of distinctiveness varies depending of the level of familiarity with faces of a particular race. Japanese subjects are generally exposed to Caucasian faces more than British subjects to Japanese faces. The authors also performed old/new face recognition experiments using distinctive and typical faces from Japanese and British individuals. The experiments showed that British subjects recognized British faces significantly better than Japanese faces, but Japanese did not show an own-race bias effect. Similar results have also been reported by Lindsay et al. [2] between Caucasians and Africans. Both results provide evidence for the other-race effect, and indicate that familiarity with the other race minimizes this effect.

One possible explanation for the other-race effect comes from the fact that the most appropriate features for discriminating own-race faces are not diagnostic for other-race faces [6]. For instance, Africans focus more on the shape and location of the eyes, eyebrows and ears, whereas Caucasians focus more on hair texture, and hair and eye color [2, 7]. This suggests that the other-race effect may be reduced by drawing attention to the most distinctive feature of a given face, potentially overriding the own-race feature biases of the viewer. Hills and Lewis [8] work supports this hypothesis. The authors showed that other-race effects could be reduced by familiarizing subjects with own-race faces containing features critical for differentiating other-race faces. Hills and Lewis' results led us to pose the question: could caricatures be used as a more general approach to direct attention to critical features for the identification of other-race faces?

Generally, people have better recollection for visually distinctive faces or for faces with one or more distinct qualities [9-14]. A prominent chin, nose, or hair style can grab attention during initial exposure and then be used as a memory aid during recognition. This simple fact can be harnessed to create more memorable stimuli. Researchers pursuing this strategy create "caricatures" of normal faces by exaggerating their distinct qualities. And, they find that people are more able to recognize these distorted faces than the veridical faces that were used to create them. This *caricature effect* is well established in the literature on face recognition [15-19]. A handful of studies subsequently have demonstrated a reverse effect in which exposure to caricatures improves recognition of an image of the veridical face [e.g., 15-17, 18, 19-21]. This *reverse-caricature effect* highlights the potential of caricatures for

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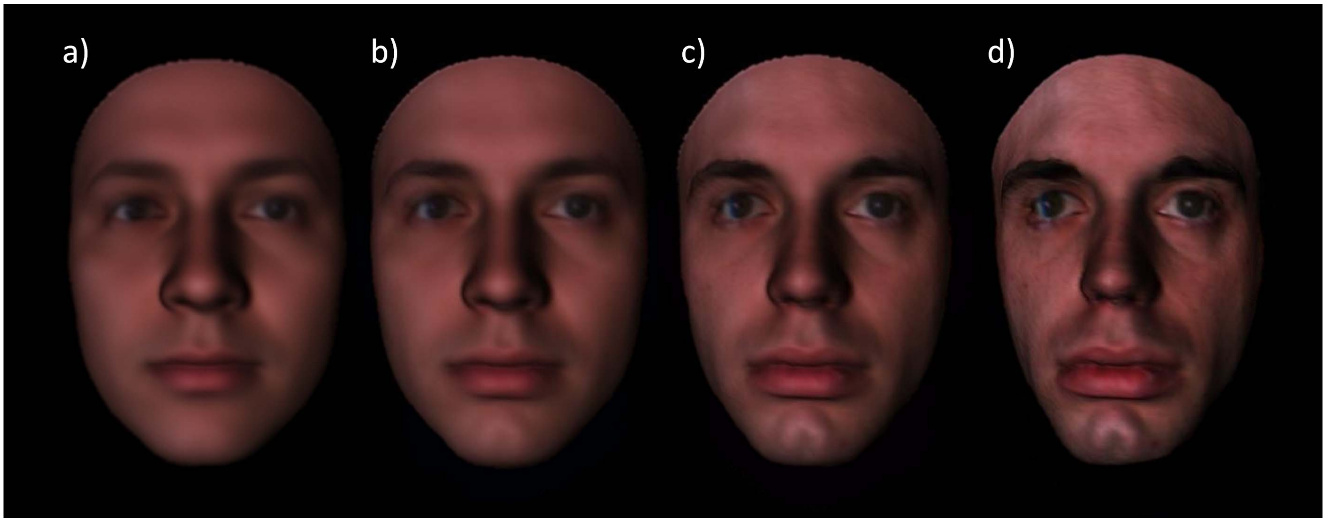

Figure 1: Sample stimuli. It shows the face of a Caucasian male at different caricaturization levels. a) f_{AVG} b) -3σ, c) -1σ, d) +1σ. The ears and neck were removed to prevent participants from using picture-matching strategies.

training in applied settings.

In this paper we investigate whether this reverse-caricature effect can be exploited to reduce other-race effects, i.e. by familiarizing subjects with other-race faces whose distinctiveness has been purposely enhanced. To achieve this objective, we developed an automated caricature generation method using 3D facial models [22], and tested our working hypothesis through a series of perceptual experiments focused on own-race vs. other-race recognition.

2. Perceptual experiments

We employed a similar old/new face recognition protocol outlined in [23, 24], where subjects are familiarized with a set of faces, and then asked to recognize those faces among a set of confounders. In an initial calibration study, we used this method to determine (*a*) the minimal degree of exaggeration between veridical and caricature faces that would lead to a caricature effect, and (*b*) the level and races that would likely produce a significant other-race effect *on this specific dataset*. This exaggeration level was then used as the basis for a recognition study that evaluated whether a brief initial exposure to frontally-presented caricaturized faces would reduce the other-race effect when tested using their veridical counterparts.

2.1. Calibration

2.1.1 Stimuli

A total of 40 face models were selected from the University of Freiburg 3DFS-100 dataset [22]. Each face consisted of a mesh with 75972 vertices, each vertex defined by its position (in 3D Cartesian coordinates) and its reflectance (in RGB space). Following Furl et al. [24], the race distribution for these models was 12 Caucasian, 12 East Asian, 8 Indians, 4 Africans, 4 Other (Middle Eastern, Hispanic, or any other group that did not fit in the first 4 groups). Indian, African, and Other faces were considered as filler stimuli since we had initially selected East Asians as the other-race target for our pool of Caucasian subjects.

In order to caricaturize faces consistently and evenly[1], each face f was first normalized by its Mahalanobis distance ($\| \|_M$) to the average face f_{AVG} [26]

$$f_N = \frac{f}{\|f - f_{AVG}\|_M} \tag{1}$$

and then caricaturized by linearly exaggerating its differences with respect to f_{AVG}:

$$f_C = f_{AVG} + (1+\alpha)(f_N - f_{AVG}) \tag{2}$$

The average face f_{AVG} was computed using all 100 faces from the 3DFS dataset. Five exaggeration levels were considered: -3σ, -2σ, -1σ, 0, +1σ, where σ was defined as the standard deviation of the distance between un-normalized faces in the dataset and their average.

$$\sigma = std(\|f - f_{AVG}\|_M) \tag{3}$$

This parameterization was chosen (as opposed to the conventional percentage factor α) because it adjusts the caricaturization level to the variability of faces in the dataset. Note that the relationship between σ and α is trivially defined by:

[1] Distinctive faces need to be caricaturized less than typical faces in order to achieve the same level of distinctiveness [25].

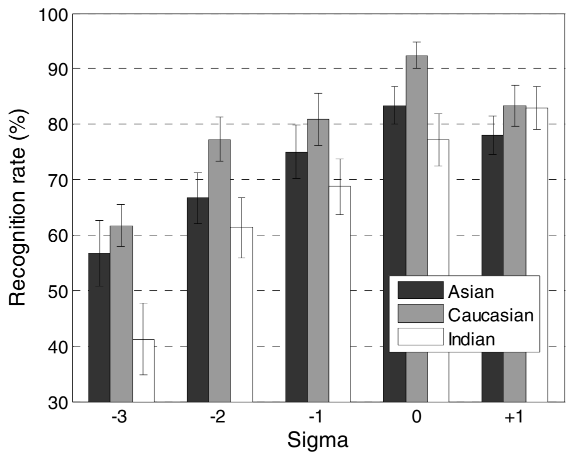

Figure 2: Recognition rate across races. Error bars represent standard errors.

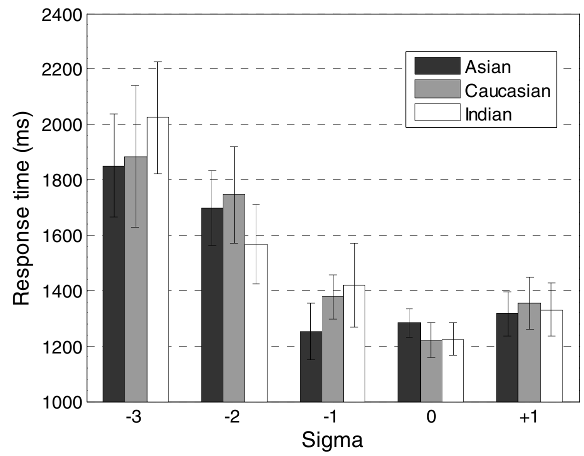

Figure 3: Response time across races. Error bars represent standard errors.

$$\alpha = \frac{k\sigma}{\|f_N - f_{AVG}\|_M};\ \forall k \in \mathbb{Z}\ s.t.\ \alpha > -1 \qquad (4)$$

Renderings of the resulting 3D caricatures for three caricaturization levels and average face are shown in Figure 1. Presentation of stimuli was performed using the DMDX display software [27].

2.1.2 Procedure

A total of 53 undergraduate Caucasian students (38 females and 15 males) from the Department of Psychology at our institution participated in the calibration study. Participants were first assigned to one of five experimental conditions, maintaining a similar gender distribution across condition (n=10, 11, 10, 11, 11). Each condition consisted of stimuli generated at a given caricaturization level (from -3σ to +1σ). Participants were familiarized with 20 frontal target faces, each presented twice in random order, 3 seconds per presentation. After the familiarization phase was completed, participants were tested on 40 faces, of which 20 faces were "new" (non-target) and 20 faces were "old" (target); all faces in the test phase were rendered with a random orientation between ±5 degrees in the three axes. Participants were asked to identify each face as "old" if they recognized it as one from the familiarization phase, or as "new" if they had not seen it before. Following [23], no time limits were imposed, but participants were asked to make the identification as rapidly as possible without sacrificing accuracy.

2.1.3 Results

Significant differences were observed for recognition accuracy across the five caricaturization levels, $F(4,48) = 20.17$, $p < 0.001$. Figure 2 shows the recognition performance across races, excluding African and Other faces, which were significantly under-represented in the stimulus set[2]. Starting from a near-chance level (~50%) for extreme anti-caricatures (-3σ), recognition performance increased with the level of caricaturization. Additionally, Figure 2 shows other-race effects on both Asian and Indian faces, but the effect is stronger on Indian faces. From these results, exaggeration levels of -1σ and 0σ were selected for veridical and caricaturized faces, respectively, on the basis that they were the closest pair with the largest statistically-significant difference in recognition performance: $M_{0\sigma} = 85.23\% \pm 1.56\%$ (Mean ± S.E.M.), $M_{-1\sigma} = 77.50\% \pm 1.29\%$, $t(19) = 3.81$, $p<0.01$ (two-tailed[3]); and they were far from the upper and lower saturation levels, which avoided potential ceiling effects. Furthermore, these caricaturization levels showed a significant other-race effect on the Indian stimuli for our selected veridical faces: $M_{\text{Caucasian}(-1\sigma)} = 80.83\% \pm 4.66\%$, $M_{\text{Indian}(-1\sigma)} = 68.75\% \pm 5.02\%$, $t(18) = 1.76$, $p < 0.05$ (one-tailed). Response times are shown in Figure 3; significant differences were found across caricaturization levels, $F(4,48) = 4.61$, $p < 0.01$, but not within caricaturization levels.

An interesting result from this calibration experiment is that other-race effects were stronger for Indian faces than for East Asian faces. Namely, the other-race effect was significant for Indian faces at all caricaturization levels except for $\sigma = +1$, whereas significant effects for East Asian faces were only observed for $\sigma = -2$ and $\sigma = 0$. While we do not have a precise explanation for this result, our conjecture is that either the specific Indian faces in our dataset were more homogeneous than the East Asian faces, or our participants had more exposure to East Asian faces, either socially or through the media.

[2] As a result, we found that faces from these two races could be singled out and recognized quite easily.
[3] All t-test are two-tailed unless indicated otherwise.

2.2. Reduction of other-race effects

Having identified suitable exaggeration levels that yielded both caricature effects and other-race effects, a second study was performed to test our working hypothesis: namely, that reverse-caricature training can reduce other-race effects.

2.2.1 Procedure

A total of 45 undergraduate students (24 females and 21 males) from the Department of Psychology at our institution participated in this study. Given that the other-race effect was found to be stronger on Indian faces, we adjusted the stimulus dataset to balance the distribution of faces: 10 Asian, 10 Caucasian, 10 Indian, 6 African, and 4 Other. The procedures were the same as in the calibration study, but participants were assigned to one of two experimental conditions: (VV) veridical familiarization-veridical test (n = 23), which served as a control group, and (CV) caricature familiarization-veridical test (n = 22), which tested our hypothesis that reverse-caricature training can reduce other-race effects. In all conditions, the same twenty randomly chosen faces were used (in either caricature or veridical form). Based on our calibration study, we used exaggeration levels of -1σ and 0σ for veridical and caricaturized faces, respectively. A similar gender distribution for participants was also maintained across experimental conditions.

2.2.2 Results

Figure 4 summarizes the results of this experiment. Participants in the VV condition showed a significant other-race effect on Indian faces: $M_{\text{Caucasian}}$ = 76.96% ± 2.84%, M_{Indian} = 68.70% ± 2.69%, $t(44) = 2.11$, $p < 0.05$. Participants in the CV condition, on the other hand, did not show significant other-race effects on Indian faces: $M_{\text{Caucasian(CV)}}$ = 79.09% ± 2.07%, $M_{\text{Indian(CV)}}$ = 77.27% ± 2.39%, $t(41) = 0.58$, *ns*. Moreover, participants in the CV condition showed a significant improvement on Indian faces when compared to participants in the VV condition: $M_{\text{Indian(CV)}}$ = 77.27% ± 2.39%, $M_{\text{Indian(VV)}}$ = 68.70% ± 2.69%, $t(43) = 2.38$, $p < 0.05$. These results suggest that the previously reported reverse-caricature effect [20, 21] can also help reduce difficulties recognizing other-race faces.

In this study we did not find a significant improvement in recognition performance of Caucasian (own-race) faces. Participants only had a small increase in recognition performance in the CV condition as compared to the VV condition: $M_{\text{Caucasian(CV)}}$ = 79.09% ± 2.07%, $M_{\text{Caucasian(VV)}}$ = 76.96% ± 2.84%, $t(40) = 0.61$, *ns*. This result is consistent with the fact that our participants were experts[4] in identifying Caucasian faces; thus, it is to be expected that caricaturization would not provide as much benefit with Caucasian faces as it would with Indian faces. Finally, consistent with our calibration results, participants did not show a significant other-race effect on East Asian faces. As we argued in the calibration study, this may be the result of our participants having had more extensive prior exposure to East Asian faces. Figure 4 shows that participant in the CV condition actually experienced a decline in performance on East Asian faces when compared to participants in the VV condition. Although this reduction was not statistically significant, our expectation was that performance on East Asian faces would have followed that on Caucasian faces. Further experimentation will be required to identify the source of this discrepancy.

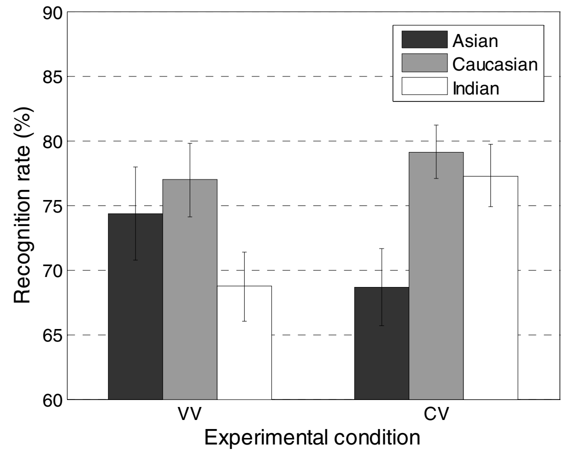

Figure 4: Recognition rate across races. Participants in the VV condition were familiarized with veridical faces and then tested with veridical faces. Participants in the CV condition were familiarized with caricatures, but tested with veridical faces. Error bars represent standard errors.

3. Conclusions

By definition, caricatures increase the salience of idiosyncratic or normatively distinct qualities. This form of distortion appears to increase the amount of memorable information available for later recognition. As a result, exposure to facial caricatures can increase later recognition of their veridical counterparts. More importantly, these distortions appear to decrease the own-race recognition advantage, possibly by allowing participants to focus on those features that are more distinctive for other-race faces. We obtained this effect in

[4] By "expert" we imply that the participant's attention is already directed towards the most diagnostic features for that race. Therefore, caricaturization of those features would not represent a significant advantage. This suggests that a more difficult experiment would be required to show a reverse-caricature effect on own-race faces. This has been the case of previous reverse-caricature reports which, unlike in our study, rendered faces without surface reflectance, and instead employed either line drawings or shape-only 3D models [20, 21].

one of the two other-race faces we studied. Our conjecture is that our Caucasian participants had a higher degree of prior exposure with East Asian faces than with Indian faces. It is also possible that, within the 3DFS dataset, the *specific* East Asian face samples may be more distinctive than Caucasian or Indian faces.

Our finding that reverse-caricature training can reduce other-race effects suggests that this is an effective paradigm to help individuals focus their attention on features that are useful for recognition. These results have important implications for the development of training tools for law enforcement and security.

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