New Zealand Journal of Psychology, 1990, 19, 70-78

Memory Representations of Unfamiliar Faces: Coding of Distinctive Information

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The distinctiveness hypothesis states that unusual aspects of faces are coded in memory. Support for this hypothesis has been found for the identification of highly familiar faces in which typicality was varied within faces using a computerized caricature generator (Rhodes, Brennan & Carey, 1987). Caricatures of personally known faces were recognized more quickly than corresponding anticaricatures and more quickly than veridical drawings. In the present study we used an old/new recognition task to test the distinctiveness hypothesis for relatively unfamiliar faces. Contrary to the hypothesis veridical drawings of previously presented faces were recognized more quickly than caricatures (or anticaricatures). Subjects rejected atypical (caricatured) new faces more quickly than typical new faces, presumably because the former were more easily distinguishable from faces in memory. We also varied the encoding strategies used when viewing the study photographs. Those strategies that allowed distinctive aspects to be coded produced the most accurate recognition of test photographs and distinctive aspects appeared to be coded spontaneously. We discuss the implications of these results for how faces are mentally represented.

Humans display a remarkable aptitude for remembering and recognizing faces (e.g. Bahrick, Bahrick, & Wittlinger, 1975) and much research has been directed at understanding this ability (e.g., Bruce, 1988; Davies, Ellis, & Shepherd, 1981; Ellis, Jeeves, Newcombe, & Young, 1986; Rhodes, 1985; Young & Ellis, 1989). On a theoretical level faces are interesting because they present a difficult problem for the visual system: How can such homogeneous stimuli, with the same basic parts in the same basic arrangement, be so readily distinguished? One suggestion is that distinctive information is important (e.g., Winograd, 1981) and that it may be coded by comparison with a norm face (Rhodes, Brennan & Carey, 1987; Valentine & Bruce, 1986a,b).[1]

Early support for the importance of distinctive information came from a study by Going and Read (1974). In an old/new recognition task they found that faces rated as unique were correctly recognized more often than faces rated as typical. A similar result has been obtained for familiar faces by Valentine and Bruce (1986a,b). Superior performance on unique faces, which contain more salient distinctive information than typical faces, suggests that we use information about distinctiveness to recognize faces. Bartlett, Hurry and Thorley (1984) found that familiarization caused greater increments in recognition performance for unusual faces than for typical ones, suggesting that improved recognition performance due to increased familiarity results from more efficient coding or use of distinctive information.

Light, Kayra-Stuart and Hollander (1979) tested the distinctiveness hypothesis by manipulating depth of processing during encoding of faces. Previous work had shown that faces judged for personality traits were remembered better than those judged for physical features (Bower and Karlin, 1974; Smith and Winograd, 1978; Warrington & Ackroyd, 1975; Winograd, 1976). Light et al. showed that if, at the time of initial exposure to the faces, subjects were asked questions requiring elaborate or deep processing (ratings of likeableness) then recognition

This research was supported by a grant from the University of Otago. We thank David Marks for the use of his equipment and Barry Dingwall for technical assistance.
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was better for distinctive faces than for typical ones. This result was interpreted as evidence that "deeper" processing facilitates the encoding of distinctive information. However, the interaction between depth of processing and distinctiveness required for this conclusion was not significant, and the result may simply reflect the usual superiority of atypical faces.

Some theorists (e.g., Zajonc, 1980) have claimed that superior recognition following "deeper" encoding occurs because affective factors are involved in making a personality judgment which are not present when judging physical features. However, Winograd (1981) proposed that personality judgments are effective simply because they lead to increased feature sampling (the elaboration hypothesis) and therefore increase the likelihood that a distinctive feature will be encoded. He showed that simple questions about a single physical feature (the "constrained features" condition) resulted in poor recognition, questions about a personality trait (the "constrained traits" condition) improved recognition, and the best recognition was obtained after a "distinctive feature scan", in which all features of a face were evaluated. Winograd also found that a simple physical feature question could be as effective as a distinctive feature scan as long as the question focused on a feature that was distinctive for that face. This suggests that it is distinctiveness per se, rather than the number of features scanned, that is important for recognition. Personality trait judgments were also better for faces with a distinctive feature than for those without a distinctive feature. Therefore the advantage of a trait judgment is that it requires a scan of all features and if any are distinctive they will be encoded and will facilitate recognition.

Studies investigating the role of distinctive information in face recognition have all compared distinctiveness across different faces. Therefore the possibility exists that other factors (e.g., attractiveness, arousal value, etc.), which vary from face to face, might have influenced these results. Ideally the same face should be compared at different levels of distinctiveness. This can be done using caricatures, in which different levels of distinctiveness are produced for the same face by exaggerating atypical aspects to varying degrees. Rhodes et al. (1987) used line drawings in which distinctiveness was varied using a computer caricature generator developed by Brennan (1982, 1985). Caricatures were produced by exaggerating distinctive aspects relative to a norm (see below for details) and anticaricatures were produced by reducing distinctive aspects. They found that increasing the distinctiveness of a personally familiar face (that of a colleague) by caricaturing it facilitated identification, whereas reducing distinctiveness impaired identification. Furthermore, caricatures were identified significantly more quickly than uncaricatured (veridical) drawings, although there was no effect of caricature level on accuracy. These results provide strong support for the distinctiveness hypothesis.

In the present study we wanted to determine whether the caricature advantage found for speed of identification of highly familiar faces would occur for recognition of relatively unfamiliar faces. The answer to this question has obvious practical significance, because of the need to faciliate identification of relatively unfamiliar faces in applied settings such as eyewitness identification or finding missing persons. However, the answer also has some interesting theoretical implications. There are two possible interpretations of the caricature advantage found for familiar faces. The first is that distinctive information is exaggerated in the long-term memory representations of highly familiar faces. The second is that caricatures are recognized more quickly than veridical drawings, not because memory representations are exaggerated, but because caricatures activate fewer distractors or activate them less strongly than do veridical drawings. If recognition depends on the *relative* activation of target and distractors, and if there is a monotonic function relating activation to similarity, then a caricature could be recognized more quickly than a veridical drawing, because the activation in distractors would drop off more quickly than would target activation as a face became caricatured, resulting in higher relative activation of the target for a caricature than a veridical stimulus.

Failure to find a caricature advantage with relatively unfamiliar faces would support the first rather than the second interpretation, because familarity should not affect the activation of distractors, whereas it is likely that considerable familiarity would be required before distinctive information became exaggerated in long-term memory representations of faces. Bartlett et al.'s results certainly suggest that improved recognition performance with increased familiarity is due to superior encoding of distinctive information.

One study has looked at accuracy, but not speed of recognition, of caricatures of unfamiliar faces (Hagen and Perkins, 1983). They found that caricatures of unfamiliar faces were less accurately recognized than photographs in an old/new recognition test. The comparison of line drawing caricatures with photographs rather than uncaricatured drawings is unfortunate, because photographs are a much more familiar medium and contain much more spatial information than line drawings. Rhodes et al. (1987) found that veridical (uncaricatured) drawings were rated as significantly better likenesses than either caricatures or anticaricatures for relatively unfamiliar faces, but it is possible that caricatures could be recognized more quickly than veridical drawings despite poorer likeness ratings. For example, supernormal stimuli elicit a stronger response than normal stimuli, yet clearly look different from the latter. Therefore in the present study we examined recognition speed and accuracy for the caricatures used by Rhodes et al. (1987).

The second aim was to determine whether subjects spontaneously code distinctive aspects of unfamiliar faces. As noted above several studies have found that coding instructions that encourage the encoding of distinctive information facilitate recognition performance. We used four encoding strategies: personality trait judgments, a distinctive feature scan, a constrained feature judgment and a spontaneous encoding condition in which no special coding instructions were given. Personality trait and distinctive feature judgments typically produce better recognition than constrained feature judgments. Previous results also suggest that the former two conditions should result in more accurate performance than spontaneous encoding (Smith & Winograd, 1978; Warrington & Ackroyd, 1975). However, it seemed to us that if distinctive information is critical in face recognition then subjects ought to code it spontaneously, and that performance in the spontaneous condition might resemble that in the distinctive feature and personality trait conditions. We thought that reaction times might be more sensitive than the accuracy measures used in previous studies, so measured reaction times as well as accuracy. We also thought that caricature level might interact with encoding condition, with a caricature advantage for recognition of the line drawings more likely for the subjects who had coded more distinctive information.

Method

Subjects

Forty undergraduates (28 females and 12 males) at the University of Otago participated in the study.

Stimuli

Twenty faces were used (10 female and 10 male). All were full-face views of members of the Stanford University Psychology Department and all displayed neutral expressions. Eighteen of these 20 faces were the same faces for which a caricature advantage was found by Rhodes et al. (1987), whose subjects knew the people depicted. None of the faces were familiar to the subjects in the present experiment.

Brennan's Caricature Generator. Line drawing caricatures of the faces were produced using Brennan's caricature generator (Brennan, 1985). Caricatures are produced in three steps. First a photograph of the face is digitized and a line drawing created. The line drawing is based on 169 points (found by eye), which are joined by the computer using spline curves to produce 37 line segments. Second, each line drawing is compared to a norm face of the same sex (the average of the three most typical faces for that sex as judged by 65 independent raters), and third, all metric differences between the two are increased (or decreased) by a specified percentage to produce a caricature (or anticaricature). The drawings were exaggerated and de-exaggerated by 25% and 50% (see Brennan, 1985 & Rhodes et al., 1987 for more detailed descriptions of the caricature generator), so that there were five drawings for each face: the veridical drawing (uncaricatured), a 25% and 50% caricature and a 25% and 50% anticaricature. An example of such a set is shown in Figure 1.

Apparatus

The caricature generator is written in MacPascal and runs on a Macintosh computer. Photographs were digitized using a Thunderware Thunderscan digitizer. Slides were presented using a rear-projection tachistoscope controlled by an Apple II Europlus microcomputer.

Design and Procedure

Encoding. Each subject was shown a set of slides consisting of ten photographs of faces (5 male and 5 female) in random order and randomly taken from the set of stimulus faces. Each slide was shown for ten seconds, during which time the subject encoded the face according to instructions given (see below). There was a five second break between slides. We used photographs rather than drawings in the study

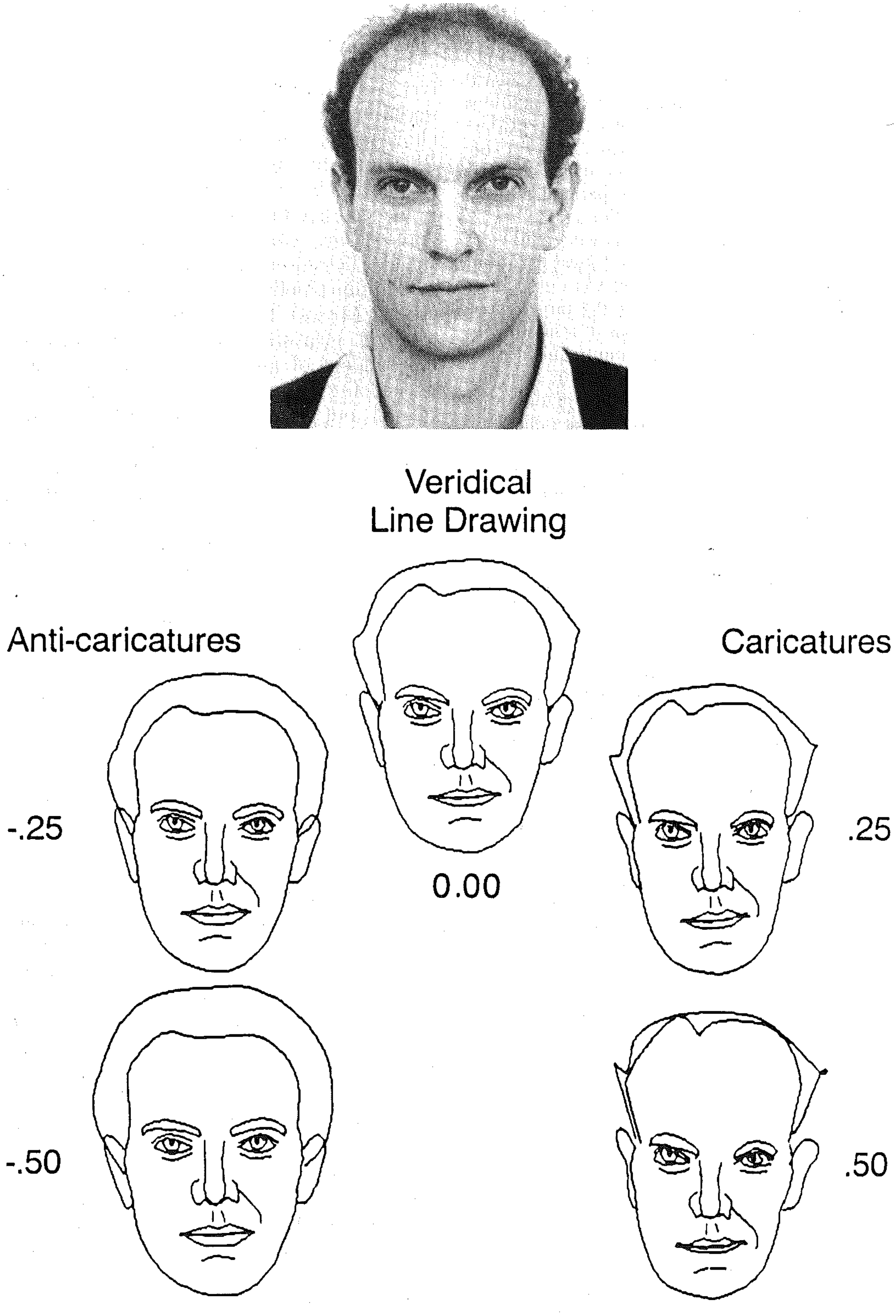

Figure 1. An example of the stimulus set for one face.

phase because this provided a closer analog to seeing real faces.

The forty subjects were divided randomly into four groups of ten. Each group was assigned different coding instructions. The coding conditions were constrained feature, personality trait, distinctive features and spontaneous coding. In the constrained features group, for each face subjects were asked questions about a particular facial feature. The questions were: (1) Does (s)he have a big nose? (ii) Does (s)he have a square jaw? (iii) Does (s)he have a high brow? Question (i) was used four times, and questions (ii) and (iii) were used three times, one question for each of the target faces. Otherwise questions were assigned randomly to faces. In the personality trait group (equivalent to Winograd's constrained traits group), for each face subjects were asked one of the following questions: (i) Does (s)he look honest? (ii) Does (s)he look friendly? (iii) Does (s)he look intelligent? Questions were assigned randomly to faces except that each question was asked either three or four times. In the distinctive features group, for each face subjects were shown a list of features — eyes, nose, chin, ears, hair, head shape, brow and mouth, and asked which feature they thought was most distinctive. In the spontaneous coding group subjects were told they would be asked questions about the slides after viewing them.

Recognition of Caricatured Drawings. Subjects were told that their memory for the faces they had just seen would be tested. They were shown the norm faces as examples of the type of faces they would see, (i.e., line drawings). Twenty slides of drawings were shown (test faces) in random order. Half of these were drawings of faces presented in Part I. Each face was shown at one level of caricature (-50%, -25%, 0, +25%, +50%) for each subject. There were equal numbers of each of the five levels of caricature for both old and new faces, and different faces were assigned to each caricature level for different subjects, so that across subjects each face appeared equally often at each caricature level. Subjects pressed the right key of a response panel if they had seen a test face before and the left key if they had not. They were instructed to use the index finger of each hand and to press a key as soon as they thought they knew the answer. Each slide was presented until the subject responded. The subject's response and reaction time were recorded. All subjects were tested individually. The experimenter was not present in the room when slides were being presented. Each subject received a different random order of test slides.

Recognition of Photographs. After the drawing recognition phase, the original 10 photographs were presented together with 10 new photographs. Each was displayed until the subject responded. A different random order of study and test photographs was used for each subject.

Results

Recognition of Drawings

Reaction times were analyzed for the two types of correct response: hits and correct rejections (false alarm rates were too low to allow meaningful analysis of reaction times). Reaction times more than 2 standard deviations above each cell mean were omitted. Four accuracy measures were analyzed: Hits, false alarms, corrected recognition and the signal detection measure d′. Corrected recognition is defined as (Hits — False alarms)/(Hits + Misses). This statistic ranges from -1 to +1 and measures recognition performance independent of any response bias. For each dependent measure 2-way ANOVAs were carried out with encoding task (the four encoding conditions) as a between subject factor and caricature level (-50%, -25%, 0%, 25%, 50%) as a within-subject factor. Missing data were replaced by the cell mean. There were few such replacements: For hits 6 subjects had missing data (one cell each) and for false alarms 4 subjects had missing data.

Reaction Times. For hits there was a significant effect of caricature level, $F(4,144) = 2.47, p < .05$ (see Figure 2). Veridical drawings were recognized faster than both caricatures and anticaricatures. Planned *t*-tests on the means showed that the veridical drawings were recognized significantly more quickly than either the 50% anticaricatures, $t(144) = 3.01, p < .01$, or the 50% caricatures, $t(144) = 2.11, p < .05$. The difference between the veridical drawings and the 25% caricatures was not significant, $t(144) = 1.39$, ns. Nor was the difference between the veridical drawings and the 25% anticaricatures significant, $t(144) = 1.31$, ns. There was no advantage for caricatures over anticaricatures at either the 25% or the 50% levels, both *t*s < 1. There was no significant effect of encoding task, $F < 1$. Nor was there any interaction between coding task and caricature level, $F(12,144) = 1.54$, ns.

For correct rejections of new faces there was a significant effect of caricature level, $F(4,144) = 4.48, p < .002$ (see Figure 3). From Figure 3 it is apparent that very typical new faces (i.e., anticaricatures) were rejected more slowly than less typical faces. Because none of these faces have been seen before caricature level corresponds to the typicality of the faces. Planned comparisons showed that new caricatures were rejected significantly more

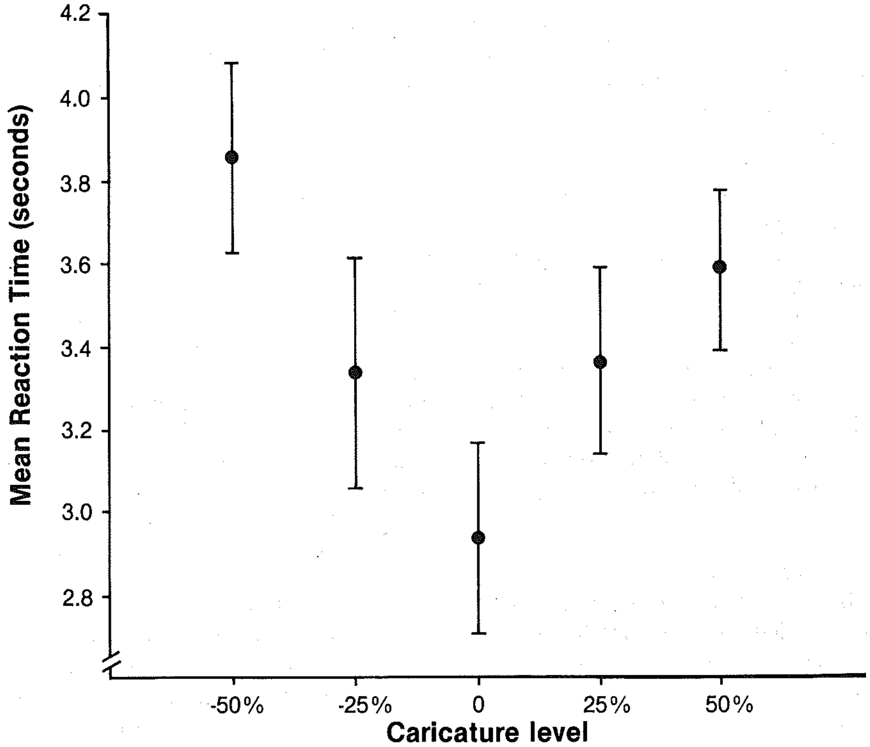

Figure 2. Drawings: Mean reaction times for hits as a function of caricature level. Standard error bars are shown.

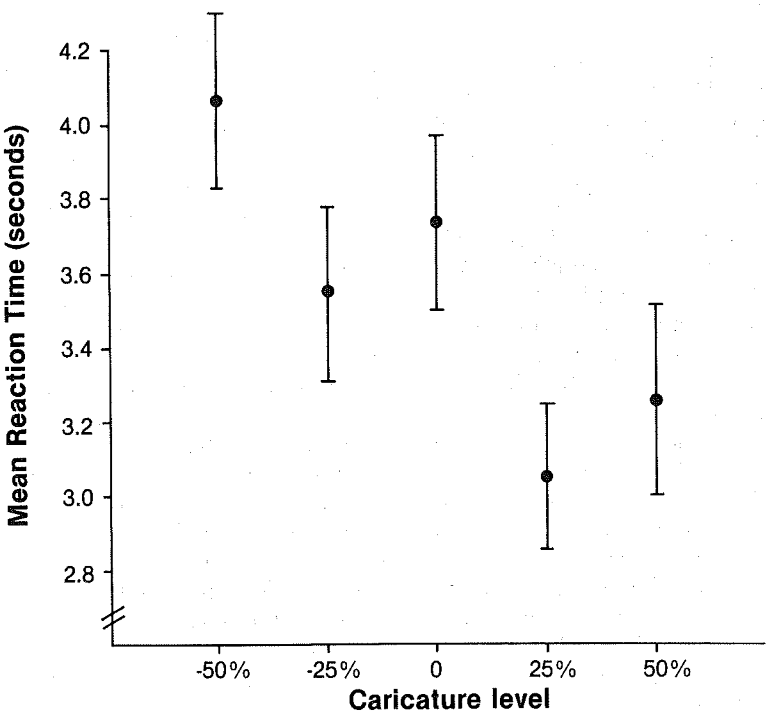

Figure 3. Drawings: Mean reaction times for correct rejections as a function of caricature level. Standard error bars are shown.

quickly than anticaricatures at both the 25% and 50% levels, $t(144) = 1.88, p < .05$, 1-tailed, and $t(144) = 3.03, p < .025$, 1-tailed, respectively. Veridical drawings did not differ significantly from the 25% anticaricatures, $t < 1$, but were significantly slower than the 25% caricatures, $t(144) = 2.59, p < .01$, 1-tailed. The 50% caricatures did not differ from the 25% caricatures, $t < 1$. There was no significant effect of encoding task, $F(3,36) = 2.22$, ns. Nor was there any interaction between encoding task and caricature level, $F(12,144) = 1.56$, ns.

Accuracy. The overall mean percent correct was 60%, which was significantly above chance, $t(36) = 2.01, p < .05$, 1-tailed. There were no significant main effects or interactions for any of the four measures of accuracy, all Fs < 1.80, ns.

Recognition of Photographs

For each dependent measure a 1-way ANOVA was carried out with encoding task as a between subjects factor.

Reaction Times. For hits there was a significant effect of task, $F(3,36) = 6.11, p < .002$. Planned t-tests showed that reaction times in the constrained condition (M = 1988 ms) were slower than in the other three conditions: $t(36) = 2.50, p < .01$ (M = 1539 ms, spontaneous), $t(36) = 3.46, p < .005$ (M = 1366 ms, distinctive), $t(36) = 3.91, p < .0005$ (M = 1285 ms, trait), all 1-tailed. There was no significant effect of encoding task for correct rejections, $F(3,36) = 1.81$, ns.

Accuracy. For hits there was a significant effect of encoding task, $F(3,36) = 6.19, p < .002$, with the constrained features condition (M = .75) worse than the other three (M = .92, .93, .92 for trait, distinctive feature and spontaneous conditions, respectively). This result is consistent with the reaction time data. There was no effect of encoding task for false alarms (which were extremely low, overall M = .06), $F < 1$, and although d′ was lowest for the constrained condition (M = 2.55 compared with 3.64, 3.55, 3.38 for trait, distinctive feature and spontaneous, respectively) the effect of encoding condition was not significant, $F(3,36) = 2.20$, ns. For corrected recognition there was a significant effect of encoding task, $F(3,36) = 2.88, p < .05$. Planned t-tests showed that the trait (M = .88), distinctive feature (M = .86) and spontaneous (M = .85) conditions were all significantly more accurate than the constrained condition (M = .67), $t(36) = 2.59, p < .01$, 1-tailed, $t(36) = 2.34, p < 0.25$, 1-tailed, and $t(36) = 2.22, p < 0.25$, 1-tailed, respectively.

Discussion

There was no evidence for a caricature advantage for recognizing relatively unfamiliar faces. Veridical drawings of the study faces were recognized as old significantly more quickly than either the 50% caricatures or the 50% anticaricatures. The 25% levels fell between the 50% and 0% levels and did not differ significantly from the 0% level. Nor was there any advantage for caricatures over anticaricatures at either level of exaggeration. The fact that an effect of caricature level was found for recognition of the drawings shows that the design was powerful enough to elicit effects despite the relatively small number of faces used.

Failure to find a caricature advantage for recognizing relatively unfamiliar faces suggests that the advantage found for personally known faces cannot be due simply to the activation of fewer distractors by the more atypical caricatures than the more typical veridical drawings. This is because there is no reason why such a mechanism should not also produce a caricature advantage for less familiar faces. The present result lends support to the idea that the caricature advantage for familiar faces occurs because distinctive information has become exaggerated in the long-term memory representations of highly familiar faces. Although this conclusion rests on a between experiment comparison, it should be noted that the caricature advantage for familiar faces found by Rhodes et al. (1987) was obtained (with different subjects obviously) with the very same stimuli used in this experiment.

For personally known faces Rhodes et al. (1987) found that caricatures were identified more quickly than the corresponding anticaricatures. This sensitivity to the presence or absence of distinctive information was not found for the relatively unfamiliar faces used here, which suggests that distinctive information is rather poorly coded, if at all, in relatively unfamiliar faces.

There is a great deal of evidence that memory representations differ for familiar and unfamiliar faces. For example, Bruce (1982) found that changes of angle or expression disrupted recognition more for unfamiliar faces than for familiar faces, indicating the existence of a more robust structural code for familiar faces. Ellis, Shepherd, & Davies (1979) found that internal features were more easily recognized than external features for familiar faces, but not for unfamiliar faces. On the basis of the present results and those of Rhodes et al. (1987) we propose that as a face becomes increasingly familiar distinctive information is more strongly coded and eventually may be exaggerated in long-term memory. Exaggeration of distinctive information would increase the discriminability of faces in memory and reduce the extent to which a face will access memory representations of other faces that resemble the target.

For new faces both 25% and 50% caricatures were rejected more quickly than the veridical drawings and the equivalent anticaricature levels. Note that for these new faces, no memory representations exist. These data do not therefore relate to the issue of whether memory representations are caricatured or not. The more distinctive caricatures would be more easily recognizable as new because they are less confusable with faces in memory. This result, obtained using stimuli in which distinctiveness is varied within faces using new technology provided by Brennan's caricature generator, provides a useful replication of the usual typicality effect in fact recognition without any possibility of confounding factors due to differences between faces.

The distinctiveness effects for recognition of caricatured drawings were found in the reaction time data but not for accuracy. Rhodes et al. (1987) also found reaction times to be a more sensitive measure. The insensitivity of accuracy measures may be due to the poor recognizability of the drawings. Alternatively it is possible that different recognition strategies are used for different levels of distinctiveness (or resemblance to memory representations). The different strategies may vary in the time taken, but ultimately yield similar accuracy. For example, fast matches may occur for images with a high degree of resemblance to the memory representations, whereas a slow search may be required for images with a lower degree of resemblance.

The results offer little support for the idea that caricatures would be useful in applied settings where a person is trying to identify a previously seen face. Veridical representations of previously seen faces were recognized best. On the other hand increasing the distinctiveness of the drawings facilitated rejection of incorrect (i.e., new) faces. Of course photographs were recognized much better than drawings irrespective of caricature level. Had caricatures yielded a consistent recognition advantage over veridical drawings there would have been good reason to develop techniques to caricature photographic images.

The distinctive feature scan and trait judgments produced faster and more accurate recognition of test photographs than constrained feature judgments. Both types of judgment have been shown to facilitate encoding of distinctive information. Moreover, performance in the spontaneous encoding condition matched that of the distinctive feature and trait judgment conditions, and was significantly better than in the constrained feature condition. Therefore coding of distinctive features appears to be carried out spontaneously during the encoding of a face, and rather than distinctiveness processing improving normal face-encoding, the constrained feature task restricts the normal coding process. Previous researchers have found that performance with "standard" instructions resembled performance with feature judgments, both of which led to significantly poorer recognition than friendliness ratings (Smith & Winograd, 1978; Warrington & Ackroyd, 1975). However, they did not measure reaction time. Warrington and Ackroyd (1975) examined errors, which presumably included both misses and false alarms, so our results cannot be compared directly to theirs. Smith and Winograd (1978) examined hits, false alarms, d′ and beta. Our results were consistent with theirs for false alarms and d′, but not for hits. It is not clear why our subjects spontaneously coded distinctive information whereas theirs did not. The main difference between the studies was that we used a range of questions in the personality and constrained feature conditions, whereas they used a single question for each, and in our spontaneous condition subjects were told that they would be asked questions about the faces, whereas their subjects were told that retention would be tested. However, it is not clear how such differences could account for the discrepancy.

There was no effect of encoding task for recognition of the drawings. Nor did encoding task interact with caricature level. This may be because the drawings were not perceived as sufficiently similar to the original stimuli (photographs) to allow generalization of the encoding effects. The low recognition rate for the drawings supports this interpretation. It also raises a problem for any attempt to reduce picture recognition effects by using different photographs at study than used to generate the test drawings, a procedure that would be likely to reduce recognition performance even further.

In summary, we examined whether manipulating distinctiveness within test faces would affect their recognizability and whether distinctive information was coded spontaneously for relatively unfamiliar faces. Contrary to the findings when these faces were familiar to the subjects (Rhodes et al., 1987) veridical drawings were recognized more quickly than either caricatures or anticaricatures and there was no advantage for caricatures over anticaricatures. These results are consistent with the idea that people are relatively insensitive to distinctive information in unfamiliar faces. However, when we compared the effects of different encoding instructions on memory for unfamiliar faces distinctive information appeared to be coded spontaneously. The possibility therefore remains open that had the drawings been more recognizable, distinctiveness effects might have been obtained.

[1] It is worth noting that although this distinctiveness hypothesis appears highly plausible, other coding strategies are possible. For example, faces could be coded in terms of their typical aspects (also relative to a norm), which would be different for each face. In this case exaggeration of distinctive information should not facilitate recognition, and distinctive faces should not be recognized better than more typical ones. Rather, increasing the typicality of a face should facilitate recognition and more typical faces would be easier to recognize than less typical faces. There is no empirical support for these predictions and hence for the hypothesis that faces are coded in terms of their typical aspects.

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