Psychonomic Bulletin & Review
2002, 9 (2), 327-334

Recognizing the un-real McCoy: Priming and the modularity of face recognition

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Fodor (1983) has proposed that face perception is carried out by an informationally encapsulated module, whose operation is unaffected by context or expectancies. We tested the modularity hypothesis by examining whether discriminations between normal and distorted versions of famous faces can be primed, either by the name of an associated person (semantic context) or by a valid cue as to the identity of the target face (expectancy). A preliminary experiment showed that, in the absence of priming, discriminations between normal and distorted versions of a face were unaffected by whether the target faces were familiar or not, confirming that these judgments tap perceptual, not postperceptual (semantic), coding processes. In Experiment 1, accuracy was significantly higher when target face pairs were preceded by related name primes, as compared with unrelated ones. In Experiment 2, reaction times were significantly faster for targets preceded by a valid identity cue than for targets preceded by an invalid one. Neither effect could be explained as a speed–accuracy tradeoff. These results fail to support Fodor's conjecture that face processing is encapsulated.

How might our knowledge, expectations, and beliefs about the world influence the way we perceive it? Fodor (1983, 1990) has argued that perceptual analysis is characterized by an insensitivity to one's beliefs, background knowledge, expectancies, and goals and that this *informational encapsulation* is a core feature of perceptual analysis. According to his modularity theory, perceptual analysis is carried out by a set of encapsulated, special-purpose processors, or *modules*, whose operation is unaffected by information external to the module. These modules deliver perceptual representations to a central system, which evaluates them in the light of other information to arrive at beliefs about the world. In addition to the core feature of encapsulation, modules are characterized by domain specificity, fast and mandatory operation, neural hardwiring, characteristic patterns of breakdown and development (associated with innate programming), production of shallow (not semantically interpreted) outputs, and opaqueness (inaccessibility of representations computed inside the module to central processing).

Fodor (1983, p. 47) proposed face recognition as a likely candidate for a module. This conjecture gains support from evidence that faces are recognized by a fast, mandatory (Young, Ellis, Flude, McWeeny, & Hay, 1986), and domain-specific system that uses specialized neural structures, exhibits characteristic patterns of breakdown (de Haan, Young, & Newcombe, 1987; de Renzi, 1986; Farah, Levinson, & Klein, 1995; Farah, Wilson, Drain, & Tanaka, 1995; Feinberg, Schindler, Ochoa, Kwan, & Farah, 1994; McNeil & Warrington, 1993; Moscovitch, Winocur, & Behrmann, 1997), and has some innate programming (Goren, Sarty, & Wu, 1975; Valenza, Simion, Cassia, & Umiltà, 1996).

What is less clear is whether face recognition is informationally encapsulated. The aim of this paper is to test the encapsulation claim for faces. In order to do so, we must specify the output of the putative face recognition module. We take the output to be the activation of a structural description of a face.[1] This suggestion is consistent with the notion that modules produce shallow (i.e., semantically uninterpreted) outputs. For ease of exposition, we will refer to within-module processing as perceptual and to postmodular processing as postperceptual or semantic.

If face recognition is encapsulated, the activation of structural descriptions of individual faces should not be influenced by goals, beliefs, background knowledge, or expectations. Evidence of such priming effects would, therefore, falsify the encapsulation claim, provided that two conditions are met: First, the *source* of the priming information must be outside the module, and second, the *locus* of the priming effect must be inside the module—that is, it must be perceptual (for further discussion, see Rhodes & Tremewan, 1993).

An early priming study by Bruce and Valentine (1986) found that familiarity judgments for target faces were facilitated when the target face was preceded by a prime face of an associated individual. However, this study does not satisfy the source criterion, because the primes and the targets are both processed by the putative face module. The

Part of this work was reported in an honors thesis submitted to the University of Western Australia by the first author. We thank Linda Jeffery for assistance with stimulus construction, Alison Clark and Jo Roberts for assistance with data collection, Graham Byatt for assistance with data analysis, and Jim Neely for helpful discussions about the study. Correspondence concerning this article should be addressed to G. Rhodes, Department of Psychology, University of Western Australia, Nedlands, Perth, WA 6907, Australia (e-mail: gill@psy.uwa.edu.au).

source of the priming could, therefore, result from spreading activation between associated representations of faces stored within the face module.

Rhodes and Tremewan (1993) used names (of semantically related or unrelated individuals) to prime familiarity (fame) judgments about faces, a procedure that satisfies the source condition, because names are not processed by the face module. Using this cross-module priming procedure, Rhodes and Tremewan found greater sensitivity (A') and faster reaction times (RTs) for target faces following related than following unrelated name primes and proposed that face recognition may not be encapsulated.

This interpretation, however, requires that the locus criterion is satisfied. The primed discrimination must be perceptually based, not based on postperceptual or semantic information. Rhodes and Tremewan (1993) argued that the locus in their study was likely to be perceptual because familiarity judgments depend on computations carried out within the face module (Bruce & Young, 1986), because the perceptual demands of the task were emphasized (thus reducing the contribution of postperceptual processing to the responses), and because the priming effects interacted with perceptual factors of distinctiveness and visibility (thus implicating a perceptual locus for the priming effects, according to Sternberg's, 1969, admittedly controversial additive factors logic).

There are, however, reasons to doubt that the locus criterion has been satisfied in Rhodes and Tremewan's (1993) study. First, a revision of Bruce and Young's (1986) model of face recognition locates familiarity judgments at the postperceptual level of person identity nodes (PINs; Burton, Bruce, & Johnston, 1990).[2] These nodes can be activated by inputs from a variety of modalities (e.g., a face or a name) and are associated with semantic information about individuals. Given that familiar faces activate more semantic information than do unfamiliar faces, it is plausible that familiarity judgments might be based on the amount of semantic information activated by a target face, as is suggested in the updated model. In this case, familiarity judgments would be postperceptual, and evidence of priming by related names would not challenge the encapsulation of face recognition.

Second, brain-imaging results also indicate that familiarity judgments are postperceptual, in the sense that they are not modality specific. A recent event-related potential (ERP) study showed identical scalp topography for the (cross-module) priming component of ERPs to both name and face targets (Schweinberger, 1996). Given that the scalp topography differed for the perceptual processing of faces and names (indicating spatial sensitivity of the ERPs), identical topography for the priming of names and faces suggests that the priming effects occur at a common, nonmodality-specific, postperceptual locus. Furthermore, priming affected a relatively late component of the ERPs, which also points to a postperceptual locus.

The present study was designed to test the hypothesis that face recognition is encapsulated, by examining priming effects on a more clearly perceptual discrimination. Instead of asking participants to determine whether target faces were familiar, we asked them to discriminate between (simultaneously presented) normal and abnormal versions of famous faces by indicating the strange version. The abnormal versions were created by distorting the spatial relations between features, so that they were clearly outside the normal range of variation found in faces but still conformed to the basic first-order face configuration of eyes above nose above mouth (Diamond & Carey, 1986).[3] We thought that strangeness discriminations were unlikely to be mediated by postrecognition semantic cues (identity-specific information associated with a face, such as its age, occupation, name, etc.), because they could be made simply by noting the presence of abnormal spatial relations in one of the faces. This could be done either explicitly, by comparing the faces with a prototype (cf. Rhodes, Brennan, & Carey, 1987), or implicitly, using perceptual fluency as a cue. We could not, however, completely rule out the possibility that the discriminations are based on semantic cues. For example, participants might recognize the normal famous face and then respond that the other version is "strange." Alternatively, semantic information might be more fully or rapidly activated by normal than by abnormal versions of familiar faces, thus providing a subtle semantic cue for the discrimination.

We began, therefore, with a preliminary experiment in order to confirm that the strangeness judgments were indeed based on perceptual, rather than semantic, cues. We reasoned that if semantic cues were being used, responses should be faster and more accurate for strangeness discriminations of familiar face pairs than for those of unfamiliar face pairs. Only familiar faces can be recognized, so the recognition strategy described above would be useful only for discriminations of familiar face pairs. The subtler strategy, based on differences in the amount of semantic information activated by the two versions in each pair, would also give an advantage to the familiar pairs. For familiar faces, the normal versions would trigger associated semantic information more readily than would the abnormal versions, resulting in a semantic cue for discriminating the normal and abnormal versions. In contrast, there would be little difference in amount of semantic activation triggered by normal and abnormal versions of unfamiliar faces, because neither would activate much semantic information and so the difference in semantic information activated by the two would provide a poor cue for the discrimination. If, however, the discrimination is based on a (prerecognition) perceptual cue, such as abnormal spatial relations, performance should be unaffected by the familiarity of the faces used.

In the preliminary experiment, 32 participants were asked to discriminate between normal and abnormal versions of 24 famous faces and 24 unfamiliar faces. The procedure was identical to that of Experiment 1 (see below), except that name primes were not shown and face familiarity replaced prime type as a factor. We simply asked the participants to tell us which face in each pair looked strange. Responses to famous and unfamiliar faces did not differ significantly in either speed ($F < 1$; famous faces, M = 689 msec, SD = 31 msec; unfamiliar faces, M = 700 msec, SD = 33 msec) or accuracy [$F(1,31) = 2.24$, n.s.; famous faces, M = 80.7, SD = 0.9; unfamiliar faces, M = 82.3, SD = 1.1]. Although it is conceivable that this study failed to detect a real effect, this seems unlikely, given that accuracy was poorer for familiar than for unfamiliar faces, with only an 11-msec speed advantage. Therefore, we will take these results as evidence that strangeness discriminations are based on perceptual rather than semantic cues and that priming effects on these discriminations occur at a perceptual locus.

In Experiment 1, we examined the effect of semantic context on these judgments. Each face pair was preceded by the name of a person who was either semantically related or semantically unrelated to the target faces. In Experiment 2, we examined the effect of a valid cue to the identity of the target person. Each face pair was preceded either by the name of that person in capital letters (a valid identity cue) or by the name of another person in lowercase letters (an invalid identity cue). The participants were explicitly told that names shown in capital letters would be followed by two images of that person and that names shown in lowercase would be followed by two images of a random person. In both cases, the primes were names, and the targets were faces, so that the primes and the targets were processed by different modules. Any priming effects would, therefore, indicate a failure of encapsulation. In both experiments, the target pairs were presented briefly (250 msec) and were masked, to avoid ceiling effects and enable accuracy, as well as RTs, to be used as a dependent measure. A two-alternative forced-choice task was used to provide an accuracy score (percentage correct) independent of response bias effects (Rhodes & Tremewan, 1993).

EXPERIMENT 1

Method

Participants. Thirty-two adult volunteers (23 females, 9 males) participated in the discrimination task. Of these, 7 were replacements for participants who recognized fewer than half (12/24) of the name–face pairs ($n = 3$) or performed near chance (< 60%; chance = 50%; $n = 4$). Twenty additional adult volunteers participated in a stimulus selection task that we used to select well-known faces and strongly associated name–face pairs for use in the discrimination task.

Materials. Twenty-four related famous name–face pairs were used in the discrimination task. These faces were selected from 64 famous faces used in the stimulus selection task. Each was identified by at least 85% of the stimulus selection participants, and all related prime names elicited the name of the target face in at least 65% of these participants (when asked to list names of individuals associated with the prime names). The full set of names and faces is given in Appendix A. Unrelated name–face pairs were created by randomly re-pairing prime names with (unrelated) target faces. Three additional name–face pairs were used for practice trials.

The photographs of famous faces were drawn from various printed media sources. Two abnormal versions of each face were constructed by altering the spatial relations between facial components, following Searcy and Bartlett (1996, Experiment 1). The spatial distortions were constructed in Adobe Photoshop by either moving the eyes and mouth away from the nose (labeled *expanded*), or moving these features closer to the nose (*compressed*; see Figure 1). The eyes were moved 10 pixels, and the mouth was moved 5 pixels. Each face measured approximately 5 × 7 cm. The stimuli were presented in black and white on a 17-in. Hitachi monitor (screen size, 832 × 624 pixels), at a viewing distance of approximately 70 cm. Presentation was controlled using Superlab (Cedrus Corp.) on a Power Macintosh 7200/120. Each normal face version was paired with an abnormal face version, forming a target pair. A mask was created out of jumbled pieces of faces.

Procedure. Each trial started with a fixation cross (750 msec), followed by a name prime (250 msec), a blank field (250 msec), the target face pair (250 msec), and a mask that remained on the screen until a response was made. The participants initiated each trial by pressing the space bar and had to indicate as quickly and accurately as possible which face in each target pair looked strange (left or right) by pressing keys labeled "left" or "right." They were also instructed to "attend to each name preceding the faces as this may help you to make a decision concerning the faces." Either a related or unrelated name prime was presented before each face pair.

Each of the 24 famous face pairs was shown once with each type of prime (related or unrelated), once with each location of the strange target (left or right), and once with each type of target (expanded or compressed), resulting in 192 experimental trials. The assignment of faces to these eight experimental conditions (prime type × target location × target type) was counterbalanced across blocks, with each face appearing once in each of eight blocks and equal numbers of each experimental condition in each block. Presentation of all the stimuli was randomized within blocks, with a different random order for each participant. Eight practice trials, one for each experimental condition, preceded the main experiment. At the end of the session, the participants completed recognition checklists for the names and faces presented in the experiment. Data were included only for trials in which the participants recognized both the name prime and the face target (M = 82.7, SD = 1.6). The participants were tested individually.

Results and Discussion

The dependent measures were percentage correct and mean RTs for correct responses. RTs greater than two standard deviations above each cell mean were excluded (M = 4.6 excluded per participant, SD = 4.4). Two-way analyses of variance (ANOVAs), with prime type and block as repeated measures factors, were carried out on each dependent measure. Means and standard errors for accuracy and RT measures are shown in Table 1.

Contrary to the encapsulation claim, accuracy was significantly greater for faces preceded by related name primes than for those preceded by unrelated name primes [$F(1,31) = 4.82$, $p < .05$]. Not surprisingly, accuracy increased over blocks [$F(7,31) = 3.55$, $p < .002$], but there was no interaction between prime type and block [$F(7,217) = 1.62$, n.s.]. There was no evidence of a speed–accuracy tradeoff, with no effect of prime type on RTs ($F < 1$). There was a significant main effect of block [$F(7,31) = 28.33$, $p < .001$], with RTs decreasing across blocks, as was expected, with practice. Block interacted with prime type [$F(7,217) = 2.35$, $p < .05$], with a slightly larger and more variable decrease in RTs for related than for unrelated trials.

We also examined the effect of prime type, with faces as the random factor, to determine whether priming gen-

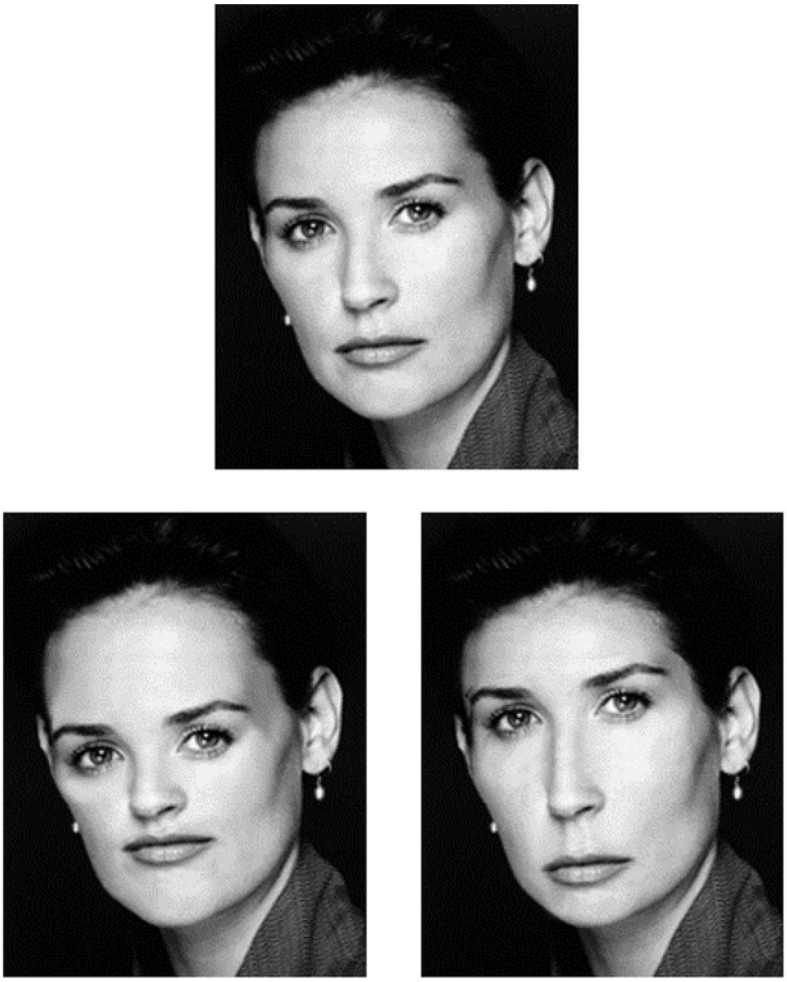

Figure 1. Normal (top), compressed (bottom left), and expanded (bottom right) versions of a famous face. Compressed versions were created by moving the eyes and mouth closer to the nose, and expanded versions were created by moving the eyes and mouth away from the nose. Both the compressed and the expanded versions were designed to be obviously distorted.

eralized across faces.[4] The priming effect was marginally significant [$F(1,23) = 2.44, p < .07$, on a one-tailed test]. The marginal result may be due to our items analysis having lower power than the analysis with participants as the random factor, because there were fewer faces than participants. Alternatively, priming may indeed be restricted to some faces, but we note that this would still violate the encapsulation claim.

EXPERIMENT 2

In Experiment 2, we examined whether a valid cue to the identity of the target images would enhance judgments about which version looked strange. Each pair of images was preceded by either a valid or an invalid cue to the identity of the person depicted. The participants were told at the outset that names printed in capital letters (valid identity cues) would be followed by two images of that face but that names in lowercase letters (invalid identity cues) did not predict who would be shown. As in Experiment 1, the participants had to decide which of the two images looked strange. We increased the number of faces to match the number of participants, so that analyses with items as the random factor would have the same power as analyses with participants as the random factor. Otherwise, the procedure was the same as that in Experiment 1.

Method

Participants. Thirty-two young adults (11 males, 21 females) participated in the main experiment in return for course credit or $5. One replaced a participant who knew fewer than 60% of the names and faces. Two were dropped from the analysis because they got less than 60% correct on the strangeness discrimination task. Twenty additional volunteers (14 female, 6 male) participated in a stimulus selection task that allowed us to select 32 well-known faces from a pool of 63 faces.

Table 1
Accuracy (Percentage Correct) and Mean Reaction Times (RTs) for Related and Unrelated Primes as a Function of Block in Experiment 1 (With Standard Errors)

	Accuracy						Mean RT (msec)					
	Prime Type						Prime Type					
	Related		Unrelated		Mean		Related		Unrelated		Mean	
Block	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
1	72.0	2.1	69.0	2.5	70.5	1.6	955	75	949	74	952	53
2	77.3	2.6	72.9	3.3	75.1	2.1	780	58	766	65	773	43
3	80.9	2.8	77.9	2.8	79.4	2.0	651	43	707	56	679	35
4	76.6	2.4	79.9	2.2	78.3	1.6	746	73	643	47	694	43
5	80.6	2.5	82.2	2.6	81.4	1.8	579	40	584	41	582	28
6	79.2	2.4	74.7	2.6	76.9	1.8	606	44	571	39	588	29
7	77.5	2.7	78.6	3.3	78.1	2.1	467	24	507	25	487	17
8	84.1	2.3	74.5	2.9	79.3	1.9	487	26	540	30	514	20
Overall	78.5	0.9	76.2	1.0			659	20	658	19		

Materials. Thirty-two famous faces were used in the discrimination task. Seventeen of these were used in Experiment 1, and 15 were new. Each was identified by at least 65% of the stimulus selection participants (cf. 85% in Experiment 1). Three additional practice faces were used in practice trials. The full set of faces is given in Appendix B. Distorted versions of the new faces were constructed in the same way as in Experiment 1. Primes consisted of names, which were printed either in capital letters (valid identity cues) or in lowercase letters (invalid identity cues).

Procedure. The procedure was the same as that for Experiment 1, except that valid and invalid identity cues replaced related and unrelated primes, respectively. Valid primes were followed by a face pair consisting of the normal and distorted versions of the named face. Invalid primes were followed by the normal and distorted versions of a randomly chosen face (with the constraint that it was not identical to or related to the name). At the end of the session, the participants completed recognition checklists for the names and faces used in the experiment, and data were included only from trials in which name primes and face targets were correctly recognized ($M = 96.3$, $SD = 9.1$).

Results and Discussion

The dependent measures were percentages correct and mean RTs for correct responses. RTs greater than two standard deviations above each cell mean were excluded ($M =$ 9.0 excluded per participant, $SD = 3.9$). Two-way ANOVAs, with cue type (valid or invalid) and block as repeated measures factors, were carried out on each dependent measure. Means and standard errors for the accuracy and RT measures are shown in Table 2.

For accuracy, there was no significant main effect of cue type ($F < 1$) or block [$F(7,203) = 1.66$, n.s.; see Table 2]. There was a significant interaction between cue type and block [$F(7,203) = 2.31$, $p < .03$], but an examination of the means for valid and invalid cues indicated that the advantage for one cue type over the other shifted unsystematically across blocks.

For RTs, there was a significant main effect of cue type [$F(1,29) = 18.71$, $p < .0002$], with valid cues producing faster responses than did invalid cues (see Table 2). There was a significant main effect of block [$F(7,203) = 23.96$, $p < .0001$], with RTs decreasing monotonically across blocks (see Table 2). Cue type also interacted with block [$F(7,203) = 2.90$, $p < .007$]. An inspection of Table 2 shows that the advantage for valid cues over invalid cues was found in all but one of the eight blocks.

RTs were substantially faster in this experiment than in Experiment 1. It is not clear why this was so, given that the participants in both experiments were asked to respond as quickly and accurately as possible. Importantly, RTs were faster than in tasks in which identity-specific information must be accessed (e.g., Young, McWeeny, Hay, & Ellis, 1986), supporting our claim that the strangeness discrimination task taps perceptual, rather than postperceptual, semantic information.

GENERAL DISCUSSION

Rhodes and Tremewan (1993) argued that priming effects provide prima facie evidence against encapsulation, provided that two conditions are met. First, the priming must come from outside the module (the source criterion), and second, the priming must affect a perceptual discrimination, not a judgment based on postperceptual/semantic information (the locus criterion). In the present study, we ensured that the source criterion was met by using name primes, which are processed outside the putative face module. We attempted to ensure that the locus criterion was met by using a task (discriminating between strange and normal versions of famous faces) that was designed to tap perceptual information, rather than postperceptual, semantic information about faces.

Our results indicate that strangeness discriminations about faces can be influenced by semantic context and conscious expectancies about the identity of the faces. In Experiment 1, performance was better when the target images were preceded by the names of semantically related individuals, as compared with trials on which the images were preceded by the names of unrelated individuals. In Experiment 2, performance was enhanced when the images were preceded by a valid as cue as to their identity. These results suggest that the perceptual processing of faces may not be encapsulated from information outside the face module.

Table 2
Accuracy (Percentage Correct) and Mean Reaction Times (RTs) for Valid and Invalid Identity Cues as a Function of Block in Experiment 2 (With Standard Errors)

	Accuracy						Mean RT (msec)					
	Cue						Cue					
	Valid		Invalid		Mean		Valid		Invalid		Mean	
Block	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
1	81.9	1.6	77.1	2.3	79.5	1.4	592	47	656	41	624	31
2	81.3	2.2	81.2	2.2	81.2	1.5	438	18	471	23	454	14
3	75.3	2.2	76.4	2.7	75.9	1.7	431	22	450	23	440	16
4	79.6	2.3	78.2	2.2	78.9	1.6	418	23	450	30	434	19
5	82.2	2.1	81.3	2.3	81.8	1.5	378	19	420	25	399	16
6	80.7	2.5	80.7	2.1	80.7	1.6	405	29	377	18	391	17
7	83.4	2.4	77.4	2.4	80.4	1.8	366	24	391	28	378	19
8	74.6	2.6	81.2	2.4	77.9	1.8	383	23	391	26	387	18
Overall	79.9	0.8	79.2	0.8			426	10	451	11		

Our results challenge the encapsulation of the face module only if we can be sure that the strangeness decisions are based on perceptual information within the module. But can we be confident that this is the case? Perhaps strangeness discriminations are mediated by differences in familiarity or in the amount of semantic information (see the introduction) generated by the normal and the distorted images. Both the PINs that code familiarity and the representations that code semantic information lie outside the module, so priming at these levels would not be problematic for encapsulation. Can we rule out such accounts?

Accounts based on differential semantic activity or differential familiarity of the normal and the distorted faces would predict faster (and/or more accurate) strangeness responses for famous than for unfamiliar face pairs, because the difference in semantic activation and familiarity between normal and distorted images is larger for famous than for unfamiliar face pairs. The results of our preliminary experiment, however, showed that strangeness discriminations were not made more quickly or more accurately for familiar face pairs. Furthermore, if strangeness judgments are based on familiarity, familiarity and strangeness judgments should take similar amounts of time, when made under similar conditions. But familiarity judgments made under identical conditions to those used here take over 1,200 msec (Rhodes & Tremewan, 1993, Experiment 3), which is much longer than the RTs reported here for strangeness judgments (Experiment 1, $M = 658–659$ msec; Experiment 2, $M = 426–451$ msec).[5] Similarly, semantic judgments take longer than strangeness judgments (e.g., Young et al., 1986). Both the speed of strangeness judgments and the fact that they are unaffected by target familiarity suggest that they are mediated by perceptual representations available early in processing, and not by postmodule representations coding familiarity or semantic attributes.

Another possibility is that strangeness decisions could be made by comparing the normal and distorted versions of the target face with a mental image of a face generated in response to the name prime and responding "strange" to the poorer match. If the face image is located outside the module, priming need not indicate a failure of encapsulation. This image-matching mechanism offers a plausible account of the results of Experiment 2. When the name prime is a valid cue to the identity of the target, strangeness decisions are facilitated because the face image matches the target. But the image-matching mechanism fails to account for the results of Experiment 1, where strangeness decisions were facilitated by viewing the names of semantically related individuals (e.g., Hillary Clinton) who bore no resemblance to the target faces (e.g., Bill Clinton). It is also unclear whether face images generated in response to name primes really are postmodular representations. Brain imaging indicates that the primary visual cortex is activated during imagery, which suggests that top-down–generated images may activate representations within perceptual modules, which would itself violate encapsulation (for reviews, see Kosslyn, 1995; Pinker, 1997).

We have considered three modular accounts and have found that none can handle all of our priming results. Furthermore, two are inconsistent with evidence that strangeness judgments are made much more quickly than familiarity or semantic judgments. We suggest that Rhodes and Tremewan's (1993) top-down model of cross-domain priming (see their Figure 2) provides a better explanation for the priming effects reported here. In that model, a name prime activates its lexical entry in a language module; activation then feeds forward into the central system, activating the semantic node for that individual and spreading to the semantic nodes of related individuals. Finally, the activation is fed back down into the face-processing module.[6] Interestingly, in this model, activation dissipates as it spreads, so that top-down priming effects should be weaker for low-level (perceptual) than for high-level (semantic) processing. In the present study, the semantic priming effect observed for strangeness judgments (a 2.3 percentage point increase in accuracy) was weaker than the priming effect reported for familiarity judgments (around 6 percentage points) by Rhodes and Tremewan. This difference is consistent with both the top-down model and the claim that strangeness judgments tap lower level processing than do familiarity judgments.

The semantic priming effect observed for strangeness decisions was found only for accuracy (with no speed–accuracy tradeoff), whereas both accuracy and RT effects have been reported for familiarity decisions (Rhodes & Tremewan, 1993). The results of Experiment 2 show that RTs for strangeness decisions certainly can be primed, albeit with identity cues, rather than with semantic primes. It remains to be seen whether these differences between dependent measures, prime types, and tasks are robust. The important point here, however, is that priming of either dependent measure in a strangeness discrimination challenges the encapsulation claim. A complete account of how semantic and identity primes affect strangeness and familiarity discriminations will require studies in which both kinds of priming and both tasks are compared directly. Another question for future studies is whether the priming produced by identity cues in Experiment 2 is an automatic effect or whether conscious expectancies about target identity must be generated for priming to occur.

If encapsulation is taken as the hallmark of modularity, as was proposed by Fodor, our results suggest that face recognition is not modular. However, face recognition clearly possesses many modular features (see the introduction for a brief review), and a modular view of face processing has had enormous heuristic power, generating fruitful research programs in experimental psychology, neuropsychology, and brain imaging. It may not, therefore, be sensible to conclude from our results that face processing is not modular. An alternative would be to adopt Coltheart's (1999) proposal that domain specificity be taken as the core feature of a module and that it is an empirical question what other modular characteristics are exhibited by any particular domain-specific system. On this view, we could conclude that there is a face-processing module but that it is not fully encapsulated.

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NOTES

1. Rhodes and Tremewan (1993) took the output to be the activation of a stored structural description. On this view, however, the module would produce no output for an unfamiliar face. By taking the output to be a structural description of the face input, we allow the module to compute a representation for any face.

2. This change in the locus of familiarity judgments allowed the model to explain differences in the duration of repetition and semantic/associative priming effects on familiarity judgments, with long-lasting repetition priming modeled by strengthening of links between face recognition units (stored structural descriptions of known faces) and their PINs and short-lived semantic priming modeled by a temporary increase in PIN activation.

3. This configuration appears to be sufficient to activate the face module (Moscovitch et al., 1997).

4. Because of the way that faces were assigned to blocks, we could not carry out a two-way ANOVA with block, as well as prime type, as a factor. Given that the effect of block was not of theoretical interest, we limited our analysis to examining the effect of prime type. A one-tailed test was used because related primes enhance performance, as compared with unrelated primes (Rhodes & Tremewan, 1993).

5. Faster RTs have been reported for primed familiarity decisions, but in those cases the faces were presented singly and for long durations (2,500 msec), and even then the RTs were longer than those for our strangeness judgments (*M*s = 779–1,124 msec) unless a very small set of faces was presented repeatedly (*M*s = 599–675 msec; Young, Flude, Hellawell, & Ellis, 1994).

6. Note that Fodor (1993) allows top-down flow of information within a module, but not top-down flow from the central system into the module.

APPENDIX A
Name–Face Pairs Used in Experiment 1

Name Prime	Related Famous Target Face
Olivia Newton-John	John Travolta
Hillary Clinton	Bill Clinton
Hazel Hawke	Bob Hawke
Nicole Kidman	Tom Cruise
Annita Keating	Paul Keating
Priscilla Presley	Elvis Presley
Yoko Ono	John Lennon

APPENDIX A (Continued)

Name Prime	Related Famous Target Face
Camilla Parker Bowles	Prince Charles
Linda McCartney	Paul McCartney
Eileen Bond	Alan Bond
Bruce Willis	Demi Moore
Nancy Reagan	Ronald Reagan
Winnie Mandela	Nelson Mandela
Liz Hurley	Hugh Grant
Sonny Bono	Cher
Tommy Lee	Pamela Anderson
Mia Farrow	Woody Allen
Janet Howard	John Howard
Lyle Lovett	Julia Roberts
Kurt Russell	Goldie Hawn
Jackie Onassis	John F. Kennedy
Lourdes Maria Ciccone	Madonna
Gwyneth Paltrow	Brad Pitt
Ricki Lake	Oprah Winfrey

APPENDIX B
Famous Faces Used in Experiment 2

Famous Target Face
Prince Charles
Bill Clinton
Kylie Minogue
Pamela Anderson
Princess Diana
Oprah Winfrey
Elvis Presley
Cher
Nelson Mandela
Tina Turner
Tom Cruise
Paul McCartney
Leonardo di Caprio
John Travolta
John Howard
Sarah Ferguson
Paul Keating
Paul Reiser
John Lennon
Tom Hanks
Bruce Willis
Ronald Reagan
Goldie Hawn
Lisa Curry-Kenny
Hugh Grant
Mick Jagger
Bob Hawke
Brooke Shields
Rachel Hunter
Whitney Houston
Gillian Anderson
Courtney Love

(Manuscript received September 10, 1998;
revision accepted for publication July 24, 2001.)