Research Article

CARICATURE EFFECTS, DISTINCTIVENESS, AND IDENTIFICATION: Testing the Face-Space Framework

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Abstract—*According to the multidimensional space framework, faces are represented as locations in a psychological face-space. Our aim was to test whether the locations of veridical, caricatured, and anticaricatured face stimuli in face-space, derived from multidimensional scaling analyses, could account for identification accuracy and distinctiveness ratings for these stimuli. Caricatures were identified more accurately and rated as more distinctive than veridical images, whereas anticaricatures were identified less accurately but were not significantly less distinctive than veridical images. In the face-space derived from multidimensional scaling, caricatures were further from the origin and less densely clustered than veridical images, whereas anticaricatures were closer to the origin and located in denser regions of the space. A quantitative model successfully predicted identification performance from the spatial locations of the stimuli. In general, the physically transformed faces were systematically mapped in the psychological space.*

One approach to object recognition (Biederman, 1987) suggests that objects are represented in terms of a limited set of generic components and the relations between these parts. The approach is well suited for recognition of objects at the basic level (e.g., desk, chair, telephone), but not for discrimination among objects such as faces, which all share the same basic parts and configuration. Highly homogeneous stimuli, such as faces, vary continuously along many dimensions and can be thought of as occupying locations in a multidimensional psychological space (MDS). Valentine (1991; Valentine & Ferrara, 1991) proposed that consideration of the spatial relationships among these internal representations can provide a unified account of the effects of factors such as perceived distinctiveness, caricaturing, and race on identification performance.

It is well known that faces that are rated as distinctive are easier to recognize than more typical faces (Going & Read, 1974; Light, Kayra-Stuart, & Hollander, 1979; Rhodes, Byatt, Tremewan, & Kennedy, 1997; Valentine, 1991; Valentine & Bruce, 1986). The rated distinctiveness of a face is thought to be determined by exemplar density, with typical faces located near the origin and distinctive faces located peripherally in the space. Therefore, given the assumption that faces form a multivariate normal distribution in the space, distinctiveness effects on identification performance are explained in terms of the difference in exemplar density (and thus number of potential distractors) between typical and distinctive faces.

Caricatures are created by exaggerating all spatial differences between individual faces and an average face (so the resulting images lie further from the center of face-space than the original faces), and anticaricatures are created by reducing these differences. Caricature studies have consistently found that caricaturing, despite distorting the original image, does not hinder and may even enhance identification, whereas anticaricaturing impairs identification (e.g., Benson & Perrett, 1991, 1994; Byatt & Rhodes, 1998; Lee & Perrett, 2000; Rhodes, Brennan, & Carey, 1987; Rhodes et al., 1997). According to the MDS framework, caricatures enhance performance because they are more distinctive (i.e., fall in a region of lower exemplar density) than the veridical images, whereas anticaricatures impair performance because they are less distinctive (i.e., occupy more densely populated regions) than the veridical images. This view is supported by evidence that caricatures are perceived to be more distinctive, and anticaricatures less distinctive, than veridical stimuli for both line drawings (Rhodes & Tremewan, 1996) and photographic-quality stimuli (Rhodes, Sumich, & Byatt, 1999).

The MDS framework is becoming an increasingly popular account of face-processing performance (e.g., Byatt & Rhodes, 1998; Chiroro & Valentine, 1995; Johnston, Kanazawa, Kato, & Oda, 1997; Rhodes et al., 1997; Valentine, 1991). Given its popularity, it is surprising that there has been little attempt to actually test the main question: Can the spatial relationships between representations in psychological face-space account for the observed distinctiveness ratings and performance data? A related question is whether transformed physical stimuli, such as caricatured and average faces, systematically map to their theorized psychological locations in face-space. It was our aim in the present study to try and answer these two questions.

Obviously, in order to test the assumptions of the MDS framework, one needs to be able to specify the relative locations of faces within a psychological face-space. This can be achieved with multidimensional scaling techniques, which derive a spatial representation of the stimuli from psychological data, such as ratings of perceived similarity (Shepard, 1980). A previous scaling study (Johnston, Milne, & Williams, 1997) found a high positive correlation ($r = .76$) between distance from the center of the derived space and distinctiveness ratings. Thus, it provided some support for one of the assumptions of the MDS framework, namely, that distinctive faces tend to lie on the periphery of the psychological space. Busey (1998) showed that faces made by blending two individual faces were more typical than those from which they had been created, and this was reflected in their location in the space.

The purpose of the present study was to test the MDS framework further. First, we wanted to establish whether identification performance for caricatured, veridical, and anticaricatured stimuli can be explained in terms of the spatial arrangement of stimuli in a psychological face-space. We modeled the performance data using the generalized context model (GCM), an established computational theory (Nosofsky, 1986). The GCM predicts response probabilities based on the relative locations of stimuli as derived from multidimensional scaling analysis. An advantage of the GCM for testing the MDS framework is that it can use the same internal representations to pre-

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dict recognition, identification, and categorization performance as conjectured by the MDS framework.

Second, we investigated the relationship between exemplar density, distance from the origin (both calculated from the multidimensional scaling solution), and perceived distinctiveness. We expected that perceived distinctiveness would be strongly related to both derived measures. We also expected that caricatures would be perceived as more distinctive and would be found in regions of lower exemplar density, further from the origin, than veridical stimuli. The opposite pattern was expected for anticaricatures. We also expected an average face created from the veridical faces to be represented at (or close to) the origin. These results would indicate that the stimuli derived from the physical transformations (caricatures and anticaricatures) map systematically onto their theorized locations in psychological face-space.

General procedural details that apply to all aspects of the study are discussed next. Specific discussion of the procedure and results for each component of the study—identification performance, distinctiveness ratings, deriving a face-space, and modeling the identification data—are then described in turn, followed by a general discussion.

GENERAL METHOD

Apparatus

Stimuli were displayed on an Apple Macintosh computer, using Superlab 1.68, with a 56-cm monitor synchronized at 60 Hz.

Stimuli

The 16 most familiar male celebrities were selected, based on an informal survey of 33 students, from an initial sample of 108 photographs (all male celebrities with no facial hair or eyeglasses). Eighty-nine photographs, including the 16 selected, were digitized at 150 dpi with 256 gray levels and normalized to the same interocular distance and orientation (horizontally aligned pupils). A composite, or prototype, was created by locating 179 feature points on each image and then computing the average shape and gray-scale intensity information. Caricatured and anticaricatured versions of each selected image were generated by exaggerating (caricatures) or reducing (anticaricatures) the metric differences between the individual and the prototype by 50% (see Fig. 1). These techniques are described in detail elsewhere (e.g., Brennan, 1985; Rowland & Perrett, 1995). The stimulus set consisted of three versions (veridical, anticaricature, and caricature) of each of the 16 celebrities, giving 48 stimuli in total. A black oval border was placed around each image to eliminate the outer hairline and extraneous background information. A mask stimulus was created by randomly scrambling an inverted male face.

Subjects

All subjects in the study were undergraduates at the University of Western Australia and received either $5 or credit toward a course requirement for participating. Different subjects participated in each of the tasks.

IDENTIFICATION TASK

Method

Forty-eight subjects (24 female, 24 male) were told that the purpose of the task was to investigate the relationship between identification and exposure duration. Following each trial, they were given a list of celebrities, each associated with a different key on the computer keyboard, and asked to press the key corresponding to the celebrity shown. A trial consisted of the mask presented for 500 ms, followed by a target face (for either 33 or 100 ms), followed by the mask again for 500 ms. Subjects were then shown the list of the names of the 16 faces, which remained visible until a response was made. There were two blocks (33- and 100-ms exposure durations) of 48 trials, with all 48 images presented, in random order, in each block. Block order was counterbalanced across subjects. Prior to testing, subjects were given examples, which consisted of two 100-ms trials.

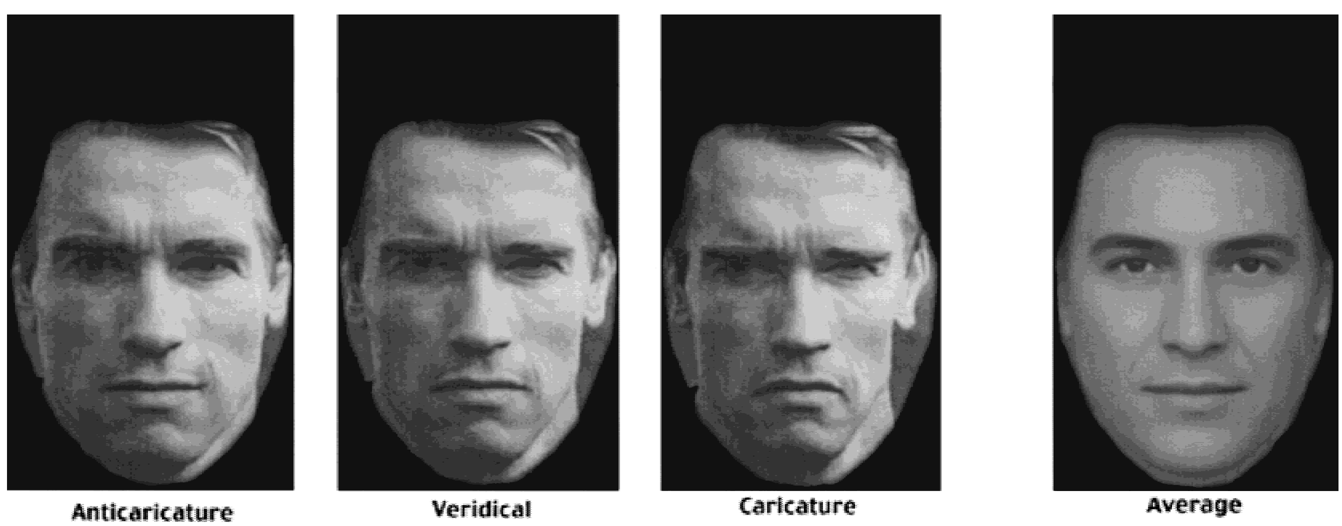

Fig. 1. Examples of the three image types—anticaricatured, veridical, and caricatured faces—and the average face.

Results and Discussion

Two-way analyses of variance (ANOVAs) were carried out on the mean percentage correct scores. Analyses were carried out with both subjects and items as the random factor. One subject was excluded from the analyses because of poor identification accuracy. Planned t tests were used to compare performance for anticaricatures, veridical images, and caricatures.

Analysis by subjects

Display duration (33 ms, 100 ms) and image type (anticaricature, veridical, caricature) were repeated measures factors. There was a significant main effect of duration, $F(1, 46) = 4.31$, $MSE = 9.24$, $p < .05$, with faces identified more accurately at 100 ms ($M = 63.4\%$, $SE = 1.6\%$) than at 33 ms ($M = 58.7\%$, $SE = 2.0\%$). There was also a main effect of image type (Fig. 2), $F(2, 92) = 35.85$, $MSE = 1.74$, $p < .0001$. Anticaricatures were identified significantly less accurately ($M = 55.5\%$, $SE = 2.2\%$) than the veridical images ($M = 62.4\%$, $SE = 2.2\%$; $t[30] = 5.81$, $p < .0001$), which in turn were identified less accurately than the caricatures ($M = 65.4\%$, $SE = 2.2\%$; $t[30] = 2.43$, $p < .05$). There was no interaction between duration and type of image, $F(2, 92) = 2.34$, $MSE = 0.01$, n.s.

Analysis by faces

Display duration and image type were within-face factors. The results generally matched those from the analysis by subjects. The main effect of duration was significant, $F(1, 15) = 15.97$, $MSE = 7.33$, $p < .005$, with faces identified more accurately at 100 ms ($M = 63.4\%$, $SE = 2.7\%$) than at 33 ms ($M = 58.7\%$, $SE = 2.6\%$). Identification accuracy also varied as a function of image type, as in the by-subject analysis, $F(2, 30) = 15.72$, $MSE = 11.65$, $p < .0001$. Again, the anticaricatures were identified less accurately ($M = 55.5\%$, $SE = 3.2\%$) than either the veridical images ($M = 62.4\%$, $SE = 3.2\%$; $t[30] = 3.85$, $p < .001$) or the caricatures ($M = 65.4\%$, $SE = 3.1\%$; $t[30] = 5.46$, $p < .0001$). However, caricatures were not identified with greater accuracy than veridical faces, $t(30) = 1.61$, n.s. There was no interaction between duration and type of image, $F(2, 30) = 1.13$, $MSE = 0.004$, n.s.

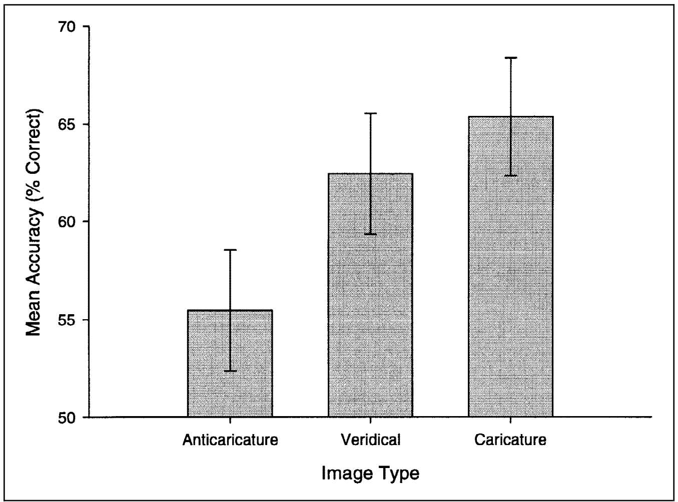

Fig. 2. Identification accuracy as a function of image type. Standard error bars are shown.

RATED DISTINCTIVENESS

Method

Sixteen subjects (8 female, 8 male) rated the distinctiveness of each of the 48 faces, presented in a random order, on a scale from 1 (*extremely nondistinctive*) to 7 (*extremely distinctive*). Distinctiveness was explained as looking different from other faces and being easy to be picked out from a crowd of faces, famous or otherwise (cf. Rhodes et al., 1999; Valentine, 1991).

Results and Discussion

Analysis by subjects

A one-way ANOVA with a repeated measures factor of image type (anticaricature, veridical, caricature) was carried out on the distinctiveness ratings. A significant main effect was found, $F(2, 30) = 16.10$, $MSE = 0.163$, $p < .0001$ (Fig. 3). Planned comparisons showed that caricatures ($M = 5.0$, $SE = 0.2$) were judged to be significantly more distinctive than either veridical faces ($M = 4.5$, $SE = 0.2$; $t[30] = 3.94$, $p < .0005$) or anticaricatures ($M = 4.3$, $SE = 0.1$; $t[30] = 5.50$, $p < .0001$). Anticaricatures did not differ significantly in distinctiveness from veridical faces, $t(30) = 1.56$, n.s.

Analysis by faces

Image type (anticaricature, veridical, caricature) was a within-face factor. The results generally matched those from the analysis by subjects. A significant main effect was found, $F(2, 28) = 16.89$, $MSE = 0.155$, $p < .00005$. Planned comparisons showed that caricatures ($M = 5.0$, $SE = 0.2$) were judged to be significantly more distinctive than either veridical faces ($M = 4.5$, $SE = 0.2$; $t[30] = 4.04$, $p <$

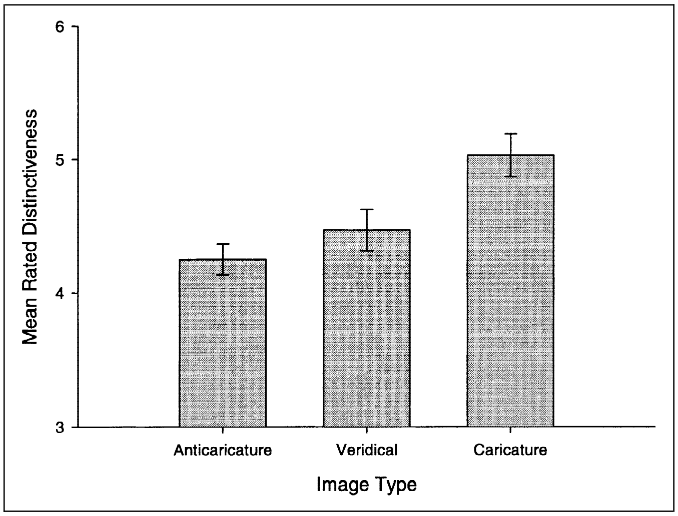

Fig. 3. Rated distinctiveness as a function of image type. Ratings were on a scale from 1 (*extremely nondistinctive*) to 7 (*extremely distinctive*). Standard error bars are shown.

.0005) or anticaricatures ($M = 4.3$, $SE = 0.2$; $t[30] = 5.64$, $p < .0001$). Anticaricatures did not differ significantly in distinctiveness from veridical faces, $t(30) = 1.60$, n.s.

DERIVING A FACE-SPACE USING MULTIDIMENSIONAL SCALING

Method

Twenty-four subjects (12 female, 12 male) made similarity ratings for all pairs of faces on a scale from 1 (*least similar*) to 15 (*most similar*). The stimuli were presented side by side in pairs. The average face stimulus was also included, giving a total of 1,176 pairs. Presentation order was randomized, and left-right order of each pair was counterbalanced so that for each pair of faces, A and B, half the subjects saw A on the left and half saw B on the left.

Results and Discussion

The similarity ratings were converted into dissimilarity ratings (by subtracting from 16). The dissimilarity ratings were subjected to an ALSCAL analysis (Takane, Young, & Leeuw, 1976), which recovers for each stimulus the spatial location that best fits the data. Solutions were obtained for one through six dimensions. The stress decreased as the number of dimensions increased, with the stress lowest at six dimensions (Kruskal's Stress 1 = 0.19; Kruskal & Wish, 1978, p. 26). The six-dimensional solution was selected as the best description of the data.[1] The distribution of stimuli on Dimensions 1 and 2 is shown in Figure 4.

Three measures were calculated for each face from the multidimensional scaling coordinates: the distance to the average face; the distance to the origin; and exemplar density, defined as the mean distance of each face to all other faces (so that high values of this measure correspond to low exemplar density). These data are summarized in Table 1. One-way repeated measures ANOVAs were carried out separately on these three measures, with image type (anticaricature, veridical, caricature) as the independent variable. Significant main effects of image type were found for distance from the average face, $F(2, 30) = 43.29$, $MSE = 0.005$, $p < .0001$; distance from the origin, $F(2, 30) = 9.38$, $MSE = 0.002$, $p < .001$; and exemplar density, $F(2, 30) = 10.87$, $MSE = 0.001$, $p < .0005$. Planned t tests were used to compare relative distances and exemplar density for anticaricatured, veridical, and caricatured faces. The results for the planned t tests are shown in Table 1.

Correlational analyses showed that distance from the origin was significantly correlated with exemplar density, $r(96) = .99$, $p < .0001$, verifying that the further faces were from the origin, the further apart from each other they became. Distinctiveness ratings were reliable (Cronbach's $\alpha = .93$), and these were averaged across subjects to calculate a mean distinctiveness rating for each face. Mean rated distinctiveness correlated significantly with exemplar density, $r(94) = .72$, $p < .001$; distance from the average, $r(94) = .46$, $p < .001$; and distance from the origin, $r(94) = .43$, $p < .005$.

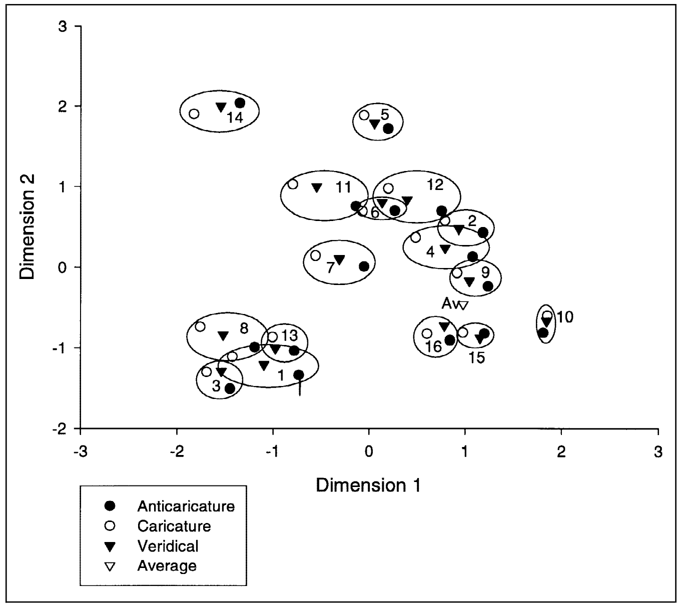

Fig. 4. Scatter plot showing locations of the stimuli on Dimensions 1 and 2. The three versions of each individual are grouped; see Table 3 for the individual corresponding to each number.

To summarize, caricatures were located in less dense regions of face-space than either veridical images or anticaricatures. Furthermore, as predicted, the more distant faces were from the origin, the more sparsely distributed they became (i.e., the lower the exemplar density). Caricatured images were further from both the average face and the origin of the space than were the veridical images. The anticaricatures were located closer to the average face and to the origin than were the veridical images. These findings support previous explanations for caricature effects, namely, that caricatured faces are relatively easy to identify because the reduction in exemplar density and associated reduction in distractor activation can offset the mismatch from the veridical representation (Rhodes, 1996). They also support the previous explanation that anticaricatures are difficult to identify because, in addition to being offset from the veridical, they are located in regions of high exemplar density. Our results also suggest that, in general, the physical transformations used to create caricatures and anticaricatures create representations that occupy the expected positions in psychological face-space.

Unexpectedly, the average face was located in a region of low exemplar density, further from the origin than any of the other image types,[2] and had extreme values on Dimensions 1 (see Fig. 4) and 6. Its location may well be influenced by its smooth, blurred texture (see Fig. 1), which is due to the blending process (Langlois, Roggman, &

1. The choice of six dimensions for the space was verified by a cross-validation technique (M. Steyvers, personal communication, June 1999) in which the data were split into two sets of 12 subjects. ALSCAL analyses were carried out to calculate solutions in one to six dimensions for one of these sets. For each of these six solutions, the euclidean distance between each pair of faces in the resulting solution was calculated, and Spearman's rank-order correlation was computed between these distances and the dissimilarity between the faces as rated by the second set of subjects. The optimal dimensionality is that at which this correlation peaks—in this instance, the six-dimensional solution, $r(96) = .80$.

2. In an n-dimensional space, it is possible for the average face to be further from the origin than most other faces in the space and for veridical faces to be closer to both the average and the origin than caricatures. This can occur when the average is extreme on one or more sets of dimensions, but not on others.

Table 1. *Relative locations of stimuli in the space*

Image type	Mean distance to average	Mean distance to origin	Mean exemplar density[a]
Anticaricature	3.34 (0.20)	2.41 (0.04)	3.36 (0.02)
Veridical	3.47 (0.20)	2.44 (0.03)	3.38 (0.02)
Caricature	3.58 (0.21)	2.47 (0.03)	3.40 (0.03)
Average	—	2.52	3.46
Range	1.46–4.77	2.27–2.82	3.26–3.67
Comparisons[b]	C >** V >*** A	Av > C >* V >* A	Av > C >* V >† A

Note. Standard errors are given in parentheses.
[a]High values on this measure correspond to low exemplar density.
[b]Significant differences between image types are indicated as follows: †p = .06 (t = 2.0), *p < .05 (ts > 2.11), **p < .0005 (t = 4.19), ***p < .0001 (t = 5.10); df = 30 for all comparisons. A = anticaricature, Av = average, C = caricature, V = veridical face.

Musselman, 1994). Interestingly, however, Dimension 1 was negatively correlated with rated distinctiveness, $r(94) = -.65$, $p < .0001$, suggesting that the location of the average may also be related to its low distinctiveness (see Nishitani, Yoshikawa, & Akamatsu, 1999, for evidence that averaged composites are rated low in distinctiveness).

MODELING IDENTIFICATION DATA

Method

Identification performance was modeled using a quantitative model based on the GCM (Nosofsky, 1985, 1986). In the present task, there were two variations of each veridical stimulus (the caricature and anticaricature) and all three versions mapped to the same response, as opposed to the usual one-to-one mapping between stimuli and responses in an identification task. We assume that people do not store caricatured or anticaricatured representations of faces. Therefore, in our model, the probability that stimulus i produces response j, $P(R_j|S_i)$, is found by, first, multiplying the similarity of stimulus i to the veridical face j by the response bias for face j. The result is then divided by the summed similarity of stimulus i to each veridical face j, multiplied by its respective response bias,

$$P(R_j|S_i) = \frac{b_j s_{ij}}{\sum_J b_j s_{ij}},$$

where J is the set of all veridical faces and b_j represents the response bias for face j. The similarity between stimulus i and face j, s_{ij}, is defined by a negative exponential decay function of psychological distance (Shepard, 1957):

$$s_{ij} = e^{-d_{ij}}.$$

The psychological distance (d_{ij}) is modeled as a weighted euclidean distance,

$$d_{ij} = c\left[\sum_M w_m |x_{im} - x_{jm}|^2\right]^{\frac{1}{2}},$$

where c is a sensitivity parameter that accounts for the overall discriminability of stimuli in the M-dimensional space, x_{im} is the value of face i on dimension m, and w_m is the relative weighting of dimension m.

The parameters in the model are the sensitivity parameter, c; the six attention weights (which indicate the importance of each dimension for this task); and 16 response biases (which indicate the strength of the response bias for each name). The attention weights and response biases each sum to 1, giving 21 free parameters.

Results and Discussion

A computer search was used to find the parameter values that minimized the goodness of fit, G^2 (actually a measure of "badness" of fit; Dodson, Prinzmetal, & Shimamura, 1998; Riefer & Batchelder, 1988), of the predicted to the observed identification data. The attention weights and G^2 values for this model are shown in Table 2 (top row). The response biases are shown in Table 3.

The model provided a very good fit to the overall identification data, accounting for 92% of the variance. It also predicted part of the observed pattern for caricatures, veridical images, and anticaricatures, namely, that anticaricatures would be identified more poorly than veridical images, $t(30) = 9.34$, $p < .0001$, and caricatures, $t(30) = 2.26$, $p < .04$. However, it also predicted that caricatures would be identified more poorly than veridical images, $t(30) = 7.08$, $p < .0001$, contrary to the observed performance.

Nosofsky (1985) has suggested that a Gaussian similarity function may capture the similarity of homogeneous, overlearned stimuli (of which famous faces are an obvious example) better than an exponential decay similarity function. We therefore tested a second identification model, using the Gaussian decay similarity function,

$$s_{ij} = e^{-d_{ij}^2}.$$

The overall fit of this model was not as good as the fit of the previous one, accounting for 80% of the variance (see Table 2, bottom row). This model did, however, predict a pattern of caricature effects

Table 2. *Model-fitting results*

Similarity function	G^2	r^2	c	Attention weights: Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6
$s_{ij} = e^{-d_{ij}}$	887	.92	6.0	0.14	0.23	0.16	0.13	0.15	0.19
$s_{ij} = e^{-d^2_{ij}}$	1,436	.80	3.0	0.15	0.20	0.16	0.14	0.15	0.19

similar to the one observed[3]: Predicted performance was significantly worse for anticaricatures than for veridical faces, $t(30) = 3.36$, $p < .005$, and there was no significant difference in predicted performance for caricatures and veridical faces ($t < 1$, $p > .6$).

We also examined the contributions of the response bias parameters by investigating the performance of a restricted version of each model, with attention weights and sensitivity parameter only (i.e., with 6 rather than 21 free parameters). For both the exponential decay and the Gaussian models, the full models provided a significantly better fit than the restricted versions—exponential: $\chi^2(15) = 242$, $p < .001$; Gaussian: $\chi^2(15) = 229$, $p < .001$. Interestingly, the restricted version of each model predicted the same caricature effects as its respective 21-parameter version, suggesting that the caricature effects were successfully modeled with only 6 free parameters.

GENERAL DISCUSSION

Valentine (1991) has suggested that the MDS framework is a useful heuristic for understanding the representation of faces in memory and that the spatial relations between faces in a multidimensional space can provide a unified account of various aspects of face perception. Our main aim was to test whether identification performance for caricatured, veridical, and anticaricatured stimuli could be explained in terms of the spatial arrangement of stimuli in a psychological face-space. We found the expected pattern of caricature effects, with caricatures identified more accurately, and anticaricatures identified less accurately, than veridical faces (Lee & Perrett, 1997; Rhodes et al., 1987). The modeling results generally supported the MDS framework, with reasonably good overall fits of identification performance for each of the models examined. The Gaussian similarity model predicted the observed caricature effects more successfully than the exponential decay model, suggesting that it better captured relatively subtle differences between versions of the same face.

The second goal of the study was to determine whether physically transformed faces (anticaricatures and caricatures) map onto a psychological face-space in the way assumed by the multidimensional framework, that is, with caricatured stimuli located further from, and anticaricatures closer to, the average face and the origin of the space than veridical stimuli (Rhodes, 1996; Rhodes et al., 1997; Valentine, 1991). We found that caricatures were rated as more distinctive, were located more peripherally in the space, and were located in regions of relatively low exemplar density compared with veridical images. Anticaricatures were located closer both to the average face and to the center of the space than veridical stimuli, although the difference in distinctiveness between anticaricatures and veridical stimuli was not significant. These findings support the MDS framework and are consistent with a previous scaling study (Johnston, Milne, & Williams, 1997), which found that distinctive faces were located peripherally in a derived space.

There were, however, some puzzling aspects of the results. One was that distinctiveness correlated strongly (and negatively) with Dimension 1 of the derived face-space, which is unexpected because distinctiveness is held to be a global feature of face-space, and should increase with distance from the mean on all dimensions. Given the importance of the concept of distinctiveness, this issue is clearly in need of further investigation. Another unexpected finding was that the average face was not located in the center of the face-space. We speculate that its smooth texture (an artifact of the blending process used to create the average), compared with that of the other images, may have affected subjects' similarity decisions.

Valentine (1991) suggested that the face-space framework can provide a unified account of many face-perception phenomena. We

3. The model's predictions are based on similarity data collapsed across subjects, so they must be compared with identification data collapsed across subjects, that is, the ANOVA with faces as a random factor.

Table 3. *Response biases*

Celebrity name	Identification number	Response bias for exponential decay model[a]	Response bias for Gaussian model[a]
Arnold Schwarzenegger	1	.019	.019
Pierce Brosnan	2	.102	.094
Clint Eastwood	3	.047	.050
Tom Cruise	4	.051	.049
Johnny Depp	5	.111	.107
Elvis Presley	6	.085	.090
Harrison Ford	7	.055	.055
Hugh Grant	8	.070	.073
Kevin Costner	9	.059	.058
Mel Gibson	10	.077	.077
Michael J. Fox	11	.045	.047
Brad Pitt	12	.065	.063
Robert Redford	13	.085	.084
Rowan Atkinson	14	.037	.046
Patrick Swayze	15	.062	.060
Bruce Willis	16	.029	.029

[a]These numbers represent the bias to respond with a particular name (the biases are constrained to sum to 1). If all faces were to be named by participants with equal frequency, each response bias would be equal to .063.

have shown that it can provide a good explanation for the identification of caricatured, veridical, and anticaricatured representations of famous faces. Busey and Tunnicliff (1999) have shown that old/new recognition performance with unfamiliar faces can also be explained by the framework. We are currently investigating whether identification, old/new recognition, and race-classification performance can all be predicted from a single multidimensional scaling solution.

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