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

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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

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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 $\pm 2$ 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