

Spatial Attention in Nonconscious Processing

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*Research Article*

The Role of Spatial Attention in Nonconscious Processing

A Comparison of Face and Nonface Stimuli

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**ABSTRACT**—Recent findings from the masked priming paradigm have revealed a surprising influence of higher-level cognitive systems (i.e., attention) on nonconscious cognitive processes. These data have effectively undermined the long-standing assumption in cognitive science that nonconscious processes are carried out independently of attention and have quickly led to the opposite view that attention is a prerequisite for nonconscious processes. Here we present evidence for a middle position by showing that the dependence of nonconscious processes on attention varies with the type of information to be processed. Specifically, we found that nonconsciously perceived faces engaged cognitive processes regardless of attention, whereas nonface stimuli engaged cognitive processes only when attended. These qualitatively different patterns suggest two distinct processing routes: one that is modulated by visual attention and one that is not.

Over the past 20 years, research has convincingly demonstrated that subliminally presented prime stimuli are able to modulate the processing of subsequently presented target stimuli (Dehaene et al., 1998; Finkbeiner & Caramazza, 2008; Forster & Davis, 1984). These subliminal, or nonconscious, priming effects were, until very recently, assumed to index “automatic,” stimulus-driven processes that are carried out independently of attentional resources (Greenwald, 1992; Posner & Snyder, 1975; Schneider & Shiffrin, 1977). It was a great surprise, then, when Naccache, Blandin, and Dehaene (2002) demonstrated that subliminal priming effects depended on attention.

Naccache et al. (2002) had participants categorize target numbers as either greater or less than 5 by pressing one of two buttons. The visible target was preceded by a masked prime that either fell on the same side of 5 as the target (congruent trial) or fell on the opposite side of 5 (incongruent trial). The prime and target stimuli were embedded in streams of achromatic masks (15–25 masks with 71-ms duration) such that participants could not reliably anticipate the onset of the target stimuli. Critically, masked congruence priming (faster response latencies on congruent trials) was obtained only on those trials in which a salient cue (a green square) appeared in the stream of masks just prior to the prime-target pair. This finding has been taken to demonstrate that temporal attention needs to be “focused” appropriately for masked congruence priming to be obtained. Recently, this result has been replicated in an event-related potential paradigm (Keifer & Brendel, 2006), as well as in a study that compared the performance of older and younger adults (Fabre, Lemaire, & Grainger, 2007).

In a closely related paradigm that manipulated transient spatial attention, Lachter, Forster, and Ruthruff (2004) found that only spatially attended primes produced repetition priming in a lexical decision task. This finding was recently replicated by Besner, Risko, and Sklair (2005)

and then extended by Marzouki, Grainger, and Theeuwes (2007), who used a letter-identification task.

Taken together, these findings have convincingly undermined the long-standing assumption that nonconsciously elicited processes are carried out independently of attention. In light of these findings, the classic view, which maintained that nonconscious processes and attention are independent, has been replaced with the polar opposite view—that attention is required for subliminally presented stimuli to engage cognitive processes (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Keifer & Brendel, 2006). In this article, we argue for a third position that contrasts with both the classic, complete-independence view and the newer, complete-dependence view. We present evidence suggesting that the dependence of nonconscious cognitive processes on attention varies with the type of information to be processed.

To date, the demonstration that nonconscious processes depend on attention has been limited to tasks that tap either word- or number-recognition processes. These processes have been acquired only recently in human evolutionary history and, not surprisingly, are carried out in phylogenetically new visual cortical regions (Dehaene et al., 2004; Gaillard et al., 2006). Visual attention is known to modulate neural processes in these areas (Corbetta, Miezin, Dobmeyer, Shulman, & Petersen, 1990; Murray & Wojciulik, 2004; Wojciulik, Kanwisher, & Driver, 1998).

With this in mind, our motivation for the present study was to investigate the role of attention in the nonconscious processing of faces. We chose to use face stimuli because, although it is well established that the processing of faces in visual cortices is modulated by visual attention (cf. Wojciulik et al., 1998), it is also thought that face processing proceeds in part along

an evolutionarily older subcortical route (cf. Johnson, 2005; Vuilleumier, Armony, Driver, & Dolan, 2003). We reasoned that if the subcortical hypothesis is correct, and if the modulatory effects of visual attention are limited to visual cortical processes, then it should be possible to observe evidence of face processing that is independent of visual attention. Our results are consistent with this line of reasoning. Specifically, we found that masked pictures of nonface stimuli produced priming, but, like masked words and numbers, only when attended. Masked pictures of faces, in contrast, produced priming regardless of whether they were spatially attended.

## **EXPERIMENTS 1 AND 2**

In Experiment 1, participants categorized line drawings of animals and tools (Experiment 1a) or photographs of male and female faces (Experiment 1b). In Experiment 2, participants categorized photographs of animals and vegetables (Experiment 2a) or, again, photographs of male and female faces (Experiment 2b).

### **Method**

#### Participants

Twenty different individuals participated in each experiment (total of 80 participants) for course credit or pay. All participants were recruited from the Macquarie University community and had normal or corrected-to-normal vision.

#### Stimuli

In each experiment, five exemplars were drawn from each of two distinct categories and used as targets. Two additional exemplars, one from each category, were used as primes (see Fig. 1 for all stimuli). In Experiment 1a, the stimuli were line drawings selected from the International Picture Naming Project (Szekely et al., 2004); in the remaining experiments we

used photographs. The face pictures were gray-scale and cropped to fit within a standard-sized black oval that excluded hair and the external facial contour; they were obtained from the Karolinska Directed Emotional Faces (KDEF) database (Lundqvist, Flykt, & Öhman, 1998). Faces were equated for luminance by adjusting the brightness setting of each face so that it was within 0.05 standard deviation from the mean luminance of the faces (as per Maxwell & Davidson, 2004). Contrast was equated in a similar manner. The nonface photographs were obtained from Hemera Photo-Objects Collections (Hemera Photo Objects, Gatineau, Quebec, Canada); they were placed in the standard-sized black oval and equated with the average face for luminance and contrast. Each picture subtended 3° of visual angle vertically and 2.5° of visual angle horizontally from a viewing distance of 60 cm. The backward mask was a checkerboard (Experiment 1a) or a scrambled composite of two prime pictures.

### Procedure and Design

Participants were instructed to categorize the target pictures as quickly and as accurately as possible by pressing one of two buttons. For example, in the experiments with face stimuli, participants indicated whether the target face was male or female by pressing an appropriate button. In the remaining experiments, participants indicated whether the target was an animal or a tool (Experiment 1a) or whether it was an animal or a vegetable (Experiment 2a). The basic trial structure was adapted from Lachter et al. (2004, Experiment 5). Stimuli were presented in two locations, one directly above the center of the computer monitor and the other directly below (see Fig. 2). The prime and target stimuli were either from the same category (congruent) or from opposite categories (incongruent), and the spatial cue appeared either in the location of the prime (prime cued) or in the location of the target (target cued). Each of the 10 target pictures appeared in each combination of the four conditions four times, for a total of 160 trials. Stimuli were

presented in a different pseudorandom order for each participant, with the only constraints being that the same target stimulus did not appear on 2 consecutive trials and no more than 4 trials in a row elicited the same category response.

Prime stimuli were always presented in the top location for 50 ms, and target stimuli were always presented in the bottom location for 300 ms. We presented targets briefly and in a fixed position to ensure that participants would direct their attention away from the prime location and toward the target location. Thus, we assume that in the target-cued condition (spatial cue appeared in the location of the target), both voluntarily and involuntarily directed spatial attention were in the location of the target stimulus.<sup>1</sup> By holding the location of voluntarily directed attention constant, this paradigm offers a powerful test of the role of involuntarily captured spatial attention in the processing of masked prime stimuli.

Following the main experiment, participants were informed of the presence of the masked primes in the top row and then asked to complete a forced-choice prime-discrimination task. This task was identical to the categorization task in the experiment proper in every way except that in this case participants had to make two responses: one to the target stimulus and then one to the prime stimulus. Participants were instructed to categorize targets and primes in the same way. To ensure that participants attended to the target stimulus just as they had done in the main experiment, we elicited prime-discrimination responses only on trials with correct first responses. Trials with incorrect first responses were repeated later in the task, so that there would be equal numbers of trials (80) in the prime-cued and target-cued conditions. Including 40 practice trials that preceded the main experiment, and the 160 trials of the prime-discrimination task, the experiment consisted of 360 trials.

## **Results**

Incorrect responses were discarded from the response time (RT) analyses, and outliers were treated by setting them equal to the value 2.5 standard deviations above or below the overall mean for each subject.

### Omnibus Analysis

To examine the overall results of Experiments 1 and 2, we conducted a 2 (task: face vs. nonface)  $\times$  2 (experiment)  $\times$  2 (cue type: prime cued vs. target cued)  $\times$  2 (prime type: congruent vs. incongruent) analysis of variance (ANOVA) over RTs, with task and experiment as between-groups factors. This ANOVA revealed main effects of task,  $F(1, 76) = 37.32$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .33$ ; experiment,  $F(1, 76) = 30.09$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .28$ ; cue type,  $F(1, 76) = 7.35$ ,  $p_{\text{rep}} = .96$ ,  $\eta_p^2 = .09$ ; and prime type,  $F(1, 76) = 29.27$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .28$ . The three-way interaction of task, cue type, and prime type was reliable,  $F(1, 76) = 4.94$ ,  $p_{\text{rep}} = .91$ ,  $\eta_p^2 = .06$ . This interaction indicates that the masked congruence-priming effect was modulated by spatial attention differently in the face and nonface tasks. To look at this result further, we analyzed responses in the face and nonface tasks separately.

### Experiments 1a and 2a: Masked Congruence Priming With Nonface Stimuli

The 2  $\times$  2  $\times$  2 repeated measures ANOVA over RTs, with the factors of experiment, cue type, and prime type, revealed an effect of prime type,  $F(1, 38) = 10.75$ ,  $p_{\text{rep}} = .98$ ,  $\eta_p^2 = .22$ , as well as a reliable interaction between cue type and prime type,  $F(1, 38) = 12.28$ ,  $p_{\text{rep}} = .99$ ,  $\eta_p^2 = .24$ , but no other effects.<sup>2</sup> As is clear in Figure 3, reliable masked congruence priming was obtained in the prime-cued condition,  $F(1, 39) = 25.97$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .40$ , but not in the target-cued condition ( $F < 1$ ).

We conducted the same 2  $\times$  2  $\times$  2 repeated measures ANOVA to examine the error rates. This analysis revealed a main effect of prime type,  $F(1, 38) = 32.29$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .46$ , as well

as a reliable interaction between cue type and prime type,  $F(1, 38) = 9.32$ ,  $p_{\text{rep}} = .97$ ,  $\eta_p^2 = .20$  (see Fig. 3). The follow-up analyses revealed a reliable masked congruence-priming effect in the prime-cued condition,  $F(1, 39) = 33.94$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .47$ , but not in the target-cued condition ( $F < 1$ ).

We calculated  $d'$  in the prime-discrimination task by treating one of the prime pictures as the signal and the other as noise. For each participant, we calculated two mean  $d'$  values, one in the prime-cued condition and one in the target-cued condition. These subject means were then entered into two separate one-sample  $t$  tests. The mean  $d'$  value was 0.22 in the prime-cued condition and 0.23 in the target-cued condition. In neither case did  $d'$  differ from the null mean, which indicates that participants were unable to discriminate the masked primes.

#### Experiments 1b and 2b: Masked Congruence Priming With Face Stimuli

With face stimuli, the 2 (experiment)  $\times$  2 (cue type)  $\times$  2 (prime type) ANOVA over RTs revealed a very different pattern: main effects of cue type,  $F(1, 38) = 12.11$ ,  $p_{\text{rep}} = .97$ ,  $\eta_p^2 = .24$ , and of prime type,  $F(1, 38) = 19.04$ ,  $p_{\text{rep}} = 1.0$ ,  $\eta_p^2 = .33$ , but no interaction between these two factors ( $F < 1$ ; see Fig. 3). The follow-up analyses confirmed an effect of congruence priming in both the prime-cued condition,  $F(1, 39) = 8.50$ ,  $p_{\text{rep}} = .96$ ,  $\eta_p^2 = .18$ , and the target-cued condition,  $F(1, 39) = 10.60$ ,  $p_{\text{rep}} = .98$ ,  $\eta_p^2 = .21$ . The same ANOVA on the error rates did not reveal any reliable main effects or interactions (all  $p$ s  $> .15$ ; see Fig. 3).

To calculate  $d'$ , we treated the female face prime as the signal and the male face prime as noise. In this case, the mean  $d'$  value was  $-0.06$  in the prime-cued condition and  $0.07$  in the target-cued condition. Again,  $d'$  did not differ from the null mean in either case.

#### Distribution Analysis

We followed up our analyses of mean response latencies by constructing cumulative density functions (Bub, Masson, & Lalonde, 2006; Finkbeiner & Caramazza, 2008; Ridderinkhof, 2002). We did this to investigate the possibility that priming effects went undetected in the nonface tasks because responses were too fast. It is clear from the plots in Figure 4, though, that priming was observed throughout the entire distribution for face stimuli and only in the fastest quintiles for nonfaces. Thus, it is unlikely that the priming observed with face stimuli was due to the longer response latencies for those stimuli.

### **EXPERIMENT 3**

The results of Experiments 1 and 2 demonstrate that masked congruence priming with face, but not nonface, stimuli arises independently of spatial attention. We investigated this apparent independence more closely in Experiments 3 and 4.

In Experiment 3, we adopted a spatial cuing paradigm that allowed us to manipulate the stimulus onset asynchrony (SOA) between the spatial cue and the prime stimulus. We did this to see if the magnitude of the masked priming effect would covary with the magnitude of the spatial cuing effect. If the nonconscious processing of faces does not depend on spatial attention, then it should be possible to manipulate the spatial cuing effect independently of the masked congruence-priming effect. Indeed, we found that it was.

#### **Method**

Twenty individuals with normal or corrected-to-normal vision participated for course credit or pay. The prime and target stimuli were the same as those used in the previous face-categorization experiments (see Fig. 1).

The critical difference between this experiment and the previous ones was in the trial structure (see Fig. 5). In this experiment, we included a central fixation point, and the spatial cue

was a yellow box that appeared either above the location of the prime or below the location of the target. We manipulated three factors: SOA (20, 60, and 100 ms), cue type (prime cued, target cued), and prime type (congruent, incongruent). Each of the 10 target pictures appeared in each combination of conditions six times, for a total of 720 trials. The prime-discrimination task following the main experiment consisted of 240 trials (40 trials for each combination of cue type and SOA).

## Results

The 3 (SOA)  $\times$  2 (cue type)  $\times$  2 (prime type) within-subjects ANOVA over RTs revealed main effects of cue type,  $F(1, 19) = 12.37$ ,  $p_{rep} = .98$ ,  $\eta_p^2 = .39$ , and prime type,  $F(1, 19) = 31.37$ ,  $p_{rep} = 1.0$ ,  $\eta_p^2 = .62$ , but no effect of SOA ( $F < 1$ ). Just as in the previous face-categorization experiments, there was no interaction between cue type and prime type ( $F < 1$ ; see Fig. 6). Although the interaction between SOA and cue type was only marginally significant,  $F(2, 38) = 2.71$ ,  $p_{rep} = .85$ ,  $\eta_p^2 = .13$ , it is worth noting that the magnitude of the spatial cuing effect increased with SOA, from 0 ms at the shortest SOA (20 ms), to 9 ms at the next SOA (60 ms), to 17 ms at the longest SOA (100 ms). Despite this, the magnitude of the masked congruence-priming effect did not vary across the three SOAs. No other interactions approached significance (all  $F_s < 1$ ).

We conducted the same 3  $\times$  2  $\times$  2 ANOVA to examine the error rates. This analysis revealed no main effects and no interactions (all  $p_s > .15$ ; see Fig. 6).

To calculate  $\underline{d}'$ , we treated the female face prime as the signal. We analyzed the  $\underline{d}'$  data in three different ways. First, the mean  $\underline{d}'$  values were entered into a 3 (SOA)  $\times$  2 (cue type) repeated measures ANOVA to determine if there were any effects of SOA or cue type on the prime-discrimination measure. There were not (all  $F_s < 1$ ). Second, we calculated an overall  $\underline{d}'$

value for each participant across the six conditions and entered these values into a one-sample  $t$  test. The grand average was 0.05 and did not differ from the null mean,  $t(19) = 0.99$ ,  $p > .3$ .

Third, for each of the six conditions in the  $3 \times 2$  factorial design, we conducted a separate one-sample  $t$  test over participants'  $d'$  scores. None of these  $t$  tests reached significance (all  $ps > .1$ ).

## EXPERIMENT 4

Given the effectiveness of our manipulation of spatial attention with nonface stimuli, it is tempting to conclude that the masked priming effects observed with face stimuli were independent of spatial attention. But the possibility still remains that, although our manipulation of spatial attention was sufficiently strong to prevent processing of nonfaces in the target-cued condition, it may not have been sufficiently strong to prevent the face primes from capturing spatial attention. In that case, the face primes would have been attended not only in the prime-cued condition, but also in the target-cued condition, and this would explain why priming was observed in both conditions. We addressed this concern in Experiment 4 by contrasting the effect of masked face and nonface primes on participants' performance in an attentionally demanding line-orientation task. To anticipate our results once again, we found a robust effect of spatial cuing, but we found no evidence that the masked face primes captured spatial attention more than the masked nonface primes.

### Method

Twelve individuals with normal or corrected-to-normal vision participated for course credit. The trial structure was identical to that of Experiment 3 (see Fig. 5). In this case, though, we used only the 100-ms SOA, and we replaced the target stimuli with line gratings that were tilted  $2^\circ$  to the left or right (see Fig. 1). In the spatial cuing condition, the cuing procedure was identical to that of Experiment 3. On the 200 trials in this condition, the prime stimulus was a

scrambled composite of the face and nonface primes used in the previous experiments. On the remaining 200 trials, the face and nonface primes from Experiment 2 were presented (see Fig. 1), but with no spatial cue. The backward mask from the previous male/female categorization experiments was used on all trials. Trials from the two conditions were interleaved and presented in a different random order for each participant; participants were told to indicate the orientation of the line gratings as quickly and as accurately as possible by pressing one of two buttons.

We reasoned that if masked face primes capture spatial attention more than masked nonface primes, then the face primes should produce a cost (relative to the nonface prime), just as the spatial cue produces a cost when it appears in the location of the prime (relative to the location of the target). We found no such difference between the face and nonface primes.

## **Results**

When the spatial cue was presented, 11 of the 12 participants were slower to indicate the target's orientation when the cue appeared in the location of the prime ( $M = 636$  ms) than when it appeared in the location of the target ( $M = 623$  ms),  $t(11) = 3.16$ ,  $p < .01$ . In contrast, participants' RTs were identical in the context of masked faces ( $M = 638$  ms) and masked nonfaces ( $M = 638$  ms). This finding indicates that masked face primes did not capture spatial attention any more than did masked nonface primes.

As in the experiments with face targets, the analysis of the accuracy rates ( $M = 86\%$ ) did not reveal any differences between conditions (all  $ps > .5$ ).

## **GENERAL DISCUSSION**

We have reported two major findings that provide a significant step forward in understanding the relationship between nonconscious processing and attention. First, we found that nonconscious processing of nonface stimuli depends critically on spatial attention. These

results replicate and extend earlier findings that have been reported for nonface stimuli, including numbers (Naccache et al., 2002), letters (Marzouki et al., 2007), and words (Lachter et al., 2004). Second, and more crucially, we found that masked priming effects with face stimuli do not depend on spatial attention.<sup>3</sup>

Our finding that face stimuli in unattended locations can be processed is consistent with earlier findings from different paradigms. For example, it has been observed that patients with visual neglect and extinction are much better at detecting faces than nonfaces in their neglected visual field (Vuilleumier, 2000). Similarly, it has been found that normal participants who are engaged in an attentionally demanding task at fixation are able to discriminate faces, but not nonfaces, that are presented very briefly in the periphery (Reddy, Wilken, & Koch, 2004). A critical difference between these earlier studies and our own, though, is that in the previous studies, participants were asked to report or discriminate the stimulus that appeared in the supposedly unattended location. Under these task conditions, it is likely that participants attended, if only minimally, to the location in which the critical stimuli appeared. In contrast, the location of the prime stimuli was never task relevant in the experiments reported here. Hence, we suggest that our finding of priming with unattended faces in the present study is the first and most convincing demonstration that nonconscious cognitive processes may proceed without attention.

Why did face and nonface stimuli yield qualitatively different patterns of results in this study? We tentatively suggest that although both object- and face-recognition processes proceed via a cortical visual route that is subject to modulation by visual attention, nonconscious sex-discrimination processes are carried out along a subcortical route that escapes modulation by visual attention (Johnson, 2005; Vuilleumier et al., 2003). Consistent with this possibility are the

findings that the subcortical face-processing route receives visual input via magnocellular channels, which carry low-spatial-frequency information (Johnson, 2005; Vuilleumier et al., 2003), and that individuals preferentially make use of low-spatial-frequency visual information in sex-discrimination tasks (Deruelle & Fagot, 2005; Goffaux, Jemel, Jacques, Rossion, & Schyns, 2003; Schyns, Bonnar, & Gosselin, 2002). Moreover, it has recently been reported that subliminally presented stimuli in the periphery do not produce retinotopic V1 responses when visual attention is engaged centrally (Bahrami, Lavie, & Rees, 2007). Thus, it appears that if subliminally presented stimuli in unattended locations are to engage cognitive processes, they must do so via a processing route that circumvents V1. We suggest that the subcortical face route (Johnson, 2005; Vuilleumier et al., 2003) may be one such route.

## **CONCLUSION**

Several different research groups have now reported the essential role of spatiotemporal attention in the processing of subliminally presented stimuli. These findings have been striking because they have undermined the long-standing assumption that nonconscious processes are elicited independently of attention (Greenwald, 1992; Posner & Snyder, 1975; Schneider & Shiffrin, 1977). But evidence against the simple view of independence between attention and nonconscious cognitive processes does not necessarily compel the opposite and equally simple view that nonconscious processes are completely dependent on attention. The present study reveals a more subtle relationship whereby the dependence of nonconscious processes on attention varies with the type of information to be processed. Specifically, subliminally presented faces engaged cognitive processes both when attended and when unattended, whereas subliminally presented nonfaces engaged cognitive processes only when attended.

**Acknowledgments**—We would like to thank Anina Rich, Mark Williams, Max Coltheart, and other members of the Macquarie Centre for Cognitive Science for their comments and suggestions. We thank Dustin Deunert and Nadine Heyworth for their help in testing subjects. This work was supported in part by an Australian Research Fellowship from the Australian Research Council to M.F. and by a Macquarie University Research Fellowship to R.P.

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<sup>1</sup>Note that as far as the participants were aware, nothing in the top location was relevant to the task. Thus, we also presume that “task-based” attention (Reddy, Moradi, & Koch, 2007) was focused on the target location.

<sup>2</sup>Because the experiment factor did not interact with any of the other factors, we report only the results collapsed across this factor. It is worth mentioning, though, that analyses of the individual experiments yielded an identical pattern of reliable effects.

<sup>3</sup>Note that we are not implying that attention has no effect on face-recognition processes. Our findings simply suggest that spatial attention is not a prerequisite for nonconscious sex-discrimination processes.

**Fig. 1.** Target, prime, and mask stimuli used in Experiments 1 through 4. The same male and female faces were used in all of the sex-discrimination experiments (Experiments 1b, 2b, and 3). Line drawings of animals and tools were used in Experiment 1a, and photographs of animals and vegetables were used in Experiment 2a. In Experiment 4, the target stimuli were two line gratings tilted to the left or right. In that experiment, a scrambled composite was used in place of the prime stimulus on half of the trials; on the remaining trials, the photographs depicted here appeared equally often as primes. The backward masks were scrambled composites of the prime stimuli used in a given experiment, except in Experiment 1a, in which the backward mask was a checkerboard pattern.

**Fig. 2.** Depiction of two congruent trials from Experiments 1 and 2. Each trial consisted of a stream of stimuli in the top and bottom positions on a computer screen. Prime stimuli were always presented in the top location, and target stimuli were always presented in the bottom location; other stimuli consisted of forward masks (checkerboard pattern), a spatial cue (a black circle), and a backward mask (scrambled composite of the prime stimuli); the durations of the stimuli are indicated and were the same for items in the top and bottom positions. The trial shown at the top depicts the prime-cued condition; the trial shown at the bottom depicts the target-cued condition. Note that the only difference between these conditions was whether the cue was in the prime or target location. On congruent trials, the prime and target stimuli were drawn from the same category. On incongruent trials, the prime and target stimuli were drawn from opposite categories.

**Fig. 3.** Mean response latencies and error rates in Experiments 1 and 2 as a function of type of target (face or nonface), prime type (congruent or incongruent) and cue type (prime or target cued).

**Fig. 4.** Cumulative density functions for prime-cued trials (top panel) and target-cued trials (bottom panel) in Experiments 1 and 2. Each graph shows results separately for the four combinations of prime type (congruent or incongruent) and target type (face or nonface).

**Fig. 5.** Depiction of a congruent, target-cued trial in Experiment 3. The spatial cue (a bright yellow rectangle, shown here in black) appeared simultaneously with the forward mask for 20, 60, or 100 ms and then remained on the screen during the presentation of the prime stimulus. The cue appeared below the bottom stimulus in the target-cued condition and above the top stimulus in the prime-cued condition. The prime (and forward mask) were presented for 50 ms, and the target (and backward mask) for 300 ms.

**Fig. 6.** Mean response latencies and error rates in Experiment 3 (male/female categorization) as a function of stimulus onset asynchrony, prime type (congruent or incongruent), and cue type (prime or target cued).