

## **Do pictures of faces, and which ones, capture attention in the inattentive blindness paradigm?**

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### **ABSTRACT**

Faces and self-referential materials (eg the own name) are more likely to capture attention in the inattentive blindness (IB) paradigm than others stimuli. This effect is presumably due to the meaning of these stimuli rather than to their familiarity (Mack and Rock 1998). IB has mostly been investigated with schematic stimuli in previous work. In the present study, the generalisability of this finding was tested using photographic stimuli. In support to the view that faces constitute a special category of stimuli, it was found that pictures of faces resisted more to IB than pictures of common objects (Experiment 1) or than pictures of inverted faces (Experiment 2). In a third experiment, the influence of face familiarity and identity (ie the participant's own face, a friend's face and an unknown face) on IB rates was evaluated. Unexpectedly, no differential resistance to blindness across these three kinds of faces was found. In conclusion, picture of faces attracted attention more than pictures of objects or inverted faces in the IB paradigm. However, this effect was not dependent on face familiarity or identity.

### **Keywords**

Attention capture, inattentive blindness, face processing, face recognition, familiarity, object recognition, self-face, self processing, visual attention.

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## 1 INTRODUCTION

Inattention blindness (IB) occurs when an observer fails to detect the unexpected presence of a stimulus in his/her visual field. This phenomenon was discovered by Mack and Rock (1998) with a paradigm they designed to investigate the relationships between perception and attention. In this paradigm, observers focus on a length judgment task that consists in reporting which arm (vertical or horizontal) of a flashed large cross is longer than the other. This procedure is used during two or three trials (ie non-critical trials). Then, on the third or fourth trial (ie critical trial), a *critical stimulus* (CS) is unexpectedly presented besides the large cross (see Figure 1). At this moment, observers are in conditions of *inattention* since they could not expect the appearance of the CS. Immediately after the length judgment task, they are questioned about their detection of this CS and are asked to describe it or to pick it out in a set of alternatives. After two or three non-critical trials, the CS is presented a second time. Observers are then in conditions of *divided attention*, since they can expect the appearance of a CS. Finally, in a last *control* trial, observers are instructed to ignore the length judgment task and to stare at fixation. Full attention is thus devoted to the processing of the CS allowing the verification of its perceptibility.

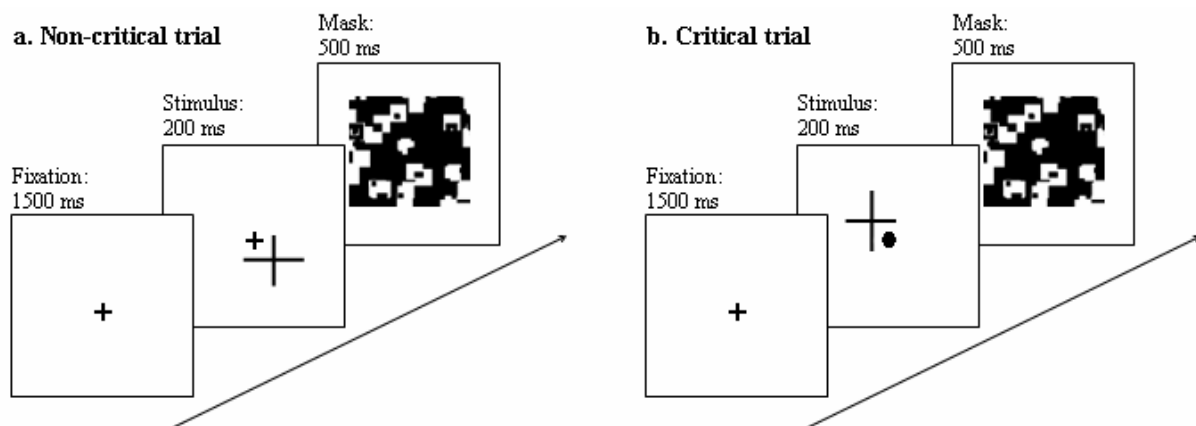


Figure 1. Presentation sequence of a non-critical trial (a) and critical trial (b): the critical stimulus (CS) appears at fixation besides the large cross (adapted from Mack and Rock 1998).

In Mack and Rock's early experiments, CS consisted in simple geometrical shapes (eg a square, a coloured spot). They found that a high rate of observers (up to 85%) failed to detect such CS and concluded that perception requires attention or in other words, that attention must first be captured before perception can occur. Then, the possibility of certain important and meaningful stimuli being particularly prone to capture attention was examined.

Mack and Rock (1998) used their participant's own name as CS to address that question. Indeed, the own name has been described as particularly important with regard to its capacity to grab attention (eg by comparison with neutral words, Moray 1959). Accordingly, Mack and Rock found that the own name was more resistant to IB than other stimuli (eg other names or highly frequent words). Hence, they concluded that the own name captures attention because of its importance (rather than because of its lexicality or familiarity) which is in favour of a late selection theory (Deutsch and Deutsch 1963) assuming that attentional selection occurs at a relatively 'late' stage of the visual processing.

Mack and Rock (1998) likewise tested whether faces (another important stimulus, see eg Bruce 1998) would be better detected than other objects. They used cartoon-like faces and found that a happy face icon was more resistant to IB compared to other kinds of CS (sad, neutral, scrambled, or inverted happy faces as well as circles). Since they also found that IB

rates were significantly lower when the own name or the happy face icon were presented than when a highly frequent word (eg 'The') was presented under comparable conditions, they concluded that familiarity alone cannot account for the detection of the own name or the happy face icon. Later, Mack et al (2002) confirmed the notion that one's own name and a happy face icon capture attention because of their importance using three different paradigms (attentional blink, RSVP with varying load and stimulus crowding).

Patient studies also demonstrated the influence of such important stimuli on attention. For instance Vuilleumier and Schwartz (2001) showed that faces and emotional expressions can be processed despite lying on the unattended hemifield in brain-damaged patients presenting hemineglect. Recently, Perrin et al (2006) using ERP showed that minimally conscious patients and some vegetative state patients present differential P3 component in response to their own name by comparison with other names.

In sum, these studies thus suggest that stimuli of great social importance have the ability to capture attention. However, faces used in Mack and Rock (1998)'s experiments were cartoon-like happy faces and it is unknown whether the effects would still hold if more realistic stimuli were presented. Other studies using photographic stimuli in change detection paradigms have indicated that faces seem to be prioritised in terms of allocation of attention. For instance, David et al (2006) showed that, in natural scenes, gradual changes in facial expressions were better detected than gradual changes in objects' colour. Similarly, Ro et al (2001) showed that changes to a single face presented among objects of different categories were better detected than changes to these objects (but see Palermo and Rhodes 2003). These studies thus suggest that realistic pictures of faces are preferentially attended to than pictures of other objects but they do not demonstrate that faces capture attention. Recently however, Theeuwes and Van der Stigchel (2006) used the inhibition of return phenomenon to show that when a face and an object are simultaneously presented, attention automatically shifts towards the location of the face. Hence, a realistic facial stimulus might also capture attention in the IB paradigm.

The first aim of this study was to assess this hypothesis. In Experiment 1 we tested whether pictures of faces resist more to IB than pictures of other non-facial objects (fruits and vegetables). In addition, in Experiment 2, we compared the capacity of upright faces and inverted faces (ie stimuli matched for their low level properties) to capture attention.

The second aim of this study was to examine whether the familiarity or the identity of a face can affect its resistance to blindness. More specifically, we assessed whether the self-face that combines two properties likely to capture attention (ie it is both a facial and a self-relevant stimulus) is particularly resistant to IB. Indeed, the capacity of familiar and/or self-referential stimuli to capture attention remains unclear. In a change detection task involving highly familiar (famous) and recently learned faces, Buttle and Raymond (2003) showed that changes involving a famous face were better detected than changes involving a less familiar face. This study suggests that familiar faces could be better detected than unfamiliar ones but does not allow any prediction about the self-face. Actually, few studies (Brédart et al 2006; Devue and Brédart 2008; Laarni et al 2000; Ninomiya et al 1998; Tong and Nakayama 1999) have used the self-face to investigate the attentional properties of self-referential stimuli. Previous studies rather used the own name than the self-face (see eg Bundesen et al 1997; Gronau et al 2003; Harris et al 2004; Harris and Pashler 2004; Kawahara and Yamada 2004; Mack et al 2002; Mack and Rock 1998; Wolford and Morrison 1980). Yet the own face is more exclusively a self-referential stimulus than the own name which can be shared with other people. Moreover, control to these self-referential stimuli was sometimes inappropriate (ie neutral or unfamiliar stimuli were used).

In Experiment 3, we thus compared the performance obtained with the self-face, with a highly and personally familiar face (ie a friend's face) or with an unknown face presented as

CS. Thus, the comparison of the self-face with the friend's face would give the best possible approximation of the role of the self-referential component in attentional capture whereas the comparison with an unknown face would inform us on familiarity effects. To assess possible bias of the participants, we incorporated a trial in which no CS was presented but which was nonetheless followed by an assessment of the detection and recognition of an additional item. This way, we could determine the presence of false positives, and more importantly in the third experiment, whether participants were biased to see their own face. To keep all three experiments comparable, we also added this catch trial in experiments 1 and 2.

## 2 EXPERIMENT 1

### 2.1 Method

**2.1.1 Participants.** Forty-eight participants (18 men) from the University of Liège took part in the experiment on voluntary basis. They were naïve as to the purpose of the experiment and had normal or corrected-to-normal vision. They gave their informed consent prior their inclusion in the experiment. As the crucial point in this paradigm is that a given participant can only be confronted once to one critical trial in condition of inattention, we used a between-subjects design. Thus, participants were randomly assigned to one of two experimental conditions: 'face' (n = 24) or 'object' (n = 24) as CS.

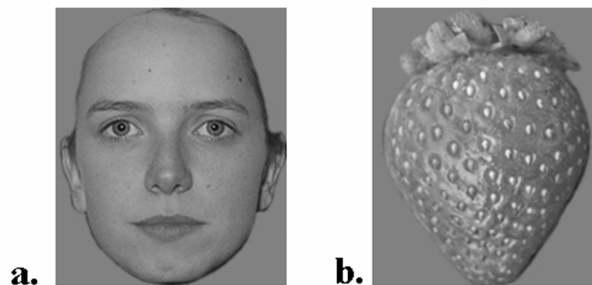


Figure 2. Examples of a facial stimulus (a) and of an object stimulus (b).

**2.1.2 Stimuli.** There were 8 possible CS: four oval-shaped objects (a lemon, a strawberry, a potato and a pear) and four unfamiliar faces (two males and two females). The size of these stimuli was about 0.9 degrees in width and 1.3 degrees in height (at a viewing distance of 56 cm and with a resolution of 0.035 cm per pixel). Each facial stimulus was obtained by cropping pictures between the hairline and the chin with the image manipulation software Gimp 2<sup>1</sup>. It was given an oval shape by tracing an ellipse in a rectangle of 25 X 35 pixels. Extraneous background information was concealed (see Figure 2a). The object stimuli were constructed using the same parameters as for faces (see Figure 2b). Contrast and luminance of each of these pictures were equalised by the experimenter. Each of the 4 objects and of the 4 faces was presented as CS to six different participants.

The arms of the cross that served as the stimulus for the length judgment task were black and had 4 different sizes comprised between 3.6 and 4.5 degrees (the two intermediate sizes being equal to 3.9 and 4.1 degrees). The mask was a square of 8.9 degrees covering the area in which stimuli could appear. All these stimuli were presented on a mean grey background (see Figure 3).

**2.1.3 Procedure.** Participants were tested individually in a dimly lighted room on a personal computer. They viewed stimuli at a distance of 56 cm controlled by means of a chin-rest. The stimuli were presented on a CRT 17 inches monitor with an 85 Hz refresh rate and the resolution of the screen was set to 1024 by 768 pixels. The presentation of the stimuli was

controlled and responses were recorded with E-Prime 1.0 software<sup>2</sup>. Participants were instructed that they should perform a task on geometrical shapes. They were asked to stare at a centred fixation cross and to judge which arm of a larger cross presented very briefly was longer compared to the other one. Each trial was initiated by a key press of the participant when he/she was ready. A fixation cross was presented for 1500 ms. Then, a larger cross appeared for 200 ms randomly in one of the four quadrants on a 45° diagonal from the fixation, the arms intersection being at 2.3° from the fixation. The two arms of the cross were chosen randomly among the four possible sizes with the constraint that both of them could not have the same size. Participants indicated their decision with a key press (“b”= vertical or “n”= horizontal). During critical and control trials, a CS appeared at fixation (ie at the location of the fixation cross) for 200 ms at the same time as the larger cross. Finally a mask was presented for 500 ms.

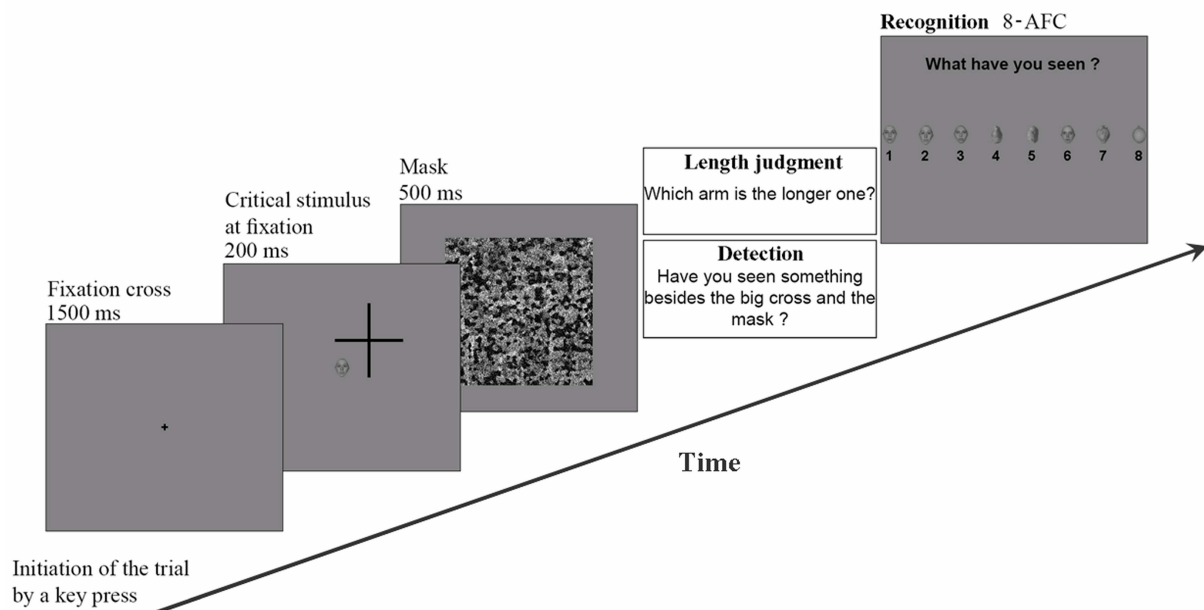


Figure 3. Time course of a critical trial in experiments 1, 2 and 3.

Each participant was presented with 9 trials (see Table 1). CS was presented during the fourth (*inattention trial*), the eighth (*divided attention trial*) and the ninth trial (*control trial*). The same CS was presented throughout the whole experiment to a given participant. After each critical trial, participants were asked if they had seen anything besides the large cross and the mask (referred to as the black and white spotted square) that was not present during previous trials. Regardless of their response, they had to choose what had just been presented among an 8-AFC composed of the four faces and the four objects. These eight items randomly appeared in one of eight possible locations (see Figure 3). In order to assess whether participants were prone to produce false positive, the CS was *not* presented during the sixth trial (*bias trial*). However, the participants were still questioned about the presence of something additional and they had to pick out what ‘had been presented’ in the 8-AFC. Before the ninth trial (*control trial*), participants were urged to concentrate on the centre of the screen and to stare at the fixation cross without paying attention anymore to the large cross. They were again asked if they had seen something additional and had to pick it out in the 8-AFC.

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Cross alone	Cross alone	Cross alone	Cross +	Cross alone	Cross alone	Cross alone	Cross +	To-be-ignored cross +
			Critical stimulus				Critical stimulus	Critical stimulus
			8-AFC		8-AFC		8-AFC	8-AFC
			<b>Inattention</b>		<b>Bias</b>		<b>Divided attention</b>	<b>Control</b>

*Table 1. Illustration of the procedure used in experiments 1, 2 and 3.*

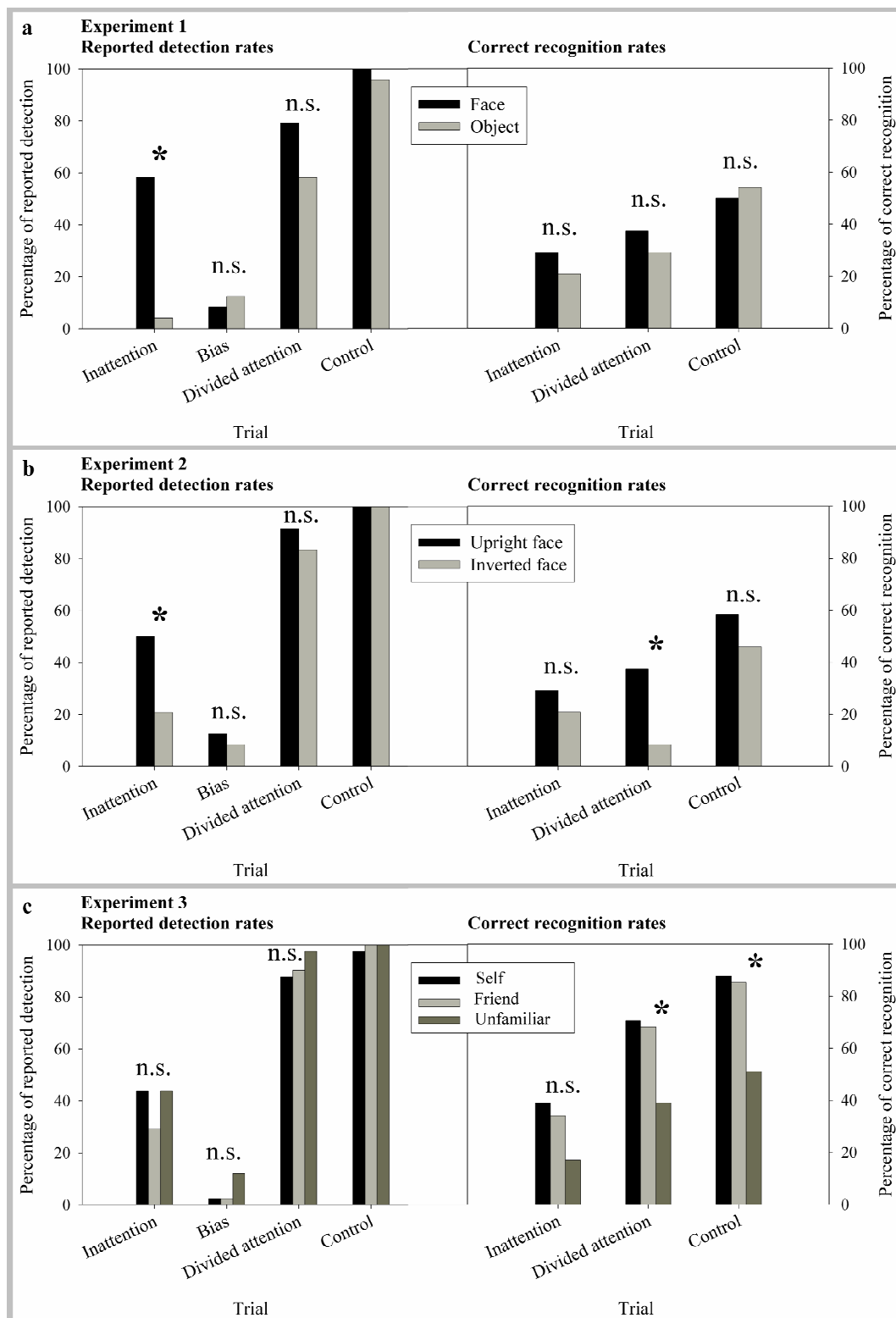
## 2.2 Results

Since the present study was aimed at evaluating in the ability of faces or other stimuli to capture attention when they appear unexpectedly in condition of inattention, we focused our analyses on the inattention trial (ie first critical trial) for all analyses reported hereafter. Moreover, in the ‘detection rates’ section, we examined the tendency of participants to report the presence of an additional item whereas nothing has actually been presented by means of the bias trial.

*2.2.1 Length judgment task.* First the performance on the primary task (ie line length judgement) was analysed. The overall accuracy on this task was 66%. A Chi-square analysis showed that the accuracy did not differ significantly between the two groups on the inattention trial,  $\chi^2(1) = 2.42$ ,  $p = 0.12$ . Moreover, the rates of correct responses on critical trials (trials 4 and 8 being pooled), 68%, did not differ significantly from that on adjacent non-critical trials (trials 3, 5, 6 and 7 being pooled), 71%,  $\chi^2(1) < 1$ , which suggests that the presence of a CS did not significantly divert attention from the length judgment task.

*2.2.2 Detection rates.* We compared the detection rates as a function of the type of CS presented (ie face versus object) during the first critical trial by means of a Chi-square analysis. Faces (58%) were significantly better detected than objects (4%),  $\chi^2(1) = 16.39$ ,  $p < 0.001$ . In addition, the bias trial indicated that only 2 participants from the ‘face’ condition (8%) and 3 from the ‘object’ condition (12.5%) reported seeing something whereas nothing had been presented. Complete results are presented on the left panel on Figure 4a for exhaustiveness.

*2.2.3 Correct recognition rates.* We compared the ability of participants to recognise the CS that has been presented on the inattention trial by means of another Chi-square analysis. The correct recognition rates did not differ significantly between faces (29%) and objects (21%),  $\chi^2(1) < 1$ . Complete results are presented on the right panel of Figure 4a. Finally, for the sake of exhaustiveness, results of analyses examining the recognition rates conditioned on whether the presence of the critical stimulus had been reported or not are presented on Figure 5a. These analyses show no significant differences in the ability to recognise faces and objects either when they had or had not been detected, and on any of the trials (inattention, divided attention and control).



*Figure 4. Left panels: Percentage of participants that reported having detected an additional stimulus as a function of the type of critical stimulus (CS) presented in critical and bias trials of Experiment 1 (a), Experiment 2 (b) and Experiment 3 (c). Right panels: Percentage of correct recognition of the CS among an 8-AFC. ‘\*’ refers to a significant  $p$  value  $< 0.05$  (Chi-square analyses); ‘n.s.’ refers to a non-significant  $p$  value  $> 0.05$ . Note that we did not conduct analyses on the detection rates of the control trial because performance was at ceiling. This control trial indicates that the CS were readily visible in conditions of full attention.*

## **2.3 Discussion**

Current results confirm previous findings, now with realistic photographic stimuli, that faces are more resistant to IB than other objects (Mack and Rock 1998). In general terms, this finding is consistent with the idea that faces are more likely to grab attention than other objects (Mack et al 2002; see also Ro et al 2001; Theeuwes and Van der Stigchel 2006; but see Palermo and Rhodes 2003). The present experiment that used realistic photographic stimuli also shows an overall IB effect of 69%. The present findings thus provide a confirmation of previous findings demonstrating the robustness of the IB effect (otherwise already demonstrated in more complex situations such as dynamic events, see Simons and Chabris 1999).

Although faces were better detected than objects during the inattention trial, recognition rates did not differ significantly between faces and objects. This shows that despite the fact that they are not easily identifiable, faces possess the ability to capture attention more than another category of objects. This poor recognition performance is probably due to the difficulty to recognise a small novel face, presented unexpectedly while participants are engaged in another task, after a relatively short exposure (eg Bruce et al 2001). Crucially though, even if participants were not capable of recognising a face in such conditions, this face nevertheless had a strong power to attract attention and reduce IB rates dramatically.

The bias trial also indicated that few participants (5 on 48, = 10.4%) were biased to report seeing something when nothing was actually presented. This suggests that those reporting seeing something on the first critical trial really did so since most participants were able to correctly report that nothing was presented<sup>3</sup>.

It cannot be excluded that the results of Experiment 1 reflect some low-level differences between faces and other objects. For instance, because of their inner features, faces could be less homogenous than objects, rendering the former more readily detectable than the latter. To address this possibility, we conducted a second experiment in which we compared the detection of upright and inverted faces.

## **3 EXPERIMENT 2**

The aim of this second experiment was thus to compare faces to another kind of CS that have exactly the same low level properties as faces (contrast, luminance, complexity, etc) but that is not perceived as a face, ie inverted faces. Indeed, it has been suggested that inverted faces are not processed as faces but rather as objects (eg Valentine 1988). Hence, if a detection advantage for upright faces by comparison with inverted faces is obtained, it would confirm the view that the advantage is due to their meaning rather than to other lower level characteristics.

### **3.1 Method**

*3.1.1 Participants.* We recruited 48 new participants (11 men) from the University of Liège. They were randomly assigned to one of two experimental conditions: 'upright face' (n = 24) or 'inverted face' (n = 24) as CS. They were naïve as to the purpose of the experiment and had normal or corrected-to-normal vision. They gave their informed consent prior their inclusion in the experiment.

*3.1.2 Stimuli and procedure.* The stimuli and the procedure were exactly the same as in Experiment 1 except that the four objects used in Experiment 1 were replaced by the four unfamiliar faces that had been flipped vertically. Each of these 8 CS was presented throughout the whole experiment to 6 different participants. The 8-AFC now comprised 4 upright faces and the same 4 inverted faces.



## **3.2 Results**

**3.2.1 Length judgment task.** The overall accuracy on the length judgment task was 65 % which is similar to the 66% obtained in Experiment 1. Chi-square analyses showed that the accuracy did not differ significantly between the two groups on the inattention trial,  $\chi^2(1) = 1.37, p = 0.24$ . Moreover, the rates of correct responses on critical trials (trials 4 and 8 being pooled), 59%, did not differ significantly from that on adjacent non-critical trials (trials 3, 5, 6 and 7 being pooled), 66%,  $\chi^2(1) = 1.27, p = 0.26$ .

**3.2.2 Detection rates.** As in Experiment 1 upright faces resisted more to IB than other stimuli. Indeed, upright faces (50%) were significantly better detected than inverted faces (21%),  $\chi^2(1) = 4.46, p = 0.035$ . Moreover, the bias trial indicated that only 3 participants from the 'upright face' condition (12.5%) and 2 from the 'inverted face' condition (8%) reported the presence of an additional item when nothing had actually been presented. Complete results are presented on the left panel of Figure 4b for exhaustiveness.

**3.2.3 Recognition rates.** The correct recognition rates did not differ significantly between upright faces (29%) and inverted faces (21%) after their first appearance,  $\chi^2(1) < 1$ . Complete results are presented on the right panel of Figure 4b. In addition, Figure 5b illustrates the recognition rates conditioned on whether the presence of the critical stimulus had been reported or not. Upright faces were not significantly better detected than inverted faces except in the divided attention trial after participants reported the detection of the CS.

## **3.3 Discussion**

This second experiment confirms the findings of Experiment 1 that faces are more resistant to inattention blindness than other stimuli. Here the stimuli of comparison were the same faces that were either upright or inverted. Since upright and inverted faces had exactly the same low level properties, this detection advantage for upright faces is thus imputable to their meaning. In the present experiment, the overall IB rates was 64.5% which is consistent with the IB effect found in Experiment 1 and again confirms the robustness of the IB effect. In line with Experiment 1, few participants (5 on 48, = 10.4%) reported seeing something when nothing was actually presented during the bias trial.

Finally, as in Experiment 1, upright faces benefited from a detection advantage without being better recognised than inverted faces after their first appearance.

In the preceding experiments we showed that an unfamiliar face grabs more attention than other stimuli. We will now examine whether familiarity and identity of a face influence its ability to capture attention.

## **4 EXPERIMENT 3**

In this experiment, the resistance to blindness of three types of faces differing in identity and familiarity was compared. The CS was either an unfamiliar face (as in Experiment 1 and 2) or a familiar face. In that latter case, the CS was either the participant's own face or the face of a participant's friend.

### **4.1 Method**

**4.1.1 Participants.** One hundred and forty-four participants (37 men) from the University of Liège participated in the experiment on a voluntary basis. Each of them had been photographed previously in the Cognitive Psychology Unit for their participation in a self and familiar face recognition experiment (each participant had taken part to these experiments with a friend/colleague and they were control of each other). They were recruited by phone (on average 11 months after they had been photographed) and were asked to participate in a

visual perception experiment about geometrical shapes that appeared to be completely unrelated. Participants were randomly assigned to one of three experimental conditions: 'self-face' ( $n = 48$ ), 'friend's face' ( $n = 49$ ) and 'unknown face' ( $n = 47$ ) as CS. They were naïve as to the purpose of the experiment and had normal or corrected-to-normal vision. They gave their informed consent prior their inclusion in the experiment.

*4.1.2 Stimuli.* Now, the CS was either a greyscale picture of a familiar or of an unfamiliar face. These facial stimuli were constructed using the same parameters as those described above. When the CS was unfamiliar ('unknown face' condition), it was chosen among a set of 6 unknown faces (3 males and 3 females). When the CS was a familiar face, it was either the participant's own face ('self-face' condition) or the face of a participant's friend ('friend's face' condition).

*4.1.3 Procedure.* The procedure was exactly the same as in Experiment 1 and 2 except that the 8-AFC was now tailored for each participant. The 8-AFC was always composed of four faces of the same gender as the participant and of the same four objects as in Experiment 1. The four faces were two unknown faces and two familiar faces (the participant's own face and his/her friend's face). Hence, whatever the group the participant belonged to, he/she had to choose between two familiar and two unfamiliar faces and could not make a default decision based on the face familiarity if he/she had not really recognised it. The four objects served as filler items in the 8-AFC and were never presented as CS during this experiment.

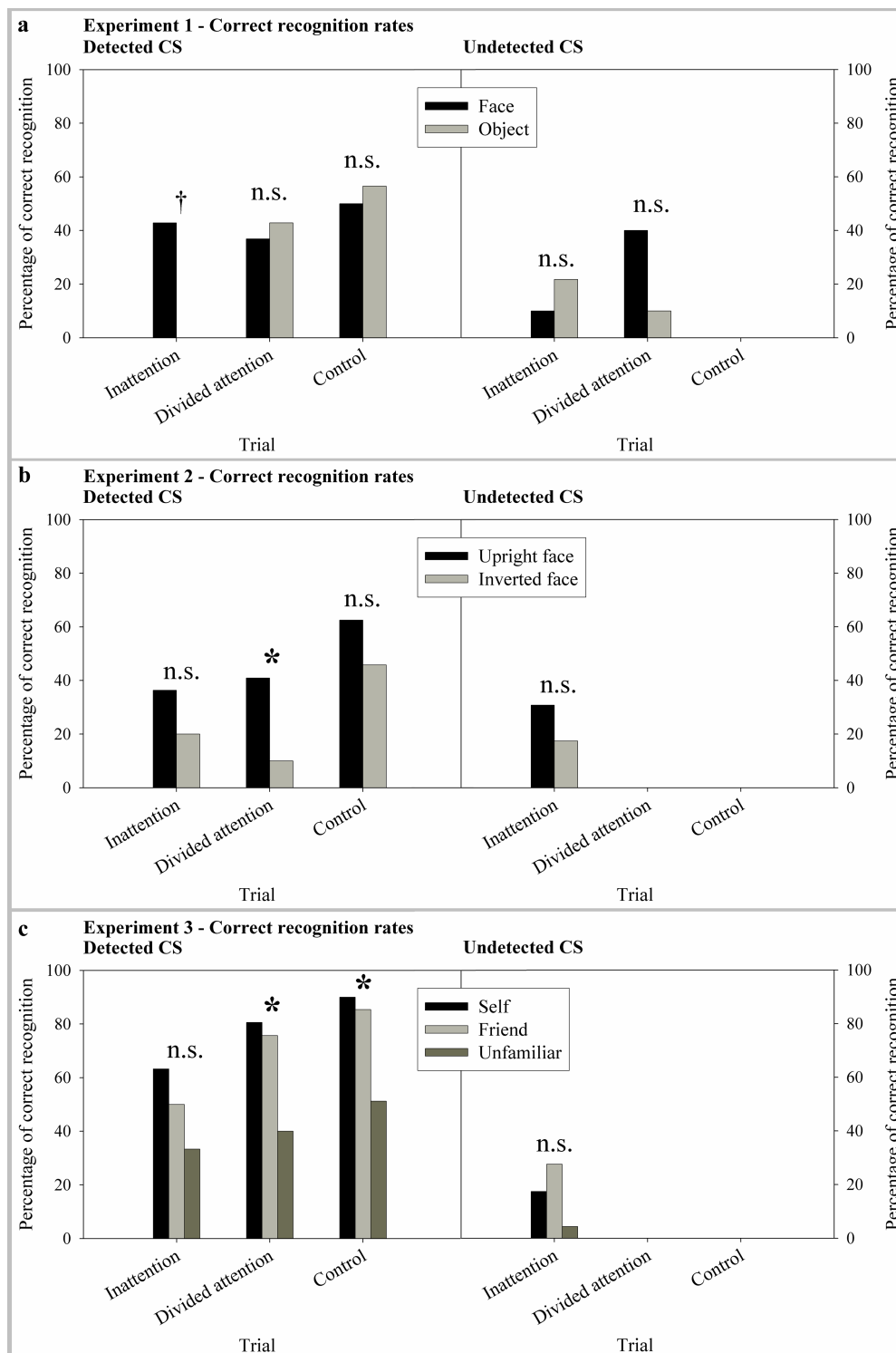
In addition, after the 9 trials, participants were presented with the four faces and were asked to identify them. To make sure that the possible differences obtained between the three groups of participants were due to the different familiarity of the CS they had been presented, participants who were not able to identify one (would it be their own face or their friend's face) or both familiar faces were discarded.

## **4.2 Results**

Twenty-one participants could not identify at least one of the two familiar faces during the final identification phase (ie 7 participants in the 'self-face' condition, 8 in the 'friend's face' condition and 6 in the 'unknown face' condition) and were discarded from further analyses (there were thus 41 participants per condition)<sup>4</sup>.

*4.2.1 Length judgment task.* The overall accuracy on the length judgment task was equal to 69%, which is in line with the two previous experiments. Chi-square analyses showed that the accuracy did not differ significantly between the three conditions on the inattention trial,  $\chi^2(2) = 2.36$ ,  $p > 0.25$ . Performance on critical trials (trials 4 and 8 being pooled), 70%, did not differ significantly from that on adjacent non-critical trials (trials 3, 5, 6 and 7 being pooled), 75%,  $\chi^2(1) = 1.52$ ,  $p = 0.22$ .

*4.2.2 Detection rates.* Here we focused again on inattention trial to examine whether the self-relevance and familiarity of faces can influence their resistance to blindness. The null hypothesis that all three types of faces are equally resistant to blindness could not be rejected since the facial identity did not significantly influence the detection rates (self-face = 44%, friend's face = 29%, unknown face = 44%),  $\chi^2(2) = 2.46$ ,  $p > 0.25$ . However, to ensure that this numerical difference of 15% between the 'friend's face' condition and the two other conditions did not reflect a genuine effect that the global Chi-square could not reveal, we perform two 2x2 analyses with the 'friend's face' condition tested against the two other conditions. These two analyses did not reveal significant differences between the friend's face condition and the other conditions, both  $\chi^2(1) = 1.89$ ,  $p = 0.17$ .



*Figure 5. Percentage of correct recognition of the critical stimulus (CS) depending on whether its presence was reported (left panels) or not (right panels) in Experiment 1 (a), Experiment 2 (b) and Experiment 3 (c). ‘\*’ refers to a significant  $p$  value  $< 0.05$  (Chi-square analyses); ‘n.s.’ refers to a non-significant  $p$  value  $> 0.05$ . † A statistical analysis was not possible here because of an insufficient number of observations in the ‘object’ condition. Note that the absence of correct recognition of undetected CS on divided attention and control trials is due to detection rates (see the left panel of Figure 4) that were at or near ceiling on those trials.*

At the bias trial, only one participant in the 'self-face' condition (2.44%), one in the 'friend's face' condition (2.44%) and five in the 'unknown face' condition (12.20%) reported seeing something when nothing additional was actually presented. Complete results are presented on the left panel of Figure 4c for exhaustiveness.

*4.2.3 Correct recognition rates.* A Chi-square analysis showed that the familiarity of the face tended to increase the recognition of the CS presented during the inattention trial (self-face = 39%, friend's face = 34%, unknown face = 17%). However, the difference between the three groups was not significant,  $\chi^2(2) = 5.18$ ,  $0.10 > p > 0.05$ . The right panel of Figure 4c nonetheless shows that this advantage of both familiar faces over the unknown face was significant in the divided attention and in the control trial. Figure 5c illustrates the recognition rates conditioned on whether the presence of the critical stimulus had been reported or not. In the inattention trial, the familiarity of the faces did not significantly enhance their recognition either when they had been detected or not. By contrast, familiarity significantly affected recognition rates on subsequent divided attention and control trials for detected items.

*4.2.4 Bias trial.* We examined the participants' choices after the bias trial to evaluate whether they were biased to think that the experiment dealt with their own face and therefore that their own face had been presented. Overall (ie irrespective of participants reporting the presence of an additional item or not), 12 participants (9.76%) chose their own face when nothing had actually been presented: 2 (4.9%) from the 'self-face' condition, 7 (17.1%) from the 'friend's face' condition and 3 (7.3%) from the 'unknown face' condition. In addition, binomial tests (confidence interval thresholded at  $\alpha = 0.05$ ) were used to assess whether these rates differed from what had been expected by chance (ie 12.5%). Participants from the 'friend's face' and 'unknown face' conditions chose their own face at random and participants from the 'self-face' condition chose their own face less often than expected by chance when nothing had been presented.

Among participants who reported having seen something on the bias trial (ie 7 participants, see above), none chose the self-face in the 'self-face' condition, one did so in the 'friend's face' condition and none did it in the 'unknown face' condition.

### **4.3 Discussion**

Unexpectedly, the results of this third experiment do not suggest any significant influence of self-relevance or of face familiarity on detection rates since all faces grabbed attention similarly. A first explanation for this null effect is that the combination of two properties likely to grab attention (ie facial aspect and self-relevance) does not increase the resistance of the self-face to blindness. Indeed, it seems that the detection rates reported when the self face was presented (ie 44%) was similar to those found for unfamiliar faces across our three experiments (ie 44% in the present experiment, 58% in Experiment 1, and 50% in Experiment 2, thus 51% on average).

However, our results indicated a non-significant numerical difference of 15% between the reported detection rates for a friend's face (ie 29%) and the two other types of faces (ie 44% for both). Therefore, an alternative explanation for this null effect might simply be a lack of statistical power. Indeed, IB experiments require a large number of subjects in order to reach good power and because participants were unexpectedly presented with their own face and a friend's face, we were limited by the number of participants we could recruit. Nevertheless, while there might be a power issue regarding a potential difference between the friend's face and the other faces, there seems to be no power issue regarding the comparison between the own face (44%) and the unknown face (also 44%). So, even if the difference between the friend's face and other faces was significant, this would not mean that the self-

face particularly attract attention but rather that the friend's face is less prone to attract attention than another face.

Nonetheless, there are two points that suggest that the non-significant difference between the 'friend's face' condition and the two other conditions does not reflect a genuine difference in the attention-grabbing capacity of such a highly familiar face. First, such a decrease in detection for the friend's face in comparison with a less familiar face (the unknown face) is quite unexpected. We would rather have expected a linear effect where the attention-grabbing capacities decreased as the familiarity decreased (ie self-face > friend's face > unfamiliar face, see eg Buttle and Raymond 2003). Second, a more thorough analysis of recognition data showed that the friend's face, contrary to the others, was relatively well recognised when participants did not report that they had seen something additional after the first critical trial (see the right panel of Figure 5c). Indeed, in that situation, 28% of participants accurately recognised their friend's face, against 17% that recognised their own face and 4% that recognised an unfamiliar face. Binomial tests indicated that the recognition of undetected CS was at random level for the self-face (Critical Interval = 3% to 28%) and for the unknown face (C.I. = 3% to 28%) but significantly higher than random level for the friend's face (C.I. = 4% to 27%)<sup>5</sup>. In other words, although they reported that they did not detect the presence of an additional item, participants from the 'friend's face' condition picked out their friend's face in the 8-AFC more often than expected by chance. This could indicate that some participants who detected their friend's face did not report it (eg because they did not remember that they had previously participated in an experiment in which they were paired with this particular person, found it 'weird' to perceive such a picture and were unsure of their perception) but nonetheless recognised it in the 8-AFC. This explanation is plausible if one imagines the situation of the participant. He/she, in most cases, is tested by an experimenter he/she does not know, on average 11 months after having been photographed to participate in another familiar faces experiment with his/her friend. Thus, it seems quite unlikely that this experimenter knows the identity of his/her friends and in addition have their pictures (see also footnote number 4)! In this situation, they had some reasons to be reluctant to report such a perception.

At the bias trial, like in the two other experiments<sup>6</sup>, there were only few false positives since only 7 participants out of 123 (5.70%) reported seeing something when nothing was actually presented. The bias trial also allowed us to verify whether participants were biased to think that their own face had been presented due to their previous participation in a self-face experiment. Apparently it was not the case since participants were less than 10% to choose their own face when nothing was presented (ie after the bias trial). Moreover, after the bias trial, in all three conditions the choice of the self-face was not higher than random level and actually, in the 'self-face' condition, the choice of the own face was even lower than expected by chance.

Finally, recognition rates indicated that familiar faces tended to be better recognised than unfamiliar faces even if the former were not more resistant to blindness than the latter (see Figure 4c).

## **5 GENERAL DISCUSSION**

Previous studies using the IB paradigm have shown that some categories of important and meaningful stimuli such as faces or self-referential materials (eg the participant's own name) particularly capture attention and resist IB compared to stimuli of a lesser importance (Mack and Rock 1998). The present study aimed at investigating the resistance of such important stimuli to IB with realistic facial stimuli and to investigate further the role of familiarity and self-relevance in the IB phenomenon.

### **5.1 Detection rates and resistance of facial stimuli to blindness**

Experiment 1 showed that faces were significantly better detected than pictures of common objects (ie 58% versus 4% of detection) under condition of inattention confirming with more realistic stimuli previous findings about the special attentional properties of faces (Mack and Rock 1998; Ro et al 2001; Theeuwes and Van der Stigchel 2006; but see Palermo and Rhodes 2003). In addition, results of Experiment 2 showed that upright faces were also better detected than inverted faces (ie 50% versus 20% of detection) ruling out any alternative explanation in terms of potential low level inherent differences between faces and objects. Finally, results of Experiment 3 showed no significant difference between the detection rates of the self-face (44%), a friend's face (29%) and an unknown face (44%). In addition, the self-face was clearly detected in the same range as an unknown face in all three experiments. In other words, even though the self-face combines two properties likely to grab attention, it does not resist more to blindness than another face. There are two possible interpretations of this result:

(1) *Self-referential stimuli have no special abilities to capture attention.* The first possibility is that self-relevance itself does not particularly capture attention in conditions of inattention (as shown in Experiment 3) and that a face is sufficiently important and meaningful to capture attention whatever its identity (as shown in Experiment 1 and Experiment 2). This would be in agreement with previous findings showing that self-referential stimuli do not automatically capture attention (Bundesen et al 1997; Gronau et al 2003; Harris et al 2004; Harris and Pashler 2004; Kawahara and Yamada 2004; Laarni et al 2000). The conditions in which self-referential stimuli have been shown to elicit attentional bias by comparison with other stimuli were as follow: when they were presented as distractor but that their processing was somehow related with the ongoing task (Brédart et al 2006; Gronau et al 2003; Kawahara and Yamada 2004), when - if unrelated with the ongoing task - they were presented centrally (ie within the observer's focus of attention, see Devue and Brédart 2008; Gronau et al 2003) and when enough attentional resources were available for their processing (Harris and Pashler 2004). Therefore, the current study indicates another situation in which self-referential stimuli might not be particularly prone to capture attention: when they are unexpectedly and briefly presented at the centre of the visual field while observers are engaged in another unrelated and demanding task.

(2) *Need of attention to process identity.* The second interpretation of our results could be that attentional capture is indeed determined by meaning and significance (see Mack and Rock 1998), but by a 'rough' meaning, at a processing stage where precise semantic details and fine sub-categorisation are not available yet (ie a 'not that late' selection of attention, see eg Lachter et al 2004 for a similar view). Indeed, previous models of face recognition (eg Bruce and Young 1986) suggest that faces may be processed at different levels of specificity, from a general (ie face vs. non-face decision) to a very specific level (ie determining the identity of a face). In order for faces to capture attention outside our direct attentional focus, it is required that there are perceptual processes that automatically scan and analyse the visual field for face stimuli. Because faces capture attention one has to assume that faces are discriminated by some 'pre-attentive' or unconscious processing (Theeuwes and Van der Stigchel 2006). The current findings suggest that the discrimination between a face and a non-face configuration can be based on this early pre-attentive processing (that could take place in the occipito-temporal cortex, see Devue et al 2007). However, in order to discern the identity of the face, a second 'attentive' processing stage (possibly originating in the fusiform gyrus, see Devue et al 2007) may be necessary. This could explain why faces are more likely to capture attention than other stimuli (see Experiment 1 and Experiment 2) while faces of different identities and levels of familiarity do not differ in their attention-grabbing capabilities (see Experiment 3). It would be interesting to address further the generalisability

of our finding to other types of facial classification (eg gender, gaze direction, race, or emotional expression) with realistic photographic stimuli.

In sum, further work is necessary to determine the exact reason of the present null effect. One might ask however why some other studies found that self-referential stimuli *capture* or *attract* attention (eg Brédart et al 2006; Mack et al 2002; Mack and Rock 1998; Moray 1959; Shapiro et al 1997; Wolford and Morrison 1980) if this null effect reflects a genuine absence of difference in the capacity of different faces to resist to blindness. We propose a '*retention hypothesis*' to explain the discrepancy between the present results and other ones. We suggest that terms such as attentional 'capture', 'attraction' or 'draw' might have been used inadequately.

It could be that in studies showing "self effects", self-referential stimuli did not capture attention but actually caused a difficulty to disengage attention because the paradigms used allowed the participants to attend to those stimuli (eg if the self-referential stimuli were located within the observer's focus of attention, see Devue and Brédart 2008; Shapiro et al 1997; Wolford and Morrison 1980; or if task demands allowed attentional shifts towards peripheral self-referential stimuli, see Brédart et al 2006). In those studies "self-effects" were either reflected by an increase or by a decrease in performance. On the one hand, self-referential stimuli could be advantaged (enhanced reportability, see eg Shapiro et al 1997; Wolford and Morrison 1980) by comparison with other stimuli. This advantage may be due to self-referential stimuli being processed more efficiently than less familiar stimuli once they were located in the observer's focus of attention (see eg Bundesen et al 1997). This assumption is supported by our recognition data: once a face had attracted attention (because of its facial properties per se) and that this face happened to be a familiar face, it was better recognised than a novel face. On the other hand, self-referential-stimuli could also interfere with the realisation of other tasks (ie an increase of reaction times or of error rates, see eg Devue and Brédart 2008; Harris and Pashler 2004; Wolford and Morrison 1980). This interference could be explained by a difficulty to disengage attention from those stimuli once they were attended by the observer. In other words, it is possible that although the self-face may not *capture* attention it nonetheless *retains* attention more than other faces once attention is focused on it (see Fox et al 2001 for a similar claim with fear-related stimuli). A recent eye-movement study (Devue et al submitted) supports this assumption by showing that the self-face does not receive a saccade faster in a visual search task but is fixated longer than unfamiliar faces. Therefore, the absence of specific "self-effects" in other studies could be accounted for by a difficulty to attend to these stimuli, resulting in an absence of attentional retention (eg if self-referential stimuli were located outside the focus of attention and that their presentation was irrelevant for the task at hand, see Laarni et al 2000), rather than by a lack of attentional capture.

## **5.2 Recognition rates**

In our two first experiments faces were not better recognised than common objects (Experiment 1) or that inverted faces (Experiment 2) in the inattention trial despite that faces were more readily detected than other stimuli. This is in line with our hypothesis formulated above that the visual system can detect facial structures pre-attentively but that further processing is necessary to access other information such as identity. Recognising a novel face after a so short exposure seems quite difficult (eg Bruce et al 2001)

In Experiment 3, familiar faces were overall better recognised than unknown faces (after several presentation of the CS) even though all three faces similarly attracted attention. These recognition results are consistent with the two hypotheses formulated above to explain our detection results. Indeed, the recognition performance suggests that once attention was on a face, the processing of familiar faces was facilitated by comparison with that of a face met

for the first time. This advantage in terms of recognition for familiar faces has been shown previously (see for instance Bruce et al 2001) and is probably due to the fact that the robust representation built after an extensive experience with highly familiar persons' faces facilitates their processing (Tong and Nakayama 1999).

Note that the fact that the same CS was presented to a given participant throughout the experiment might have facilitated its recognition on trials 8 and 9. However, after having seen the 8-AFC following the first presentation of the CS (as well as after the bias trial), participants knew exactly which stimuli could possibly be presented. This exposition to all the possible CS probably also made the detection and the recognition of the CS easier on trials 8 and 9 but this would have hold if we had presented different CS on trials 8 and 9.

### **5.3 False positives and participants' bias**

In our three experiments, the bias trial (ie the sixth trial without CS) showed that false positives were quite unlikely (ie around or less than 10%). This indicates that participants who reported the presence of the CS after the inattention trial did so accurately since they were capable of judging that nothing had been presented in the following bias trial.

Because it was presented after the inattention trial, the bias trial did not constitute a perfect measure of the occurrences of false positives. However, it was impossible to check the occurrence of false positives before the first critical inattention trial since an observer can only be once in condition of inattention in the IB paradigm. Nonetheless, in the specific context of our third experiment this trial allowed us to control that participants were not biased to think that the experiment dealt with their own face. Results indicated that participants did not tend to infer that their own face had been presented and that the responses they gave on the other trials were quite trustworthy.

### **5.4 Conclusion**

To summarise, our results showed that pictures of unknown faces were better detected than pictures of common objects or inverted faces. Moreover the self-relevance and the familiarity of a face did not affect its resistance to blindness. However, once a familiar face was attended, its processing was facilitated by comparison with that of a novel face. This study gives rise to novel hypotheses to investigate. The first possibility is that self-referential materials have no special attention-grabbing capacities, at least in the conditions defined by the IB paradigm. The second possibility is that the precise meaning of a facial stimulus is not yet available at the moment attention is captured and that attention is necessary to process identity.



## Footnotes

<sup>1</sup> [www.gimp.org](http://www.gimp.org)

<sup>2</sup> <http://www.pstnet.com/products/e-prime/>

<sup>3</sup> However, one could argue that participants were not in the same situation during the inattention trial and during the bias trial in which attention was in fact already divided due to the earlier presentation of the first critical trial (we thank Ian Thornton for this suggestion). In order to answer this potential criticism, we recruited 18 new participants to whom the first critical trial (inattention) was not presented anymore. Thus, following three non-critical trials, the bias trial constituted the first trial after which participants were asked whether they had detected something additional. Results showed that 5 participants (28%) reported seeing something although nothing had been presented. When asked to describe what they had seen before the 8-AFC, not surprisingly, 3 participants were not able to answer and just had a feeling of having seen something, 1 described a picture composed of points appearing after the big cross and before the mask, and 1 described a strange large image with plants. These two descriptions clearly fit the appearance of the mask and indicate that some participants may confuse the perception of the mask with that of an additional item. These participants probably noticed the mask because of the question and confused it with something additional because they had not noticed it before. It is thus possible that the rates of false positives seemed higher when nothing was presented at first because participants did not know what there was to 'see' whereas when the bias trial was presented after a genuine critical trial people knew what could be presented and by consequence were surer that they had not seen such thing. This problem of false positives had already been addressed by Mack and Rock (1998). In a control experiment similar to that conducted here, they found that 25% of participants reported that there was something although nothing had been presented. Thus, according to Mack and Rock (1998), "to avoid appearing either dumb or blind, these subjects may have answered yes to our question even though they actually had not seen anything else" (p238). They concluded that the rate of IB is generally underestimated since these cases are actually additional cases of IB.

<sup>4</sup> Nonetheless, it has to be mentioned here that most of these 21 participants recognised the stimuli as being their own face and their friend's face after we told them. Some of them admitted that they thought they had recognised the faces but did not dare to tell so. Some of them were also a bit stunned as they did not understand how the pictures of these faces could have ended up in the present experiment.

<sup>5</sup> Even though Chi-square analysis showed no significant effect of the type of face, as reported on the right panel of Figure 5c.

<sup>6</sup> The reported detection rate in the present experiment was not significantly different from that obtained in Experiment 1,  $\chi^2(1) = 1.18$ ,  $p = 0.28$ ; or in Experiment 2,  $\chi^2(1) = 1.18$ ,  $p = 0.28$ .

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