DO MENTAL BELIEFS OF BEING SEEN AFFECT ATTENTIONAL ORIENTING TRIGGERED BY GAZE DIRECTION? A BEHAVIORAL STUDY.

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Gaze is a socially relevant signal that can influence attentional orienting in the observer. Gaze studies have verified that gaze cueing effect (that is, attentional shift to the same direction the gaze is pointing at) is highly reflexive, but it is not entirely immune to top-down controlling, such as mental state attributions. Direct gaze, as an arousing and socially relevant stimulus, can capture and hold attention making it more difficult to disengage from it. Studies examining gaze and attention have commonly used pictures of faces or schematic faces as stimuli. However, some studies have found that using pictures of faces instead of actual live faces may lose some of the social effects governing mentalizing processes elicited in the observer.

In the present study we investigated if mental beliefs of being seen affect attentional orienting triggered by a live model's gaze direction. The dependent measure in this study was participants' (n=20) manual reaction time to laterally presented target stimulus. The study consisted of two different tasks: a classic gaze cueing task (model posing laterally averted gazes) and another task to investigate if direct gaze captures and holds the attention (in this task the model posed either straight or downward averted gaze). The participants' assignment was to look at the model through a computer controlled shutter and react to an LED that lit either on the left or on the right of the shutter. Once the participant saw the LED lit, they pressed a button and their reaction times were analyzed. Both tasks were conducted in two conditions: one where the participants believed the model could see through the shutter (see through -condition) and another where they believed the model could not see through the shutter because of a one-way mirror (blocked vision -condition). The participants also filled out questionnaires about social presence.

In the classic gaze cueing task, the gaze cueing effect was observed in both conditions (see through – and blocked vision-condition) and there were no significant differences in reaction times between the conditions. There was no difference in self-reported social presence between the two conditions. In the attentional capture task, reaction times were actually shorter for direct gaze than to downward gaze at the stimulus onset asynchrony of 500 ms. Self-reported social presence was higher for see through -condition than for blocked vision -condition.

The results in the gaze cueing task did not replicate previous findings that attributing "seeing" mental state to the model would enhance the cueing effect. More research is needed to identify the top-down control processes that may modulate gaze cueing. In the attentional capture task, we were unable to replicate previous finding, that perceiving direct gaze would capture and hold the attention of the observer thus resulting in longer reaction times to direct compared to downward gaze. More research is needed in this area as well. Using live models instead of faces should continue to be pursued when studying social cognition.

Keywords: gaze cueing, eye contact, attention, social cognition, theory of mind

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INTRODUCTION

Gaze is a powerful social signal, and it is used to regulate interaction, express intimacy, and exert social control among other things (Kleinke, 1986). People read a lot into gaze: for example liking, attraction, attentiveness, and even competence are evaluated partly based on gazing behavior. Human eyes are unique compared to the eyes of other primates: the human sclera (the white part of the eye surrounding the iris) is more exposed than in other primates making the detection of gaze direction easier (Kobayashi & Kohshima, 1997). Humans are very accurate at determining other peoples' gaze direction (Gamer & Hecht, 2007; Symons, Lee, Kedrone & Nishimura, 2004) and gaze discrimination behavior starts at a young age: even infants as young as two days old are able to discriminate straight gaze from averted gaze (Farroni, Csibra, Simion, & Johnson, 2002). Children start to show gaze cueing behavior few months after birth (Farroni, Johnson, Brockbank, & Simion, 2000; Hood, Willen, & Driver, 1998) and it seems that at the age of six months the infants start to understand the communicative function of the gaze (Senju & Csibra, 2008).

Following others' gaze direction has at least three functions (Nummenmaa, 2011). Firstly, we can detect important stimuli or events in our environment that we might have otherwise missed. Secondly, we can predict the intentions of others faster and more accurately since gaze gives us information about their interests and goals (this ability to understand the mental states of others is called theory of mind; see for example Baron-Cohen, 1995). Thirdly, gaze following is the basis for joint (or shared) attention, which is pivotal to social learning and exchanging thoughts about objects in our perceivable environment. Given the importance of perceiving others' gaze, it is not surprising that it has effects on our attention, which we will discuss next.

Gaze direction and attention

There is a large amount of evidence that seeing a laterally averted gaze shifts viewers' attention automatically to the same direction the gaze is pointing at (eg. Driver et al. 1999; Hietanen, 1999; Schuller & Rossion, 2001, 2004). This phenomenon is known as gaze cueing. The phenomenon is so strong that it is observed even when it would be more beneficial to shift attention to the opposite direction the gaze is cueing at (Downing, Dodds, & Bray, 2004; Friesen, Ristic, & Kingstone, 2004). Although cueing can be produced also with other directional cues, such as arrows (eg. Friesen et al., 2004; Hietanen, Leppänen, Nummenmaa, & Astikainen, 2008; Ristic, Friesen, & Kingstone, 2002), there has been a debate that gaze cueing is special compared to other kind of directional cues. Cueing effect can be slightly stronger for gaze cues than for symbolic cues (Friesen et al., 2004), and gaze cueing disappears when the contrast polarity of the eyes is reversed, which is not to be expected to happen with other kind of cues (Ricciardelli, Betta, Pruner, & Turatto, 2009). It has been suggested that although symbolic cues and gaze cues can produce seemingly similar behavioral effects (that is, attentional shifts), there are different attentional mechanisms activated when we are perceiving gaze cues versus arrow cues (Hietanen, Nummenmaa, Nyman, Parkkola, & Hämäläinen, 2006; Marotta, Lupiáñez, Martella, & Casagrande 2012). Indeed, there is evidence that different brain networks activate during gaze cueing versus cueing by other directional cues (Hietanen et al., 2006; Kingstone, Tipper, Ristic, & Ngan, 2004; Ristic, Kelland, Friesen, & Kingstone, 2002). However, it has also been suggested that these differences observed might be due to difference in quantity rather than quality (Tipper, Handy, Giesbrecht, & Kingstone, 2008).

The reason why gaze and other kind of cues activate different mechanisms in the brain is thought to have something to do with social aspects of gaze. According to a meta-analysis of functional imaging studies, brain areas involved in eye gaze perception include the superior temporal sulcus (STS) region, amygdala, superior parietal lobule, postcentral sulcus, frontal eye field, inferior frontal cortex, and medial prefrontal cortex (Nummenmaa & Calder, 2009). Gaze perception and theory of mind tasks engage similar regions of medial frontal cortex (Calder et al., 2002). To support the idea that gaze cueing is indeed special compared to other cues because of its social relevance, a study showed that when the same, ambiguous stimulus could be perceived either as a pair of eyes under a hat or as a car, the cueing effect was observed only when the stimulus was perceived as eyes, but not when exactly the same stimulus was perceived as a car (Ristic & Kingstone, 2005). Also, in the same study, it was observed that when the stimulus was first introduced as a car the cueing effect did not occur, but when the stimulus was introduced after this as eyes, the cueing effect was observed. However, if the stimulus was first introduced as a pair of eyes, the cueing effect continued to occur also after the stimulus was reintroduced as a car. So, the eyes could no more be "unseen" and "redefined" as a car even though instructed otherwise (a similar phenomenon of an ambiguous stimulus continued to be seen as a face, Bentin & Golland, 2002).

Another example of top-down control processes affecting gaze cueing is that gaze cueing can be disrupted if there is no joint attention (Kawai, 2011). In the study, when a schematic face's line of sight to target stimulus was blocked by a vertical bar, also the gaze cueing effect was disrupted. When the line of sight to the target stimulus was not blocked, the gaze cueing effect was observed. In conclusion, gaze cueing is automatic in the sense that it occurs without or despite conscious effort, but it is not immune to top-down control processes.

In real life we do not encounter only averted gazes, but also gazes directed at us. A gaze directed at oneself may mean that the gazer is about to approach, and one should prepare accordingly. According to an fMRI study, eye contact and hearing one's name called activate the same regions in the brain (Kampe, Frith, & Frith, 2003). Direct gaze, compared to averted gaze, can elicit a relative left-sided asymmetry in electroencephalographic brain activity linked to approach tendency, as well as larger skin conductance responses indicating more intense autonomic activation (Hietanen, Leppänen, Peltola, Linna-aho, & Ruuhiala, 2008). In a PET study it was found that the right amygdala and other areas in the limbic system showed increased activity to eye contact compared to averted gaze, suggesting that eye contact may induce stronger emotional responses than averted gaze (Kawashima et al. 1999). Indeed, eye contact has been associated with heightened arousal (Conty, Russo, et al. 2010; Hietanen, Leppänen, Peltola, et al., 2008; Myllyneva, Ranta, & Hietanen, 2015), and it evokes greater activity in the STS than averted gaze (Conty, N'Diaye, Tijus, & George, 2007; Pelphrey, Viola, & McCarthy, 2004).

There are studies that have indicated that eye contact may capture the attention and hold it in a way that shifting the attention away from the eyes to target stimuli takes longer than it would take from closed eyes (Conty, Gimmig, Belletier, George, & Huguet, 2010; Senju & Hasegawa, 2005) or averted gaze (Conty, Gimmig, et al., 2010; Senju & Hasegawa, 2005). Also, direct gaze is detected faster than averted gaze (Conty, Tijus, Hugueville, Coelho, & George, 2006; Senju & Hasegawa, 2006). People are more accurate at detecting gaze changing from averted gaze to direct gaze than from direct gaze changing to averted gaze, and better at detecting gaze changing from direct to averted or averted to direct gaze than averted gaze changing laterally to the left or to the right (Yokoyama, Ishibashi, Hongoh, & Kita, 2011). In a study where participants were to detect appearance of a peripheral target while viewing a picture of a face with direct gaze, vertically averted gaze or closed eyes, it was found that detection of the target took longer when viewing direct gaze compared to vertically averted gaze or closed eyes (Senju & Hasegawa, 2005). In this study there were two different conditions, an overlap condition and a gap condition. In the gap condition there was a gap between the face stimulus offset and target stimulus onset, whereas in the overlap condition the face stimulus remained present when the target stimulus appeared in the periphery. The detection of the peripheral target stimulus took longer when the stimulus face had direct gaze compared to averted gaze or closed eyes, but this differentiation was only seen in the overlap condition and not observed in the gap condition. Authors suggested that direct gaze, being socially and communicatively relevant stimulus, caused difficulties in disengaging from it.

Although gazing (eye contact) is usually interpreted as an invitation for interaction, it may as well be interpreted as threatening depending on, for example, facial expression and situational factors (Kleinke, 1986). In other animals straight gaze is usually interpreted as a threat (Emery, 2000) and adolescents with social anxiety respond to eye contact aversely, assessing being subjected to direct gaze as unpleasant whereas controls without social anxiety assess the direct gaze directed at them as mildly pleasant (Myllyneva et al., 2015). Thus, direct gaze can elicit different reactions to it depending on a range of situational as well as personal factors. However, as gaze directed at ourselves implies that the gazer is attending towards us, it is important to start to form a suitable reaction to an anticipated interaction.

Gaze and theory of mind

As mentioned previously, theory of mind is the ability to understand the mental states of others (eg. Baron-Cohen, 1995). Although taking another person's perspective is thought to be a complex, learned process, there is also evidence that there may be some more automatic aspects to the theory of mind (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010; Schneider, Bayliss, Becker, & Dux, 2012) that emerge even as early as at the age of 7 months (Kovács, Téglás, & Endress 2010). Indeed, it has been proposed that there are two systems tracking others’ beliefs: one that is automatic and cognitively efficient yet limited, and another that is cognitively more demanding but also more flexible (Apperly & Butterfill, 2009). This first system can be thought to encode others’ beliefs in a similar way we encode observable input (Kovács et al., 2010), whereas the other system is needed in more complex situations such as false-belief tasks or when lying to someone. What comes to perceiving others’ gaze direction and theory of mind processes elicited by it, both systems can be at work: we may simply encode where they are looking at and quickly conclude that the thing they are looking at is not relevant to us, or we may continue to process why they are looking at that thing and would it be relevant to us to also engage in the same thing. There is evidence that gaze cueing can be affected by mental state attribution even when participants are not asked to encode others' mental states (Kawai, 2011; Teufel, Alexis, Clayton, & Davis, 2010).

Do we attach mental states to pictures of faces or schematic faces with varying gaze directions? We must have at least the ability to do since people can attach mental states even to simple geometric shapes (Heider & Simmel, 1944) and surely it appears we actually do so (eg. Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Bayliss et al, 2013; Kawai, 2013; Pelphrey, Morris, & McCarthy, 2005). But how do schematic faces or pictures of faces compare to live, real life faces they are representing? Interestingly, some studies have found that using live faces instead of pictures of faces have resulted in differences that were detected only when using live faces but not when using pictures of faces (Hietanen, Leppänen, Peltola, et al., 2008; Pönkänen, Peltola, & Hietanen, 2011; Pönkänen, Alhoniemi, Leppänen, & Hietanen, 2011; Pönkänen et al., 2008). For example, in an event-related potential (ERP) study, it was found that face-sensitive ERPs (N170 and EPN) were greater for direct *vs* averted or closed eyes only when the stimulus was a live face, not when the participants were presented a picture of the same face (Pönkänen, Alhoniemi, et al., 2011). The researchers hypothesized that this could be because of the social, potentially even interactional nature of the stimulus. Direct gaze and averted gaze have been found to elicit frontal EEG asymmetry, but only when faces were seen live, not when participants were viewing a picture (Hietanen, Leppänen, Peltola, et al., 2008). In the same study also skin conductance responses were higher to direct gaze compared to averted gaze only when viewing live faces, indicating heightened arousal when viewing direct gaze live. So the use of pictures of faces instead of actual humans is not as clear cut as one could expect when studying and making interpretations regarding facial processing. Showing pictures of faces on a computer screen instead of actual faces have clear methodological advantages, since they are easier to control meticulously. However, if at the price of absolute control we may gain more ecological validity and thus, more generalizable knowledge we should try to pursue it.

Similar steps towards ecological validity were taken in a cueing study, where participants viewed a "live" video of a model wearing goggles and turning his head to the left or right (Teufel et al., 2010). In the study it was observed, that participants' gaze following behavior was affected by the assumption whether the model could see through the goggles or not. Participants were successfully led to believe that they saw a live video link coming from an adjacent room, thus creating a more naturalistic (potentially more social) setting compared to static images shown on a computer screen. In reality they were watching prerecorded video sequences. The participants were asked to fixate the center of the screen and to discriminate the letters ("L" or "T") appearing beside the video as quickly as possible. They were told that the other person (the model wearing goggles) in the "live video link" was participating in another study conducted at the same time and turning his head either left or right. In Experiment 1, a nonpredictive design was used and participants were told the head turn does not indicate where the letter will appear, whereas in Experiment 2, there was a counterpredictive design and the participants were told the letter would be twice as likely to appear on the side away from where the other person gazes. Before the actual task, the participants were introduced to the goggles the model ("other participant") was wearing during the experiment the lenses of both goggles were highly mirrored and on the outside the lenses looked similar. On the inside, however, the other pair was transparent allowing the model to see through them and the other pair was opaque thus blocking the model's view. Through this manipulation of the goggles, the participants were to attribute either "seeing" or "nonseeing" mental state to the model. In the nonpredictive design gaze cueing effect was stronger in the seeing condition compared to nonseeing condition, and in the counterpredictive design seeing condition reduced attention shifts away from the model's gaze direction compared to nonseeing condition. Taken together, the results suggest that simply attributing "seeing" mental state to a model created a bias to attend toward the model's gaze direction even when it was nonpredictive or even counterpredictive to the target stimulus. Importantly, the mental state attribution was the only thing manipulated. In another study, where simply the mental beliefs of being seen or not were manipulated, the researchers found differentiated physiological responses to direct compared to averted gaze only when the observers attributed the "seeing" mental state to the model although from the observers perspective the stimulus remained identical (Myllyneva & Hietanen, 2015). In this study a live model was used as stimulus and participants' belief of being seen or not was obtained through a one-way mirror deceit. The participants were lead to believe that a one-way mirror was placed between them and the model and thus the model could no longer see them even though the participants continued to be able to see the model. Social presence and self-awareness were measured with self-assessment forms and results revealed that public self-awareness and social presence were evaluated to be higher when the model could see the participant compared to situation where the model could not see the participant. The results supported the authors' hypothesis that the critical factor for "differences in physiological and self-assessed measures in seeing a real person and seeing a picture" is "the observer's knowledge of being the target of another individual's attention or not".

Current study

The aim of this study was to find if one's mental attributions of being seen have an impact on one's attention shifting in a simple gaze cueing task measuring reaction times to laterally presented target stimulus. Another aim was to study if one's mental attributions of being seen have an impact on reaction times to laterally presented target stimulus when viewing direct gaze, which is expected to capture and hold the attention of the observer. Hence this study consisted of two different tasks: the Gaze cueing task and another further referred to as the Attentional capture task. In the Gaze cueing task the participants' looked at a live model whose gaze was averted either to the left or to the right. In the Attentional capture task the live model looked either straight (eye contact) or down (downward averted gaze). In both tasks the participants' objective was to detect a light presented either to the left or to the right of the fixation stimulus face by a press of a button. The model's gaze was static which allowed exact stimulus onset asynchronies (time interval between stimulus appearance and target stimulus appearance) to be determined. In this study stimulus onset asynchronies of 200, 500, and 1000 ms were used to investigate the time course of gaze cueing effect and attentional capture linked to eye contact.

Both tasks were conducted in two different conditions: see through –condition (ST) and blocked vision –condition (BV). In the ST-condition the participants believed that the live model was able to see through the shutter that was in between the model and the participant. In the BV-condition the participants believed that the model could not see through the shutter because of a one-way mirror. So here we used the same mirror deceit as in the study by Myllyneva and Hietanen (2015). These conditions were reminiscent also of those in Teufel et al. (2010) study, where they used goggles to manipulate the belief of whether or not the model could see. In contrast to Teufel et al. (2010) study, in this study the participants could see the eyes of the model and the stimulus remained static. The head remained facing forward and only the gaze direction varied across trials. The participants filled out questionnaires about self-reported social presence both in ST- and BV-condition similarly as in Myllyneva and Hietanen (2015) study.

For the Gaze cueing task, the hypothesis was that the gaze cueing effect (shorter reaction times to validly cued trials compared to invalidly cued trials) would be observed in ST-condition and in the BV–condition, but that the cueing effect would be larger when participants believed that also the live model could see through the shutter (as in Experiment 1 in Teufel et al., 2010).

For the Attentional capture task, the hypothesis was that reaction times would be longer when model poses eye contact compared to when model poses downward gaze, similarly as in Senju and Hasegawa's (2005) study. It was also expected that this phenomenon would be enhanced in ST-condition since it has been found that mutual eye contact resulted in greater autonomic responses associated with attention orienting by motivationally important stimuli (Myllyneva & Hietanen, 2015).

It was also expected that self-reported social presence would be evaluated higher in the ST-condition than in the BV-condition in both tasks, as was the case in Myllyneva & Hietanen (2015) study where the model posed both straight and averted gaze. Social presence is usually distinguished from physical presence – physical presence means physically being there whereas social presence is tied to *feeling of being there* physically (Heeter, 2003) or to put it another way, not simply existing but actually being present. If the model was able to see through the shutter, maybe the participants would feel more socially present in order to be ready for possible interaction even though there was no actual reason to anticipate it to happen. In the BV-condition there would be even less of a chance of interaction, so maybe participants would feel less socially present than in the ST-condition.

METHODS

Participants

The participants were 28 undergraduate students (15 males). All participants reported normal or corrected-to-normal vision and were unaware of the purpose of the experiment. The participants took part in the experiment voluntarily and gained either a course credit or a movie ticket for participation. Eight participants (2 males) were excluded from the analysis, three because there were some inconsistencies in the instruction or carrying out the procedure, four because they did not believe in the mirror deceit and one because they made too many catch trial errors during the tasks. Hence the final sample consisted of 20 participants (13 males) and the mean age of the final sample was 22.43 years (age range 19 – 29 years). The participants were debriefed after the experiment.

Stimuli

The stimulus in the experiment was a face of a live model. Two undergraduate students modelled for stimulus faces (a male and a female). In the experiment, the model had four different gaze directions: in the Attentional capture task straight gaze or downward gaze, and in the Gaze cueing task gaze averted to the left or to the right. The model's head was oriented directly towards the participant and the model maintained a neutral expression. The stimulus face was presented through a liquid-crystal shutter attached to a panel that was placed between the model and the participant. The size of the shutter was 22 cm x 38 cm (width x height). The participant was 85 cm away from the shutter and 115 cm away from the model. The participants rested their heads on a chin rest to ensure that the distance and height in relation to LEDs remained the same throughout the experiment.

The target stimulus was a dim LED attached to the panel. There was one LED on each side (left and right) of the shutter. The distance between the LEDs was 24 cm and the LEDs were at the height of 26 cm as measured from the bottom frame. Since the participants' distance to the lights was 85 cm, the LEDs distance from the centre point of the frame was 8° of visual angle.

The stimulus presentation was controlled by E-Prime software (E-Prime 2.0, Psychology Software Tools). E-Prime controlled the liquid-crystal shutter as well as the LEDs. The shutter switched between opaque and transparent state in 1 millisecond.

Design

There were two different tasks in the experiment. In both tasks, the dependent measure was participants’ reaction time (RT) to the target stimulus (an LED). The first task was a Gaze cueing task, where the model posed laterally averted gaze. In this task, the gaze was either congruent or incongruent in relation to the location of the target stimulus (an LED). The other task was an Attentional capture task, where the model posed either a straight gaze or a downwards averted gaze. Also in this task, the RTs to the target stimulus were analyzed.

Both tasks were carried out in two different conditions: in a “See Through” (ST) -condition where the participant believed the model could see him/her through the shutter and in a “Blocked Vision” (BV) -condition where the participant believed the model could not see him/her through the shutter. In the ST-condition, the model and the participant were able to see each other when the shutter was in a transparent state. The participants were told that the model could also see the LEDs turn on, even though this was not actually the case. This was to enable the participant to adopt an illusion of “seeing something shared”, something that they both could perceive. In the BV-condition (“Blocked Vision”) the participants were led to believe that a one-way mirror was added between the model and the participant so that the model could not see the participant or the LED lights even though the participant was still able to see the model and the LEDs.

Trials in both the Gaze cueing task and Attentional capture task were similar. Each trial began with the shutter being in an opaque state. Then the shutter switched to a transparent state and the participant saw the model. After either 200, 500, or 1000 ms one of the LEDs attached to the sides of the shutter turned on and the participant was to press the button in the response box as soon as he/she perceived the light. Immediately after pressing the button the shutter switched back to an opaque state, the LED turned off, and there was a 2000 ms interval before the next trial began. During this time the model received information via earbuds of the next gaze direction and prepared accordingly. If the participant did not press the button at all, the shutter switched back to opaque after 2000 ms.

The Gaze cueing task consisted of 264 trials (132 for ST-condition and 132 for BV-condition). These included 24 catch trials when the LED light did not lit at all. The purpose of this was to encourage participants not to press the button before they actually perceived the light. Ergo, there were 240 actual trials in the task, 20 trials for each experimental condition (condition x stimulus onset asynchrony x gaze congruency). These details were the same for the Attentional capture task as well, 20 trials for each experimental condition (condition x stimulus onset asynchrony x gaze direction).

The gaze directions were balanced so that in the Gaze cueing task there were as many congruent as incongruent gaze trials (also as many left averted as right averted gazes) and in the Attentional capture task there were as many straight gazes as there were downward averted gazes. Both tasks had three different SOAs (stimulus onset asynchronies): 200 ms, 500 ms and 1000 ms. This was to ensure that the participants would not learn when the light was about to turn on and press the button automatically after a known period of time. Another reason for different SOAs was to investigate the time course of gaze cueing effect and attentional capture effect linked to direct gaze. There were an equal number of trials in each SOA. All of the trial attributes were (pseudo)randomized so that there would not be more than three same gaze directions or gaze congruence conditions or SOAs in a row. The location of the LEDs were also balanced and randomized so that the light would not lit more than three times in a row on the same side (left or right). The gender of the model was also balanced across female and male participants.

Procedure

When the participants arrived to the laboratory, the experimenter described the general procedure and showed how the liquid-crystal shutter functioned. The participants were told that the purpose of this experiment was to study the effect of seeing a face on attention and that this would be measured with reaction times. The experimenter was careful not to mention that the actual interest was in the gaze direction of the model and not merely the presence of a face. After this, a written consent was gathered and the participant received more detailed instructions. The participant was told that his/her task was to look at the model's face, while keeping his/her eyes at the centre and press the button on the response box with their dominant hands' index finger as soon as they perceived an LED light lit either on the left or the right side of the shutter. The participant was also told about the catch trials and advised not to press the response key before the LED was lit. The participant was asked to keep looking at the eyes of the model (or between the model's eyes, if the former felt uncomfortable) and not to shift their eyes towards the LEDs at any time. They were reassured that they could still see the lights with their peripheral vision.

After instructions, the participant was introduced to a one-way mirror used in the BV-condition. The participant was explained that by adding a special one-way mirror between the model and the participant, the model could no longer see through the shutter even though the participants view did not change. In reality there was not a one-way mirror, but a deceit was carried out by the model first placing a transparent sheet on the shutter window in such a way, that the participant saw that something was added on the shutter. Then the experimenter and the participant walked to the other side of the shutter to see that the "mirror" actually blocked the vision from the model's side. While the participant was walking to the other side of the partition, the model quickly placed another, opaque aluminum-coloured sheet in front of the shutter so that the view was actually blocked. When the participant reached the model's side of the shutter, he/she saw that the sheet actually was opaque in nature and the view was blocked from that side of the shutter. While the participant returned back to his/her own seat, the model quietly but quickly removed the lastly added opaque sheet leaving the participant to believe that the firstly inserted (transparent) sheet actually blocked the view from the model's side of the shutter. The participant was asked to keep in mind whether the mirror was in place or not so that they would be aware of the condition during the task.

Then both the LED lights were lit so that the participant could advice the model to sit at the centre of the shutter from the participants point of view, and also that the model's eyes were at the same level with the LEDs. After this the participant was reminded shortly of the instructions, and a block of practice trials was carried out so that the participant became familiar with the experiment. The test block consisted of 20 trials including catch trials. The practice block was always run without the mirror.

After the practice block the participant filled a modified Social Presence Form (SPF) questionnaire (Myllyneva & Hietanen, 2015) based on how they felt during the practice block. Then the experimenter prepared the participant for the actual block by telling that it is exactly like the practice block, but only longer and would last for a few minutes. If there were no questions from the participant, the experimenter reminded the participant about which condition was to take place (ST or BV) and, depending on the task, told that the model was either looking downwards or directly at the participant (Attentional capture task), or either to the left or to the right (Gaze cueing task).

The experiment then went on so that the participant completed the first task (Gaze cueing or Attentional capture) in the first condition (ST or BV) and filled out the SPF form. Then the participant continued to second task in this same condition and filled out the SPF form. Only after this the condition was changed and the participant completed both tasks in this latter condition. Between each task there was a pause during which the model and the participant could rest for a while. After each pause and at the beginning of every task the position of the model was corrected if needed. Also after each pause and at the beginning of every task the participant was reminded of the nature of the condition (if the mirror was there or not).

When the experiment was over the participant was asked how they felt about the experiment and whether they felt any different during the different tasks or conditions. The debriefing was carried out and mirror deceit was revealed. The participants were asked directly if they had suspected that the model could see them in the BV-condition. If a participant expressed doubts about the mirror deceit, the participant was excluded from the analysis.

Data analysis

First it was analyzed that the participants had not pressed the button in the catch trials too often (acceptable error rate was set to be at ≤10 %). One participant had done this and was excluded from the final analysis. The catch trial error rate in the final sample ranged between 0–4.2 % and average catch trial error rate was 1.6 %. For the remaining participants, catch trial errors were not included in the analysis. Reaction times shorter than 100 ms and longer than 1000 ms were removed before the analysis. After this, each participants' mean reaction time was calculated, and reaction times falling outside the window of mean +/- 2 SD were also removed. After this filtering the mean reaction time for each stimulus condition was calculated for each participant.

For the social presence measurement, the items in the modified SPF –questionnaire (Myllyneva & Hietanen, 2015) that needed to be reversed were reversed, and the mean score was calculated for each participant.

RESULTS

Gaze cueing task

Reaction times were subjected to a three-way repeated measures ANOVA: 2 (Condition: See Through/ Blocked Vision) x 2 (Gaze congruency: congruent gaze/ incongruent gaze) x 3 (SOA: 200/500/1000 ms). The main effect of Gaze Congruency was significant ($F_{(1,19)}$ = 23.9 p < 0.001). Reaction times were shorter for congruent gaze ($\bar{x}$ = 290 ms) than for incongruent gaze ($\bar{x}$ = 295 ms).

The main effect of the SOA was also significant ($F_{(2,38)}$ = 20.5, p < 0.001). Pairwise comparisons indicated that reaction times were longer at the SOA of 200 ms ($\bar{x}$ = 309 ms) compared to SOAs of 500 ms ($\bar{x}$ = 284 ms , $t_{(19)}$ = 5.9, p < 0.001) and 1000 ms ($\bar{x}$ = 286 ms, $t_{(19)}$ = 4.0, p < 0.001).

Neither the main effect of Condition nor any interactions were significant (all ps > 0.3). The mean reaction times are presented in Table 1.

Table 1. The mean reaction times (and SDs) in the Gaze cueing task.

	See Through –condition		**Blocked Vision –condition**	
SOA	**Congruent gaze**	**Incongruent gaze**	**Congruent gaze**	**Incongruent gaze**
200 ms	308 (58.5)	313 (60.1)	304 (55.8)	310 (57.8)
500 ms	284 (45.8)	287 (50.7)	279 (43.3)	286 (41.9)
1000 ms	285 (42.6)	290 (43.5)	282 (35.4)	286 (38.7)

The self-evaluation ratings of social presence were subjected to a t-test. Scale range in scores was 1–7. There was no difference between the Blocked Vision –condition ($\bar{x}$ = 3.75) and the See Through –condition ($\bar{x}$ = 3.81) in the self-reported social presence ($t_{(19)} = 0.7$, $p > 0.5$).

Attentional capture task

Reaction times were subjected to a three-way repeated measures ANOVA: 2 (Condition: See Through/Blocked Vision) x 2 (Gaze direction: straight gaze/ downward gaze) x 3 (SOA: 200/500/1000 ms). The main effect of the SOA was significant ($F_{(2,38)} = 50.0$, $p < 0.001$). Again, the reaction times were longer at the SOA of 200 ms ($\bar{x}$ = 317 ms) compared to SOAs of 500 ms ($\bar{x}$ = 288 ms , $t_{(19)} = 7.7$, $p < 0.001$) and 1000 ms ($\bar{x}$ = 290 ms, $t_{(19)} = 6.2$, $p < 0.001$). Other main effects were non-significant (both *p*s > 0.1).

There was also a significant interaction of Gaze direction x SOA ($F_{(2,38)} = 6.4$, $p < 0.01$). Because of the significant two-way interaction, the effect of gaze direction was analyzed separately at each SOA. T-tests indicated that reaction times were shorter for straight gaze compared to downward gaze at the SOA of 500 ms ($t_{(19)} = 3.6$, $p < 0.01$).

There was also a significant three-way interaction of Condition x Gaze direction x SOA ($F_{(2,38)} = 3.3$, $p < 0.05$). Because of the significant three-way interaction, the effect of gaze direction was analyzed separately at each SOA and condition. However, further t-tests did not confirm this observed three way interaction. By looking at Figure 1, it appears that the observed three-way interaction (not confirmed by the post-hoc analyses) was due to differences at the SOA of 1000 ms. Indeed, the difference between reaction times to straight *vs* downward gaze was approaching significance at the SOA of 1000 ms in the BV-condition ($p = 0.078$) whereas in the ST-condition it did not ($p = 0.254$) Other interactions were non-significant (all *p*s > 0.2). The mean reaction times in the Attentional capture task are presented in Figure 1.

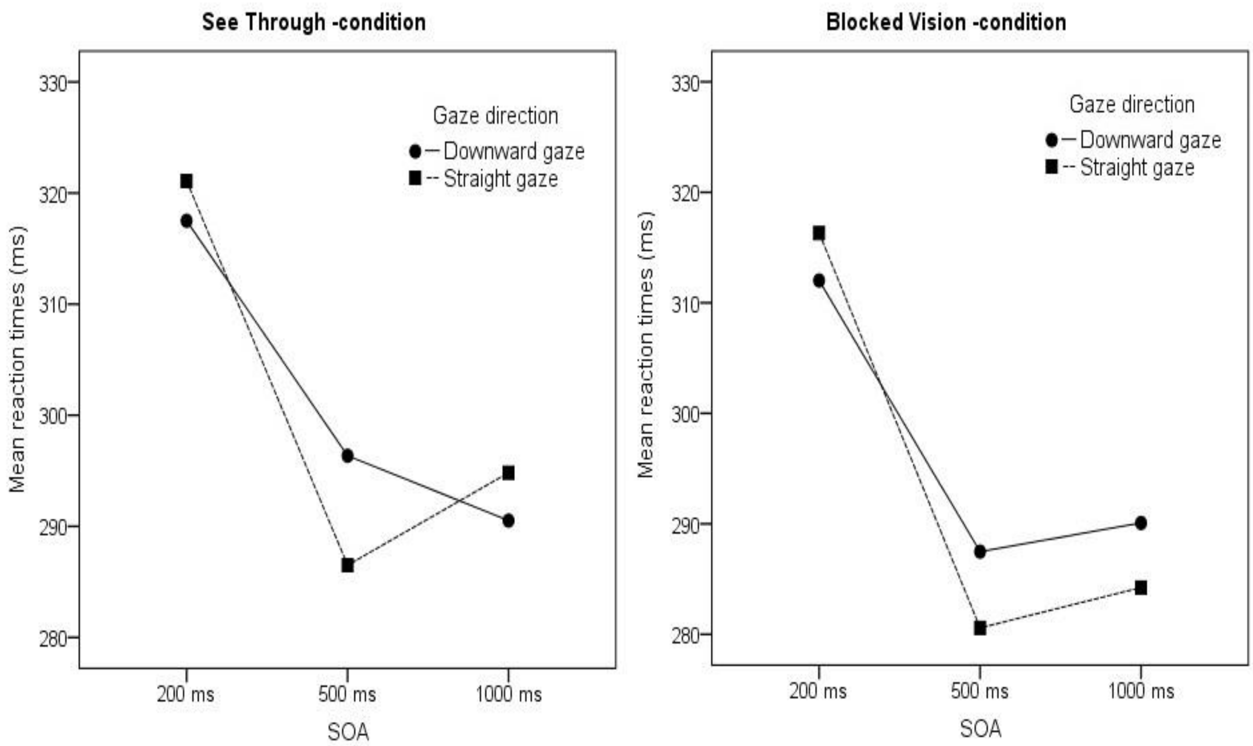

Figure 1. The mean reaction times in the Attentional capture task.

The self-evaluation ratings of social presence were subjected to a t-test. Scale range in scores was 1–7. The social presence was evaluated to be higher in the ST-condition ($\bar{x}$ = 4.13) compared to the BV-condition ($\bar{x}$ = 3.81) in the Attentional capture task ($t_{(19)} = 2.2$, $p < 0.05$).

DISCUSSION

The aim of this study was to investigate if belief of being seen would affect the attentional orienting triggered by gaze direction. Another aim was to study if one's mental attributions of being seen have an impact on reaction times to laterally presented target stimulus when viewing direct gaze, which was expected to capture and hold the attention of the observer. The study consisted of simple reaction time tasks, where the participants' task was to react to an LED lit while viewing a live model through a liquid-crystal shutter. To investigate the two questions, there were two different tasks: a Gaze cueing task where the model looked either to the right or to the left thus having either a congruent or incongruent gaze. The other task was called an Attentional capture task, where the model either had straight gaze or a downward averted gaze. Both of these tasks were also carried out in two different conditions: in the see-through (ST) condition the participants' believed the model could see through the shutter. In the blocked-vision (BV) condition, the participants' believed the model could not see through the shutter because of an added one-way mirror. There were three different stimulus onset asynchronies (SOAs). That is, how long after the shutter became transparent did the target LED lit. The participants also filled out forms measuring social presence.

Results

In the Gaze cueing task the only results were that, as expected, the reaction times were shorter when the stimulus appeared on the same side the gaze was cueing at, and that reaction times were longest at SOA of 200 ms. As already mentioned in the introduction, gaze cueing effect has been widely established in a number of studies (eg. Driver et al. 1999; Hietanen, 1999; Schuller & Rossion, 2001, 2004), so this result was not surprising but rather expected. One could also argue that the longest reaction times at 200 ms were also fairly expected simply because of the shorter foreperiod (Niemi & Näätänen, 1981). This kind of shortening of reaction times as the SOA lengthened has been observed in similar studies where there were different SOAs (eg. Friesen et al., 2004; Hietanen & Leppänen, 2003). There was neither main effect of condition (BV or ST), nor any interactions, and thus we could not replicate the finding observed in a similar study, that attributing "seeing" state to model would enhance the gaze cueing effect (Teufel et al., 2010). Contrary to Teufel et al. (2010) study, in this study the stimulus was not dynamic. Could it be that the perception of movement contributed to the gaze cueing effect in their study? Motion may have an enhancing effect in gaze cueing studies (Farroni et al., 2000; Frischen, Bayliss, & Tipper, 2007).

One possibility of course is, that the participants did not attribute the mental state of seeing or not seeing to the model even though they were reminded of the condition before every block. Indeed, there was no difference between the ST- and BV-condition in self-reported social presence. However, in Teufel et al. (2010) they did not measure social presence and it is not known if social presence is actually needed for the enhanced cueing effect they observed in "seeing" condition. In their experiment however, the participant did not have to rely on their memory to remember which condition was in question ("seeing" or "nonseeing") because of the different colored goggles. It is possible that in this study the participants forgot the condition as the block continued or did not pay enough attention to which condition was in question – both ST- and BV-condition looked identical to the participants and the blocks were quite long in duration.

In the Attentional capture task reaction times were again longest at SOA of 200 ms. Other main effects were non-significant. There was a significant interaction of SOA and gaze direction and further analyses revealed that reaction times were shorter for straight gaze than downward gaze at the SOA of 500 ms. This was against the hypothesis that eye contact would capture attention, thus making reaction times longer and therefore did not replicate the findings of a similar study also using an SOA of 500 ms (Senju & Hasegawa, 2005). In their study they used pictures of faces whereas we used live models. Could it be that the live model was a socially stronger stimulus and therefore cued attention downward (Teufel et al., 2010)? Then, in contrast, Senju and Hasegawa's study (2005) the picture of a face with downward gaze may not have been a socially strong enough stimulus to cue attention downward. However, if we assume this to be the case, then why did the use of live model not also enhance the attentional capture of straight gaze perceived by Senju and Hasegawa (2005)?

Another difference to Senju and Hasegawa (2005) study is the head deviation, in their study the stimulus face had a slightly deviated head orientation whereas in this study the head was facing forward. However, it is difficult to say if a deviated head view would have had an effect in the present study. Maybe direct gaze with deviated head orientation could have initiated even higher sense of being watched by another, since with direct head view it is possible to think the other is simply "looking forward" and not "looking at me" whereas with deviated head view it is harder to explain why the other one would be looking at my direction but not me. Direct gaze is detected faster than averted gaze among distractors of averted gazes (for averted gaze search the distractors were straight gazes) but only with deviated head (Conty et al., 2006). Eyes are not the only thing we can use to determine others' focus of attention, but we can also use the head or body direction as a clue if eyes are invisible (Emery, 2000). The hierarchy is that if eyes are visible, then the eyes are the best clue to determine the focus of their attention. Since the orientation of eyes, head and body are often in line, deviated head with straight gaze may be more powerfully signaling the attention is actually at the observer. However, differentiated physiological reactions to eye contact compared to averted gaze, which have been hypothesized to be caused by mentalizing processes, have been found with straight head orientation (eg. Hietanen, Leppänen, Peltola, et al., 2008; Myllyneva & Hietanen, 2015; Myllyneva et al., 2015; Pönkänen, Alhoniemi et al., 2011).

There was a three-way interaction of gaze direction, SOA and condition in the Attentional capture task. Further analyses did not confirm this interaction but, as already mentioned in results, looking at Figure 1 it looks the reason for this interaction was at the SOA of 1000 ms. Indeed the difference between reaction times to direct *vs* downward gaze was approaching significance at the SOA of 1000 ms in the BV-condition (p = 0,078) whereas in the ST-condition it did not (p = 0,254). Maybe with a larger number of participants this trend would have been observed. If so, could the relatively longer reaction times to direct gaze in ST-condition be because of Senju & Hasegawa's (2005) observation of attentional capture and holding? They observed the increased dwell time in direct gaze only at shorter SOA of 500 ms but not with longer SOA of 1200 ms which is closer to 1000 ms used in current study. One explanation could be that straight gaze began to be disturbing only after participants judged it as prolonged and thus mentalizing processes (why is he/she looking at me for so long?) occupied more of processing capacity resulting in longer reaction times (Conty, Gimmig, et al., 2010) and maybe even elicited stronger emotional reactions (Kawashima et al., 1999). Certainly, the social presence was rated to be higher in the ST-condition in this task, but it cannot be said to be because of direct gaze since both gaze directions were included in the assessment. As mentioned previously, with direct head view it is maybe easier to judge the other one as simply looking forward but not at us.

The social presence was rated higher in the ST-condition compared to BV-condition in the Attentional capture task. However there was no significant difference in social presence in the Gaze cueing task. This raises a question whether the eye contact was the sole contributor in observed differences in social presence between the conditions of being seen or not in Myllyneva and Hietanen (2015) study where direct gaze and laterally averted gazes were used. Again, it would be tempting to assume that here the direct gaze was indeed the cause for higher social presence scores, but since both direct and downward gaze were included in the assessment the issue cannot be resolved here either. However, here the difference between the two conditions most likely means that participants remembered which condition was taking place when doing the task even though the duration was equal to the Gaze cueing task. It is still possible that the participants remembered the conditions also in the Gaze cueing task, but they did not result to differences in social presence.

Limitations and future implications

The sample size in this study was relatively small (n=20), which may explain why the post-hoc analyses conducted after the three-way interaction did not result in significant effects. However, this sample size is well in line with other gaze cueing studies (eg. n=8 and n=9 in Driver et al., 1999;

n=14 in Schuller & Rossion, 2001; n=12 in Schuller & Rossion, 2004; n=32 and n=16 in Teufel et al., 2010).

The use of a live model instead of pictorial stimuli naturally decreases the level of control. There is a possibility for human error when live models are posing, since they may, for example, unconsciously pose a bit different micro facial expressions in different conditions even though trying to maintain a neutral expression. If there had been a real one-way mirror (that would not change the participants' view to the model at all) to be used, the issue with models' posing would still remain. This loss of control in stimulus presentation is hard to get around. Teufel et al. (2010) did this by pre-recorded videos, but even in this case it has to be noticed that video link is no longer face-to-face interaction even if it may be the closest possible way to mimic face-to-face interaction. However, because of using live models instead of pictorial stimuli may produce different physiological reactions (eg. Hietanen, Leppänen, Peltola, et al., 2008; Pönkänen, Alhoniemi, et al., 2011; Pönkänen et al., 2008; Pönkänen, Peltola et al., 2011), in the future gaze cueing studies, as well as other studies, using live models should continue to be pursued.

The use of downward gaze as control stimulus for direct gaze may have been a mistake, if the downward gaze indeed cued attention downward. It would have been possible to use closed eyes as a control stimulus (Senju & Hasegawa, 2005), but using closed eyes as the only control stimulus could be problematic because of the arguably rare occurrence of perceiving closed eyes on an awake person. Perhaps the combination of all these three gaze conditions could be investigated in the future.

Another interesting question would be, if eye contact could be the reason for the higher social presence ratings in the ST-condition over BV-condition. There is intuitive appeal for this because of direct gaze's communicative meaning (eg. Kleinke, 1986). To investigate this, eye contact would have to be presented alone. But if this is done, it is likely that the meaning of the experiment would be revealed to participants and thus they might give answers that they would expect the researchers hope for. Therefore there should be a "dummy task" to cover the real interest of the experiment, maybe even a reaction time task as in this study, but direct gaze and averted gaze should be presented in different blocks.

There is a question to be raised about simplifying even the current study. It could have been beneficial to investigate the hypotheses in two different experiments using two samples. Then the length of the experiment would have diminished and thus, perhaps, making it easier for the participants to remember which condition (BV or ST) was in question. It might be that the design was too complicated in that there were two different tasks and filling of questionnaires before the condition change. Maybe these distracted the participants and they did not bear in mind which condition was taking place clearly enough to result in significant differences between the conditions.

One possible reason for the inability to replicate Teufel et al. (2010) findings is that participants did not actually remember which condition was taking place after the beginning of the block. Perhaps in the future this issue could be circulated by adding something to remind participants of the condition (for example a small light) that would be balanced between participants. Another possible solution is to make the experiment shorter. This could be attained by focusing on fewer SOAs at a time. Another possible reason for the inability to replicate findings could be, as mentioned previously, the static stimulus. Lachat, Conty, Hugueville, and George (2012) have already showed that gaze cueing studies can be done using live model and dynamic gaze, however in that case determining exact SOAs is not possible and would probably require videotaping thus adding more effort required to carrying out and analyzing in the experiment.

All in all, there were left a number of questions as to why we were not able to replicate the previous findings and contrary to our hypotheses, belief of being seen did not affect attentional orienting triggered by gaze direction. However, in this study we confirmed that gaze cueing is possible to investigate using live model (also Lachat et al., 2012). This study also gave some confirmation that the mirror deceit can be used to study beliefs of being seen or not, in that participants were surprised to learn about the deceit (also Myllyneva & Hietanen, 2015; Myllyneva et al., 2015). However, it seems that without reminders or clues of which condition is in question the belief of being seen or not may not be attributed, may be forgotten or it loses its power in temporally long lasting experiments.

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