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Straight gaze facilitates face processing but does not cause involuntary attentional capture

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ABSTRACT

This study aimed to investigate the conditions under which eyes with a straight gaze capture attention more than eyes with an averted gaze, a phenomenon called the stare-in-the-crowd effect. In Experiment 1, we measured attentional capture by distractor faces with either straight or averted gaze that were shown among faces with closed eyes. Gaze direction of the distractor face was irrelevant because participants searched for a tilted face and indicated its gender. The presence of the distractor face with open eyes resulted in slower reaction times, but gaze direction had no effect, suggesting that straight gaze does not result in more involuntary attentional capture than averted gaze. In three further experiments with the same stimuli, the gaze direction of the target, and not the distractor, was varied. Better performance with straight than averted gaze of the target face was observed when the gaze direction or gender of the target face had to be discriminated. However, no difference between straight and averted was observed when only the presence of a face with open eyes had to be detected. Thus, the stare-in-the crowd effect is only observed when eye gaze is selected as part of the target and only when features of the face have to be discriminated. Our findings suggest that preference for straight gaze bears on target-related processes rather than on attentional capture per se.

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Straight gaze; visual search; attention selection; gaze contact; attention capture

Humans are highly sensitive to eyes and to the direction of the gaze of others, especially when others are looking at them (straight gaze) (i.e., Calder, Jenkins, Cassel, & Clifford, 2008; Cline, 1967). Thus, a straight gaze is more easily detected than a gaze directed away from the beholder (averted gaze). Typically, in visual search tasks, a straight gaze among averted gaze distractors is detected faster than an averted gaze among straight gaze distractors. The faster detection of straight gaze among other gaze directions is known as the stare-in-the-crowd effect (Conty, Tijus, Hugueville, Coelho, & George, 2006; Doi & Ueda, 2007; Doi, Ueda, & Shinohara, 2009; Palanica & Itier, 2011; Senju, Hasegawa, & Tojo, 2005; von Grünau & Anston, 1995). It has been observed with different types of stimuli, including eyes-only (Conty et al., 2006), full-face (Doi et al., 2009), or entire-body-with-face stimuli (Palanica & Itier, 2011). Models have proposed that straight gaze may be processed by a subcortical face detection system, which would enhance its detection even at peripheral locations (Senju & Johnson, 2009a, 2009b). Accordingly, the stare-in-the-crowd effect has been taken as evidence for preferred detection of straight compared to averted gaze.

Individuals sometimes have a feeling of being watched, even when paying attention to something else. For instance, if someone sitting opposite us on the tramway is looking at us while we are fixating on our smartphone, it is likely that we register the direction of their gaze without looking directly at them, even when other faces are present. It seems that people can effortlessly detect when a person in their periphery is looking at them. For instance, it is possible to discriminate the direction of gaze in the periphery while engaged in a demanding perceptual task at central fixation (Yokoyama, Sakai, Noguchi, & Kita, 2014) and Conty, Gimmig, Belletier, George, and Huguet (2010) established that direct gaze might distract attention during a Stroop task. These studies show that we can detect that someone is looking at us even when we do not directly pay attention to the person. However, little is known about whether

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direct gaze captures attention more strongly than averted gaze during visual search for an unrelated target (i.e., when the gaze stimuli are visual distractors). Alternatively, it may be that the preferential processing of direct over averted gaze is limited to target processing.

Indeed, attentional capture by a stimulus feature can be measured as enhanced target processing or as increased visual distraction, depending on whether the feature of interest occurs in the target or in the distractor. In the latter case, attentional capture is observed as an increase in reaction times (RTs) in the presence of an irrelevant-but-salient stimulus. The salient distractor competes with the task-relevant stimuli for the allocation of attention, resulting in longer RTs to the target (Theeuwes, 1992, 2010). With this paradigm, it has been established that simple stimulus features such as colour, shape, size, luminance, and onsets may capture attention (Schreij, Owens, & Theeuwes, 2008). However, the evidence for attentional capture by faces is scarce (Langton, Law, Burton, & Schweinberger, 2008). It is unknown whether faces with straight gaze cause stronger distraction than faces with averted gaze, as suggested by the stare-in-the-crowd-effect.

In Experiment 1, we examined whether a salient gaze distractor may capture attention. We used a visual search task where faces with closed eyes were used as target and nontargets (Cooper, Law, & Langton, 2013). Only the eyes of the gaze distractor were open. The target face was a slightly rotated face among fully upright faces. The gaze direction of the distractor was either straight or averted. The location of target and distractor were unpredictable in order to prevent the possibility of focusing attention on a specific location, which reduces attentional capture (Theeuwes, 1991). All faces were shown in a frontal view, which is known to capture attention (Farroni, Csibra, Simion, & Johnson, 2002; Johnson, Dziurawiec, Ellis, & Morton, 1991; Palanica & Itier, 2014).[1]

To our knowledge, this is the first time that straight and averted gazes are used as task-irrelevant distractors in a visual search experiment. If straight gaze elicited attentional capture, we would expect longer RTs to the target in the presence of a straight-gaze compared to an averted-gaze distractor. Alternatively, it may be that the processing of gaze direction requires focused attention (Burton, Bindemann, Langton, Schweinberger, & Jenkins, 2009) and might not be processed preferentially as a distractor (Doi & Shinohara, 2013). Moreover, the luminance contrast between the sclera (the white region of the eye) and the iris in opened eyes (Kobayashi & Kohshima, 2001) is a salient physical stimulus regardless of gaze direction (Mormann et al., 2015). This suggests that opened-eyes distractors may elicit attention capture irrespective of their gaze direction, hence without any asymmetry between straight and averted gaze distractors.

Table 1. Mean and standard deviation (in parenthesis) for reaction times and accuracy in the four experiments.

	Reaction time	Accuracy
Experiment 1 ($n = 13$)		
Straight gaze distractor	931 (78)	93.0 (3.3)
Averted gaze distractor	932 (78)	92.2 (4.0)
No gaze distractor	917 (75)	93.0 (4.3)
Experiment 2 ($n = 13$)		
Straight gaze	771 (99)	92.0 (4.4)
Averted gaze	809 (117)	86.5 (8.6)
Experiment 3 ($n = 14$)		
Straight gaze	858 (106)	91.3 (4.5)
Averted gaze	878 (112)	92.0 (4.1)
Experiment 4 ($n = 17$)		
Straight gaze present	601 (68)	96.3 (2.6)
Averted gaze present	606 (60)	95.4 (3.1)
Straight gaze absent	645 (79)	98.0 (2.1)
Averted gaze absent	639 (83)	97.8 (1.9)

Reaction times are in milliseconds and accuracy in percent correct responses. Note that straight and averted gaze targets were blocked in Experiment 4.

Experiment 1

Method

Participants

All participants were students from the University of Geneva without neurological or psychological difficulties. The present study was approved by the ethics committee of the Faculty of Psychology and Educational Sciences at the University of Geneva and the participants provided their informed consent to participate in the study. Thirteen participants (seven female; age: $M \pm SD = 20 \pm 1.35$ years) performed Experiment 1 (see Table 1).

Apparatus and stimuli

Stimulus presentation was coded with the Cogent Software package (http://www.vislab.ucl.ac.uk/cogent.php) in Matlab 2006 (Mathworks, Natick, MA, USA). The stimuli consisted of six different frontal faces (three male). The distractor face had a straight gaze or averted gaze (30° leftward and 30° rightward) and the remaining faces had closed eyes. The stimuli were selected from a database used in previous studies on gaze perception (Conty et al., 2006; Conty, N'Diaye, Tijus, & George, 2007; George, Driver, & Dolan, 2001; Vuilleumier, George, Lister, Armony, & Driver, 2005). All stimuli were in scales of grey. The luminance and the size of the stimuli were equalized with Photoshop CS6 to avoid any low-level imbalances. The position of the mouth and eyes were normalized across all stimuli. All stimuli were cropped in an elliptical mask (4° × 3.3° of visual angle; see Figure 1). A fixation cross (0.24° × 0.24°) was shown in the centre of the screen and the faces were displayed at 4.5° of visual angle. The target stimulus was tilted by ±20° in the frontal plane.

Procedure

The participants were instructed to identify the gender of the tilted face with right or left arrow keys as quickly and as accurately as possible. A trial started with the presentation of the fixation cross for randomly 600 to 1600 ms. Then, the visual search array was displayed until the participant responded. Feedback was provided following incorrect responses. Stimulus-response mapping was counterbalanced across participants. To familiarize the participants with the task, participants completed 48 practice trials prior to the start of the first block of the experiment.

Search displays contained six different individual faces. Five of the faces were fully upright and constituted the distractors whereas the sixth face was slightly tilted and constituted the target. Participants were instructed to maintain fixation on the central fixation cross throughout the experiment. The eyes of all faces were closed in one-third of the trials, while in the other two-thirds an opened-eyes distractor face with straight or averted gaze (50% each) was present among the distractor faces. The choice of the target identities, the presence of the gaze singleton, and the location of the tilted face varied randomly across trials. Therefore, each of the six identities was used as a possible target at the lateral positions of the array. The target never appeared on the vertical midline. Additionally, each identity could be the distractor singleton with either straight or averted gaze. This resulted in a total of 1152 trials, distributed over 24 blocks of 48 trials.

Statistical analysis

Incorrect trials were excluded from the RT analysis and we computed the median RT for each distractor condition: when no distractor was present, when a straight-gaze distractor was present, and when an averted-gaze distractor was present. We then performed a repeated-measures univariate analysis of variance (rANOVA) on these median RTs, with the distractor condition as within-subject factor. The assumption for sphericity was checked and *p* values were corrected according to Greenhouse-Geisser. *F*, *p* values, and effect sizes (η_p^2) are reported. Post-hoc comparisons were performed using the HSD Test of Tukey, which takes into account multiple comparisons. The same statistical analysis was performed on the accuracy (percentage of correct responses) of gender categorization of target faces.

Results

The results are summarized in Figure 2 and detailed in Table 1.

Reaction times

The rANOVA revealed a main effect of distractor, $F(2,24) = 4.89$, $p < .05$, $\eta_p^2 = .29$. Post-hoc Tukey tests found significantly ($p < .05$) slower RTs in the presence of a straight-gaze ($M \pm SD = 931 \pm 78$ ms) or an averted-gaze distractor (932 ± 78 ms) than in the absence of a distractor (917 ± 75 ms). However, there was no significant RT difference between the opened-eyes distractor conditions, that is, between straight-gaze and averted-gaze distractor ($p = .99$).

Accuracy

The accuracy of gender categorization was not significantly different between the three distractor conditions ($F < 1$).

Discussion

In this first experiment, our results revealed that the presence of an opened-eyes distractor singleton increased RTs to an unrelated target (i.e., a tilted face), showing that the salient gaze stimulus captured attention involuntarily in a bottom-up manner (Theeuwes, 1992, 2010). However, the attentional capture effect did not vary between straight and averted gaze. This suggests that, irrespective of gaze

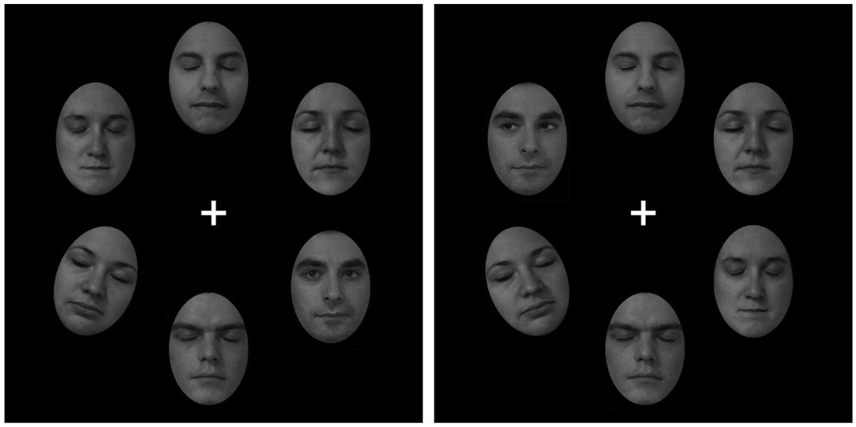

Figure 1. Example of search displays from Experiments 1, 2, 3, and 4. On the left, the visual search display consists of a straight-gaze face among closed-eyes faces and one of the closed-eyes faces is tilted to the right. On the right, the visual search display consists of an averted-gaze face among closed-eyes faces and one of the closed-eyes faces is tilted to the left. The tilted face was the target face in Experiment 1, while the opened-eyes face was the target in Experiments 2, 3, and 4.

direction, opened eyes were salient in the context of closed eyes due to their physical characteristics (i.e., large white sclera contrasting with the iris/pupil; Kobayashi & Kohshima, 2001).

This result may reflect the involvement of an "Eye Direction Detector" (EDD) that detects the presence of opened eyes and operates upstream from gaze processing and shared or joint attention processes (Baron-Cohen, 1994). The EDD may rely on coarse processing mechanisms allowing the pre-attentive detection of eye configuration, and possibly involves a fast subcortical processing pathway (Johnson, Senju, & Tomalski, 2015; Senju & Johnson, 2009b).

However, our data do not support the hypothesis of stronger attentional capture by straight gaze as compared to averted gaze when these stimuli are irrelevant distractors with respect to the task at hand. This is consistent with the recent evidence gathered by Cooper et al. (2013) and Doi and Shinohara (2013), who did not establish any attentional capture for

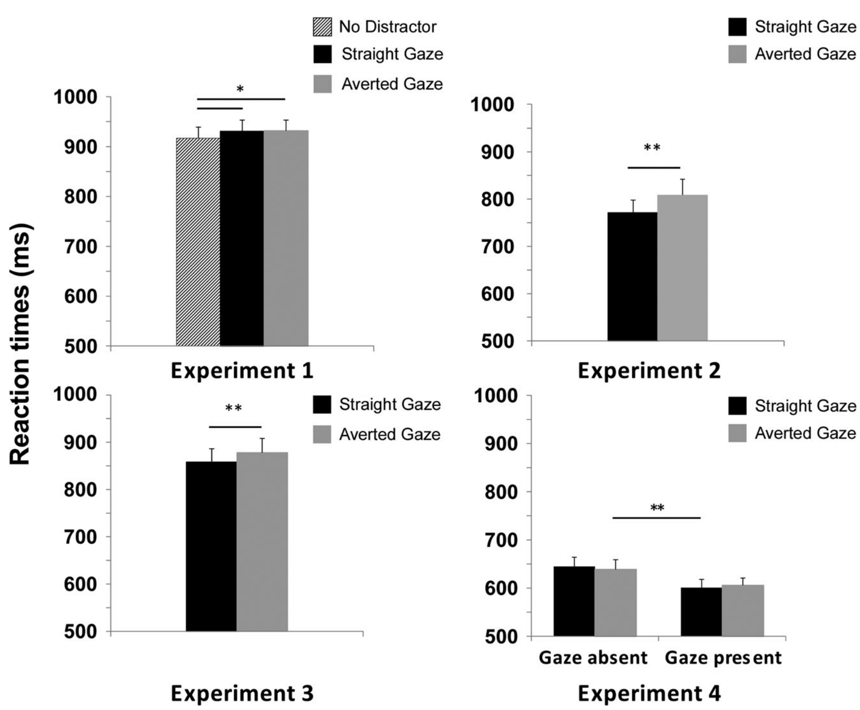

Figure 2. Mean reaction times (in ms) in Experiments 1, 2, 3, and 4. The straight gaze conditions are in black and the averted gaze conditions in light grey. The vertical lines represent the standard errors of the means. *$p < 0.5$; **$p < .01$.

straight gaze. These results may appear to stand in contrast with the findings of several researchers who reported faster detection of straight gaze targets relative to averted gaze targets in visual search tasks (Conty et al., 2006; Doi et al., 2009; Doi & Ueda, 2007; von Grünau & Anston, 1995; Palanica & Itier, 2011; Senju et al., 2005), in gender discrimination tasks (Macrae, Hood, Milne, Rowe, & Mason, 2002) and in gaze discrimination tasks (Palanica & Itier, 2014). However, a key explanation for these discrepant results may be that straight or averted gaze stimuli served as search targets in these studies, whereas they were displayed as incidental distractors in the present experiment. Hence, the preference for straight gaze might require the eyes or the face to be selected by attention (Doi & Shinohara, 2013). In other words, the preference for straight gaze might be produced by processes following attentional selection.

In order to test this hypothesis, we ran Experiment 2 with the same stimuli but a different task. Instead of being instructed to ignore the face with open eyes, participants were asked to report its gaze direction. As before, the opened-eyes target was presented among closed-eyes nontarget faces and we compared the RTs for discriminating straight versus averted gaze of the target. Our prediction was that faster response times would be observed for straight than averted gaze targets.

Experiment 2

Method

Participants

Thirteen participants (10 female; 23 ± 2.77 years; see Table 1) from the same pool as in Experiment 1 participated.

Stimuli

The stimuli were identical to the ones used in Experiment 1.

Procedure

On each trial, five closed-eyes faces and one opened-eyes target face were presented. The target was a straight gaze in half of the trials and an averted gaze in the other half (see Figure 1). Participants were required to discriminate the gaze direction (straight or averted) of the opened-eyes target singleton. Due to the task requirements, we removed the no opened-eyes stimulus condition. In order to use the same displays for all experiments, one of the five distractor faces was tilted sideways as in Experiment 1. Participants were asked not to consider the orientation of this face. As in Experiment 1, the opened-eyes stimulus singleton could appear at all but the midline locations.

Statistical analysis

Incorrect trials were excluded from the RT analysis. Paired Student's *t*-tests were used to compare participants' median RT and accuracies for straight-gaze versus averted-gaze trials. Effect sizes are reported in the form of Cohen's *d*.

Results

The results are summarized in Figure 2 and detailed in Table 1.

Reaction times

The *t*-test showed a significant difference between RTs to straight and averted gaze targets, $t(12) = -3.56$, $p < .01$, $d = .35$. Participants were faster at discriminating the position of the eyes of straight (771 ± 99 ms) than averted (809 ± 117 ms) gaze targets.

Accuracy

The accuracy was higher for straight (92 ± 4.4%; see Table 1) than averted (86.5 ± 8.6%) gaze targets, $t(12) = 3.7$, $p < .01$, $d = .81$.

Discussion

In Experiment 2, where the face with open eyes was the target and participants had to discriminate its gaze direction, straight gazes were discriminated faster than averted gazes. Thus, when participants were required to select the face with opened-eyes among distractor faces with closed-eyes and to process its eye region, the stare-in-the-crowd effect emerged (Palanica & Itier, 2014). It therefore seems that the deployment of attention toward eye gaze is necessary for the preference for straight gaze to occur.

However, does the present result truly depend on the explicit processing of and the response to gaze direction? Indeed, this result could also reflect a bias for straight gaze as compared to averted gaze, which would potentially lead to a faster and more accurate response to straight gaze. Humans indeed show a bias to perceive others' gaze as directed toward them, particularly in the presence of perceptual uncertainty, which might be generated by visual search tasks (Mareschal, Calder, & Clifford, 2013; Mareschal, Otsuka, & Clifford, 2014). As a result of this bias, participants may have been prone to respond "straight" faster and more often than "averted". Thus, the preference for straight gazes in Experiment 2 might be interpreted as a response bias rather than enhanced perceptual processing of straight gaze.

To control for this possibility, we performed a third experiment that was identical to Experiment 2 but used a gender categorization task. Face categorization with respect to age, gender, facial expression, or race may assess the role of the processing of facial features and their configuration in the preference for straight gaze. In other words, this task required participants to process the facial features and their configuration while gaze direction was incidental to it (Doi & Shinohara, 2013). Previous studies indicated faster RTs in gender categorization for straight-gaze faces relative to averted-gaze faces (Macrae et al., 2002). In Experiment 3, we tested whether a similar result might be obtained in our visual search task. The target face was a male or female face with open eyes that showed either a straight or an averted gaze. The direction of gaze of the face target was irrelevant and the participants' task was to categorize the gender of the target face. We predicted shorter RTs for gender categorization with straight than averted gaze of the target face.

Experiment 3

Method

Participants

Fourteen participants (8 female; 19.79 ± 0.97 years) from the same pool as above performed the experiment (see Table 1).

Stimuli

The stimuli were the same as in the previous experiments.

Procedure

The procedure was similar to Experiment 2 except for the instruction. Instead of judging gaze direction, participants were asked to discriminate the gender of the face with open eyes. The gaze direction of the face with open eyes was straight or averted. In half of the trials, the response was "female" and in the other half "male". The subjects responded with the left and right arrow keys of the keyboard. As before, one of the five distractor faces was tilted sideways. There were 576 trials.

Statistical analysis

Incorrect trials were excluded from the RT analysis. We used paired Student's *t*-tests in order to compare the median reaction times and response accuracy in the straight-gaze versus the averted-gaze conditions.

Results

The results are summarized in Figure 2 and detailed in Table 1.

Reaction times

The RTs of gender categorization were significantly different for the straight and the averted-gaze conditions, $t(13) = -3.19$, $p < .01$, $d = .18$. RTs were faster when the target face had a straight (858 ± 106 ms; see Figure 2) than an averted (878 ± 112 ms) gaze.

Accuracy

The accuracy of gender discrimination did not significantly differ ($p = .49$).

Discussion

In Experiment 3, we investigated whether the processing of straight-gaze faces was faster in a task of gender discrimination. The task required target face selection and the analysis of facial features (Zhao & Hayward, 2010). Participants discriminated the gender of the face with open-eyes faster when its gaze was straight compared to when its gaze was averted. Because gaze direction was independent of the gender categorization task, it is unlikely that a response bias for straight gaze would explain the result (Mareschal et al., 2013, 2014).

Our results suggest that the occurrence of the stare-in-the crowd effect is limited to conditions where the gaze stimulus is part of the target face, even though explicit gaze direction processing was not necessary.

It is noteworthy that in the present experiment, the stare-in-the-crowd effect was evident in the results although opened-eyes target faces were surrounded by closed-eyes distractors (Cooper et al., 2013). Thus, distractor features per se and the dissimilarity between target and distractors may not be the key factors in the stare-in-the-crowd effect. Rather, it seems that perceptual processing of faces with a straight gaze is facilitated.

Interestingly, it has previously been reported that the stare-in-the-crowd effect is not observed in a simple detection task where straight or averted gaze targets have to be detected among closed-eyes distractors (Cooper et al., 2013). However, target detection may be entirely based on saliency in this task. Specifically, the detection of the salient luminance contrast between the white sclera and the surrounding skin or iris in opened eyes (Kobayashi & Kohshima, 2001) is sufficient to allow for the detection of the target. Advanced processing of facial features is not required. In other words, this task may only rely on the detection of open eyes and may not require the processing of gaze direction, which is likely to take place downstream from eye detection (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995), at a level where featural and configural face information is processed. In an attempt to replicate Cooper et al.'s (2013) results, we ran an opened-eyes detection task where faces with straight and averted gaze were presented as the targets among closed-eyes nontargets (Cooper et al., 2013).

Experiment 4

Method

Participants

Seventeen students (nine female; 21.35 ± 3.48 years) from the same pool as above participated (see Table 1).

Materials and apparatus

The stimuli were identical to Experiment 1.

Procedure

The procedure was similar to Experiment 1, but the task differed. Participants were required to detect the presence versus the absence of an opened-eyes target embedded among closed-eyes faces. More specifically, in one block of trials they were asked to detect the presence of a straight gaze among closed eyes and, in another block of trials, they had to detect the presence of an averted gaze among closed eyes. There was a total of 192 trials in one of six blocks. Straight and averted gaze targets alternated between blocks and block order was counterbalanced across subjects. As before, one of the six faces was tilted sideways as in Experiment 1 and participants were informed not to consider the orientation of the face. The total number of trials was 1152.

Statistical analysis

Incorrect trials were excluded from the RT analysis. A rANOVA with target presence (present, absent) and trial block (straight gaze target, averted gaze target) as within-subject factors was conducted on RTs and accuracy.

Results

Reaction times

We found a main effect of target presence, $F(1,16) = 25.42$, $p < .01$, $\eta_p^2 = .61$. Participants were faster to indicate the presence (604 ± 64 ms) than the absence (642 ± 81 ms) of the target. Neither the effect of gaze direction ($F < 1$) nor the interaction of target presence and trial block ($F(1,16) = 1.32$) approached significance. In other words, RTs were not significantly faster for the detection of straight- than averted-gaze targets.

Accuracy

The results showed a main effect of target presence. Participants were more accurate on target-absent trials (97.73 ± 1.96%; see Table 1) than on target-present trials (95.73 ± 2.87%), $F(1,16) = 13.86$, $p < .01$, $\eta_p^2 = .46$. Neither the effect of gaze (F = 1.8) nor the interaction of target presence and trial block ($F < 1$) approached significance.

Discussion

Experiment 4 was designed to test the influence of the level of facial feature processing (i.e., feature discrimination or mere detection of the face target) required for the stare-in-the-crowd effect. In this experiment, the processing of the facial features of the target was not necessary. We used a gaze detection task where either straight- or averted-gaze targets (presented in different blocks) were to be detected among closed-eyes face distractors (Cooper et al., 2013). The task depended on the detection of the salient contrast between iris and sclera region (Kobayashi & Kohshima, 2001) in opened eyes (relative to closed eyes). Hence, although successful performance required attentional selection of the target face, it did not require any detailed processing of facial features. In particular, processing of gaze direction was not necessary. In agreement with recent findings (Cooper et al., 2013), there was no evidence for a stare-in-the-crowd effect in this experiment.

General discussion

In the present study, we examined attentional capture by a straight gaze in visual search tasks. In all experiments, we used visual search displays with faces that had closed eyes. This manipulation reduced the perceptual imbalance between the gaze direction of interest and the remaining stimuli. Recently, it was proposed that this perceptual imbalance was the origin of the "stare-in-the-crowd" effect (Cooper et al., 2013). Experiment 1 revealed that, when gaze was irrelevant to the task, attentional capture by a gaze distractor was only attributable to the saliency of opened compared to closed eyes. That is, it did not matter whether the gaze of the face with open eyes was straight or averted. In Experiments 2 and 3, using the same visual search displays as in Experiment 1, gaze direction of the target face was manipulated. Experiment 2 revealed faster discrimination of gaze direction when gaze was straight as opposed to averted. In Experiment 3, the direction of gaze of the target face was again manipulated but it was irrelevant for the task. The gender of the target face was categorized faster when it had a straight compared to an averted gaze. Finally, in Experiment 4, we reduced the level of processing of face features in a paradigm similar to previous studies (Conty et al., 2006; Cooper et al., 2013; Doi et al., 2009; Doi & Ueda, 2007; Palanica & Itier, 2011; Senju et al., 2005), except that the target face had to be detected among closed-eyes face distractors as in Cooper et al. (2013). We did not find faster detection of target faces with straight compared to averted gaze.

In our experiments, straight gaze did not capture attention more than averted gaze when displayed as an irrelevant peripheral distractor or when face processing was not mandatory. Previous studies reported stronger attentional capture by straight gaze when the stimulus was close to the central target (Conty et al., 2010) or outside the focus of attention but relevant for the task because gaze direction had to be reported in a dual task (Yokoyama et al., 2014). Experiment 1 provided evidence that straight- and averted-gaze distractor singletons captured attention equivalently, most probably due to the large saliency of open eyes among closed eyes (Kobayashi & Kohshima, 2001). In contrast, the data from Experiments 2 and 3 support the idea that straight gaze is processed faster than averted gaze when gaze direction is presented at the target location. Altogether, Experiments 1, 2, and 3 indicate that the stare-in-the-crowd effect emerges only in situations where gaze direction of the target face is manipulated. Therefore, the stare-in-the-crowd effect seems to depend on the attentional selection of the face with straight or averted gaze. Further, Experiment 3—using a gender categorization task—suggested that gaze does not need to be processed explicitly and can be incidental to the task at hand. However, Experiment 4 placed a boundary condition on the stare-in-the-crowd effect. When mere detection of an opened-eyes face target was requested, no advantage for straight over averted gaze detection was observed. Hence, the stare-in-the-crowd effect requires processing of the features and/or configuration of the target face.

Previous researchers have claimed that straight gaze captures visual attention (Conty et al., 2006; Doi et al., 2009; Doi & Ueda, 2007; Palanica & Itier, 2011; Senju et al., 2005; von Grünau & Anston, 1995). In all these experiments, researchers used a visual search task with a straight-gaze target displayed among averted-gaze nontargets or an averted-gaze target displayed among straight-gaze nontargets, with frontal or deviated head positions of the faces. Due to the interference from the surrounding nontargets with a different gaze or/and head direction, it is likely that visual search was quite inefficient and each item had to be processed individually to complete the task. Therefore, in this context, the processing of the facial features of each item might be required, even for a detection task. Therefore, serial search might cause the search asymmetry between targets with straight and averted gaze direction (viz. stare-in-the-crowd effect) commonly found in these studies.

Altogether, the current and previous studies emphasize the importance of context in gaze processing. In natural conditions, gaze is not processed as an isolated feature but rather in a context of other faces and the perception of gaze direction involves the integration of the orientation of facial features, the direction of the head, and the position of the eyes (Cline, 1967; Langton, 2000; Otsuka, Mareschal, Calder, & Clifford, 2014; Sweeny & Whitney, 2014). This implies that gaze direction may be most relevant to attention when it is processed in a face context. In brief, the stare-in-the-crowd effect appears to be markedly influenced by context and task demands.

Thus, the stare-in-the crowd effect depends on the level of target processing required during the task. The results of Experiments 2, 3, and 4 provided evidence that faster behavioural processing of straight-gaze over averted-gaze targets depends on in-depth face processing. Nevertheless, since RTs measure the final result of several processing stages, the preference for straight relative to averted gaze may originate in multiple processing stages, such as during target detection, attentional deployment, maintenance of the target in working memory, or/and decision making. Cognitive electrophysiological methods may be required to identify the processing stage giving rise to the stare-in-the-crowd effect. For instance, event-related potentials (ERPs) allow an accurate measure (at the millisecond time scale) of the different processing stages involved in the perception of gaze direction, such as face and gaze encoding, via the N170 (Towler & Eimer, 2015); spatial attention deployment via the N2pc (Eimer, 1996; Luck & Hillyard, 1994); and later storage in working memory via the contralateral delay activity (CDA) (i.e., Anderson, Vogel, & Awh, 2011). Therefore, ERPs may be an interesting tool to further characterize the origin of the stare-in-the-crowd effect (Doi et al., 2009) when the target is surrounded by closed eyes or attentional capture effects imperceptible at the behavioural level (Burra, Barras, Coll, & Kerzel, 2016).

Lastly, the current study is limited by the fact that only a single kind of task was used to manipulate the level of processing of face features, namely gender categorization. Developing a more nuanced understanding of the level of processing of facial features necessary for the stare-in-the-crowd effect could involve other face processing tasks, such as judgments of facial expression (Doi & Shinohara, 2013), age, or race. Moreover, one may suggest that the failure to observe the stare-in-the-crowd effect in Experiments 1 and 4 may be related to a ceiling or a floor effect. Despite mean RTs being slightly shorter in Experiment 3 (where we found the effect) than in Experiment 1 (where it was absent), we did not observe any statistical difference between these experiments. Therefore, it seems unlikely that the lack of distractor effect was due to RTs being at ceiling. Regarding the fast RTs in Experiment 4, we agree that the detection task was markedly different from Experiments 1, 2, and 3 with discrimination tasks (gender or gaze-related). Accordingly, RTs were statistically faster in Experiment 4 compared to the other experiments. However, we note that in an experiment similar to ours in many respects (Cooper et al., 2013), Experience 3 did not find a flat search slope and concluded that visual search was, at best, only “quite efficient” but not “pop-out”. In other words, RTs were influenced by the number of items displayed in the visual search display (4 and 8). Therefore, the lack of preference for straight over averted gaze is unlikely to result from a floor effect.

In summary, we demonstrated in four experiments that the stare-in-the-crowd effect is dependent on target selection and facial feature processing. There are boundary conditions demonstrating that straight gaze does not capture visual-spatial attention *stricto sensu*; rather, the stare-in-the-crowd effect seems to be associated with facial feature processing occurring after target selection.

Note

1. Most of the studies that investigated the stare-in-the-crowd effect used faces with deviated head in order to control for symmetry bias, i.e., a straight gaze with a frontal head appears to be more symmetrical than an averted gaze with a straight head (Conty et al., 2006; Cooper et al., 2013; Senju et al., 2005). However, we argue that the incongruity of the gaze direction and head orientation (Langton, Watt, & Bruce, 2000; Ricciardelli & Driver, 2008) might then enhance the attention capture by straight gaze. We therefore chose to use frontal face views.

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