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Eyes only? Perceiving eye contact is neither sufficient nor necessary for attentional capture by face direction

Anne Böckler [a,*], Robrecht P.R.D. van der Wel [b], Timothy N. Welsh [c,d]

[a] Max-Planck-Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
[b] Department of Psychology, Rutgers University, Camden, USA
[c] Faculty of Kinesiology & Physical Education, University of Toronto, Toronto, Canada
[d] Centre for motor Control, University of Toronto, Toronto, Canada

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ABSTRACT

Direct eye contact and motion onset both constitute powerful cues that capture attention. Recent research suggests that (social) gaze and (non-social) motion onset influence information processing in parallel, even when combined as sudden onset direct gaze cues (i.e., faces suddenly establishing eye contact). The present study investigated the role of eye visibility for attention capture by these sudden onset face cues. To this end, face direction was manipulated (away or towards onlooker) while faces had closed eyes (eliminating visibility of eyes, Experiment 1), wore sunglasses (eliminating visible eyes, but allowing for the expectation of eyes to be open, Experiment 2), and were inverted with visible eyes (disrupting the integration of eyes and faces, Experiment 3). Participants classified targets appearing on one of four faces. Initially, two faces were oriented towards participants and two faces were oriented away from participants. Simultaneous to target presentation, one averted face became directed and one directed face became averted. Attention capture by face direction (i.e., facilitation for faces directed towards participants) was absent when eyes were closed, but present when faces wore sunglasses. Sudden onset direct faces can, hence, induce attentional capture, even when lacking eye cues. Inverted faces, by contrast, did not elicit attentional capture. Thus, when eyes cannot be integrated into a holistic face representation they are not sufficient to capture attention. Overall, the results suggest that visibility of eyes is neither necessary nor sufficient for the sudden direct face effect.

1. Introduction

Humans are incredibly sensitive to the direction of other people's gaze — in particular whether the gaze is directed towards them (direct gaze) or away from them (averted gaze). When faces depict direct gaze (i.e., establish eye contact with the observer), they capture attention (Hood, Macrae, Cole-Davies, & Dias, 2003; Senju & Hasegawa, 2005; Vuilleumier, George, Lister, Armony, & Driver, 2005) and modulate subsequent attentional and cognitive processing of (social) information (Kleinke, 1986; see Senju & Johnson, 2009 for a review), thereby fostering communication and successful social interaction (Csibra & Gergely, 2009; Richardson & Dale, 2005). Of course, humans respond to numerous cues, many of which are not per se social in nature. Particularly powerful cues are typically defined by a sudden transition or change in the environment, such as the appearance/onset of a new object or a change in color or luminance of an existing object. Another dynamic stimulus that has received increasing experimental attention is the onset of motion. For example, Abrams and Christ (2003) have provided evidence that the sudden onset of motion provides a potent exogenous cue that captures attention (see also Al-Aidroos, Guo, & Pratt, 2010).

Although social and non-social attention cues can be independent from one another, they are paired in many real life situations, that is, they co-occur in time and space. An example of the co-occurrence of cues that are social in nature and cues that are not necessarily social is when a person suddenly looks at you. This instance entails both the social cue of direct eye contact and the cue of sudden onset motion. In a previous study, we investigated the effect of sudden onset eye contact on attentional capture, specifically asking whether direct eye gaze cues exert their influence independent of such motion cues (Böckler, van der Wel, & Welsh, 2014). For this purpose, participants classified letters that were presented randomly on one of four faces. In an initial display, two faces showed direct gaze (eye contact with the participant, head oriented towards participant) and two faces showed averted gaze (looking towards the lower left side of the display, head averted in same direction). Simultaneous with the presentation of the target or 900 ms prior to target presentation, one of the faces with averted gaze switched to direct gaze (and direct head orientation), and one of the faces with direct gaze switched to averted gaze (and averted head orientation). The other faces remained static and maintained their initial gaze direction. As a result, when the target was presented one face showed neither cue

* Corresponding author at: MPI for Human Cognitive and Brain Sciences, Stephanstr. 1A, 04103 Leipzig, Germany.
E-mail address: aboeckler@cbs.mpg.de (A. Böckler).

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(no motion and no direct gaze–static averted), one face showed only the social cue (no motion, but direct gaze–static direct gaze), one face showed only the motion cue (motion, but no direct gaze–sudden averted gaze), and one face displayed both cues (motion and direct gaze–sudden direct gaze).

We found that when the target was presented simultaneously to the change in gaze, reaction times (RTs) to targets were shortest when the targets were presented at the location of sudden onset direct gaze. When a stimulus onset asynchrony (SOA) was implemented and the target appeared 900 ms after the gaze transition, direct gaze cues still had facilitating effects while sudden onset motion cues had detrimental effects on RT (this latter detrimental effect of motion likely being associated with inhibition of return (e.g., Klein, 2000; Posner & Cohen, 1984)). Based on the pattern of results, it was concluded that direct gaze and sudden onset motion cues have independent influences on target identification and that two parallel attentional channels underlie the sudden direct gaze effect.

Although the results of Böckler et al. (2014) indicate independent influences of eye gaze and head motion cues, the characteristics of the social stimulus that led to the direct gaze effect remain an open question. The effect of sudden onset motion has been argued to be based on the operation of a single object-processing system that is involved in the fast recognition of novel and suddenly moving objects (Abrams & Christ, 2003; see Kourtzi, Bülthoff, Erb, & Grodd, 2002 for the similarity in underlying neural mechanisms). For direct gaze effects, on the other hand, different arguments and approaches have been put forward. While some scholars have emphasized the powerful effect of direct eye gaze as a bottom-up cue that rapidly and directly boosts activation in social brain areas (e.g., Senju & Johnson, 2009), others have focused on the communicative aspects of direct gaze. Csibra and Gergely (2009) have argued, for example, that eye contact and other forms of behavior directed towards a person (e.g., calling them by their name) can signal a communicative intent towards the observer. In the present study, we further investigated attentional capture by directed social behavior by manipulating the gaze and face cues. In the previous study (Böckler et al., 2014), head orientation and gaze orientation were always paralleled, and the specific role of the eyes for attentional capture remains open (see Hietanen, 1999; Langton, 2000 for differentiation of head and gaze orientation in attention cueing paradigms). The present study was conducted to better understand the influence of direct gaze in the capture of attention by the sudden onset of face orientation towards the participant. Is the visibility of eyes a necessary precondition for the effect? And is visibility of the eyes sufficient for attention capture by faces or is the participants' interpretation of the scene (e.g., as communicative in nature) also crucial?

To address these issues, we employed the paradigm used in Böckler et al. (2014) and, across three experiments, independently manipulated the presence of direct eye gaze (a bottom-up cue, according to Senju & Johnson, 2009). In Experiment 1, the faces were displayed with closed eyes, hence, they lacked direct eye gaze cues. If visibility of the eyes is necessary for attentional capture by a sudden onset social cue, there should be no effect of face direction in this experiment. If, by contrast, faces oriented towards participants still facilitate responses, this would point towards other factors such as face direction playing a crucial role in attentional capture by directed social behavior. In Experiment 2, faces were displayed wearing sunglasses. As in Experiment 1, these faces lacked the cue of direct eye gaze, but preserved head orientation as a potentially meaningful cue for communicative or approach behavior. The key difference between Experiments 1 and 2 was that the cue of direct eye gaze could be intuited in case of the sun glasses (Nuku & Bekkering, 2008; Teufel et al., 2009). Attentional capture by face direction in this experiment would suggest that direct gaze is not a necessary precondition for attentional capture by face direction. Finally, in Experiment 3, the cue of direct eye gaze was re-instantiated by presenting faces with open eyes. The faces in Experiment 3, however, were presented upside-down. Inverted faces are typically not integrated in a holistic representation, but are processed in a feature based local manner (Williams, Moss, & Bradshaw, 2004). If the mere presence of visible direct eye gaze is sufficient to elicit the (sudden) direct gaze effect, a facilitation effect for direct gaze cues should be observed in this experiment. If, by contrast, the context information of the upright face is needed for the influence of direct eye gaze to emerge, a facilitation effect for direct gaze should not be observed.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Sixteen participants (9 women, all right-handed) with a mean age of 25.6 years took part in the study and were compensated with 7 euro. All of the participants had normal or corrected-to-normal vision. Participants completed a written informed consent form and provided background information. The procedures complied with the ethical standards of the 1964 Declaration of Helsinki regarding the treatment of human participants in research.

2.1.2. Experimental setup and procedure

The procedure was based on our previous study (Böckler et al., 2014). Participants were seated at a desk in front of a 17-in TFT monitor (screen resolution of 1680 by 1050 pixels) at a distance of 80 cm and placed their hands on a keyboard. Each trial consisted of two displays (see Fig. 1a). The first display showed images of four female faces around a central fixation, each with the number "8" on their forehead. Each image was 200 by 250 pixels ($3.8 \times 4.7°$ visual angle) and presented on a black background. All the faces were images of the same woman, but varied in terms of their direction: two faces were directed towards participants and two faces were averted. The eyes of each face were closed. The second display appeared 1500 milliseconds after the first and contained two sets of changes. First, two of the images of the first frame were replaced with different images, so that one of the faces changed from direct to averted, and one changed from averted to direct (inducing apparent motion; e.g., Wertheimer, 1912). The faces at the other two locations remained unchanged, with one facing participants and one facing away throughout the trial. The images and orientations of the faces themselves were irrelevant for the actual task. Second, the Fig. 8 placeholders were replaced by one target letter ("H" or "S") and three distractors ("E" or "U"). There was only one target in a display and the remaining three distractor letters were always the same letter.

Participants were instructed to maintain fixation on the fixation cross at the center of the screen. The task was to identify the target letter as fast as possible by pressing either the S or the H key (for the target letters S and H, respectively) on a keyboard with their index fingers of the left and right hand, respectively. Note that even though stimulus–response assignment was not counterbalanced, response location was counterbalanced relative to stimulus location.

In total, there were 384 trials. Gaze direction, image position, and target/distractor combination were randomized. Before the experimental trials, participants completed 8 practice trials to ensure that they understood the task. Participants had a chance to take a short break after 192 trials. Matlab's PsychToolbox extension (Brainard, 1997; Pelli, 1997) was used for stimulus presentation and response recording. A customized script compiled and formatted the data with Matlab, and then exported the data to SPSS for further analysis.

2.2. Results and discussion

Reaction time (RT) was identified as the time interval from the onset of the target/distractor display until the first key was pressed. RTs associated with incorrect responses were eliminated from the data set (1.7% of the data). RTs that were outside of ± 2 SDs of the mean RT for each participant were eliminated from the data set (2.3% of the data). The remaining RTs were grouped according to condition (i.e., the data were

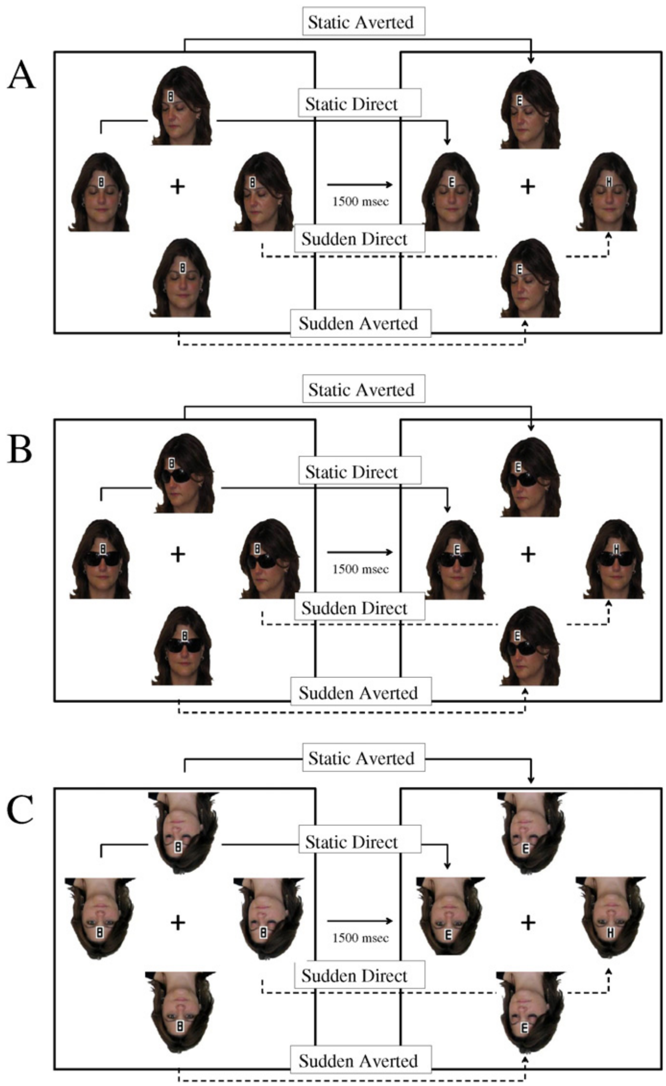

Fig. 1. Illustration of the two displays and each experimental condition in Experiment 1 (panel A), Experiment 2 (panel B), and Experiment 3 (panel C).

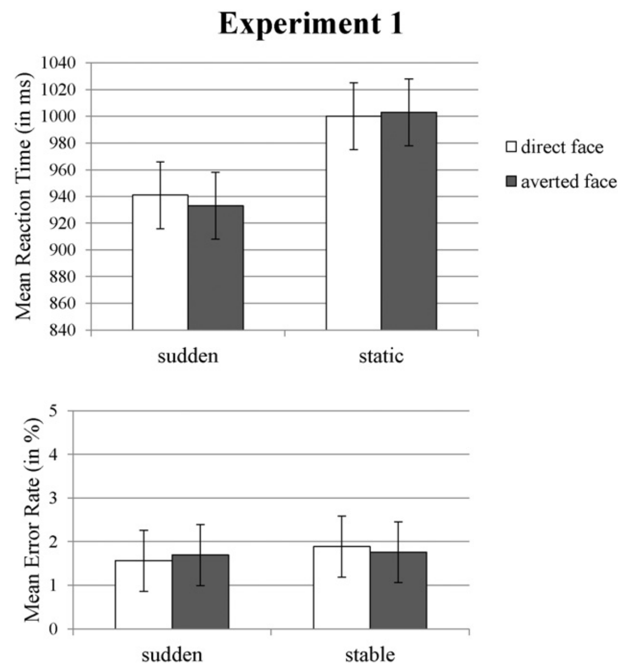

Fig. 2. Mean response time and error rates as a function of Motion and Face Direction for Experiments 1. Error bars display within-subjects confidence intervals based on Loftus & Masson, 1994.

collapsed across the location and identity of the target and distracters). Mean RTs and the total number of errors were calculated and submitted to separate 2 (Face Direction: direct, averted) by 2 (Motion: sudden, static) repeated measures ANOVAs. Results are depicted in Fig. 2. Note that the factor Gaze Direction refers to the final orientation of the face when the target/distractor display was presented, not to the original orientation presented at the beginning of the trial.

The analysis of RTs revealed a main effect of Motion, $F(1, 15) = 32.4$, $p < .001$, $\eta^2 = .684$. Consistent with previous research, RTs to targets presented on the sudden onset motion faces (those that changed face orientation) were shorter (937 ms) than RTs to targets on the static faces (1002 ms). No effect was found for Face Direction, $F(1, 15) < 1$, $\eta^2 = .010$, and the interaction of Motion and Face Direction was likewise not significant, $F(1, 15) < 1$, $\eta^2 = .037$. To investigate the interrelation of the two different cue types, a Pearson correlation was performed on the effects of Face Direction and Motion. It revealed no significant correlation ($r = -.34$, $p = .19$).[1] The analysis of response errors did not reveal any significant effects (Fs < 1), suggesting that the pattern of RTs was not associated with a speed-accuracy trade-off.

To statistically compare the effect of face orientation in the present experiment with results of an experiment in which faces had open instead of closed eyes (everything else being identical), we included data from a previous study (Experiment 1; Böckler et al., 2014) and performed an ANOVA including the additional between-subjects factor of Experiment. Results revealed a significant interaction of Experiment and Face Direction [$F(1, 30) = 7.0$, $p < .05$, $\eta^2 = .189$], suggesting that the effect of Face Direction was significantly larger when eyes were open than when eyes were closed.

The results of Experiment 1 indicate that the target was processed more efficiently when it was presented at the location of a moving face in comparison to a static face, replicating previous reports of attentional capture for motion stimuli (Abrams & Christ, 2003; Böckler et al., 2014). In contrast to previous findings for direct versus averted gaze, no effect was found for the direction of the face when eyes were closed, even at the location of the motion cue. A face with eyes closed that is (suddenly) directed towards the viewer is, hence, not a cue that captures attention, which is consistent with findings that eye gaze has a stronger and more immediate effect on subsequent attentional and cognitive processing than averted gaze or closed eyes (Senju & Johnson, 2009).

3. Experiment 2

In the second experiment, we aimed to further investigate the necessity of eye contact for attention capture by face orientation. To do so, a more ambiguous situation was instantiated in which faces were wearing sunglasses. Although direct eye gaze is still absent in this setting, there is no visible evidence that eyes are closed and face orientation towards participants still implicates communicative or approach behavior. The experience of interacting with people wearing sunglasses (or with wearing them oneself) might affect the processing of these faces because others' eyes are usually open behind the sunglasses. In this way, direct gaze could be intuited even though the eyes are not actually seen (Nuku & Bekkering, 2008; Teufel et al., 2009). It is important to

[1] Note that responses in this paradigm are relatively slow (see also Böckler et al., 2014) and participants, while being instructed to maintain fixation at the center, might have performed overt eye-movements in addition to covert shifts of attention. To reduce the effect of any explicit strategies related to shifts of attention we excluded trials in which RTs were 2 SDs above or below the mean RT for every participant. While the execution of eye movements does not preclude our interpretations due to the use of full counterbalancing, future studies could help understand the contribution of saccades to the observed result pattern.

note here that the purpose of this experiment was not to assess the influence of belief per say, but to use the manipulation of sunglasses to prevent the participant from seeing the eyes directly while creating a scenario in which the unseen eyes under the glasses could, in principle, be open. This context of Experiment 2 is contrasted to Experiment 1 where the eyes were definitely closed. If attention capture by face direction requires visibility of direct eye gaze, then no effect of face direction in the sunglasses condition should be observed (see Experiment 1). If an effect of face direction is found, this would suggest that visibility of eyes is not necessary for attention capture by face orientation.

3.1. Methods

3.1.1. Participants

A different cohort of 16 right-handed participants (10 women) with a mean age of 26.5 years completed Experiment 2. All individuals had normal or corrected-to-normal vision and signed informed consent forms prior to participation.

3.1.2. Experimental setup and procedure

The same method and procedure as Experiment 1 was employed in Experiment 2 except for one difference — the faces now wore sunglasses to prevent the participant from seeing the eyes (see Fig. 1b).

3.2. Results and discussion

RTs in error trials (2.4%) and RTs that were outside of ±2 SDs of the mean for each participant (2.3%) were eliminated from the data set. Mean RTs and the percentage of errors were calculated and submitted to separate 2 (Face Direction: direct, averted) by 2 (Motion: sudden, static) repeated measures ANOVAs. The results are depicted in Fig. 3.

The analysis of RTs revealed a main effect of Motion, $F(1, 15) = 62.6$, $p < .001$, $\eta^2 = .807$. Consistent with Experiment 1, RTs to targets on the sudden onset motion faces were shorter (944 ms) than to targets on the static faces (1056 ms). Again, no main effect was found for Face Direction, $F(1, 15) < 1$, $\eta^2 = .059$. Interestingly, we found a significant two-way interaction of Motion and Face Direction, $F(1, 15) = 9.3$, $p < .01$, $\eta^2 = .382$. This interaction emerged because RTs were shorter for targets at the sudden movement direct faces as compared to sudden movement averted faces, $t(15) = 2.4$, $p < .05$, whereas no difference was found between direct and averted gazes in the static condition, $t(15) < 1$. The Pearson correlation on the effects of Face Direction and Motion revealed no significant correlation ($r = -.08$, $p = .76$). The analysis of response errors revealed a significant main effect of Motion, $F(1, 15) = 13.5$, $p < .01$, $\eta^2 = .473$, due to more errors for static (3.0%) faces than for sudden (1.8%) faces. No other effects were significant, $Fs < 1$ suggesting that the pattern of RTs was not associated with a speed-accuracy trade-off.

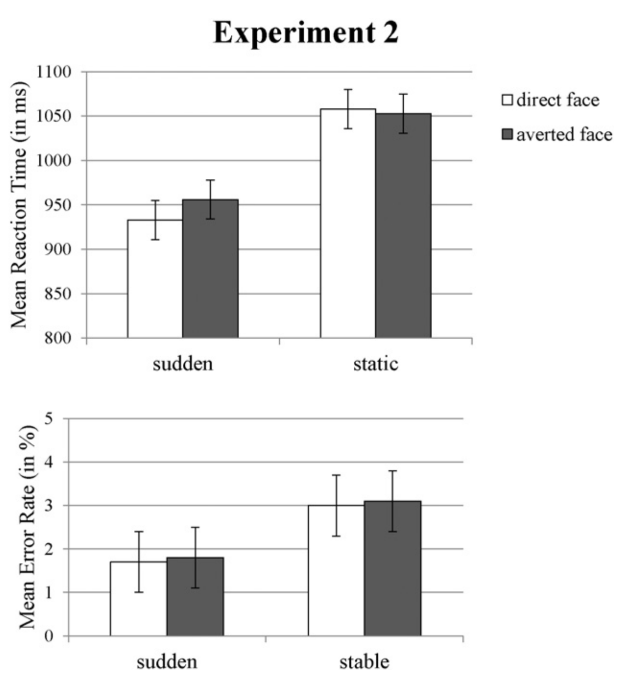

Fig. 3. Mean response time and error rates as a function of Motion and Gaze Direction for Experiment 2. Error bars display within-subjects confidence intervals based on Loftus & Masson, 1994.

Participants were debriefed after the experiment and asked specifically, whether they thought the eyes behind the sunglasses were open or closed and whether they thought the faces were looking at them or not when directed towards them. Thirteen out of the 16 participants answered the questions and all of them reported that they assumed the eyes to be open behind sunglasses and looking at them when depicted in the frontal view.

To explore differences between the processing of face direction without visible eyes because the eyes were closed versus hidden behind sunglasses, a subsequent ANOVA was performed that included the between-subject factor Experiment (Experiment 1 versus Experiment 2) and the within-subject factors Motion (sudden, static) and Face Direction (direct, averted). The results of this analysis revealed no overall differences in RTs or error rates between Experiments 1 and 2, $Fs < 1$. Crucially, the three-way interaction of Experiment, Motion, and Face Direction was significant, $F(1, 30) = 5.2$, $p < .05$, $\eta^2 = .147$. This analysis confirms that the pattern of effects between the two experiments was reliably different: while no effect of face direction was revealed for faces with closed eyes, faces with sunglasses elicited facilitation for direct faces when these faces moved and changed orientation.

As in Experiment 1, we conducted an additional analysis that included data from the previous study (open eyes; Böckler et al., 2014) in an ANOVA including the between-subjects factor Experiment. Results revealed no significant interaction of Experiment and Face Direction [$F(1, 30) = 1.6$, $p = .21$, $\eta^2 = .052$], suggesting that – even though Face Direction did not reach significance in Experiment 2 – the effect of Face Direction was not significantly reduced compared to the previous study.

The results of Experiment 2 suggest that faces directed towards the observer can capture attention in the absence of visible eyes. Hence, vision of eye gaze is not a necessary requirement for the sudden direct gaze/face effect to emerge. What drives this effect in the present experiment? Results of Experiment 1 (no facilitation for direct faces with closed eyes) indicate that a face orienting towards participants is not sufficient to capture attention. The crucial difference between closed eyes and eyes covered by sunglasses is that eyes behind sunglasses could, in principle, be open, which would implicate preserved communicative or approach behavior in case of (sudden) face orientation towards the participant. The results of the completed exit questionnaires confirmed that participants believed that the eyes were open and looking at them under the glasses. Previous research suggests that beliefs about eyes open under sunglasses can influence stimulus processing (Nuku & Bekkering, 2008; Teufel et al., 2009). Thus, participants' interpretation of the visual scene as (suddenly) being looked at through the sunglasses may have shaped the processing of direct face cues so that the faces now captured attention.

Interestingly, this facilitation effect for direct faces in the sunglass condition depended on whether or not face orientation changed suddenly. This latter finding is numerically (but not statistically) different from what was observed in Böckler et al. (2014), in which a facilitation effect was found regardless of whether the face was static or moving. The interaction of face direction and motion suggests that the face cue only captured attention in combination with a motion cue, possibly because it is a weaker attentional (Senju & Johnson, 2009) and communicative cue (Csibra & Gergely, 2009) than direct eye gaze.

4. Experiment 3

Experiment 2 revealed that attentional capture by face direction can occur even in the absence of visible eyes. In a final experiment, we aimed at investigating whether attentional capture can be disrupted when the cue of direct gaze is *present*, but meaningful context information is lacking. We therefore re-instantiated direct eye gaze by presenting faces with open eyes, but changed the contextual processing of the faces by presenting them in an inverted orientation. Previous research has shown that inverted faces are processed differently from upright faces in that they are not encoded into a holistic representation, but are processed in a local, feature based manner (Williams et al., 2004). If the mere presence of the direct eye gaze cue is sufficient to elicit the (sudden) direct gaze effect, we should find facilitation for faces directed at participants even when faces are inverted. However, disrupting the integration of gaze cues in a meaningful face representation likely hampers the processing of face direction as a meaningful, potentially communicative, social signal (Csibra & Gergely, 2009). If meaningful context information of the face is also necessary for the sudden gaze effect to occur, we should not find facilitation for direct gaze in this experiment.

4.1. Methods

4.1.1. Participants

A different cohort of 16 right-handed participants (6 women) with a mean age of 26.5 years completed Experiment 2. All individuals had normal or corrected-to-normal vision and signed informed consent forms prior to participation.

4.1.2. Experimental setup and procedure

The same method and procedure as Experiments 1 and 2 was employed in Experiment 3 except for two differences: 1) the faces were inverted, and, 2) the eyes were open (see Fig. 1c).

4.2. Results and discussion

RTs in error trials (2.2%) and RTs that were outside of ±2 SDs of the mean for each participant (2.8%) were eliminated from the data set. Mean RTs and the percentage of errors were calculated and submitted to separate 2 (Face Direction: direct, averted) by 2 (Motion: sudden, static) repeated measures ANOVAs. Results are depicted in Fig. 4.

The analysis of RTs revealed a main effect of Motion, $F(1, 15) = 4.5$, $p < .05$, $\eta^2 = .232$. Consistent with Experiments 1 and 2, RTs to targets on the sudden onset motion faces were shorter (991 ms) than to targets on the static faces (1023 ms). No main effect was found for Face Direction, $F(1, 15) < 1$, $\eta^2 = .005$, and no interaction was found for Motion and Face Direction, $F(1, 15) < 1$, $\eta^2 = .003$ (Fig. 4). The Pearson correlation on the effects of Face Direction and Motion revealed no significant correlation ($r = .19$, $p = .49$). The analysis of response errors revealed no main effect of Motion, no effect of Face Direction, and no interaction, $Fs(1, 15) \leq 1.3$, $\eta^2 \leq .080$. This result suggests that the pattern of RTs was not associated with a speed-accuracy trade-off.

To investigate whether the effects of Face Direction and Motion in Experiment 3 were statistically different from those in Experiment 2, we conducted an additional ANOVA comparing the results of Experiments 2 and 3. When experiments were combined, one participant was a statistical outlier in terms of overall performance (mean of z-transformed RTs and errors rates) and was excluded from the subsequent analysis. RTs and error rates did not differ between experiments, $Fs\ (1, 29) < 1.1$, $ps > .3$, $\eta^2 < .034$. The three-way interaction of Face Direction, Motion, and Experiment was significant, $F\ (1, 29) = 4.2$, $p < .05$, $\eta^2 = .126$. We take this as an indication that Experiments 2 and 3 were reliably different in terms of the presence of the sudden direct face effect.

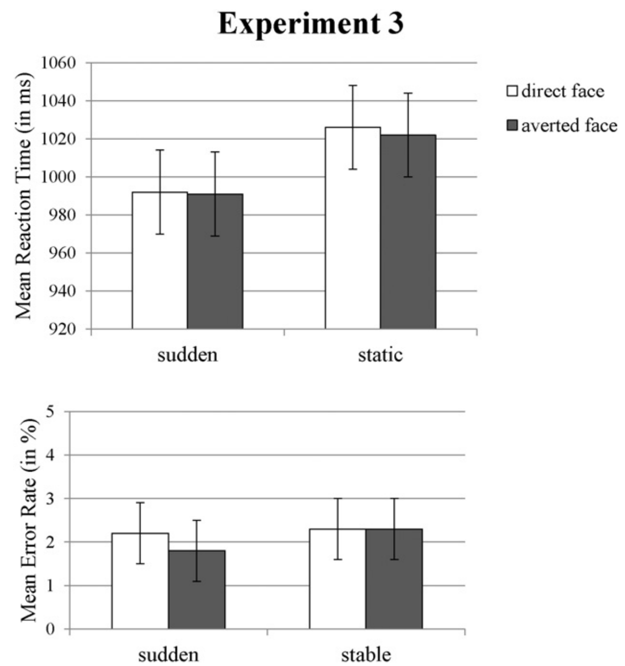

Fig. 4. Mean response time and error rates as a function of Motion and Gaze Direction for Experiment 3. Error bars display within-subjects confidence intervals based on Loftus & Masson, 1994.

Again, we conducted the additional analysis that included data from the previous study (open eyes and upright faces; Böckler et al., 2014) and performed an ANOVA including the between-subjects factor Experiment. This analysis revealed a significant interaction of Experiment and Face Direction [$F(1, 30) = 6.4$, $p < .05$, $\eta^2 = .176$], suggesting that the effect of Face Direction was significantly larger when faces were upright than when faces were inverted.

The results of Experiment 3 suggest that the mere presence of direct eye gaze is not sufficient to induce the (sudden) direct gaze effect. It has been argued that inverted faces are not encoded in holistic representations (Williams et al., 2004). This argument is supported by studies showing that different neurons respond to eyes and to faces, and that eye-sensitive neurons are inhibited when upright faces are shown, but that both face and eye-sensitive neurons respond when inverted faces are shown (suggesting that the faces and eyes are not processed holistically when inverted) (Itier, Alain, Sedore, & McIntosh, 2007; Itier, Latinus, & Taylor, 2006; Itier & Taylor, 2004). Hence, when gaze (i.e., eyes) was processed locally, instead of in the context of meaningful faces, participants may not have perceived or interpreted face/gaze direction as more or less meaningful (i.e., communicative). Even though the eyes in Experiment 3 were still apparently directed versus averted from participants, the lack of meaningful context information may have rendered the gaze cue inefficient in capturing attention.

5. General discussion

The present study investigated the effect of gaze/face cues and sudden onset motion cues that co-occurred in time and space on subsequent attention processes. Specifically, three experiments examined the necessity and the sufficiency of eye visibility for the occurrence of a (sudden) direct face effect. In the first experiment, faces were presented with closed eyes, preserving head orientation towards participants while eliminating eye gaze. No attentional capture associated with face direction was revealed in this experiment, suggesting an important role of eye gaze for capturing attention. This finding substantiates prior reports of strong and immediate (bottom-up) effects of direct gaze on a broad range of attentional and cognitive processes that was reduced for averted faces or faces with closed eyes (Senju & Johnson, 2009, for an overview), and extends these findings by directly investigating effects of head orientation when eyes are closed.

When the eyes were covered with sunglasses (Experiment 2), however, faces that were suddenly directed towards viewers captured attention. Thus, even though direct eye gaze was still absent, the combination of motion and gaze/head orientation towards participants captured attention, suggesting that eye visibility is not a necessary precondition for attentional capture by directed social behavior. Given that mere orientation of the face (i.e., head turn) towards participants did not capture attention when the eyelids were closed (Experiment 1), the attentional capture by the sudden direct face wearing sunglasses may be brought about by the (top-down) expectation that the eyes behind the sunglasses were open and, most likely, looking at the viewer. Results of the debriefing session confirmed that this is what participants assumed. Overall, this result is in line with the idea that a crucial part of our susceptibility to direct gaze is the communicative signal of being addressed by someone else (Csibra & Gergely, 2009); an aspect that was spared in our face stimuli with sunglasses when they were directed towards participants. Of course, the degree to which participants assumed the faces displayed communicative intent or approach behavior cannot be inferred. These issues have been more directly assessed in previous research (Nuku & Bekkering, 2008; Teufel et al., 2009) and could be specifically manipulated in future experiments. Note also, that the sunglasses condition in the present study was not used to directly assess belief, but whether or not vision of the eyes was necessary for the sudden direct face effect.

Interestingly, attentional capture by directed head orientation in Experiment 2 was only found when this cue was combined with a sudden onset motion cue — that is, when the face suddenly oriented towards the viewer. This finding suggests that the more ambiguous social cue in this experiment elicited processing benefits only when combined with another powerful (exogenous) cue. When faces are static (lacking the additional cue), the effect either does not appear or degrades too fast to be revealed in the present experimental setup. Given, though, that the main effect of face direction in this experiment was not statistically different from the effect of face direction in a previous study, strong conclusions cannot be drawn at this point. In order to fully understand the interplay of gaze and motion cues, however, it will be crucial to further investigate whether and how gaze and motion cues interact in settings of ambiguous or absent eye contact. Future studies could employ SOA manipulations (see Böckler et al., 2014) to induce inhibition of return with motion cues but not with gaze cues, and examine whether these cues interact when eyes are closed, invisible, or embedded in inverted faces. A further interesting question for future research is to investigate whether and how more ambiguous gaze cues (e.g., faces wearing sunglasses) can invoke similar attention capture as more obviously social cues (e.g., faces showing direct gaze). Can attention capture by gaze be elicited, for instance, when participants are informed that eyes behind sunglasses are open (belief manipulation) or when faces with sunglasses are presented intermixed with faces whose eyes are definitely closed (contrast effect)?

Finally, we examined whether the presence of direct eye gaze is sufficient to capture attention even when it is not integrated into a meaningful (potentially communicative) face representation (Experiment 3). Results revealed that for inverted faces, even though the face clearly showed direct versus averted eye gaze, the direct gaze cue did not capture attention. This finding suggests that the mere presence of the direct eye gaze cue is not sufficient for the sudden direct gaze effect to occur. The context information provided by the face seems crucial for the gaze cues to shape subsequent attentional processes. When this information was lacking (by disrupting the integration of the gaze cues into face stimuli), attention was not affected by the (sudden) direct gaze cue. This finding further substantiates the claim that human sensitivity to direct gaze does not only arise from the strong bottom-up cue that direct eye contact represents (Senju & Johnson, 2009), but may also be based on the communicative properties that eye contact entails — at least when embedded in a meaningful face stimulus (Csibra & Gergely, 2009).

The relevance of direct gaze in everyday interactions has been stressed by various different psychological fields. Some researchers have mainly addressed the power of direct gaze (i.e., eyes looking at the viewer) in modulating subsequent brain activation and cognitive processes (see Senju & Johnson, 2009, for an overview), whereas others have focused on the role of eye contact in communication (Tomasello & Carpenter, 2007; Tomasello, Carpenter, Call, Behne, & Moll, 2005), action coordination (Clark & Krych, 2004; Sebanz, Bekkering, & Knoblich, 2006), and the regulation of social relations (Böckler, Hömke, & Sebanz, 2014; Ham & Tronick, 2006). In ongoing interactions, direct gaze often functions as an ostensive signal, communicating that the looked-at person is the addressee of a communicative intent and that the subsequent action/information is going to be meaningful. As such, direct eye contact can enhance imitation, gaze following, and learning (Csibra & Gergely, 2009; Senju & Csibra, 2008; Wang, Newport, & de Hamilton, 2011). The present study showed that face orientation towards the viewer also has the potential to capture attention. Future studies will need to a) disentangle the role of gaze direction and face direction by independently manipulating both cues and b) further investigate the effect of face direction cues that signify approach or communicative behavior on subsequent imitation and learning behavior.

Although the effect of the face direction cue is modulated by the context of the stimuli, it is interesting to note that the effect of motion remained relatively resilient to the context. The effects of motion differed in relative magnitude across the Experiments, but significant main effects for motion were present across each of the Experiments. It is likely that motion captured attention in each case because it was part of an attentional set for dynamic stimuli (Folk, Remington, & Johnston, 1992) or because attention systems are very sensitive to onset of motion (Al-Aidroos et al., 2010). Overall, the contrast between the context-dependent modulation of the gaze cues (Böckler et al., 2014; vs. Experiments 1–3 of the present data) and the general resilience of the motion cues to context together with the absence of a correlation of the two types of cues is consistent with the hypothesis that their underlying processing channels operate relatively independently — though additional and more direct testing of this hypothesis is required.

5.1. Conclusion

To conclude, the present findings shed new light on social direction cues by showing that direct eye contact is neither necessary nor sufficient for attention capture by (sudden) direct face orientation. When eye visibility was eliminated by depicting faces with closed eyes (Experiment 1), attention was not captured by the orientation of faces towards participants. Faces wearing sunglasses, by contrast, elicited a processing benefit for faces suddenly oriented towards viewers (Experiment 2), suggesting that visibility of the eyes is not necessary for face direction to influence attentional processing. Finally, Experiment 3 employed inverted faces with open eyes and revealed that even when eyes were visible, the lack of a meaningful face context disrupted attention capture. Taken together, there is more to social cues than eyes alone. Eye contact is not effective when it cannot be meaningfully integrated into the face information. By contrast, a face that is directed towards us is powerful enough to capture our attention, even on a sunny day.

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