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Why Faces Are and Are Not Special: An Effect of Expertise

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Recognition memory for faces is hampered much more by inverted presentation than is memory for any other material so far examined. The present study demonstrates that faces are not unique with regard to this vulnerability to inversion. The experiments also attempt to isolate the source of the inversion effect. In one experiment, use of stimuli (landscapes) in which spatial relations among elements are potentially important distinguishing features is shown not to guarantee a large inversion effect. Two additional experiments show that for dog experts sufficiently knowledgeable to individuate dogs of the same breed, memory for photographs of dogs of that breed is as disrupted by inversion as is face recognition. A final experiment indicates that the effect of orientation on memory for faces does not depend on inability to identify single features of these stimuli upside down. These experiments are consistent with the view that experts represent items in memory in terms of distinguishing features of a different kind than do novices. Speculations as to the type of feature used and neuropsychological and developmental implications of this accomplishment are offered.

Perception of human faces is strongly influenced by their orientation. Although inverted photographs of faces remain identifiable, they lose expressive characteristics and become difficult or impossible to categorize in terms of age, mood, and attractiveness. Failure to recognize familiar individuals in photographs viewed upside down is a well-known phenomenon (see, e.g., Arnheim, 1954; Attneave, 1967; Brooks & Goldstein, 1963; Kohler, 1940; Rock, 1974; Yarmey, 1971). Rock argued that because the important distinguishing features of faces are represented in memory with respect to the normal upright, an inverted face must be mentally righted before it can be recognized. He showed that it is difficult to reorient stimuli that have multiple parts, and especially difficult to recognize inverted stimuli in which distinguishing features involve relations among adjacent contours. Faces appear rich in just this sort of distinguishing feature; on these grounds they might be expected to be especially vulnerable to inversion. Thompson's (1980) "Thatcher illusion" provides a striking demonstration that spatial relations among features crucial in the perception of upright faces are not apparent when faces are upside down.

In standard recognition memory paradigms, faces presented for inspection upside down and later presented for recognition (still upside down) are much more poorly discriminated from distractors than if the photographs are inspected and then recognized upright (Carey, Diamond, & Woods, 1980; Hochberg & Galper, 1967; Phillips & Rawles, 1979; Scapinello & Yarmey, 1970; Yin, 1969, 1970a). Moreover, there is considerable evidence that faces are more sensitive to inversion than are any other classes of stimuli. Yin (1969, 1970a) compared recognition memory for several classes of familiar mono-oriented objects: human faces, houses, airplanes, stick figures of people in motion, bridges, and costumes (17th and 18th century clothing from paintings). For all of these object classes, performance was better when stimuli were inspected and recognized upright than when they were inspected and recognized upside down. This suggests that knowledge about each class, represented in memory with respect to the upright, is accessed during the representation of new instances of all of these classes. However, the advantage of the upright orientation was much greater for faces than for any other class. In Yin's studies, recognition of upright photographs of faces exceeded recognition of inverted faces by more than 25 percentage points, whereas the effect of inversion on the other classes ranged from 2 to 10 percentage points. Other investigators also found that inversion detracts relatively little from recognition memory for stimuli other than human faces. Dallett, Wilcox, and D'Andrea (1968) assessed the effect of orientation on memory for complex scenes taken from magazines. When the materials were inspected and recognized upright, discrimination of these scenes from conceptually similar distractors was 84% correct; when the materials were inspected and recognized inverted, performance fell by only 6 percentage points. Similar results come from a study by Scapinello and Yarmey (1970), who showed that recognition of human faces was impaired by inversion much more than was recognition of dog faces or buildings.

That recognition of human faces is more vulnerable to stimulus inversion than is recognition of any other class of stimuli has been considered as evidence that faces are "special." Yin (1969, 1970a, 1970b) inferred that neural specialization has evolved so as to support a processor specific to human faces. In addition to the unique vulnerability of faces to inversion, his evidence for this claim included the fact that patients with certain right-hemisphere lesions were impaired relative to normals and left-

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hemisphere controls only at recognizing upright faces, not at recognizing either inverted faces or upright or inverted houses. Yin hypothesized that these patients had sustained damage to their specialized face processor.

The claim that faces are special may alternatively be construed to imply that there is something unique about the kind of features that distinguish human faces. It would be the use of this type of distinguishing feature that underlies the sensitivity of faces to inversion, not necessarily a special processor. Therefore, faces may well be special in this "special-kind-of-features" sense without necessarily implicating evolution of neural substrate dedicated to processing faces. That is, the unique problems that human faces may present to a general purpose recognition device might fully account for any special properties of the distinguishing features that are used to individuate faces.

The features that distinguish faces from one another appear to fall on a continuum from "isolated" to "relational." Relatively isolated features can be specified without reference to several parts of the face at once. Examples include color and texture of hair, presence and shape of a mustache, beard, or eyeglasses. At the other end of the continuum are aspects of the shape of the face (e.g., wide-set eyes with a low forehead). Perhaps the degree of reliance on highly relational distinguishing features differentiates the representation of faces from the representation of instances of other classes. Several considerations make this plausible. First, most adults are familiar with thousands of faces and are able to recognize individuals despite changes in hairstyle, hair color, facial hair, presence of eyeglasses, and so on. It is likely that representation of a face in terms of relational features is necessary to differentiate among so many physically similar stimuli. Harmon (1973) presented evidence that configural information alone is sufficient to support face recognition. He showed that photographs were recognizable even if high-frequency information required to represent individual features was degraded by systematic blurring. Haig (1984) showed that perceivers are sensitive to tiny perturbations of internal spacing of the features of photographs of faces. Most pertinently, Sergent (1984) provided direct evidence that inversion differentially disrupts the use of relational aspects of schematic faces in a matching task. When the stimuli were upright, the distinguishing features contributed interactively to reaction times, whereas when the faces were inverted the features contributing to differences were processed serially and independently. Moreover, the most relational feature—internal spacing—was processed differently in upright and inverted faces.

The experiments reported here test the hypothesis that the large effect of inversion on face recognition results from the fact that faces are individuated in terms of relational distinguishing features. Although face recognition appears to require use of such features, recognition of members of many classes with which faces have been compared does not. For houses, pictures of complex scenes, costumes, buildings, and bridges, representation in terms of isolated features could support recognition. For example, a house could be remembered on the basis of a distinctive drainpipe or fence, a bridge on the basis of distinctive metalwork, a costume on the basis of a distinctive collar, and a cemetery scene on the basis of a single, distinctive gravestone. However, not all of the stimuli that have been compared with human faces afford salient isolatable features. Dog faces do not, stick figures of people do not, and airplane silhouettes do not. Members of these classes might well have the potential to be individuated on the basis of a distinctive configuration of parts. However, the subjects of these experiments did not have great expertise in individuating members of these classes. Most individuals do not have representations of even 10 dog faces or airplanes or stick figures, let alone hundreds or thousands.

In Experiment 1 we examined the effect of inversion on encoding one additional class of stimuli—landscapes, which were chosen because they share several characteristics of faces. Like faces, landscape scenes clearly afford relational distinguishing features in addition to isolated features. Two clearings in the woods are distinguishable by the spatial arrangement of similar parts as well as by salient landmarks. Like faces, landscapes are a very familiar class; individuals recognize hundreds of particular spots, and encoding places where one has been is an important part of finding one's way around. Also, like faces, landscapes are difficult to encode verbally, and Deffenbacher, Carr, and Leu (1981) found the two to be similarly sensitive to retroactive interference as compared with words and simple line drawings.

Experiment 1

The goal of Experiment 1 was to compare the relative effects of inversion on faces and landscapes. We used the procedure originally used by Yin (1969).

Method

Subjects. Sixteen undergraduates were paid for their participation as subjects.

Materials. Black and white photographs were mounted on plain white 3-in. × 5-in. index cards. The faces measured 1.25 in. × 1 in. and the landscapes 3.25 in. × 2 in. The faces were those used by Yin (1969): studio photographs of adult males without eyeglasses, beards, or mustaches. The landscapes were selected from a pool of 103 photographs taken at 63 different New England locations. There were four types of landscapes: mountains with horizon lines, bodies of water, rocky outcroppings, and meadows. No scene contained any man-made object. Within each class, some pairs of photographs were paired for use as target and distractor items. Essentially the same features were present in both members of each pair; the two differed primarily in spatial arrangement of features. Examples of the stimuli are provided in Figure 1.

Two series of photographs were assembled so that one could be presented to each subject upright and the other upside down. For each series, the inspection set consisted of 20 faces and 20 landscapes (5 of each type) pseudorandomly mixed so that there was one face and one landscape at the beginning and end of the set and no more than 4 consecutive items were all faces or all landscapes. For each inspection set, a recognition set was constructed, consisting of 12 inspection faces paired with 12 distractor faces and 12 inspection landscapes paired with 12 distractor landscapes. The first and last 2 items of each inspection set and 6 other items of each type were not presented for recognition. On the basis of pilot data, items were chosen so that performance on faces and landscapes upright would be comparable. A practice inspection series consisting of 3 faces and 3 landscapes and a practice forced-choice recognition series was also constructed.

Procedure. The procedure was that used by Yin (1969). Subjects were told to look at the pictures and to try to remember them. Immediately after inspection, subjects were given the recognition series and were asked to indicate which member of each pair had been in the inspection series. A small practice series (presented upright) was used to illustrate the forced-choice procedure. The two test series were then presented. The order and orientation in which the two series were viewed were independently counterbalanced across subjects. Before the inverted series was inspected subjects were told that the materials would be upside down during inspection and recognition. Subjects were allowed 3 s to inspect each item in the inspection series. Subjects paced themselves during recognition.

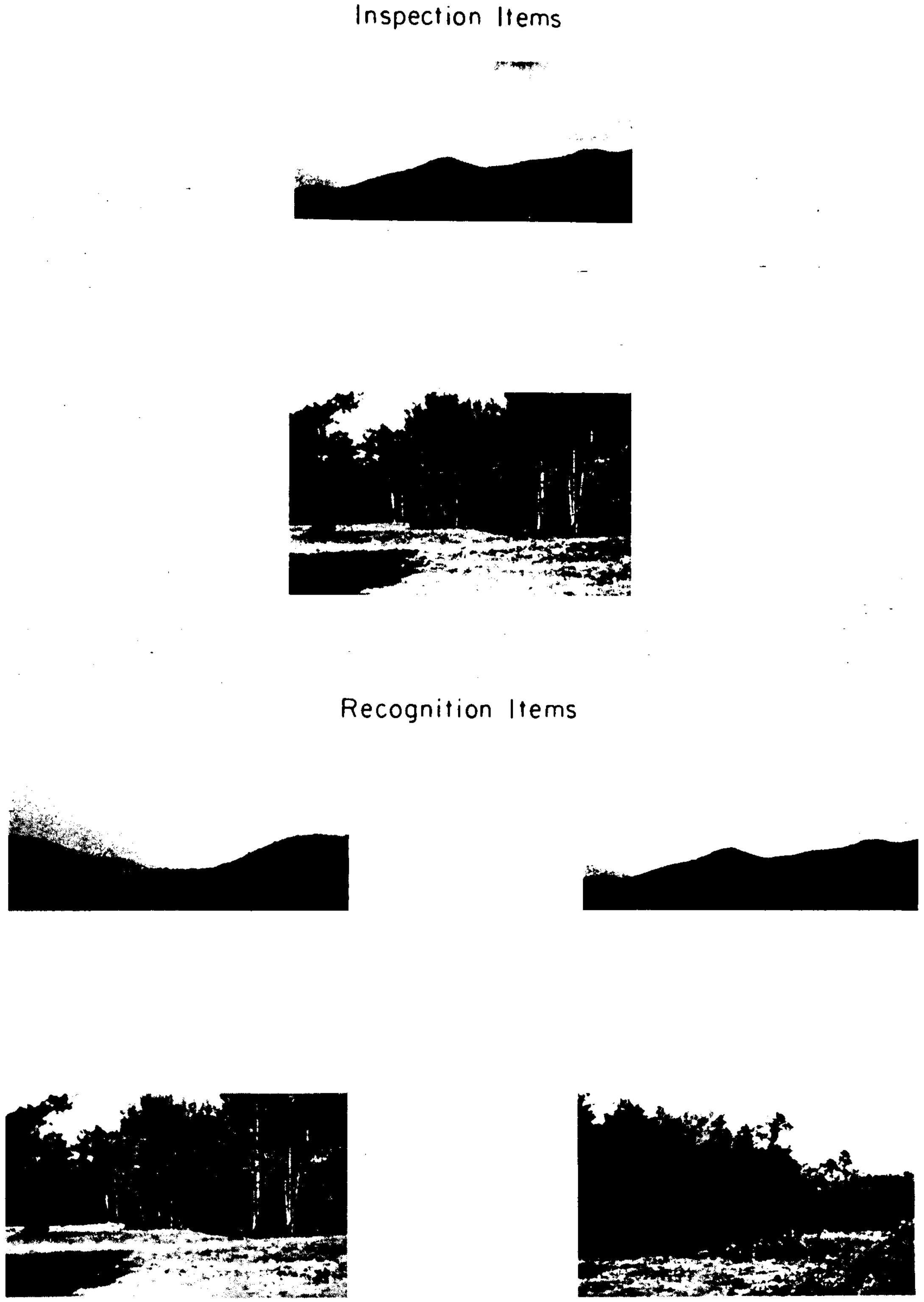

Figure 1. Examples of landscape stimuli used in Experiment 1.

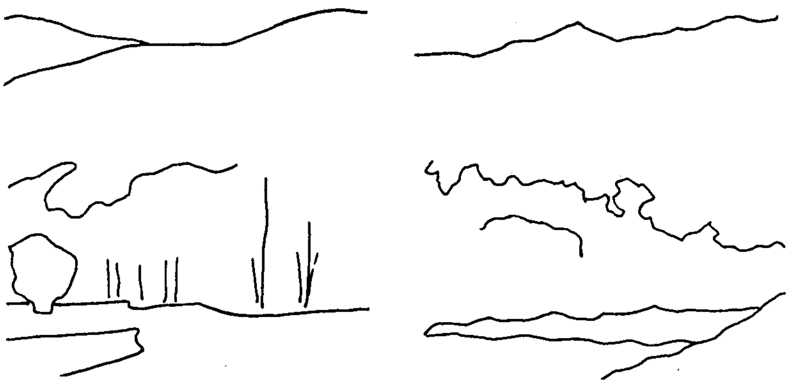

Figure 2. Major configurations of the pairs of landscapes shown as examples of recognition items in Figure 1.

Results and Discussion

In the upright condition, subjects' performance on the two materials was comparable; for faces 90% of responses were correct and for landscapes 88% of responses were correct. In the inverted condition, performance fell to 71% correct for faces and 79% correct for landscapes. An analysis of variance (ANOVA), with material (faces vs. landscapes) and orientation (upright vs. upside down) as within-subject factors, yielded a significant main effect for orientation, $F(1, 15) = 21.67$, $p < .001$, and no main effect for material. A significant interaction of material and orientation, $F(1, 15) = 6.11$, $p < .03$, indicated that faces were more vulnerable to inversion than were landscapes. A Newman-Keuls analysis with a criterion level of .01 showed that performance on both materials was better in the upright condition.

Inverting landscapes makes them look odd, just as inverting faces makes them look odd. The disruption of shading information sometimes makes it difficult to interpret what is in the picture; in our stimuli this was particularly true for scenes that included bodies of water. Nonetheless, in this recognition memory task, the magnitude of the effect of inversion on landscape recognition (9 percentage points) was in the range for all previously examined nonface stimuli, lower than the magnitude of the inversion effect for face recognition (19 percentage points).

It is possible that relatively isolated features may be more abundant in the case of landscapes than in the case of faces. However, examination of the sample stimuli in Figure 1 suggests another possible difference between faces and landscapes. Human faces share the same basic configuration (two eyes above a nose, above a mouth, all centered in a roughly oval outline); all meadow scenes (or all mountain horizons or rocky outcroppings or water scenes) do not.

Viewed as meaningless shapes, the major configurations comprising the landscape scenes are quite discriminable (see Figure 2). In contrast, as meaningless shapes, any two faces are quite alike. The difference between human faces and landscapes as classes of stimuli can be stated precisely. It is possible to locate on any face a large number of points (e.g., tip of nose, left pupil, right pupil, bottom of chin). Fewer than 200 such points, connected appropriately, are sufficient to define a recognizable line drawing of an individual face (Brennan, 1985). More important, corresponding points may be identified on any two faces, and the faces, suitably normalized and digitized in this way, may be averaged. The resulting figure is also recognizable as a face. This property, related to that tapped by Galton's (1928/1983) composite portraiture method and by Rosch's (1978) superimposition test, is what is meant by "sharing the same configuration." Classes that do not share a configuration, such as two arbitrarily chosen landscapes or houses, may differ in the spatial relations among similar parts (e.g., the distance between a foreground rock and a background tree). These constitute what can be called *first-order relational properties.* However, for faces and other classes sharing a configuration, first-order relational properties are thereby constrained; members of these classes are individuated by distinctive relations among the elements that define the shared configuration. We refer to these as *second-order relational properties.*

There are many classes other than human faces in which all members share an overall configuration. In all these classes, second-order relational properties may serve to individuate members. Any class of animals within which individuals are identifiable, such as dogs, would be a candidate for use of such properties as distinguishing features. Even so, Scapinello and Yarmey (1970) found recognition of dog faces considerably less vulnerable to inversion than recognition of human faces. Their subjects, however, were undergraduates and had no particular knowledge of dogs. We reasoned that perhaps only subjects with sufficient knowledge to be capable of individuating large numbers of dogs of the same breed would be likely to process their figures in the way that normal adults process human faces. This suggests that for dog experts, recognition memory may be as vulnerable to stimulus inversion as is recognition of human faces for everyone. This should not be so for novices.

Experiment 2

Experiment 2 examined the relation between expertise and the size of the inversion effect. Dog experts and novices were presented photographs of dogs and human faces in each orientation. We expected a three-way interaction of subject group (novices vs. experts), materials (dogs vs. faces), and orientation (upright vs. inverted). For dog experts, the effect of inversion on recognition of dogs and faces should be comparable. For novices inversion should affect face recognition more than it affects dog recognition.

Method

Materials. The materials for this study consisted of photographs of dogs and human faces mounted on 3-in. × 5-in. index cards. Dog experts (breeders and judges) told us that they recognize dogs on the basis of the whole dog rather than its face. Therefore, we obtained whole-body or three-quarter profile photographs of champion dogs from the archives of the American Kennel Club (AKC) in New York City. We used three breeds: Irish setters, Scottish terriers, and poodles. Within each breed, photographs were chosen so that the animals' stances and isolated distinguishing features (such as degree of shine on the coat) were similar. The photographs were rephotographed to eliminate background cues and to equalize the photographic contrast between the dogs and background.

A final set of 72 dog photographs was assembled, consisting of 12 pairs of photographs of each of the three breeds. The two members of each pair were chosen to be as similar as possible. One member of each pair was designated a target and the other a distractor. These pairs were used to form two comparable series. Each series consisted of 18 inspection photographs and 18 forced-choice recognition pairs, in which a duplicate of each inspection photograph was paired with a distractor of one of the two other breeds. Examples of the dog stimuli are shown in Figure 3.

New face materials were also prepared. A set of 184 photographs—half of men and half of women—was taken from college yearbooks. The photographs were cropped beneath the chin to eliminate as much clothing as possible, and none of the faces chosen had distinguishing features such as beards, mustaches, earrings, or eyeglasses. Pairs were formed based on photographs of people of the same sex who had similar poses, hairstyles, and coloring. Two series were formed, each with 36 inspection photographs and 36 forced-choice recognition pairs. Recognition pairs consisted of a duplicate of an inspection photograph paired with its matched distractor.

Subjects. Subjects were 32 undergraduates (the novices), who were paid for their participation, and 16 dog experts who were not compensated. We located dog experts through the 1982 *AKC Directory of Dog Show and Obedience Judges.* Four judges were found, all of whom agreed to participate. These four experts referred several others, some of whom suggested still others. The remaining 12 experts were obtained from this pool. Of the experts not listed as judges in the AKC Directory, 3 described themselves as judges, 5 described themselves as breeder/handlers, and the remaining 4 indicated a sustained interest in dogs, expressed in activities such as frequent attendance at dog shows. Experts were asked to list all breeds for which they had expertise. Eleven of the experts listed one (and in each case only one) of the three breeds used in the experiment, whereas the remaining 5 listed other breeds. The mean age of the dog experts was 46 years (range = 29 to 58 years).

Procedure. Subjects were told that they would see photographs of faces and dogs and were instructed to look at each photo and try to remember it. Each inspection item was presented for 5 s. Subjects inspected one series and immediately afterward were shown the associated forced-choice recognition series, through which they then proceeded at their own rate. Before the inverted series was presented, subjects were informed that the items would be upside down both for inspection and subsequent recognition. They were also told that two different photographs—one for inspection and one for recognition—of the same dog might sometime be used. This instruction was designed to discourage reliance on idiosyncratic pictorial cues that might have survived our rephotographing of the dog pictures.

A practice inspection set of three faces followed by a recognition set of three target-distractor pairs was formed. The practice set was presented upright to illustrate the forced-choice procedure. Each subject was subsequently presented one series of dog photographs and one series of faces upright and the other series of each material upside down. The order in which materials were presented (dogs first, faces first), series, and orientation were counterbalanced across subjects within each group.

All subjects were presented two series of 36 faces (1 upright and 1 inverted). Dog experts were presented two series of 18 dog photographs (1 upright and 1 inverted). One group of novices was also presented with two full series of 18 dog photographs each. In an attempt to equalize the performance level of experts and novices for the upright condition, another group of novices was presented the dog photographs subdivided into smaller sets. These subjects were presented two sets of 9 dog photographs upright and two sets of 9 dog photographs inverted; each set consisted of 3 dogs of each breed. The two subsets of each series were presented in immediate succession.

Results and Discussion

The accuracy of each group is shown in Figure 4. All subjects had a large inversion effect on faces, and the experts had the largest inversion effect on dogs. The data were entered into an ANOVA; material and orientation were entered as within-subject factors, and subject group (expert, novice large set, novice small sets) was entered as a between-subjects factor. Main effects emerged for orientation, $F(1, 45) = 98.78$, $p < .001$, and material $F(1, 45) = 25.30$, $p < .001$. Upright stimuli were better recognized (83% correct) than inverted stimuli (69% correct), and faces were better recognized (80% correct) than dogs (72%). The interaction between material and orientation was significant, $F(1, 45) = 24.03$, $p < .001$. Recognition of faces fell from 89% correct upright to 70% correct inverted, whereas recognition of dogs fell only from 76% correct upright to 69% correct inverted. However, the comparison of interest—the three-way interaction of subject group, material, and orientation—did not approach the .05 level of significance, $F(2, 45) = 0.80$, $p > .10$.

A Newman-Keuls analysis with a criterion level of .01 was used to examine the inversion effect for each group of subjects with each kind of material. For all three groups, performance on upright faces was significantly better than that on inverted faces. Experts also recognized upright photographs of dogs significantly better than inverted photographs (78% correct upright, 66% correct inverted), whereas for nonexperts the advantage for upright presentation was not significant at either set size (for small sets 78% correct upright and 75% correct inverted; for the large set 73% correct upright and 65% correct inverted). Despite the fact that the predicted three-way interaction was not significant, we found these data encouraging. Expertise appeared to influence, albeit only slightly, the size of the inversion effect on dogs. Novices showed effects of orientation exactly in the 2 to 10 percentage point range previously observed for all other nonface stimuli. Experts were more vulnerable to stimulus inversion when encoding dogs than were novices, although not significantly so.

Several aspects of this experiment made it a less-than-optimal test of the hypothesis. First, the three breeds of dogs belong to different dog groups. Setters are judged with sporting dogs; terriers are judged with terriers; poodles are judged with nonsporting dogs and toys. If experts specialize in more than one breed, the breeds are usually in the same group. Further, the breeds used were not well-matched to the self-described expertise of these subjects; of the 48 pairings (3 breeds by 16 experts), only 11 were matches. Thus, it is probable that although more sophisticated about dogs than the novices, the experts did not possess sufficient knowledge to individuate these stimuli on the basis of second-order relational properties. Experiment 3 was designed to eliminate this possibility.

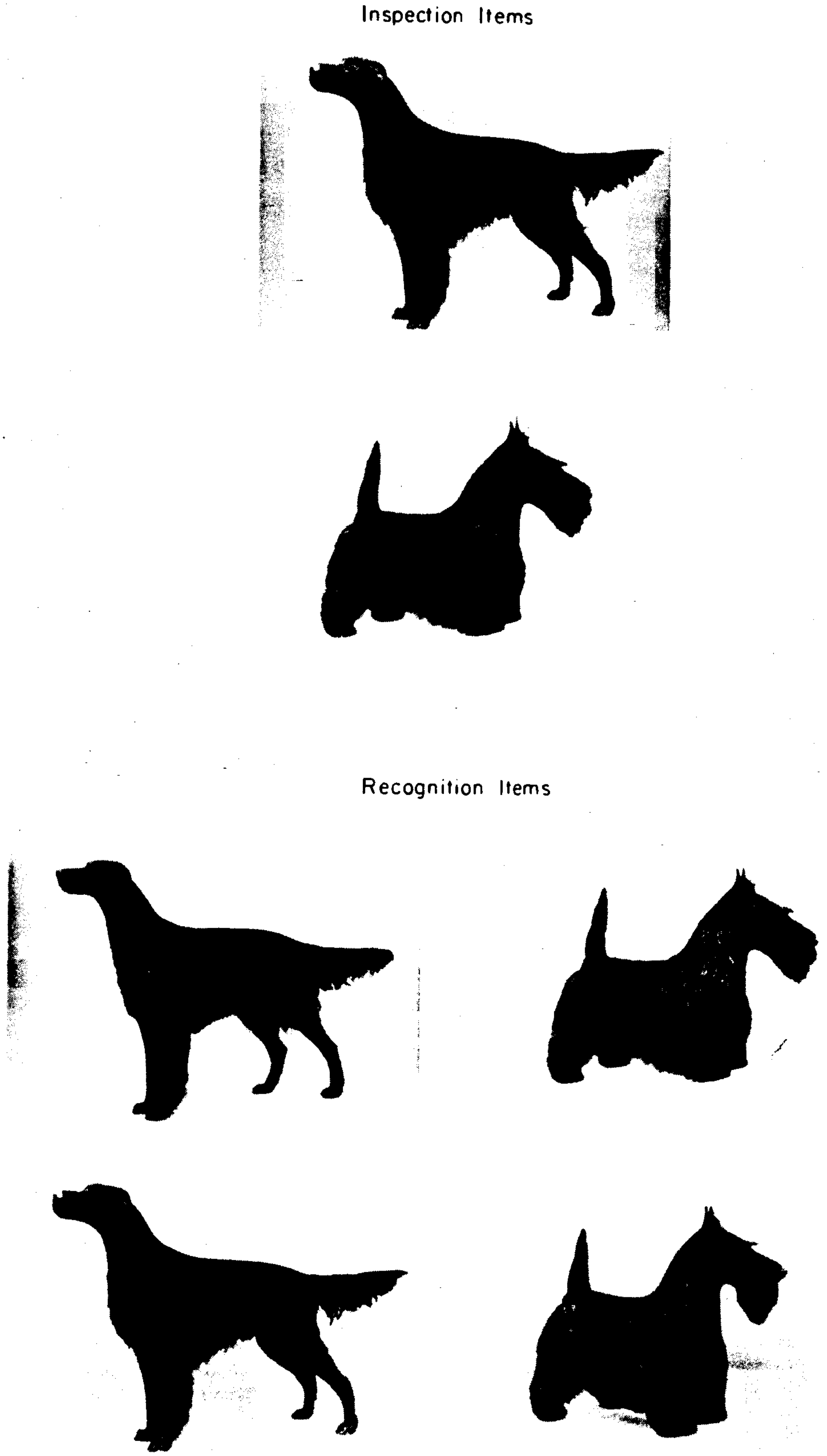

Figure 3. Examples of dog stimuli used in Experiment 2.

Experiment 3

Experiment 3 was another probe for the three-way interaction between expertise, material, and orientation. In this case, however, the materials were restricted to breeds on which the experts were indeed expert.

Method

Subjects. Subjects were 16 sporting dog experts and 32 undergraduate novices. Experts were given a bottle of wine for their participation; novices were paid.

Twelve of the experts were listed in the AKC Directory as judges; of these, 10 were also breeders and/or handlers. The remaining experts were also breeders and/or handlers. When asked to indicate the three breeds of their greatest expertise, 8 named Irish setter first, the remaining 8 named cocker spaniel first, and 10 of the 16 included both breeds among the three named. The mean age of the experts was 64 years (range = 42 to 77 years). The experts reported that they had actively worked with dogs for an average of 31 years, and that they participated in an average of 18 dog shows each year.

Materials. All stimuli were mounted on 3-in. × 5-in. index cards. Two new series of yearbook faces comparable to those used in Experiment 2 were assembled. The dog stimuli were photographs of champion Irish setters and cocker spaniels obtained from the AKC archives. They were rephotographed as for Experiment 2. Photographs of dalmations and dachshunds were also used as fillers in the inspection series, but were not tested for recognition.

The faces were assembled into two comparable series, each consisting of 36 inspection items and 36 forced-choice recognition pairs. The dogs were also assembled into two comparable series and then each series was divided in half to produce two subseries, each with an inspection set of 8 items. Experts saw two subseries of dogs in each orientation. The first and last items in each inspection subseries were a dalmation and a dachshund, and the middle 6 items were 3 cocker spaniels and 3 Irish setters. Forced-choice recognition items consisted of target dogs paired with distractors of the same breed.

One group of novices saw, in each orientation, the same two subseries as did the experts. To equate performance of experts and novices on upright photographs of dogs, we presented another group of novices the photographs divided into three smaller subseries. Each of these series began and ended with a dachshund or dalmation. Two of these subseries contained 3 sporting dogs and one contained 4.

Procedure. The procedure was the same as for Experiment 2.

Results

Figure 5 shows the performance of each group on each material in each orientation. For faces, all subjects showed the typical large recognition decrement with inversion (for all three groups together 88% of responses were correct for upright photographs and 65% were correct for inverted photographs). For experts, there was a similar effect for photographs of dogs; 81% of responses for upright photographs were correct and for inverted photographs 59% were correct. In contrast, novices were not affected by orientation at either set size (for small sets 79% of responses were correct for upright figures, and 81% were correct for inverted figures; for the large set 73% were correct for upright figures, and 71% were correct for inverted).

These data were entered into an ANOVA; subject group was a between-subjects factor, and material and orientation were within-subject factors. Most important, the predicted three-way interaction of subject group, material, and orientation was significant, $F(2, 45) = 9.40$, $p < .001$. A Newman-Keuls analysis with a .01 criterion level indicated that, for all subject groups, faces upright were recognized better than faces upside down, but only for experts were dogs upright recognized better than dogs upside down.

As intended, there was no significant effect of material. There was, however, a significant effect of group, $F(2, 45) = 7.94$, $p < .001$, the undergraduate novices were superior to the experts. As

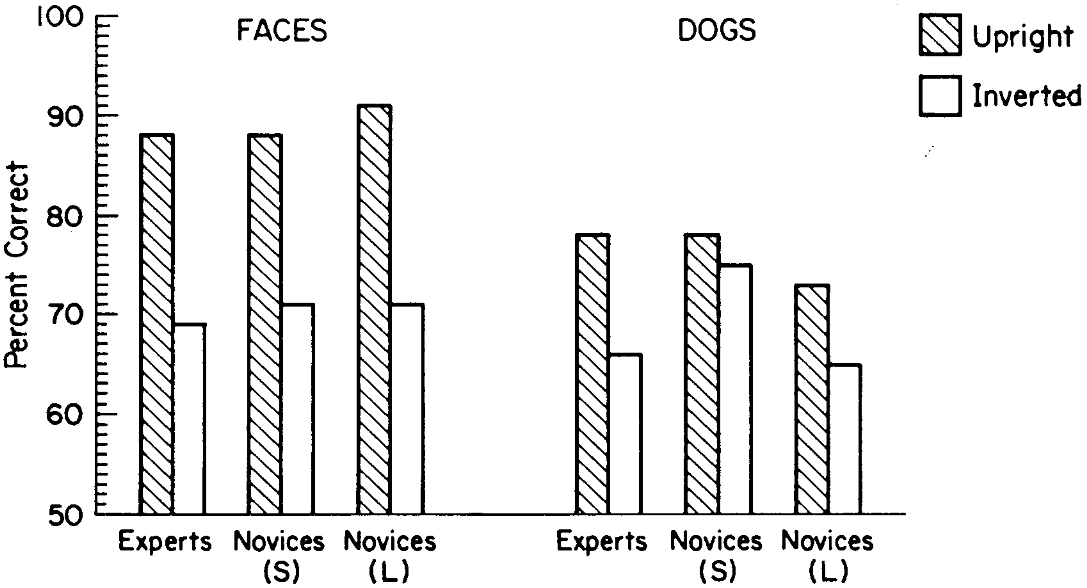

Figure 4. Performance of experts and novices on faces and dogs presented upright and inverted in Experiment 2. Novices (S) were given a small set size on dogs, whereas novices (L) were given the same large set size as were experts.

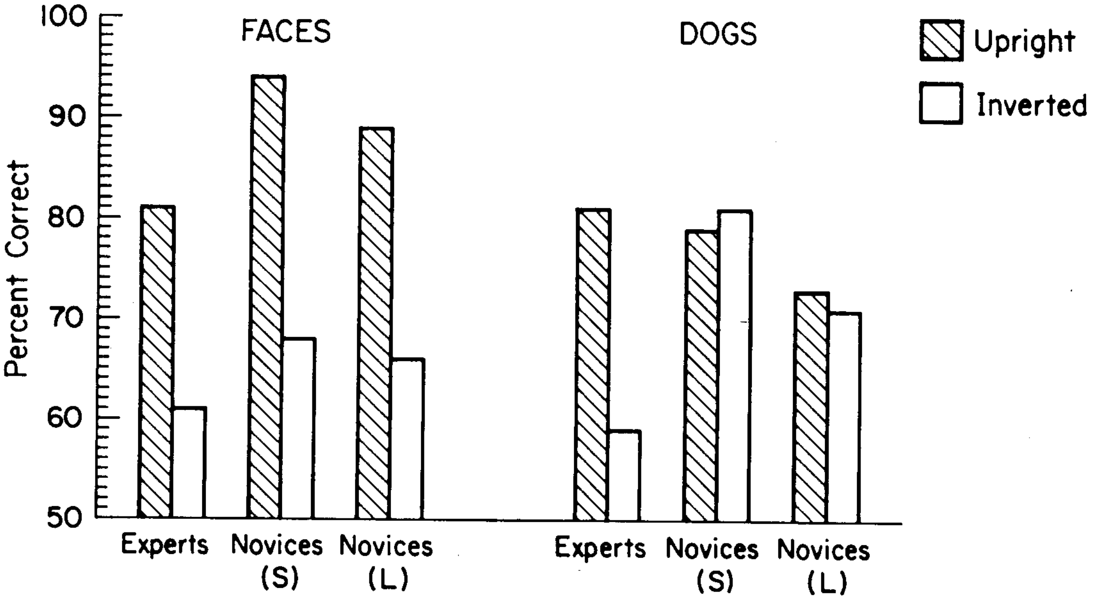

Figure 5. Performance of experts and novices on faces and dogs presented upright and inverted in Experiment 3. Novices (S) were given a small set size on dogs, whereas novices (L) were given the same large set size as were experts.

Figure 5 shows, this advantage was found for both materials. (The interaction of group with material was not significant.) Presumably this difference reflects the relatively advanced age of the experts. Bartlett and Leslie (1985) showed that elderly subjects are deficient relative to younger subjects in recognizing faces shown only in a single view. Therefore, although expertise resulted in an inversion effect on encoding dogs comparable to the well-established inversion effect on face encoding, expertise did not result in significantly better performance. A Newman-Keuls analysis indicated that the experts' accuracy on upright dog figures was not significantly greater than that of novices who were presented dogs at the same large set size.

We conclude that memory for photographs of individual dogs can be as vulnerable to inversion as is face recognition. The effect emerges when the dog figures presented are of precisely those breeds which the subject has judged, bred, and handled over several decades, a condition met in Experiment 3 but not in Experiment 2. In contrast to experts, novices in both these experiments performed no better on upright than on inverted dogs, indicating that the distinguishing features, in terms of which the items were represented, were equally available in the two orientations. Because we attempted to eliminate pictorial cues unrelated to the dogs themselves, we assume that the novices used such isolated features as tufts of hair or the distinctive angle of one leg. Insensitivity to inversion suggests that novices simply do not have knowledge of any dog breed helpful in individuating its members. Rather, they must rely on features characterizing the stimuli as patterns, features not affected by orientation. The imperviousness of dog recognition to orientation contrasts with the usual small but significant inversion effect on recognition of nonface stimuli, as shown, for example, in Experiment 1 for landscapes. It appears that the novices' relevant knowledge of dogs is minimal compared with people's knowledge of classes such as landscapes and houses.

Why should expertise result in a greater sensitivity to inversion? We suggest that with expertise comes the ability to exploit the second-order relational properties that individuate members of classes such as human faces and cocker spaniels. Further, we suggest that representation of an individual in terms of these features is particularly vulnerable to stimulus inversion. Others have offered hypotheses for the effect of experience on the size of the inversion effect that do not implicate a difference in the type of distinguishing feature used by experts and novices. Goldstein (1975) suggested that the schema for recognition becomes more rigid with experience (and thus presumably more tied to normal conditions of deployment), whereas Flin (1985) expressed the idea that increasing familiarity with a class of mono-oriented stimuli might make inverted stimuli appear increasingly odd. The Goldstein-Flin hypothesis thus implies that encoding of any given feature becomes increasingly more vulnerable to inversion as the subject becomes more expert in the domain.

Experiment 4

Experiment 4 is concerned with whether orientation affects the evaluation of faces for the presence of named features more than it affects the evaluation of houses or landscapes for the presence of named features.

Method

Subjects. Subjects were 19 undergraduates who were paid for their participation.

Materials. Two series of mixed photographs of faces, landscapes, and houses were assembled so that each subject could be presented one series in each orientation. In all there were 46 faces, 44 houses, and 48 landscapes: instances of each class were divided about equally between the two series. A mixed-practice series of 12 other photographs containing 4 of each type was also constructed. The landscapes were chosen from among those used in Experiment 1; the faces and houses were chosen from among those used by Yin (1969); additions were made to provide positive instances for some features. Within each series the three types of materials were ordered pseudorandomly so that no type occurred more than three times in succession. After half the subjects had been run, the order of items in each series was reversed for the remaining subjects.

Probes were presented in the form of a word or phrase shown just before the photograph to be judged. We attempted to probe features that were relatively isolated. The results of pilot work were used to eliminate probes that produced highly variable reaction times and to attempt to equalize the difficulty of the three types of material in the upright condition. Table 1 lists the final set of probes used for each class. Within each test set, each probe was used twice. For each type of material, the correct responses to the two occurrences of a given probe were equally often "yes" to both, "no" to both, and "yes" to one and "no" to the other. The series were ordered so that the correct response did not remain the same for more than 4 successive items.

Procedure. A four-channel tachistoscope was used to present both the probes and stimuli. Each probe was presented for 1 s, followed by 1 s of darkness. The stimulus was then presented for as long as the subject needed to make a response. Reaction times were measured to the millisecond by a digital timer started at stimulus onset and stopped by a voice key relay when the subject responded. The presentation of the next probe was controlled by the experimenter.

Subjects were instructed that for each kind of material the right answer to all the probes overall would be "no" as often as "yes." They were also told that the probed feature would be either clearly true or false of the picture, although it might not be in a central or salient location. Subjects were instructed to answer only after they had actually determined whether or not the probe was true of the picture, not to infer it, and they were asked to answer as quickly as possible without making errors.

The practice series was presented to all subjects in the upright orientation. The test series (one presented upright and the other inverted) were presented immediately afterward. The order and orientation in which the two test series were presented were counterbalanced across subjects. Before presentation of each test series, each subject was given a list of the set of probes to be used in that series. Ambiguities were clarified; the experimenter provided sketches, if needed. There was a 5-min break between the first and second test series. Before presentation of the inverted series, each subject was told that the pictures would be upside down and was urged to try to answer quickly and accurately.

Results

The error rate was low: 2.0% for faces, 4.7% for landscapes, 4.3% for houses. Items on which errors occurred were excluded from the reaction time analysis. Figure 6 shows the mean reaction time for each type of material in each orientation. An ANOVA revealed main effects for orientation, $F(1, 18) = 42.92, p < .001$, and for material, $F(2, 36) = 42.08$, $p < .001$. There was no interaction between material and orientation. A Newman-Keuls analysis with a .05 criterion level indicated that reaction times for all three kinds of material were faster for upright presentation than for inverted presentation. Faces were easier than landscapes and houses, both upright and inverted. In sum, although we did not succeed in equalizing the difficulty of all three kinds of material in the upright orientation, inversion affected all classes equally.

Faster responses and lower error rates on facial features than on features of landscapes or houses probably reflect the fact that all faces share the same overall configuration. This should facilitate performance because the subject need not search as widely to discover whether a face has a mustache or narrow eyes as to discover whether a landscape has a rock, or a house a round window. The facilitation occurs on both upright and inverted stimuli.

Table 1
Features Judged For Presence or Absence in Each Class

Faces	Landscapes	Houses
Wrinkles	Rocks	Rounded window
Beard	Mountain	Peaked roof
High forehead	Bushes	Ivy
Mustache	Boulder	Steps
Glasses	Evergreen	Porch
Narrow eyes	Water	Railing
Thick lips	Brush	Shutters
Big nose	River	Chimney
Gray hair	Cliff	Balcony
Bald	Trees	Columns
Narrow face	Grass	Window shades
Wavy hair	Sand	Brick exterior
Buck teeth	Lake	Curtains
Bushy eyebrows	Hills	Flat roof
Protruding ears	Clouds	Bay window
Dimpled chin	Meadow	Wood exterior
Double chin	Shrubs	Fence
Thin lips	Field	
	Stones	
	Leafy tree	

The absence of a Material × Orientation interaction means that stimulus inversion does not hamper the identification of nameable features of faces more than those of landscapes or houses. For all three classes, probes were chosen so as to refer to relatively isolated features. To the extent that the features used for faces are nevertheless more relational (e.g., "high forehead") than those used for houses (e.g., "shutters") and landscapes (e.g., "boulder;" see Table 1), we would expect this factor to add to the advantage for upright faces. The comparability of faces to the other classes in this task suggests that the inversion effect on face recognition does not rest on an upright advantage in processing the same kind of features that are processed when the stimulus is inverted. Although admittedly indirect, this result is consistent with our view that the inversion effect on faces (and on dogs for dog experts) is attributable to the expert perceiver's greater ability to represent the upright stimulus in terms of distinguishing second-order relational features.

Experiment 4 also bears on the claim of Mermelstein, Banks, and Prinzmetal (1979) that good Gestalt facilitates memory for particular features but not perceptual search for those same features. Using schematic faces, they replicated Homa, Haver, and Schwartz's (1976) finding that normal faces had an advantage over scrambled faces in subjects' search for a feature that was specified after offset of the face. In contrast, when the feature was specified first, Mermelstein et al. found an advantage for the scrambled face. Our data conflict with Mermelstein et al.'s finding of no advantage (indeed, a slight disadvantage) of the upright in perceptual search. However, our stimuli were real facial photographs, and our prior probes were verbal. In our case, judgment of whether the named feature is present appears to require processing similar to that involved in selecting distinguishing features in terms of which to individuate a newly presented face. Deployment of knowledge of faces held in memory appears essential in this perceptual search task as it does not in the experiments

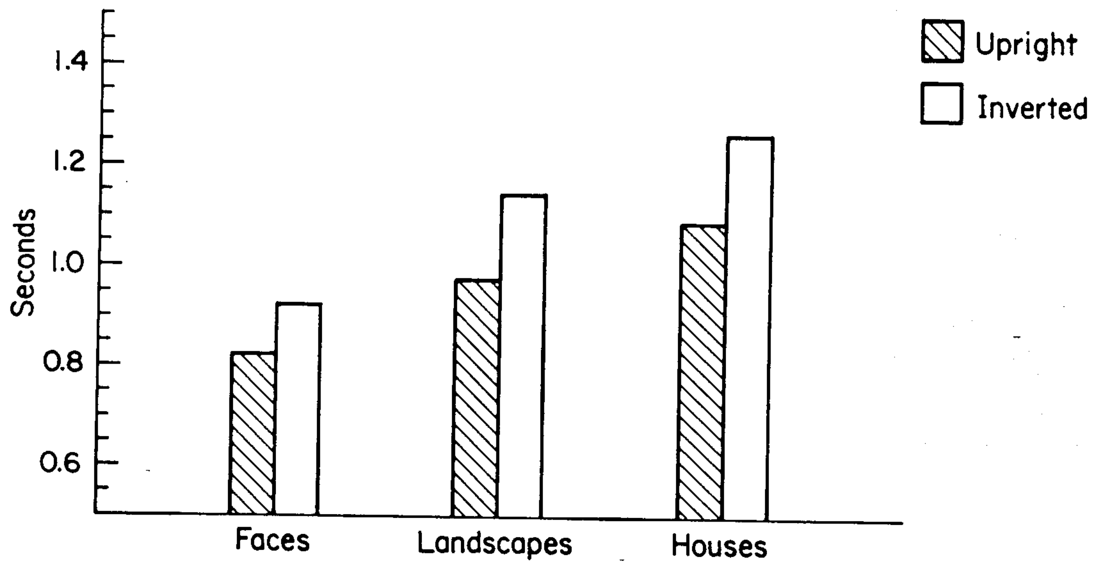

Figure 6. Reaction time to respond to probes for faces, landscapes, and houses, presented upright and inverted.

with schematic faces. It is reference to a canonical representation of this knowledge during individuation that we have suggested underlies the upright advantage for all classes of mono-oriented objects.

General Discussion

We have explored two questions. First, what is the source of the large detriment to face recognition associated with inversion? Second, are faces unique in the sense of being represented in memory in terms of distinguishing features that are especially sensitive to inversion? The second question has received a clear answer: No, faces are not special. The recognition of at least one other class of stimuli (dogs) is as sensitive to orientation as is recognition of faces provided that the perceivers are as expert at representing dogs as are adults at representing faces.

In answering the second question, we have constrained an answer to the first. Cocker spaniels or Irish setters, like faces, share the same basic configuration in the sense of the superimposition test; suitably normalized representations can be superimposed, or averaged, and the resulting representation is still recognizable as a member of that class. Although individual landscapes are surely distinguished at least in part on the basis of relational properties, all landscapes do not share the same configuration in this sense. We tentatively suggest that the large inversion effect will emerge whenever three conditions are met. First, the members of the class must share a configuration. Second, it must be possible to individuate the members of the class on the basis of second-order relational features. Third, subjects must have the expertise to exploit such features.

Other classes of stimuli besides faces and dogs should meet these conditions. Certainly any biological class whose members are individuated should do so. Relevant observations have been made of patients suffering from prosopagnosia, a neurological condition in which there is an extreme deficit in recognizing familiar faces. Although the nature of these patients' impairment in recognizing faces has received several different descriptions (see, e.g., Damasio, Damasio, & Van Hoesen, 1982; Hecaen, 1981), there are cases in which prosopagnosics who formerly had expertise with certain animals (the ability to identify species of birds, distinguish individual cows) lost the ability to recognize them when they lost the ability to recognize faces (Bornstein, 1963; Bornstein, Sroka, & Munitz, 1969). Moreover, Damasio et al. (1982) confirmed experimentally reports that prosopagnosic patients have specific difficulty recognizing unique members of nonface classes that share an overall similarity of visual shape (e.g., automobiles, abstract symbols, or some animals). Given these results and those of Experiment 3, it is unlikely that there is neural substrate dedicated to face encoding. However, it is certainly consistent with evidence from these studies of prosopagnosia to postulate a processor specialized for the encoding of members of classes who share a configuration.

Examination of patients with face-recognition impairments less severe than those found in prosopagnosia has also produced pertinent data. Focal lesions of the right hemisphere interfere selectively with the recognition of unfamiliar faces (e.g., Benton & Van Allen, 1968; De Renzi & Spinnler, 1966; Milner, 1968; Warrington & James, 1967). Yin (1970b) showed that patients with posterior right hemisphere damage were selectively impaired on upright faces, and not on either inverted faces or upright or inverted houses. The idea that the right hemisphere is selectively involved in processing upright faces is also supported by the results of divided visual field studies in adults and children. Several investigators showed a greater right-hemisphere advantage for upright than for inverted faces in tachistoscopic recognition tasks (Leehey, Carey, Diamond & Cahn, 1978; Rapaczynski & Ehrlichman, 1979; Young, 1984; Young & Bion, 1980, 1981). Both sets of results are consistent with right-hemisphere specialization for the extraction of second-order relational information in terms of which experts in a class are hypothesized to represent new instances.

In several studies the effect of inversion on face recognition has been reported to increase over the first decade of life (Carey & Diamond, 1977; Carey, Diamond & Woods, 1980; Flin, 1980; Goldstein, 1975). We suggest that increasing age brings about a gain in expertise, expressed in ability to exploit the distinguishing second-order relational features faces afford. With regard to the representation of unfamiliar faces, children under 10 years of age resemble the novices attempting to represent dogs in Experiments 2 and 3; by age 10 children become masters of faces, just as our dog experts in Experiment 3 became masters at representing sporting dogs.

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