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The Entry Point of Face Recognition: Evidence for Face Expertise

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Previous studies have shown that experts (e.g., birdwatchers) are as fast to recognize objects at subordinate levels of abstraction (e.g., robin) as they are to recognize the same object at the basic level (e.g., bird). As a test of face expertise, the current study found that adults identify faces more frequently (Experiment 1) and as quickly (Experiment 2) at the subordinate level (e.g., Bill Clinton) as at the basic level (e.g., human). Whereas brief presentation (75 ms) impaired subordinate-level recognition of nonface objects, it did not impair the subordinate level recognition of faces (Experiment 3). Finally, in an identity-matching task, subordinate-level primes facilitated the matching responses of faces but not nonface objects (Experiment 4). Collectively, these results indicate that face expertise, like expert object expertise, promotes a downward shift in recognition to more subordinate levels of abstraction.

Any object can be identified at multiple levels of abstraction. So, for example, whereas a bird can be identified as a "bird," the same bird can be identified more generally as an "animal," or more specifically as "sparrow," or a "white crown sparrow." Although all things can be categorized at different levels of abstraction, there seems to be one level, the basic level, that has a special status in object categorization. The basic level is defined as the level at which most knowledge is organized and the highest level of abstraction at which (a) a single mental image can be formed, (b) category members share a similar shape, and (c) similar motor actions are used to interact with category memory (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Rosch (1975b) and others have argued that basic-level categories are not arbitrary but are influenced by the structural properties of the external environment. Rosch (1975b) asserted that "in the perceived world, information-rich bundles of perceptual and functional attributes occur that form natural discontinuities and that basic cuts in categorization are made at these discontinuities" (p. 31). These "basic cuts" serve as *entry points* (Jolicoeur, Gluck, & Kosslyn, 1984) in recognition where the perceptual stimulus first makes contact with its underlying memorial representation.

To test the relation between basic-level categories and object recognition, Rosch et al. (1976) used several object-identification tasks. In an object-naming task, they found that participants preferred to use basic-level terms to identify objects (e.g., "chair," "dog") rather than superordinate-level terms (e.g., "furniture," "animal") or subordinate-level terms ("easy chair," "beagle"). In a category-verification task, participants were faster to verify objects at the basic level than at the superordinate or at the subordinate category levels. In an identity-matching task, where participants judged if two simultaneously presented objects were physically identical, it was found that matching responses were faster when participants had been primed with a basic-level name rather than a superordinate-level name. Critically, subordinate-level names provided no additional priming over basic-level names. On the basis of these experiments, Rosch et al. argued that the basic level of categorization provides the entry point in object recognition, that is, the level at which objects are first recognized.

Despite the structural emphasis of their theory, Rosch et al. (1976) also allowed for the role that experience might play in influencing the entry point. For example, they discussed one of their participants who was an expert airplane mechanic and found that he seemed to recognize airplanes at a more subordinate level of abstraction. Consistent with this view, Tanaka and Taylor (1991) found that experts were more likely to use subordinate-level names than basic-level names when identifying objects in their domain of expertise. In a category-verification task, experts were as fast to categorize objects from their domain of expertise at the subordinate level as they were to recognize the same object at the basic level (e.g., dog experts were able to categorize a picture of a beagle as a "beagle" as quickly as they were to categorize the same picture as a "dog"). These results suggest that entry point of recognition for experts, in contrast to novices, may shift to a level that is subordinate to the so-called basic level. Gauthier and Tarr (1997) also showed similar downward shifts in recognition after extensive training in the identification of artificial objects (e.g., Greebles). Thus, as a benchmark of expertise, representations subordinate to the basic level are as accessible as representations stored at the so-called basic level.

Although few people in the population are experts in the recognition of objects from a particular category (e.g., birds, dogs), it has been suggested that virtually all adults are experts in the recognition of faces (Carey, 1992; Carey & Diamond, 1977; Tanaka & Gauthier, 1997). Studies that investigate the effects of orientation on the recognition of face and nonface objects provide some evidence for the expert position. Although inversion disrupts the recognition of all objects, inversion *disproportionately* disrupts the recognition of faces relative to the recognition of other nonface objects (Yin, 1969). The face inversion effect has been interpreted as a marker of face-specific processes that are engaged by upright

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faces but not by inverted faces. What are the effects of experience on the face inversion effect? It has been shown that young children fail to show the same magnitude of the inversion effect as adults (Carey & Diamond, 1994). Because young children do not have extensive experience with upright faces, it has been speculated that their recognition abilities are not sufficiently developed to produce a substantial inversion effect. Similarly, other studies have shown race effects, where participants demonstrate a larger inversion effect to faces from a familiar racial group than to those from a less familiar racial group (Rhodes, Tan, Brake, & Taylor, 1989; but see Valentine, 1991). Inversion effects have also been found for nonface objects in cases where participants were experts in recognizing those nonface objects. Specifically, dog experts who specialize in a particular breed of dog have shown a substantial inversion effect when recognizing dogs from that breed (Diamond & Carey, 1986). Thus, studies examining children's recognition abilities, adults' recognition of different race faces, and experts' recognition of nonface expert objects indicate that the inversion effect on recognition is at least partly determined by the participant's experience.

What is the entry point in face recognition? If face recognition follows the pattern of other kinds of expert object recognition, people should demonstrate a downward shift in entry point recognition when identifying faces. In fact, face recognition provides the absolute test for investigating downward shifts in recognition as a result of expertise. Unlike expert bird and dog recognition, where identification typically occurs at the species (e.g., robin) and subspecies (e.g., golden retriever) levels of abstraction, face recognition requires identification at the level of unique identity, in which the individual face is the only object in the category. Given that perceptual demands increase with category specificity (Jolicoeur et al., 1984), the greatest amount of visual processing will be required to individuate faces at the most specific level of unique identity. Although models of face recognition have assumed that first recognition occurs at the level of the individual face (Bruce & Young, 1986), this assumption has gone essentially untested.

Alternatively, it is plausible that the entry point in face recognition follows Rosch et al.'s (1976) structural definition—the most inclusive level at which objects share a common shape—and therefore is at the level of "human." According to the *structural hypothesis,* people may access the unique identity level quickly, but only after the basic level of "human" is first activated. Therefore, if subordinate-level categorizations are mediated through basic-level categories, the structural account maintains that basic-level categorizations should be faster than more subordinate-level categorizations involving identity. In contrast, the *face expertise hypothesis* predicts that faces are recognized at a level subordinate to the structurally defined basic level of "human," and therefore, recognition times should be as fast as or faster than the structurally basic level. In the present study, the competing claims of the structural and the face expertise hypotheses are tested in object recognition experiments involving object naming, category verification and visual priming.

Experiment 1: Free Naming

In previous research, it has been shown that participants used basic-level names (e.g., bird, dog, chair, hammer) when asked to spontaneously identify pictures of common objects (Jolicoeur et al., 1984; Rosch et al., 1976). This result supports the notion that objects are first identified at the basic level of abstraction. However, other studies (Tanaka & Taylor, 1991) have shown that experts name objects in their domain of expertise at a level of abstraction that is subordinate to the basic level, suggesting that entry points can change as a result of experience. In Experiment 1, participants were shown pictures of familiar faces and nonface objects and asked to identify them as quickly as possible. According to the expertise hypothesis, participants should use subordinate-level names when identifying pictures of faces and basic-level names when identifying nonface objects.

Method

Participants. The 20 participants were students enrolled at Oberlin College. All participants reported normal or corrected normal vision. Participants were paid for their participation.

Stimuli. Stimuli for the naming study consisted of pictures of objects and famous faces. Object stimuli consisted of 46 black-and-white drawings and photographs of common objects mounted on 15.4 × 123.6-cm white index cards. Pictures were taken from 11 artifactual categories (musical instrument, sports equipment, vehicle, food, furniture, tool, clothing, office equipment, cooking utensil, kitchen appliance, and home electronics) and 9 natural categories (dog, bird, fish, insect, tree, flower, vegetable, fruit, and four-legged animal). Object stimuli contained sufficient detail to be identified at the subordinate level (e.g., "upright piano," "beagle"). The face stimuli consisted of black-and-white photographs of four famous people: George Bush, Bill Clinton, Princess Di, and Marilyn Monroe. The faces were selected on the basis of their familiarity and were correctly named by at least 75% of Oberlin students in a pilot study.

Procedure. Participants were seated at a table directly across from the experimenter at a distance of approximately of 1 m. Participants were instructed that they would see a series of pictures depicting common objects and their task was to "say the word that names the object as quickly as possible." The experimenter presented pictures one at a time and scored the category level (superordinate, basic, or subordinate) for each response. For the famous faces, naming responses such as "human" or "person" were scored as basic-level responses; "animal" or "living thing" as superordinate-level responses; and "woman," "man," or the proper name as subordinate-level responses. Pictures were presented at a rate of approximately one every 2 s. The order of presentation was randomized with the restriction that pictures depicting famous people were not presented on consecutive trials. At the end of the naming trials, participants were asked to rename any picture initially identified with basic- or superordinate-level names with a more specific subordinate-level name. Pictures that could not be named at the subordinate level were omitted from analysis.

Results and Discussion

Figure 1 shows percentage of basic- and subordinate-level responses for faces and nonface objects. For naming nonface objects, participants used basic-level names on 91% of the trials and subordinate-level names on 9% of the trials. None of the nonface objects were identified with superordinate-level terms. Thus, consistent with the results from other studies (Jolicoeur et al., 1984; Rosch et al., 1976), participants initially identified nonface objects with names corresponding to the basic level.

A different pattern of results was found for the naming of faces. On 14% of the trials, participants identified the faces with the basic-level terms "human" or "person," whereas on 86% of the trials, participants used a term that was subordinate to the basic-level category, such as "woman" or "Marilyn Monroe."

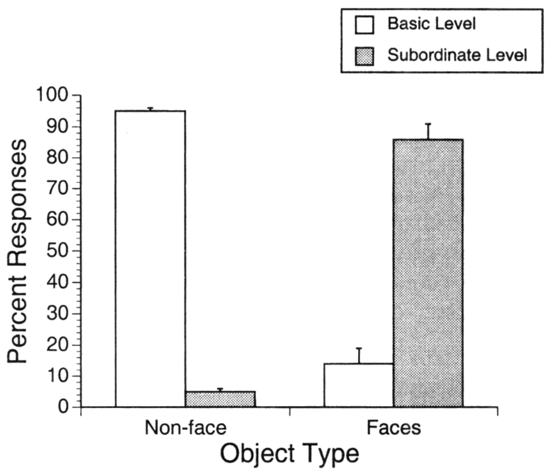

Figure 1. Results from Experiment 1 showing the percentage of basic level and subordinate level labels used to name nonface objects and faces.

Subordinate-level names were further analyzed to test whether participants were identifying faces with gender terms (i.e., "man," "woman") or proper names (e.g., "Bill Clinton"). Whereas participants chose to identify faces with gender-level terms on only 10% of the trials, they identified faces with proper names on 90% of the trials. Thus, on the majority of trials, participants chose to identify faces at the specific level of unique identity. To evaluate naming differences between face and nonface objects, I subtracted the percentage of basic-level names from the percentage of subordinate-level names and compared the difference for each object type. The difference in naming was reliable, $t(21) = 17.24$, $p < .001$, demonstrating that participants identified nonface objects with basic-level names but faces with subordinate-level names.

To summarize, the results of Experiment 1 showed that, consistent with the concept of a basic level, participants identified artifactual and natural kind objects with basic-level terms. However, as predicted by the face expertise hypothesis, participants chose not to use basic-level terms, such as "human" or "person," when identifying faces but instead chose to identify faces by their proper names. This result is analogous to the previous finding with dog and bird experts in which these object experts preferred subordinate-level names over basic-level names to identify objects in their domain of expertise (Tanaka & Taylor, 1991). Thus, one behavioral outcome of expertise is that levels of representation subordinate to the structurally defined basic level become more accessible through experience. However, face expertise recognition differs from dog and bird expertise in that dogs and birds are identified at the species (e.g., "robin") and subspecies (e.g., "Doberman pinscher") level whereas faces are identified at the most specific level of unique identity (e.g., "Bill Clinton").

It is possible that present naming results do not reflect an increased accessibility of the unique identity representation as much as a bias toward using proper names to identify the faces. That is, by social convention, we typically refer to faces by their proper names and not by other subordinate-level (e.g., "female") or basic-level (e.g., "human") terms. Participants in this task may recognize faces first at the level of human but choose to name the face with the more commonly used proper name. Hence, the use of proper names in the naming task demonstrates only a preference for this level of identification and is not indicative of the level at which the face is initially accessed in semantic memory. In Experiment 2, the accessibility of identity level representations was directly tested in a reaction time, category-verification task.

Experiment 2: Category-Verification Task

In this task, participants were presented with a superordinate-, basic-, or subordinate-level category label. A brief time later they were shown a picture and asked to indicate whether the picture was an exemplar of the category. Rosch et al. (1976) found that participants were fastest to categorize exemplars at the basic level (e.g., verifying that a picture of a robin is a "bird") and slower to categorize exemplars at the superordinate level (e.g., verifying that a robin is an "animal") and at the subordinate level (e.g., verifying that a robin is a "robin"). On the basis of this evidence, they claimed that "first cuts" in categorization or entry point recognition occurs at the basic level of abstraction.

In Experiment 2, participants were asked to categorize faces of dogs and humans at superordinate ("living thing"), basic ("dog" or "human") and subordinate levels of categorization. Dogs were selected as the appropriate contrast stimulus category to humans because previous research (Jolicoeur et al., 1984; Tanaka & Taylor, 1991) has shown that dogs are categorized first at the basic level of abstraction. According to the basic–first hypothesis, if humans, like dogs, are categorized first at the basic level, basic-level verifications should be faster than unique-identity-level verifications. That is, participants should be faster to verify that a picture of a face is a "human" than to verify the unique identity of the face (e.g., "Bill Clinton," "Princess Di").[1] However, on the basis of the previous naming study, it might be expected that the unique-identity-level representations for human faces will be more accessible than the basic-level representations. In this case, unique-identity-level verifications should be faster than basic-level verifications. That is, participants should be faster to verify the unique identity of a face (e.g., "Bill Clinton," "Princess Di") than to verify that the face is a "human."

Method

Participants. The 25 participants were students enrolled at Oberlin College. All participants reported normal or corrected normal vision. Participants were paid for their participation.

Materials. The picture stimuli consisted of eight colored dog drawings taken from *Spotter's Guide to Dogs* (Glover, 1970) and eight color photographs of faces of famous people taken from magazines. The eight dog exemplars (poodle, beagle, German shepard, collie, golden retriever, chow chow, terrier, and Doberman pinscher) were among the 20 most common dogs as determined by the American Kennel Club's list of registered dogs for 1984. The eight famous faces (George Bush, Ronald Reagan, Michael Jordan, Marilyn Monroe, Hillary Clinton, Bill Clinton, Princess Di, and

[1] It is possible that the subordinate level of gender (i.e., man, woman) might be more accessible than the unique identity level. However, in a pilot study, it was found that participants were faster to categorize familiar faces according to their identities than their gender. Consistent with this finding, other studies have shown that judgments of gender are independent of judgments of familiarity (Bruce, Ellis, Gibling, & Young, 1987).

Arnold Schwarzenegger) were identifiable by at least 85% of Oberlin College students in a pretest study. An additional 16 pictures depicting various inanimate objects (e.g., furniture, tools, musical instruments) were used as foil stimuli. Pictures were converted into an 8-bit color digitized image using a 600Zs Microtek Scanner and measured approximately 150 × 150 pixels in size.

Procedure. At the beginning of the experimental session, participants read a set of written instructions that explained the procedure for the verification task. Participants were provided with a written list of the subordinate-level terms for the 16 target exemplars. Participants were seated approximately 2 m from a computer monitor. At the beginning of each trial, a row of plus signs appeared on the computer monitor, which served as a ready signal. After a 1-s interval, the ready sign was replaced by a category name, which remained for 2.5 s and then was replaced by a picture. If the picture matched the category name, participants pressed the key marked *TRUE* on the computer keyboard; otherwise they were to respond by the pressing the key marked *FALSE.* The picture remained in view until the participant responded. Participants used the index and middle finger of their dominant hand and were instructed to respond as quickly as possible.

Each of the eight dog and human pictures was shown six times. For the three true trials, the category name matched the picture at the superordinate, basic, and subordinate levels. For each picture's three false trials, the foil category names were selected from the contrast category that was at the same level of abstraction as the target category. Consequently, subordinate-level foils shared the same basic category as the target (e.g., for the false trial, a picture of a beagle was paired with foil category "collie"); basic-level foils shared the same superordinate-level category as the target (e.g., a picture of a dog was paired with foil category "human"); and superordinate-level foils were taken from another superordinate-level category (e.g., a picture of a dog was paired with foil category "nonliving thing"). Thirty-two additional trials of filler pictures (e.g., furniture, tools, musical instruments) were presented to prevent response bias to the superordinate foils (i.e., automatically responding false to the "plant" category name). Including the 96 target and 32 filler trials, there were a total of 128 experimental trials. Presentation of the trials was randomized across participants.

Results and Discussion

In the dog category, participants correctly responded true on 98%, 99%, and 90% of the trials for superordinate-level, basic-level, and subordinate-level categorizations, respectively. For false trials, participants correctly responded on 99%, 98%, and 92% of the trials for superordinate level, basic level, and subordinate level, respectively. In the category of human, participants correctly responded true on 99%, 99%, and 99% of the trials for categorizations at the superordinate level, basic level, and subordinate level, respectively. For false trials, participants correctly responded on 99%, 98%, and 99% of the trials for superordinate level, basic level, and subordinate level, respectively.

An analysis of variance (ANOVA) was performed for reaction times of correct true responses with object domain (dog or human) and category level (superordinate, basic, or subordinate) as within-participant factors. The main effect of object domain was significant, $F(1, 24) = 6.84$, $MSE = 1{,}376{,}646$, $p < .02$. Overall, participants were faster to categorize human faces than they were to categorize dogs. The main effect of category level was also significant, $F(2, 24) = 4.64$, $MSE = 1{,}084{,}765$, $p < .02$. The critical Object Domain × Category Level interaction was also significant, $F(2, 48) = 3.88$, $MSE = 937{,}426$, $p < .03$. As shown in Figure 2, participants were significantly faster to categorize

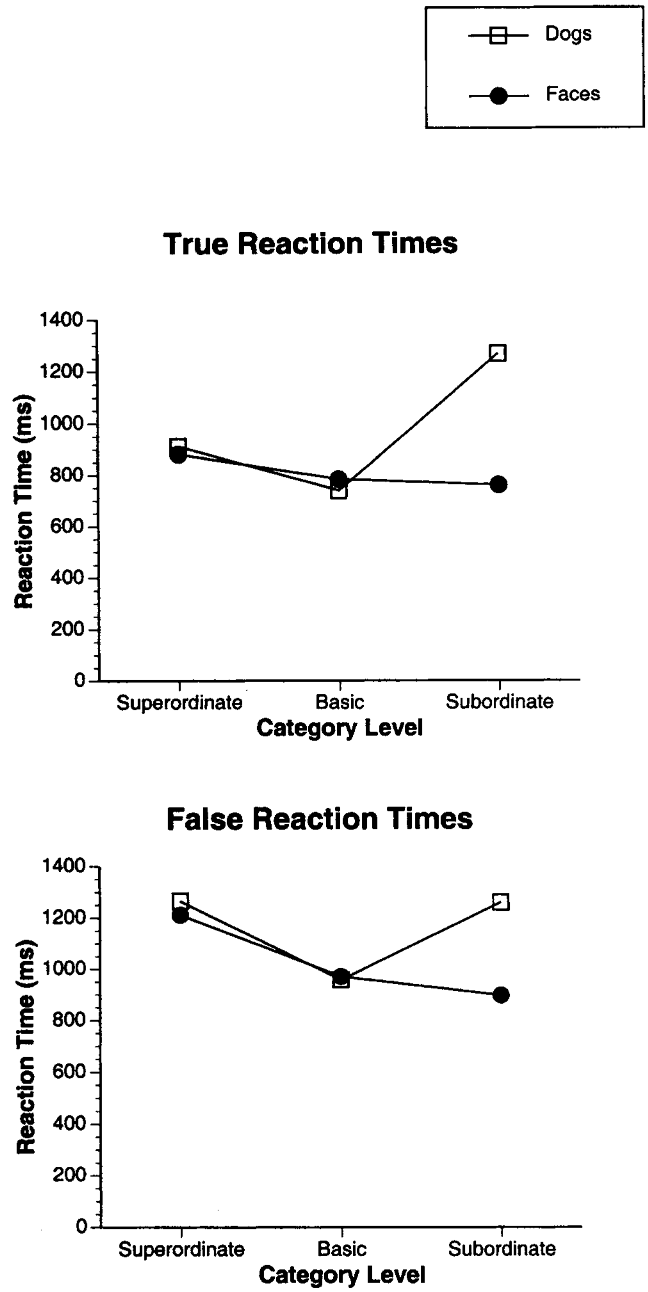

Figure 2. Results from Experiment 2 showing the mean reaction times for categorizing dogs and faces at the superordinate, basic, and subordinate levels in the true and false conditions.

dogs at the basic level than at the subordinate level, $F(1, 24) = 5.24$, $MSE = 665{,}471$, $p < .04$. However, for faces, participants were as fast to categorize faces at the level of unique identity (e.g., Bill Clinton) as at the basic level (e.g., human), $F(1, 24) = 1.59$, $MSE = 25{,}421$, $p > .20$.

An ANOVA was also performed for correct false reaction times with object domain (dog or human) and category level (superordinate, basic, or subordinate) as within-participant factors. The main effect of object domain was significant, $F(1, 24) = 6.51$,

MSE = 678,586, $p < .02$. Participants were faster to correctly reject human faces than they were to correctly reject dogs. Category level was significant, $F(2, 43) = 11.76$, MSE = 956,359, $p < .001$. For false responses, the Object Domain × Category Level interaction was also significant, $F(1, 24) = 5.43$, MSE = 503,898, $p < .01$. As shown in Figure 2, participants were significantly faster to correctly reject a dog at the basic level (e.g., a picture of a beagle as not a "human") than at the subordinate level (e.g., a picture of a beagle as not a "poodle"), $F(1, 24) = 7.02$, MSE = 162,332, $p < .02$. In contrast, participants were equally fast to correctly reject a human face at the unique-identity level (e.g., a picture of Bill Clinton was not "George Bush") as at the basic level (e.g., a picture of Bill Clinton was not a "dog"). Thus, consistent with their true responses, participants demonstrated a basic-level advantage for dogs but not for human faces.

In summary, the results of Experiment 2 demonstrated that people are as fast and accurate to categorize faces at a level subordinate to the basic level as they are to categorize faces at the basic level. These results parallel previous expertise studies showing that dog and bird experts categorized objects in their domain of expertise as quickly and accurately at the subordinate level as at the basic level (Tanaka & Taylor, 1991). The speeded subordinate-level categorization indicates that most normal adults qualify as face experts to the extent that their subordinate level categories are as accessible as their basic-level categories. Of note, in contrast to the dog and bird experts who showed increased accessibility of species and subspecies level categories (e.g., "robin," "beagle"), face experts demonstrate accessibility at the very specific level of unique identity (e.g., "Margaret Thatcher," "Bill Clinton").

Experiment 3: Effects of Exposure Duration on Face Recognition

Although categorizations superordinate to the basic level require additional semantic processing, it has been argued that categorizations subordinate to the basic level require additional perceptual processing. Evidence to support this view comes from a study by Jolicoeur et al. (1984) in which participants were asked to categorize pictures of common objects at superordinate ("furniture," "tool," "animal"), basic ("chair," "saw," "bird"), and subordinate ("kitchen chair," "cross-cut saw," "robin") levels of abstraction. Pictures were presented for either a long (250 ms) or a short (75 ms) exposure duration. It was found that reaction times and accuracy levels were equivalent in the short- and long-exposure conditions for basic- and superordinate-level categorizations. However, judgments were slower and less accurate when the same objects were categorized at the subordinate level under the short-exposure condition. These results suggest that additional perceptual processing is needed to abstract the visual details associated with subordinate-level decisions. Under the short-exposure condition, perceptual processing is terminated before the visual information necessary for subordinate-level categorizations is acquired. Hence, short-exposure durations will selectively disrupt subordinate-level categorizations relative to basic- and superordinate-level categorizations.

As demonstrated in Experiment 2 and other studies (Gauthier & Tarr, 1997; Johnson & Mervis, 1997; Tanaka & Taylor, 1991), the benchmark of face and object expertise is that experts are able to categorize objects at the subordinate level of abstraction as quickly and accurately as they can at the basic level. Given the perceptual demands of the subordinate-level categorizations and the facility with which experts can recognize objects at this level, I predicted that expertise would facilitate the perceptual stages of object recognition. That is, experts develop specialized "perceptual routines" that enable the rapid analysis of stimulus information from objects in the expert domain. Presumably, perceptual routines provide the mechanism by which experts can quickly recognize objects at specific levels of abstraction (Gauthier & Tarr, 1997; Johnson & Mervis, 1997; Tanaka & Taylor, 1991).

As a test of the perceptual basis of face expertise, in the following experiment, participants were asked to identify faces of well-known celebrities and politicians presented for either a short (75 ms) or long (950 ms) exposure duration. As comparison objects, pictures of common birds and dogs were also presented in the short- and long-exposure conditions. If expertise facilitates the perceptual stages of object processing, it is predicted that the shortened exposure duration should be *less* disruptive when participants identify faces at the subordinate level relative to nonface objects.

Method

Participants. Forty-four students enrolled at Oberlin College participated in this experiment. All participants reported normal or corrected normal vision. Participants received course credit for their participation in the experiment.

Materials. Target stimuli consisted of faces of eight well-known politicians and celebrities (George Bush, Bill Clinton, Cindy Crawford, Hillary Clinton, Jay Leno, Marilyn Monroe, Princess Di, and Jerry Seinfeld), pictures of eight common dogs (German shepherd, beagle, collie, poodle, Doberman pinscher, chow chow, schnauzer, and golden retriever) used in the Experiment 2, and pictures of eight common birds (cardinal, crow, dove, hawk, jay, oriole, robin, and sparrow). The selected bird exemplars were among the 10 most frequently mentioned category members with the exception of dove, which was the 15th most frequently mentioned bird (Battig & Montague, 1969).

Procedure. At the beginning of each trial, a plus sign appeared on the computer screen, which served as a ready signal. After a 1-s interval, the ready sign was replaced by a picture stimulus that was presented either for 75 ms (short-exposure condition) or 950 ms (long-exposure condition). The picture was followed by a color pattern mask that was presented for 50 ms. In the short-exposure condition, the category name was presented after a blank interval of 875 ms. In the long-exposure condition, the category name was presented immediately following the pattern mask. Thus, in both exposure conditions, 1 s separated the onset of the picture stimulus and the category name. The category name remained on the screen until the participant responded. If the picture matched the category name, participants were instructed to press the key marked *TRUE;* otherwise they were to respond by pressing the key marked *FALSE.* Participants used the index and middle fingers of their dominant hand and were instructed to respond as quickly as possible. Participants were given four practice trials before the experimental trials began. Exposure duration was a between-groups factor, in which half of the participants were run in the short-exposure condition and the other half were run in the long-exposure condition.

Each of the eight face, dog, and bird pictures was shown four times, twice in the true condition and twice in the false condition. For the two true trials, the category name matched the picture at basic and subordinate levels. For the two false trials, the foil category names were selected from the contrast category that was at the same level of abstraction as the target category. Consequently, subordinate-level foils shared the same basic category as the target (e.g., for the false trial, a picture of a beagle was paired with foil category "collie"). Basic-level foils were from one of the other two target categories (e.g., a picture of a dog was paired with foil category "face"). Exposure condition was a between-groups factor with half of the participants tested in the short-exposure condition and half tested in the long-exposure condition. The 24 stimulus pictures were tested at two levels of categorization (basic and subordinate) and two response conditions (true and false) yielding a total of 96 experimental trials. Presentation of the trials was randomized across participants.

Results

Reaction times. Reaction times and standard errors are shown in Table 1. An ANOVA was performed for reaction times with object domain (nonface or face), category level (basic or subordinate), and response (true or false) as within-participant factors and exposure duration (short or long) as a between-groups factor. The main effect of object domain was significant, $F(1, 42) = 19.96$, $MSE = 693{,}581$, $p < .001$. Overall, participants were faster to categorize human faces than they were to categorize nonface birds and dogs. The main effect of category level was also significant, $F(1, 42) = 57.88$, $MSE = 1{,}689{,}838$, $p < .001$, demonstrating that basic-level categorizations were faster than subordinate-level categorizations. However, the effects of object and categorization level were qualified by their significant interaction, $F(1, 42) = 50.97$, $MSE = 2{,}095{,}795$, $p < .001$, showing that nonface objects were categorized more quickly at the basic level whereas faces were categorized as rapidly at the subordinate level of unique identity (e.g., Bill Clinton) as they were at the basic level (e.g., face). There was a reliable Category Level × Exposure Duration interaction, $F(1, 42) = 4.64$, $MSE = 135{,}451$, $p < .05$, showing that subordinate-level categorizations were more affected by exposure duration than were basic level categorizations. The three-way Category Level × Object Domain × Response interaction was also significant, $F(1, 42) = 9.19$, $MSE = 111{,}008$, $p < .001$. No other main effects or interactions reached reliable levels ($p > .05$).

Accuracy. An ANOVA was performed for the percentage of correct responses with object domain (nonface or face), category level (basic or subordinate), and response (true or false) as within-participant factors and exposure duration (short or long) as a between-groups factor. The main effect of exposure duration was significant, $F(1, 42) = 4.23$, $MSE = 0.025$, $p < .05$, demonstrating that participants were more accurate in the long-exposure condition than in the short-exposure condition. The significant main effect of category level, $F(1, 42) = 26.67$, $MSE = 0.185$, $p < .001$, showed that basic-level decisions were more accurate than subordinate-level judgments. Exposure duration interacted with category level, $F(1, 42) = 5.18$, $MSE = 0.036$, $p < .05$, indicating that shortened exposure durations had a larger influence on subordinate-level accuracy than on basic-level accuracy. However, the critical three-way Exposure Duration × Category Level × Object Domain interaction was also significant, $F(1, 42) = 4.67$, $MSE = 0.023$, $p < .05$. Whereas exposure duration had a deleterious effect on subordinate-level decisions of nonface objects, it had no effect on the subordinate-level categorizations of faces (as shown in Figure 3). The significant main effect of response, $F(1, 42) = 9.07$, $MSE = 0.046$, $p < .01$, showed that participants committed more errors for false responses than true responses. The three-way Category Level × Object Domain × Response interaction was also significant, $F(1, 42) = 6.91$, $MSE = 0.024$, $p < .05$. No other interactions were significant ($p > .10$).

Two important results emerged from the current experiment. First, consistent with the results of the previous experiment, familiar faces were categorized as quickly and accurately at the subordinate level of unique identity as they were at the basic level. Thus, face expertise, like other forms of object expertise (Gauthier & Tarr, 1997; Johnson & Mervis, 1997; Tanaka & Taylor, 1991), results in the increased accessibility of subordinate-level representations. Second, these results revealed that exposure duration had differential effects on the basic- and subordinate-level categorizations of face and nonface objects. Whereas shortened exposure durations disrupted the accuracy with which birds and dogs were categorized at the subordinate level, it had virtually no effect on the accuracy of subordinate-level identification of familiar faces, suggesting that the visual information needed to identify faces at the subordinate level was encoded within the first 75 ms of presentation. Thus, an important consequence of visual expertise is that experts develop specialized *perceptual routines* that permit the rapid analysis of domain-specific objects. Perceptual routines may provide the critical mechanism by which experts can quickly recognize objects at specific levels of abstraction (Gauthier & Tarr, 1997; Johnson & Mervis, 1997; Tanaka & Taylor, 1991).

Table 1
Reaction Times (and Standard Errors) in Milliseconds for Nonface Objects and Faces Under Long and Short Exposure Durations

Exposure duration	Basic level		Subordinate level		
	True	False	True	False	*M*
		Nonface objects			
Long	739 (37)	780 (33)	987 (70)	979 (55)	871
Short	787 (37)	793 (34)	1,180 (89)	1,124 (94)	971
M	763	786	1,083	1,052	921
		Faces			
Long	852 (50)	815 (48)	769 (52)	848 (52)	821
Short	831 (39)	864 (63)	795 (49)	886 (44)	844
M	841	839	782	867	832

Experiment 4: Priming of Face Representations

Results from Experiments 2 and 3 indicate that experts have detailed perceptual representations of faces that can be quickly accessed in recognition. The perceptual representation of faces was directly examined in Experiment 4 using an identity-priming task. In this task, participants were presented with a word prime (basic or subordinate level) or a neutral prime, followed by two simultaneously shown pictures. The participant's task was to decide whether the two pictures were visually identical or different. Facilitation was measured by the difference in reaction time between primed and neutral trials for the same matching picture stimuli. The identity-priming paradigm assumes that the word prime activates the participant's visual representation, which in turn is used to enhance the perceptual matching response (Posner, 1969; Posner & Mitchell, 1967; Rosch, 1975a; Rosch et al., 1976). Moreover, the amount of facilitation reflects the degree to which the participant's mental representation, as elicited by the word

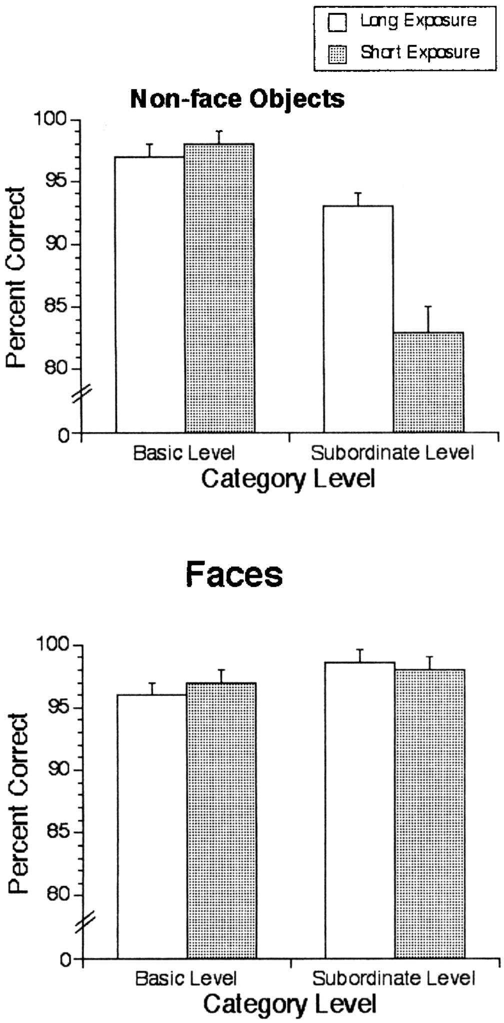

Figure 3. Results from Experiment 3 showing the percentage of correct basic- and subordinate-level responses to nonface objects and faces under short- and long-exposure conditions.

prime, corresponds to the physical picture stimulus; presumably, the closer the match between the mental representation and the visual percept, the faster the matching response.

Rosch et al. (1976) used the identity-priming task to examine the category level at which people represent objects. They found that relative to the neutral condition, basic-level words (e.g., "chair," "dog," "saw") produced significantly more facilitation than superordinate-level words (e.g., "furniture," "animal," "tool"). It is important to note that although subordinate-level words contain more information about the visual appearance of objects (e.g., folding chair, beagle, hacksaw) than basic-level words, they produced no more facilitation. From these results, Rosch et al. concluded that people represented most objects at the basic level of detail.

One explanation for the absence of priming effects for subordinate-level words is that the participants in the Rosch et al. (1976) study as novices did not have good access to subordinate-level representations that could be applied in the matching task. Assuming that experts have developed more elaborated, more accessible subordinate-level representations than novices, it is conceivable that they would be in a better position to take advantage of the subordinate-level prime. Face experts, for example, when primed with a proper name (e.g., "Bill Clinton"), should be able to activate a unique identity representation that can be brought to bear in a visual matching task yielding priming effects above those produced for basic-level words.

In the following experiment, objects and face representations were tested in a unique-identity-priming task. Prior to deciding whether two stimuli were visually identical or not, participants read either a basic-level word, a subordinate-level word, or a neutral word.[2] If participants have ready access to face representations at the level of unique identity, they should have demonstrated greater facilitation when primed with these subordinate-level words than when primed with basic-level words. Alternatively, if participants represent faces, like objects, at the basic level, no differences in facilitation should have been found between subordinate-level primes and basic-level primes.

Method

Participants. The 30 participants were students enrolled at Oberlin College. All participants reported normal or corrected normal vision. Participants were paid for their participation.

Materials. Target stimuli consisted of the eight faces and four of the dog pictures (German shepherd, collie, poodle, and Doberman pincher) used in Experiment 2. In addition, 12 new target stimuli were included in Experiment 4: four bird pictures (cardinal, sparrow, robin, and pigeon), four insect pictures (moth, wasp, ant, and fly), and four flower pictures (lily, iris, rose, and carnation). With the following exceptions, selected exemplars were among the 10 most frequently mentioned category members (Battig & Montague, 1969): Pigeon was ranked the 15th most frequently mentioned bird, moth the 12th most frequently mentioned insect, and iris the 14th most frequently mentioned flower. An additional 16 pictures were used as foils for the target stimuli. Foil stimuli were selected from the artifactual categories of musical instrument (drum, saxophone, violin, guitar), tool (hammer, backsaw, crosscut saw, screwdriver), furniture (armchair, kitchen chair, lamp, table), and car (Grand-Am, Honda Civic, Saab, Toyota Camry).

Procedure. At the beginning of each trial, a ready signal consisting of a row of plus signs appeared on the computer screen. After a 1-s interval, the ready signal was replaced by a word prime or the neutral word "blank." Word primes were either basic-level words (i.e., "person," "dog," "bird," "insect," "flower") or subordinate-level words. Two and a half seconds following the onset of the prime word or neutral word, two pictures were presented on the computer screen. The participant was instructed that if the two pictures were physically identical, he or she should push the key marked *SAME* and that if the pictures were physically different, he or she should push the key marked *DIFFERENT.* The picture pair remained on view until a response was made. Participants were told to respond as quickly and as accurately as possible.

For same responses, the basic-level (e.g., "bird"), subordinate-level (e.g., "robin"), and neutral ("blank") words were followed by two identical pictures (e.g., robin–robin). For different responses, the basic-level, subordinate-level, and neutral words were followed by pictures of two different objects (e.g., lamp–table) from one of the four foil categories (furniture, tools, cars, and musical instruments). For each different response within an object category, new foil pairings were generated. Foil

[2] Superordinate-level words were not used because previous research (Jolicoeur et al., 1984) has shown that superordinate categories do not play a direct role in object recognition processes.

objects appeared an equal number of times. Thus, the three types of word primes, 24 target items, and two response types yielded a total of 144 experimental trials. Experimental trials were randomly presented.

Results and Discussion

In the following analyses, same responses were used to measure priming effects. I obtained priming scores by calculating differences in reaction time for correct same responses when pictures were preceded by a neutral word as compared with when they were preceded by either a basic-level word or a subordinate-level word. The overall reaction times by category and priming condition are shown in Table 2. I calculated a mean basic-level and subordinate-level priming score by averaging priming scores for the four target category objects and the eight target faces at these two levels of abstraction. For each individual participant, then, a mean priming score was obtained for each of the five target categories at the two levels of abstraction.

To test for differences between the four nonface categories, mean priming scores were submitted to two-way ANOVA with category (flowers, birds, dogs, or insects) and priming condition (neutral, basic, or subordinate) as within-participant factors. Neither the main effects of category and level nor their interaction was significant ($p > .10$). Given the lack of difference between nonface categories, I formed a general object category by averaging priming values for basic- and subordinate-level responses across the four nonface categories.

As shown in Figure 4, the amount of facilitation produced by the basic-level and subordinate-level word varied depending on the category. The amount of facilitation was roughly the same when participants were primed with a basic-level object word or a subordinate-level object word, 40 ms and 51 ms, respectively. Thus, consistent with Rosch et al.'s (1976) earlier finding, there was little difference between the amount of priming for objects produced by basic-level and subordinate-level words. Faces, on the other hand, elicited different amounts of facilitation as a function of category level prime. Participants averaged 22 ms of facilitation when primed with the basic-level word "human" as compared with 92 ms when primed with a subordinate unique identity name (e.g., "Bill Clinton"). Therefore, in contrast to objects, faces showed greater facilitation for subordinate-level primes at the level of unique identity than for basic-level primes.

To test for differences in priming effects between object and face categories, an ANOVA was performed with object domain (object or face) and category level (basic or subordinate) as within-participant factors. Although category level was significant, $F(1, 29) = 10.43$, $MSE = 49{,}816$, $p < .01$, this effect was qualified by

Table 2
Reaction Times (and Standard Errors) in Milliseconds by Object Category and Prime Type

Object category	Neutral	Basic level	Subordinate level
Birds	643 (44)	555 (27)	565 (29)
Dogs	651 (49)	631 (47)	574 (30)
Flowers	614 (39)	569 (25)	598 (43)
Insects	647 (39)	629 (43)	600 (55)
Faces	638 (34)	616 (34)	546 (31)

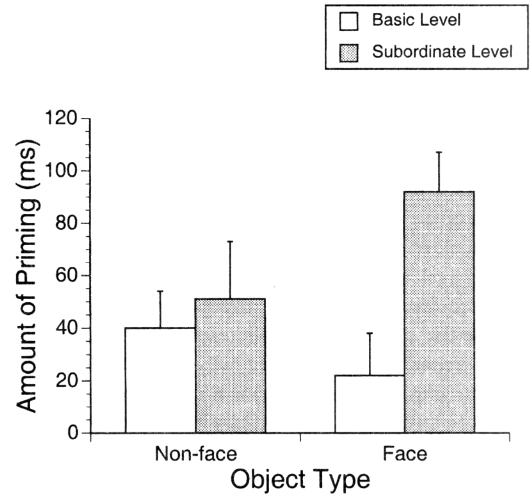

Figure 4. Results from Experiment 4 demonstrating the amount of facilitation for basic and subordinate level words for face and nonface objects.

the significant Category Level × Object Domain interaction, $F(1, 29) = 8.71$, $MSE = 25{,}201$, $p < .01$. The interaction showed that additional priming effects were found at the subordinate level for faces but not for objects. Consistent with this view, a direct comparison between basic- and subordinate-level primes for faces was significant ($p < .001$), whereas the difference between basic- and subordinate-level primes for nonface objects was not ($p > .10$). The main effect of object domain was not significant, $F(1, 29) = 0.286$, $MSE = 4{,}308$, $p > .10$.

The main finding of Experiment 4 was that whereas participants showed no difference in priming between basic-level and subordinate-level words for objects, there was a marked difference in the amount of priming produced by basic-level and subordinate-level words for faces. According to the logic of the identity-matching paradigm, this finding suggests that for faces, participants are able to activate subordinate-level representations that are brought to bear in the identity matching task.

General Discussion

These experiments address the primary question, At what level of abstraction do people *first* recognize a face? The entry point of recognition is defined as the initial point of contact between the perceptual stimulus and its memory representation. Converging evidence from four experiments suggests that the entry point of face recognition is different from the entry point of nonface object recognition. In a naming task (Experiment 1), whereas common objects were likely to be identified with basic-level names, it was found that familiar faces were more likely to be identified with unique identity names. In a category-verification task (Experiment 2), it was shown that faces were verified as quickly and accurately at the subordinate level of unique identity as they were at the basic level. Moreover, the unique-identity-level representations of faces were accessible during the first 75 ms of perceptual encoding (Experiment 3). Finally, the fine-grained visual representation of a familiar face was demonstrated in an identity-matching task (Experiment 4) in which subordinate-level proper name labels (e.g., "Bill Clinton," "George Bush") produced greater priming effects than the basic-level label (e.g., "human"). Collectively, these results argue that whereas the entry point in recognition for most objects is at a basic-level representation, the entry point in face recognition is at the subordinate level of unique identity.

The current face expertise results mirrored previous findings obtained with dog and bird experts (Tanaka & Taylor, 1991) in that both specialized object experts and face experts demonstrated a gain in subordinate-level accessibility as a consequence of expertise. A hallmark of expert recognition then is that experts are able to make very fast and accurate identifications of domain-specific stimuli that require a fine grain of perceptual detail. While the two types of expertise are similar in this respect, face expertise differs from object expertise in important ways. First, object expertise (e.g., birdwatching, x-ray analysis) is a specialized activity that is achieved by relatively few individuals and only through explicit training. Face expertise, on the other hand, is a general expertise that virtually all members of the population possess and an expertise that has been acquired without the benefit of direct instruction. In fact, persons who have lost their face expertise abilities, the clinical syndrome known as prosopagnosia, are extremely rare and have been the subject of intense study in cognitive neuropsychology (Farah, 1990).

Face expertise differs from object expertise in a second way. Although both face expertise and object expertise promote increased access to levels of representation subordinate to the basic level, the subordinate levels correspond to different levels of abstraction. In the case of object expertise, the subordinate level frequently represents the level of abstraction that is equivalent to the biological level of species (e.g., "robin") or subspecies (e.g., "chipping sparrow," "German shepherd"). In the case of face expertise, the subordinate level signifies the most specific level of unique identity where the proper name category label (e.g., "Bill Clinton") references a single object in the world (e.g., Bill Clinton). Categorization level and perceptual processing are intertwined in recognition so that as the level of specificity in recognition increases so does the amount of perceptual information. The extreme specificity at which faces are recognized therefore places maximal perceptual demands on the face recognition system. That is, in order to differentiate one familiar face from another, the face recognition system must be sensitive to fine-grained differences in featural (e.g., shape contour) and configural (e.g., distance between eyes) information (Diamond & Carey, 1986; Tanaka & Farah, 1991; Tanaka & Sengco, 1997). Despite these formidable constraints, the current results indicate that the most specific category level of unique identity is the level at which face recognition first occurs.

Experiments using positron emission tomography and functional magnetic resonance imaging (fMRI) techniques (Aguirre, Singh, & D'Esposito, 1999; Kanwisher, McDermott, & Chun, 1997; Sergent, Ohta, & MacDonald, 1992) have demonstrated that the fusiform gyrus of the temporal cortex is selectively activated by human face stimuli; this same brain area is not activated by pictures of complex geometric patterns, butterflies, or automobiles. Similarly, neurological patients who suffer from prosopagnosia are selectively impaired in their ability to recognize faces but retain their ability to recognize nonface objects, such as eyeglasses or automobiles (Damasio, Damasio, & Van Hoesen, 1982; Farah, Levison, & Klein, 1995). Together, the neuroimaging and patient evidence indicate that face recognition is subserved by a separable neural system that is specialized in the processing of face stimuli and is not centrally involved in the processing of nonface objects.

Although the converging neurophysiological evidence indicates that faces are not processed by the same neural system as objects, it is not clear whether the putative face-processing system is the product of biology, experience, or both. On the one hand, evidence supporting an innate face-processing mechanism comes from studies in which it has been shown that newborns display an attentional preference for face stimuli over nonface stimuli (Morton & Johnson, 1991). However, whereas a basic-level "face" processing appears to be mediated by a biologically innate subcortical system, Morton and Johnson suggest that everyday face recognition at the unique identity level is performed by a later maturing cortical system that is fine tuned by learning and experience. Normal face recognition may be special only in the sense that it requires precise perceptual discriminations that are acquired after many learning trials. The fusiform gyrus is particularly suited to execute the very fast and detailed visual analysis required for face recognition. However, it is possible that this same brain region could be recruited to carry out the recognition of nonface stimuli if similar task demands and stimulus properties were approximated.

As a test of the expertise account, Gauthier, Tarr, Anderson, Skudlarksi, and Gore (1999) trained participants to recognize artificial "Greeble" objects. Greebles are structurally similar to faces in that all Greebles share the same basic features and configuration. Therefore, identification of individual Greebles requires discrimination of second-order featural and configural differences. fMRI was used to measure participants' metabolic changes in the fusiform gyrus over the course of training. The critical finding was that as participants became experts in Greeble recognition, they demonstrated increased activation in the middle fusiform gyrus of the right hemisphere. Indeed, the level of fusiform activation produced by Greeble stimuli was equivalent to the level elicited by control face stimuli. Gauthier et al.'s findings show the neural substrates associated with face recognition are engaged when other kinds of expert recognition are performed. Therefore, the fusiform gyrus may not be a face area per se but a brain area involved in detailed visual analysis that is built up through experience.

Electrophysiological studies using event-related potentials suggest a further parallel between the processes of face recognition and expert object recognition. A number of studies have demonstrated that relative to nonface objects, faces elicit an enhanced negative scalp potential approximately 170 ms after stimulus onset. While the N170 has been interpreted as a neural marker of face-specific processes, Tanaka and Curran (2001) recently found that a similar negative potential is produced when bird and dog experts identify objects in their domain of expertise relative to when they identify objects outside their domain of expertise. Thus, the enhanced negative deflection may reflect a process that is involved in expert recognition for specialized expertise, such as dog judging or birdwatching, or for the more general purpose of face recognition.

In conclusion, the current results challenge a purely structural approach to entry point recognition. Although Rosch et al. (1976) and others (Murphy & Smith, 1982) correctly argued that a structurally defined basic level is frequently the level at which objects are first recognized, there are situations in which recognition can occur at the levels subordinate to the basic level. Bird experts need to identify birds at the species level (e.g., sparrow) and subspecies level (e.g., white crown sparrow), whereas people need to identify faces as individuals at the level of unique identity (e.g., "Sam," "Judy"). The current study with everyday face experts and previous studies with real-world object experts (Johnson & Mervis, 1997; Tanaka & Taylor, 1991) and laboratory-trained experts (Gauthier & Tarr, 1997) demonstrate that task demands can precipitate a downward shift in recognition. Hence, structural and behavioral definitions of the basic-level category are dissociable to the extent that the level at which objects bear a similar shape (i.e., the structurally defined basic level) need not be the level at which objects are first recognized (i.e., the behaviorally defined basic level). Perhaps a more parsimonious interpretation of the basic level is that structural constraints predispose the recognition system toward a certain level of abstraction but that this level can be modified by experience and ecological demands.

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