Chapter 3

Face Identification in the Near-Absence of Attention

3.1 Introduction

The processing of naturalistic stimuli has recently come under a fair amount of attention (Li, VanRullen et al., 2002; Rousselet, Fabre-Thorpe et al., 2002; Braun, 2003; Kayser, Kording, & Konig, 2004). In particular, Li and colleagues showed that the visual system can categorize natural scenes more efficiently than artificial geometric shapes (e.g. a red-green bisected disk from its mirror image) (Li, VanRullen et al., 2002). They therefore concluded that the attentional demands of a task are not determined by the complexity of the stimuli used, but by their nature—natural scenes versus artificial stimuli.

As we discussed in Chapter 2, we previously asked what the limits of this type of pre-attentive processing of natural stimuli might be. We were interested in determining whether attention would become necessary if the natural targets and distractors were made more similar to each other, in a more constrained stimulus space. Indeed, in contrast to the bisected disk task, where the stimulus space was restricted and the targets and distractors differed from each other along well-defined feature dimensions, in the study by Li et al. the set of images were very diverse, and both the target and distracter ensembles probably populated a high dimensional space. Thus it remained possible that natural scene processing in the near-absence of attention would break down for more constrained stimulus spaces (and thus presumably more complex discriminations).

To address this issue, we had used a face-gender discrimination task (Reddy, Wilken et al., 2004). The feature dimensions involved in this discrimination are well characterized: eye brows, eyes, jaws, noses, and mouths, in order of decreasing relevance (Brown & Perrett, 1993; Bruce, Burton et al., 1993; Yamaguchi, Hirukawa, & Kanazawa, 1995). Additionally, male and female faces share many common features, in particular their global structure, which makes the input space more constrained than other natural scene categorization tasks. Remarkably, our results demonstrated that subjects could still identify the gender of a face even when spatial attention was not fully available. Furthermore, this effect was not due to low-level feature discrimination since the male and female faces in our database were well-matched for low-level features. Additionally, we also observed an inversion effect (Yin, 1969; Valentine, 1988; Valentine & Bruce, 1988; Brown, Huey et al., 1997), which confirms that the result depends on holistic properties of faces.

Unfortunately, these results also constituted a failure in the sense that we did not succeed in finding the limit of pre-attentive natural scene processing. Instead it appears that for such pre-attentive processing to break down, even more subtle discriminations will be necessary.

In the present study we thus probe the attentional requirements of face identification. Several lines of evidence indicate that identifying a particular face is a finer and more complex discrimination task than telling male and female faces apart. For instance, current models of face recognition posit that, although gender discrimination and face recognition could proceed in distinct modules (Bruce & Young, 1986) (see however (Haxby, Hoffman, & Gobbini, 2000)), gender discrimination occurs prior to face recognition (Ellis, 1986). Psychophysical data lends credence to this hypothesis since it has been demonstrated that gender categorization is performed faster than face recognition (Sergent, 1986; Bruyer, Galvez, & Prairial, 1993). Accordingly, it has been shown that the two systems interact with each other (Rossion, 2002) and that determining the gender of a face can influence its subsequent recognition (Baudouin & Tiberghien, 2002). Additionally, face identification generally exploits higher spatial frequency information than gender discrimination. Consequently, while global descriptors appear to be sufficient for gender processing, face identification might instead be based on the finer details of a face (Sergent, 1986). Indeed, the relevant features for discriminating two female faces (for example) are necessarily more specific than those needed to categorize female and male faces (e.g. (Campbell, Benson, Wallace, Doesbergh, & Coleman, 1999).

Thus while face gender discrimination failed to achieve sufficient complexity, face identification might constitute a better candidate to probe the limits of pre-attentive processing of natural stimuli.

3.2 Methods

3.2.1 Participants

Five subjects (including the author) were tested in Experiment 1. Four of these subjects and two new subjects were tested in Experiment 2. Four subjects from Experiment 2 were tested in Experiments 3–5. All participants were undergraduate and graduate students at the California Institute of Technology. They were paid $13.50 per hour for participation in the experiment and gave informed consent. All subjects reported that they had normal or corrected-to-normal visual acuity. For the experiments, subjects were seated approximately 120 cm in front of a Macintosh G4 computer.

3.2.2 Face database

The face database used in Experiment 1 was provided by Lavanya Reddy and consisted of pictures of male and female Hollywood celebrities obtained from the web. These were usually high resolution, color shots of the faces of actors and actresses in “natural” settings. Six female and 5 male celebrities were the target individuals, and there were 24 views of each of these targets. Several views of 43 different celebrities (150 images in total), obtained under comparable conditions, were the distracter images.

For Experiments 2–4, the face database was obtained from the Max-Planck Institute in Tübingen, Germany, (http://faces.kyb.tuebingen.mpg.de) and contained seven color views of 100 male and 100 female individuals, unknown to our subjects. For these experiments five viewpoints were used (frontal view, and left and right profiles at 30˚ and 45˚). For all experiments, individuals were chosen randomly to be the targets and distractors.

3.2.3 Training

All of our subjects had previously been trained in the dual-task paradigm prior to participating in this set of experiments. However, none of them had been trained on the face-identification task. Instead, three of our subjects had been trained on the animal versus non-animal discrimination task (Li, VanRullen et al., 2002), while the rest had been trained on the face-gender discrimination task described in Chapter 2 (Reddy, Wilken et al., 2004). Details of the training procedures used in these two paradigms are similar and are described in Chapter 2 and the corresponding papers.

3.2.4 Experiment 1: face identification with famous faces

The dual-task paradigm was used to test the effects of attentional manipulation on face identification performance. The experiment consisted of two separate tasks: an attentionally demanding central letter discrimination task and a peripheral face identification task. Subjects performed these tasks in three conditions: blocks of the letter discrimination task or face identification tasks alone, or blocks of both tasks together in the dual-task condition. Each block consisted of 48 trials, with 24 target trials, and 24 distracter trials. An auditory tone was provided as feedback on incorrect trials. A typical trial is shown in Figure 3.1.

Central letter discrimination task

The letter discrimination task has been described in detail in Chapter 2. The average presentation time for the letter stimuli for this experiment was 197.0 ± 14.3 ms.

Peripheral face identification task

A face subtending approximately 2.5˚ of visual angle was presented at a random location on the edge of an imaginary rectangle subtending 8˚ x 10˚ of visual angle. The faces were backward-masked by a pattern mask composed of scrambled faces. The face-mask always appeared before the letter-masks. The average presentation time of the faces was 167.8 ± 14.4 ms.

In Experiment 1, the faces presented to subjects were of Hollywood celebrities. Before each block of this task, subjects were given the name of one of the set of target individuals. All 11 target celebrities were known to all subjects. On 24 of the 48 trials in the block, different images of this target celebrity were presented to the subject, while on the other 24 trials other celebrities of the same gender as the target were presented as distractors. The order of the trials was randomized. Subjects reported if the face was the target face or not by pressing two keys on the keyboard.

Dual-task condition

In the dual-task condition, subjects had to perform both the central letter discrimination task and the peripheral face identification task together while fixating at the center. In this experiment, subjects performed at least 7 blocks of the dual-task condition, and 3 blocks each of the central and peripheral tasks.

3.2.5 Experiment 2: face identification with non-famous faces

In a separate dual-task experiment, subjects performed a face-identification task as before, but this time with a set of non-famous faces. Except for the following details, the organization of the experiment was the same as Experiment 1. In this experiment, a set of 16 individuals from our non-famous set of faces (see above) were randomly chosen as targets. There were 24 distracter individuals. As mentioned before, we used five different views of each of these faces. Each block of trials started with a "familiarization phase" during which subjects were shown all five views of a particular target individual. They were instructed to familiarize themselves with this individual for subsequent identification in the ensuing block. By self-report, on average, subjects took 30 seconds to look at the faces before they started the block by pressing the space bar. In the block that followed, the target individual was presented on 24 of the 48 trials; while distractors of the same gender as the target were presented on the remaining trials. The targets and distracter trials were randomized, and subjects reported on each trial if the face was a target or not by pressing one of two keys on the keyboard. The average presentation time was 179.8 ± 15.8 ms for the letters and 162.3 ± 17.1 ms for the faces. These SOAs were not significantly different from those obtained for Experiment 1.

Six subjects performed 4 one-hour sessions of this experiment on 4 consecutive days. On each day, they performed 6 dual-task blocks and 4 blocks of the two single tasks. The target face was never repeated in any blocks of the experiment during a one-hour session. However, since the same target face could be presented on different days, we tested subjects in Experiment 3 on a set of unrepeated target faces.

3.2.6 Experiment 3

The layout of this experiment was identical to Experiment 2. The only difference was that on each block of trials, a new target individual was presented to subjects. Thus, targets were never repeated across blocks. Four subjects performed at least 11 blocks of the dual-task condition, and 5 blocks of the two single-task conditions in this experiment.

3.2.7 Experiment 4

In Experiment 4, 4 subjects were tested on face identification but with a set of inverted faces. This experiment was only performed with the non-famous faces. Subjects performed at least 12 blocks of the dual-task condition and 8 blocks of the two single-task conditions. In all other respects, the design of the experiment was identical to that of Experiment 2.

3.2.8 Experiment 5

In this experiment, 4 of the subjects performed a disk discrimination task in the periphery. Two color patterns—a vertically bisected disk with red and green halves and such a disk rotated by 180°—were presented to subjects. On each trial, the disk was masked by a disk divided into four red and green alternating quadrants. At least 12 blocks of the dual-task condition and 8 blocks of the two single-task conditions were collected for each subject. The average presentation time for the disks was 78.9 ± 19.4 ms.

3.3 Results

The dual-task paradigm was used to determine the effects of manipulating spatial attention on face-identification performance. One each trial, subjects were presented with different faces and were asked to report if the face was of the individual who had been designated as the target at the beginning of the block (Figure 3.1). In each block, the distractors were always of the same gender as the target. In the dual-task condition, subjects performed on both tasks, while prioritizing the central letter discrimination task.

In Experiment 1, five subjects were tested on face identification with faces of well-known Hollywood actors and actresses. A list of their names appears in Table 3.1. Subjects' performances on this task are shown in Figure 3.2a. The average performance on the letter discrimination task in the single- and dual-task conditions were 80.3 ± 5.4% and 78.2 ± 5.5%, respectively. These values are not significantly different from each other for each subject (t test, $p>.05$), indicating that in the dual-task condition the focus of attention was engaged by the letter discrimination task. Average performance on the face-identification task was 83.2 ± 5.3% when it was performed alone, and 81.1 ± 4.9% in the dual-task condition. For each of the five subjects, performance on this task in the dual-task and single-task conditions was not significantly different (t test, $p>.05$.). These results are summarized in Figure 3.2b, in which each participant's performance in the dual-task condition is plotted relative to the performance they achieved in the single-task conditions[1]. As the data shows, for each of the five subjects, dual-task performance was above 90% of their performance in the single-task condition. Eye movements would not have played a major role in achieving such performance since the peripheral faces were only presented briefly on each trial (see methods). Additionally, control experiments with an eye tracker have allowed us to verify that eye movements do not contribute to the performance achieved in the dual-task condition (Figure 2.7). These results thus indicate that subjects are able to efficiently identify famous individuals even when spatial attention is not fully available for the task.

Given these results with familiar faces, it is interesting to ask whether this performance extends to lesser known faces as well. It is possible that the subjects' ability to identify individuals in the near-absence of spatial attention is limited to a small group of famous or highly familiar people, and that identifying relative strangers would require closer attention. Accordingly, in Experiment 2 we repeated the face-identification experiment, but this time with a set of non-famous faces. As mentioned in the methods section, this face set contained five views of several unknown individuals, and on different blocks, a particular individual was chosen as the target. Before each block began, all five views of the target were presented to subjects who were instructed to acquaint themselves with that individual for subsequent identification.

Performance of six subjects on this task is shown in Figure 3.3a. The average performance on the letter discrimination task was comparable in the single- and dual-task conditions signifying that subjects were paying attention to this task in the dual-task condition (82.7 ± 3.4% and 80.3 ± 4.7%, $p>.05$, two-tailed t-test). On the peripheral task, average performance was 86.4 ± 3.0% and 82.1 ± 3.3% in the single- and dual-task conditions, respectively. The difference in performance on the face identification task

[1] The exact formula used was: normalized performance = $1/2 + 1/2.[(P_2 – 1/2) / (P_1 – 1/2)]$ where P_2 and P_1 refer to performance in the dual-task and single-task conditions, respectively.

between the single- and dual-task conditions was significant for 2 of the 6 subjects. Figure 3.3b shows the performance of each subject in the dual-task condition normalized to their performance in the single-task conditions. From this figure we see that, on average, face-identification performance in the dual-task condition was above 90% for all subjects. Thus these results demonstrate that although there is a small decrement in performance in the dual-task condition, identifying relatively unfamiliar faces is possible in the near-absence of attention. Additionally, the data also allows us to confirm that the results we observed with famous faces were really due to a face-identification process and were not a result of artifacts introduced by the image set. The images used in Experiment 1 were obtained from the web and were therefore not very well controlled for low-level or other cues specific to a particular celebrity. For instance, stars are well known for their distinctive hairstyles and facial expressions, and subjects could have based their decisions in the face-identification task on these cues. Thus, even though the image set allowed us to use a broad range of photographs of people in natural everyday environments, the face-identification results could have been disputed. The results of Experiment 2, however, confirm that subjects are able to identify individuals in the near-absence of attention, even in the absence of any obvious cues.

Over the course of Experiment 2, although a particular individual was never the target on more than one block in each session, he or she could have been re-assigned to be the target in another session. On average, for a particular target this would have occurred no more than two times, but it could still be argued that the results we have observed this far were biased by the familiarity gained with particular targets. For this reason, in Experiment 3 we re-tested four of our subjects on face identification but this time with a novel, unknown target individual on each block. Their average performance on the face-identification task was 80.4 ± 5.1% and 79.7 ± 3.1% in the single- and dual-task conditions, respectively. This difference was not significant for any of these subjects

($p>.05$). The normalized data for these subjects shown in Figure 3.4a demonstrates that even under these conditions, subjects achieve a high level of performance on this task. Over the group of subjects the normalized face-identification performance was greater that 95%.

In Experiment 1, at the beginning of each block, subjects were told who the target was by simply presenting the corresponding celebrity's name. However, this was not possible in Experiments 2 and 3 because all the targets were unknown people. Instead, before each block in these experiments, subjects were presented with all five views of the target so that they could begin to recognize them (typically subjects spent 30 seconds in examining these faces before proceeding with the block). It is possible that during this familiarization phase of the experiment, subjects memorized the overall layout of each view of the target, and in the block that followed, rather than identifying the face, they just used a template matching strategy by comparing the presented face on each trial with the templates they had in memory.

To control for this possibility we tested subjects on face identification with (unfamiliar) inverted faces in Experiment 4. As in the previous two experiments, in this experiment, subjects were presented with all five views of the target face at the beginning of each block, but this time all the faces were inverted. If subjects had indeed relied on a template-matching strategy in the previous experiments, then they would have been able to use a similar strategy with the inverted face task. This would have led to performance similar to that observed in Experiments 2 and 3. Four subjects from Experiments 2 and 3 were tested with inverted faces in Experiment 4 (Figure 3.4b). Their average performance on the face-identification task was $79.8 \pm 4.2\%$ and $67.1 \pm 3.0\%$ in the single- and dual-task conditions, respectively. This difference was significant for all of these subjects ($p<.01$). In comparing performance on upright and inverted faces, for each subject, we also observed a significant drop in face-identification performance

($p<.01$). Thus these results demonstrate that a template-matching strategy would not have been sufficient to achieve the high levels of performance observed in the previous experiments. Additionally, the results with inverted faces also confirm that subjects did not use a strategy based on low-level differences in the image set to perform the task in Experiments 2 and 3 (since otherwise similar performance levels would have been observed with upright and inverted faces).

These results thus demonstrate that subjects are able to perform subtle discriminations about the identity of individuals in the near-absence of attention. However, in all these experiments, an obvious concern arises about the efficacy of the central letter discrimination task in effectively engaging the focus of attention away from the periphery. This concern can be addressed by verifying that for some tasks that are known to require attention, performance suffers in the dual-task condition. We ensured this was the case in our dual-task condition by testing 4 of the subjects in the dual-task condition on a bisected disk discrimination task, which has been shown previously to require attention (Braun & Sagi, 1990; Braun & Julesz, 1998; Li, VanRullen et al., 2002; Reddy, Wilken et al., 2004). As is shown in Figure 3.4c, in contrast to their performance on face identification (Figure 3.4a), subjects' performance on this task was severely impaired ($p<.001$). Over the group of subjects, the average performance on this task was 53.5 ± 2.6% in the dual-task condition, compared to 80.2 ± 5.7% observed in the single-task condition. These results confirm that under our dual-task condition, the central letter discrimination task does remove some attentional resource from the periphery, resulting in performance decrements in tasks known to require attention.

3.4 Discussion

The results of these experiments extend previous findings (Li, VanRullen et al., 2002; Rousselet, Fabre-Thorpe et al., 2002; Reddy, Wilken et al., 2004) on the processing of natural stimuli in the near-absence of spatial attention by demonstrating that faceidentification is also possible when spatial attention is not fully available. Given that finer and more complex levels of discrimination are required for face identification (compared to the natural tasks previously used as has been discussed in the introduction), it is surprising that processing does not break down completely when the attentional focus is shifted away from the faces. As we mentioned earlier, the goal of the experiments described in this chapter was to ascertain how far the ability to process natural stimuli in the near-absence of spatial attention could extend. We had speculated that the face-identification task would reveal the limits of pre-attentive natural stimuli processing. Surprisingly, our results indicate that the visual system is not overwhelmed by discriminations of this caliber. While earlier work had indicated that super-ordinate levels of categorization (Mervis & Rosch, 1981) for natural stimuli (e.g. animal versus non-animal) are unimpaired in the near-absence of attention (Li, VanRullen et al., 2002), we now show that this finding extends to categorization at the individual level. In contrast to processing with natural stimuli, however, the near-absence of attention is a severe limitation to performance on discrimination of artificial geometric shapes, even though they are computationally simpler tasks.

In our data, we observed a modest drop in performance in identifying faces in the dual-task condition compared to the single-task condition (which was significant for only two subjects in Experiment 2 with the relatively unfamiliar face set, and did not occur at all with the celebrity faces in Experiment 1), but it should be remembered that some decrement in performance is expected to occur when subjects perform two tasks simultaneously. These decrements do not necessarily reflect competition for an attentional resource but could be ascribed to other factors such as having to remember two sets of instructions or produce two motor responses instead of one (Allport, 1980; Duncan, 1980b; Pashler, 1984, 1994).

Does this ability to make fine discriminations on natural stimuli also extend to other classes of natural objects, or is it only specific to faces? For instance, could one discriminate between two similar breeds of dogs in the near-absence of attention? It could be contended that the results we observe here would not generalize to other natural categories since various studies have claimed that dedicated areas in temporal cortex exist that preferentially process face stimuli, and that faces are thus of special importance to the visual system (Kanwisher, McDermott et al., 1997; Kanwisher, 2000; Grill-Spector, Knouf, & Kanwisher, 2004; Yovel & Kanwisher, 2004); (see however (Ishai, Ungerleider, Martin, Schouten, & Haxby, 1999; Ishai, Ungerleider, Martin, & Haxby, 2000; Haxby, Gobbini et al., 2001) for evidence for more distributed representations of objects in the temporal and lateral-occipital regions). However, it has also been suggested that faces are so well represented in the brain primarily because human beings are experts on face processing and that similar representations should also be observed for other well-known categories. In support of this claim, Gauthier and colleagues have shown that the areas underlying face processing also participate in the processing of other objects of expertise (such as cars for car experts) (Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999; Gauthier & Logothetis, 2000; Gauthier, Skudlarski et al., 2000; Tarr & Gauthier, 2000; Gauthier, Curran, Curby, & Collins, 2003). Thus it is possible that these regions would similarly facilitate the processing of highly familiar natural categories and that complex discriminations in the near-absence of attention would be possible for these objects as well.

In fact, the disparity between performance on natural object and artificial geometric shape discrimination in the dual-task condition could be directly linked to the difference in how familiar the visual system is with these different stimuli. Indeed in contrast to natural scenes and faces, bisected red-green disks are rarely encountered in everyday life. The different degrees of familiarity for different object categories might be mirrored by a continuum of “attentional requirements” in which faces would be one extreme. This could explain why very subtle discriminations among face stimuli (such as recognition of individuals) can be done pre-attentively, whereas, to answer the question posed above, if subjects do not routinely engage in discriminating breeds of dogs, then the corresponding task might require attention. This speculation is not entirely unreasonable since if the brain is optimally adapted for everyday stimuli, the processing of oft-encountered natural stimuli should be favored over unusual geometric shapes (Kayser, Kording et al., 2004; VanRullen, Reddy et al., 2004).

fMRI studies have shown that visual perception and imagery of famous or well-known faces activate face-selective voxels in the fusiform gyrus and other temporal areas (Dubois, Rossion et al., 1999; Leveroni, Seidenberg et al., 2000; Gorno-Tempini & Price, 2001; Rossion, Schiltz, Robaye, Pirenne, & Crommelinck, 2001; Ishai, Haxby, & Ungerleider, 2002). Furthermore, evidence for single neurons in the human temporal lobe that are selectively responsive to different views of familiar natural objects has been reported recently. These neurons have been shown to respond to famous buildings and celebrities, or to entire categories of natural objects (e.g. animals or cars; see Chapter 5 and (Kreiman, Koch et al., 2000a; Kreiman, 2002; Quian Quiroga, Reddy et al., 2005)). The hardwired selectivity of these temporal neurons, established through repeated exposures with a particular stimulus category, could underlie dual-task performance for our celebrity identification task (Experiment 1) or the animal versus non-animal categorization task (Li, VanRullen et al., 2002), respectively. On each trial, the activity of the neurons explicitly encoding the relevant famous person or natural category might be sufficient to give rise to a perception of the target (even in the near-absence of attention), resulting in the high levels of behavioral performance we observe (VanRullen, Reddy et al., 2004).

However, in the present study we have also reported that similar levels of performance are observed for relatively unfamiliar faces (Experiment 2 and 3). What are the neural candidates that could underlie the processing of unfamiliar faces in the near-absence of attention? A coding strategy based on explicitly encoding every possible face individually at the neural level is clearly neither efficient nor feasible. Furthermore, it is also unlikely that explicit representations for the target faces (such as those mentioned above for famous faces) could have been created during the approximately 30-second-long familiarization phase at the beginning of the block when subjects were presented with these faces. At the neuronal level, changes in synaptic connectivity (LTP, LTD) are known to involve much longer time scales (Abbott & Nelson, 2000; Bi & Poo, 2001). Instead, our results suggest that face processing mechanisms can be flexible and generalize their abilities to faces that have not been encountered previously, by setting up representations (not necessarily explicit) online over a few seconds. Furthermore, these representations are probably of a temporary nature since it would be wasteful to maintain permanent representations for faces one is not likely to come across again. Computational models of face processing have suggested that upon encountering a face, recognition units that describe the face are established (Bruce & Young, 1986). Undoubtedly, based on neurophysiological evidence (Hasselmo, Rolls, & Baylis, 1989; Sergent, Ohta et al., 1992; George, Dolan et al., 1999; Hoffman & Haxby, 2000), areas in the temporal lobe are likely to be implicated in this processing (Haxby, Hoffman et al., 2000; Haxby, Hoffman, & Gobbini, 2002); however, the manner in which these online representations are implemented at the neural level is still unclear and open to future research.

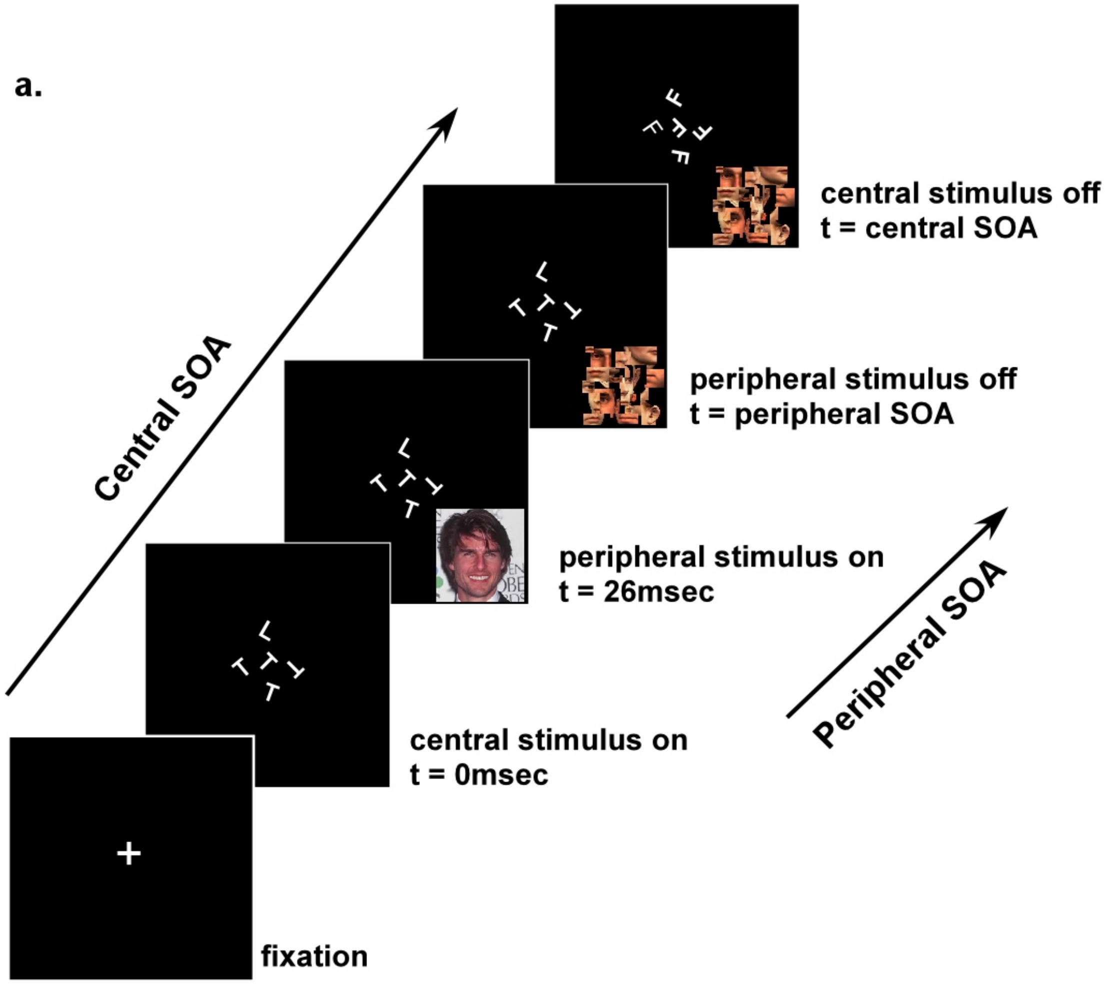

Figure 3.1: Face-identification discrimination dual-task experiment. (a) Schematic timeline for one trial in the dual-task experiment. At the end of a trial, participants are required to report whether or not the face was that of the target celebrity and/or whether the 5 central letters were the same (either 5 Ts or 5 Ls) or different (4 Ts and 1L or 4 Ls and 1T). All trials are arranged similarly, independent of the specific instructions. Both letters and faces were masked individually. Central SOA (~200 ms) and peripheral SOA (~167 ms) indicate the presentation time for letters and celebrity faces respectively.

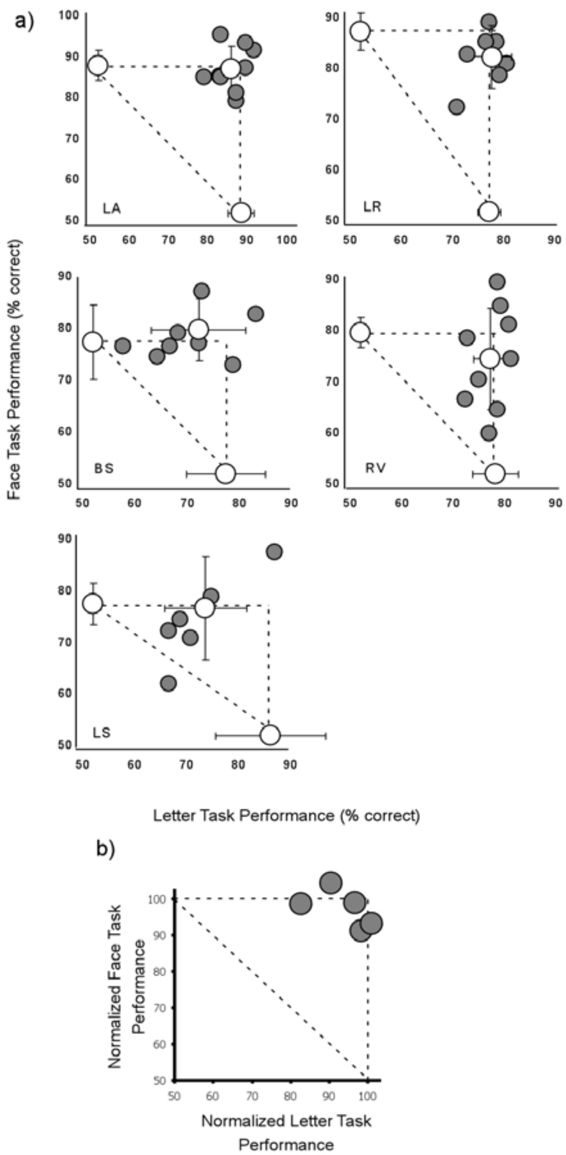

Figure 3.2. Results of the famous face-identification task (Experiment 1). *(a)* Results of 5 subjects. The horizontal axis represents performance on the attentionally demanding central letter task. The vertical axis represents performance on the peripheral celebrity identification task. Each filled circle is the participant's mean performance in the dual task in one block of 48 trials, while an open circle represents mean performance over all blocks in the three experimental conditions: single-central task, single-peripheral task, and the dual task. By default, performance of the "to-be-ignored" task is assumed to be at chance level (50%) in the single-task condition. Error bars represent standard deviation. For all participants face-identification performance in the dual-task condition is not significantly worse (*t*-test, $p>0.05$) than performance in the single-task condition indicating that face-identification suffers only minimally when performed concurrently with an attentionally demanding task. *(b)* Normalized average performance for each participant in the dual-task paradigm. Each point represents a participants' performance in the dual-task normalized to their single-task performance. Normalized values are obtained by a linear scaling, which maps the average single-task performance to 100% leaving chance at 50%. Normalized face identification performance values lie above 90% of single-task performance, suggesting that participants can perform this task remarkably well in the near-absence of attention.

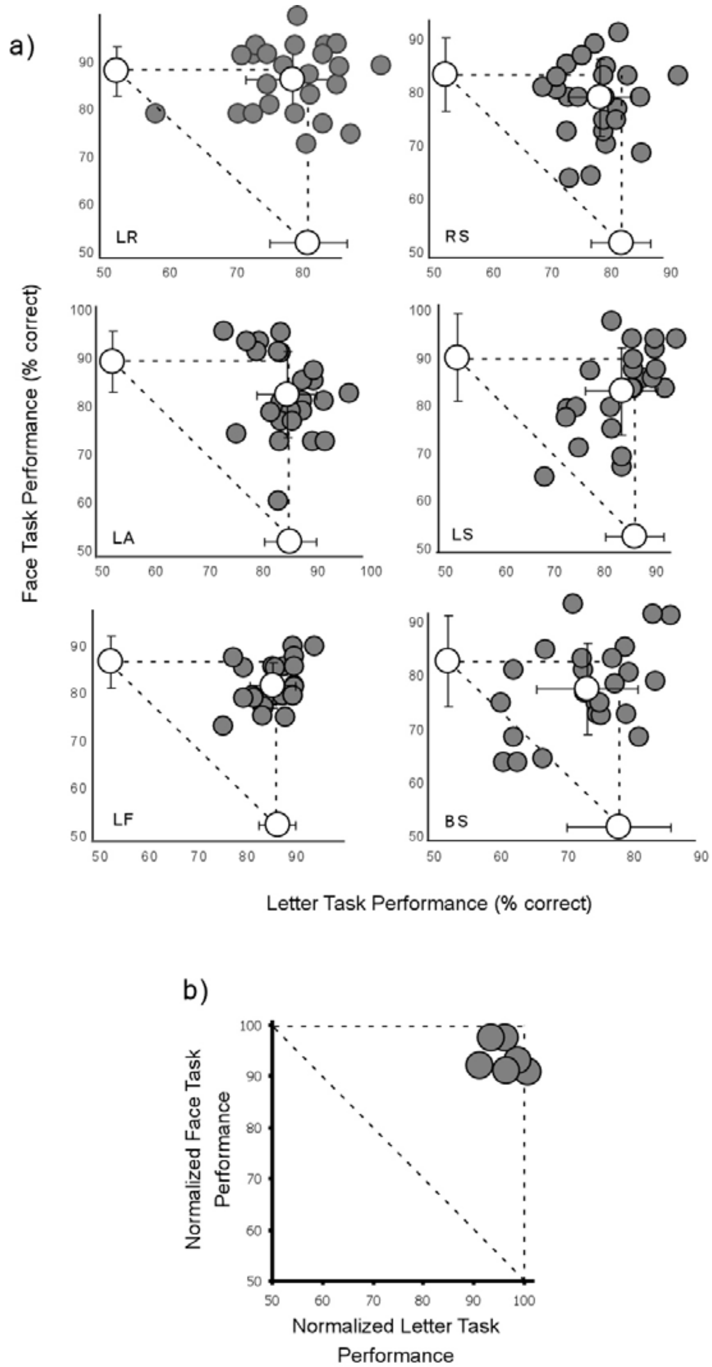

Figure 3.3. Identifying unfamiliar faces. Performance of six participants in the dual-task paradigm with the unfamiliar faces (Experiment 2). The format of this figure is the same as Figure 3.2. Normalized performance values shown in b) are >90% for all subjects. Thus, even with unfamiliar faces, subjects are able to identify faces in the near-absence of attention.

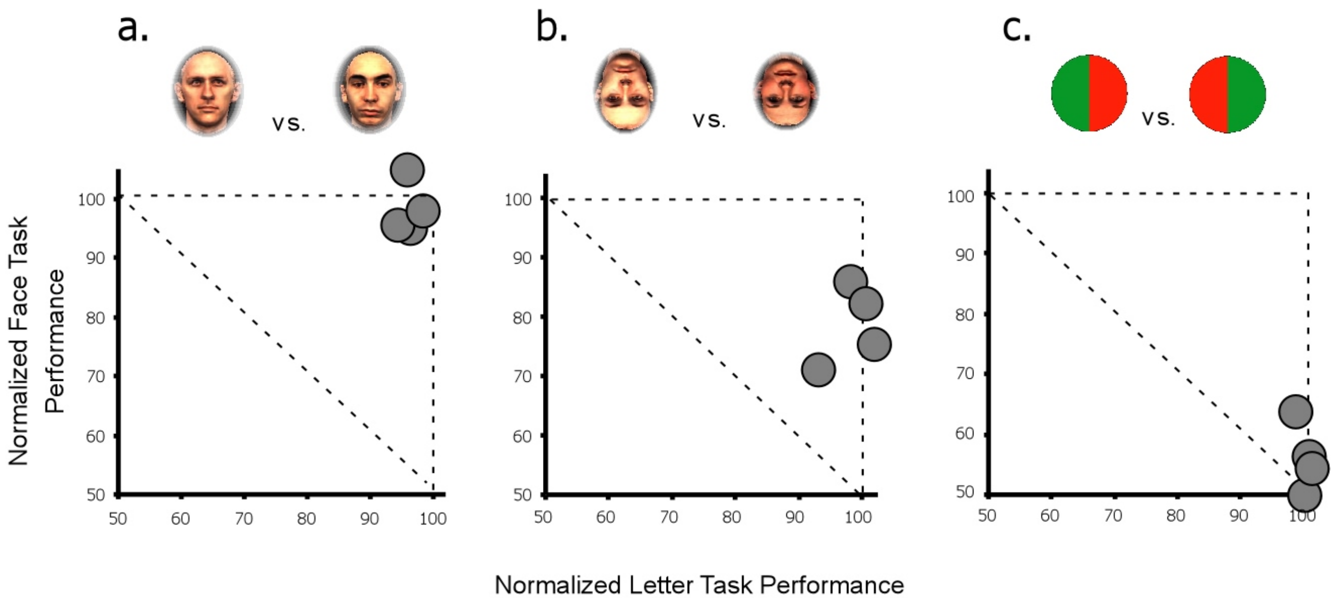

Figure 3.4. Face-identification control experiments. Normalized performance values for 4 subjects in three dual-task experiments (Experiments 3–5). a) Performance values on upright face identification with a new target face on each block of the experiment. The normalized performance is greater than 95% for each subject. b) Performance values on face-identification with inverted faces. The average normalized performance is 78.4 ± 6.6% for these subjects. A significant drop in performance is observed for each subject with inverted faces compared to upright face identification. The results indicate that the performance observed with upright faces is not due to a template matching strategy (see text), nor a strategy based on low-level differences between images. c) Performance values on a disk-discrimination task in the periphery fall to chance levels in the dual-task condition. This indicates that the central letter task does withdraw some attentional resource away from the periphery resulting in a sharp drop in performance on certain tasks.

Table 3. 1 Celebrity target and distracter images shown for face identification

Targets:

Catherine Zeta Jones
Courtney Cox
George Clooney
Harrison Ford
Jennifer Aniston
Jennifer Lopez
Julia Roberts
Nicole Kidman
Tom Cruise
Tom Hanks

Distracters:

Al Pacino	Liv Tyler
Andy Garcia	Lucy Liu
Antonio Banderas	Madonna
Arnold Schwarzenegger	Matthew McConaughey
Ben Affleck	Meg Ryan
Billy Boyd	Merryl Streep
Cameron Diaz	Miranda Otto
Colin Farrell	Nicholas Cage
Colin Firth	Orlando Bloom
Cuba Gooding Jr.	Penelope Cruz
Danny DeVito	Rene Zellwegger
Denzel Washington	Robert DiNiro
Drew Barrymore	Robin Williams
Elijah Wood	Russell Crowe
Ethan Hawke	Salma Hayek
Hugh Grant	Sarah Jessica Parker
Hugo Weaving	Sean Astin
Ian McKellen	Sean Connery
Jennifer Garner	Tim Robbins
Jim Carrey	Viggo Mortensen
Julia Stiles	Winona Ryder
Keanu Reeves	