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BRIEF REPORT

Who is looking at me? The cone of gaze widens in social phobia

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Gaze direction is an important cue that regulates social interactions and facilitates joint attention. Although humans are very accurate in determining gaze directions in general, they have a surprisingly liberal criterion for the presence of mutual gaze. Using an established psychophysical task that required observers to adjust the eyes of a virtual head to the margins of the area of mutual gaze, we examined whether the resulting cone of gaze is altered in people with social phobia. It turned out that during presence of a second virtual person, the gaze cone's width was specifically enlarged in patients with social phobia as compared to healthy controls. The size of this effect was correlated with the severity of social anxiety. As this effect was found for merely virtual lookers, it seems to be a fundamental mechanism rather than a specific effect related to the fear of being observed and evaluated by others.

Keywords: Social phobia; Gaze perception; Eye contact; Head orientation; Gaze cone.

INTRODUCTION

The gaze of others is an important signal that regulates social interactions (Kleinke, 1986). Depending on the direction of perceived gaze from the perspective of the observer or actor, two main aspects have to be distinguished. On the one hand, mutual gaze enhances the recognition of emotional facial expression (Bindemann, Burton, & Langton, 2007) and it facilitates positive evaluations of the gazing person (Mason, Tatkow, & Macrae, 2005). Averted gaze, on the other hand, is able to trigger reflexive shifts of an observer's gaze and thereby facilitates joint attention (see Langton, Watt, & Bruce, 2000, for a review).

The structure of the human eye with its high contrast between the iris and the white sclera is

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especially well suited to signal the gaze direction to another person (Langton et al., 2000) and even small changes in the luminance of the sclera are capable of modulating perceived gaze direction (Ando, 2002). It is thus not surprising that humans are very accurate in determining the gaze direction of others (e.g., Anstis, Mayhew, & Morley, 1969; Symons, Lee, Cedrone, & Nishimura, 2004). However, this precision is not exploited by observers who are being asked to report whenever they feel looked at. Several studies found a relatively wide range of gaze directions that were perceived as being directed at the observer (e.g., Gamer & Hecht, 2007; Gibson & Pick, 1963). Taken together, these data indicate that although gaze direction can be perceived very accurately in general, observers are prone to assume mutual gaze when another person is looking roughly into the direction of their own face (Vine, 1971).

Although an abnormal processing of gaze cues has been hypothesised for several clinical disorders, all of the above mentioned studies focused on the examination of healthy adults. Most clinical research in this area has focused on patients with autism spectrum disorders (e.g., Nation & Penny, 2008), and precious little is known about how gaze cues are processed in other clinical groups, such as people with social phobia. This is astonishing since social phobia is one of the most frequent mental disorders with a conservative lifetime prevalence estimate of at least 7% (Kessler, 2003). This disorder is characterised by a marked and persistent fear of social situations. When encountering these situations, extreme distress ensues and with it the tendency to avoid social situations altogether (den Boer, 1997; Kessler, 2003). Patients with social phobia tend to worry about acting in a way that will be humiliating or embarrassing. These dysfunctional cognitions are related to a fear of being observed by others, which may be associated with an abnormal processing of gaze cues.

Previous studies on gaze perception in patients with social phobia mainly concentrated on the frequency of direct eye contact with an interviewer or an audience and found some support for gaze-aversion tendencies in socially anxious persons (e.g., Daly, 1978; Farabee, Holcom, Ramsey, & Cole, 1993). This was also confirmed by recent studies that directly measured the gazing pattern of social phobic patients and found a reduced tendency to fixate the eye region in photos of faces (e.g., Horley, Williams, Gonsalvez, & Gordon, 2003). However, other studies failed to support these findings (Hofmann, Gerlach, Wender, & Roth, 1997; Wieser, Pauli, Alpers, & Mühlberger, 2009). Interestingly, these studies exclusively focused on the active gazing behaviour of socially anxious individuals instead of examining the passive perception of another person's gaze. The latter seems more likely to be disturbed in social phobia. To our knowledge, our present study is the first attempt to quantify the potentially amplified feeling of being looked at in people with social phobia.

We recently introduced a psychophysical method that allows for measuring the range of gaze directions which are taken as being directed at the observer (Gamer & Hecht, 2007). We observed that persons felt looked at when the gaze of another person, virtual or real, fell into a relatively wide range and that this range increased with the distance of the observer from the gazing person. Consequently, we suggested that a cone of gaze rather than a ray is the proper metaphor when speaking about the subjective feeling of being looked at. The width of this cone of gaze can be measured to be around 7 to 9 degrees of visual angle. Interestingly, we observed that the direction of the gaze cone was strongly affected by looker–observer distance, head rotation and visibility of the eyes whereas the gaze cone's width remained stable across these experimental manipulations (Gamer & Hecht, 2007). The current study aimed at examining whether these characteristics of the gaze cone (namely its direction and width) differ between patients with social phobia and healthy controls. Since social phobia is characterised by excessive fears about social situations that can lead to extreme distress (Kessler, 2003), we not only measured the gaze cone while confronting observers with only one virtual person in isolation (control condition), but we additionally constructed experimental conditions where a second looker was present who did or did not direct his gaze at the observer.

METHODS

Participants

Eight patients (3 female, 5 male; aged between 22 and 42 years, $M = 28.8$, $SD = 7.8$ years) fulfilling the social phobia criteria of the DSM-IV (American Psychiatric Association, 1994) were recruited at the beginning of their treatment at the psychotherapeutic outpatient clinic of the University of Mainz. Social phobia was diagnosed using the Structured Clinical Interview for DSM-IV (SCID), which was conducted by an experienced therapist with a background in cognitive behavioural therapy. Social phobia was the primary diagnosis in all patients. The control group consisted of eight healthy controls (3 female, 5 male; aged between 20 and 48 years, $M = 29.3$, $SD = 9.3$ years) carefully matched with the patient group with respect to gender, age, and education. In each group, six participants had a formal education of 13 years, one participant 10 years and the remaining observer 9 years. All patients and controls had normal or corrected-to-normal vision. They gave written informed consent indicating that their participation in this study was voluntary and that they could withdraw from the experiment at any time.

All participants completed the German version (Fydrich, 2002) of the Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989), which consists of 22 items assessing somatic symptoms, cognitions, anxiety, and escape or avoidance behaviours associated with social phobia on a 7-point Likert scale ranging from 0 (*never*) to 6 (*always*). The agoraphobia subscale, which was originally implemented in the SPAI to control for complaints of social anxiety that are only part of the clinical picture of agoraphobia (Turner, Beidel, Dancu, & Stanley, 1989, p. 37), was removed from the German version because such a suppressor function could not be empirically verified in German samples. Additionally, the number of items was reduced from 32 to 22 on the basis of item and factor analyses (Fydrich, 2002). In the current study, SPAI sum scores were linearly transformed to be comparable to the original version. The German version of the SPAI has generally proven to be of excellent psychometric quality and in the current sample, internal consistency was high in the patient group, Cronbach's $\alpha = .99$, as well as in the control group, $\alpha = .96$. SPAI sum scores ranged from 47.7 to 164.4 in patients with social phobia ($M = 114.9$, $SD = 46.3$) and from 16.7 to 64.6 in the group of controls ($M = 44.3$, $SD = 15.9$). Seven of eight patients had larger SPAI scores than all healthy controls and, correspondingly, SPAI scores differed significantly between both groups, $t(14) = 4.08$, $p < .01$.

Apparatus

The observer was seated on a height-adjustable chair directly in front of a 17″ flat screen (resolution: 1280 × 1024 pixels; colour depth: 32 bits). A second, identical flat screen was placed to the right of this primary display. The 3D-software Vizard 2.14, which was installed on a conventional personal computer, allowed us to independently present naturally looking male human heads with neutral facial expressions on each screen (see Gamer & Hecht, 2007). Head rotations and gaze directions could be freely adjusted. The screen size of these virtual heads approximately equalled that of an adult human head with a width of 15.0 cm and a height of 20.5 cm. The eyes were rendered independently and could be rotated interactively to fixate any given point in a horizontal plane defined by the observer's eye height. For the purposes of the experiment, the eyes of the virtual head converged at a point in front of it corresponding to the observer's view point. A chin rest ensured that the observer was placed directly in front of the primary display with the midpoint between the eyes aligned with its centre. The distance between the observer and the virtual head on the primary display was kept constant at 100 cm.

Design and procedure

Two different conditions were realised: In the control condition, a virtual head was displayed on the primary display only. The rotation of this head was varied in a repeated measures design. It was either squarely facing the observer or it was rotated by 10° (yaw) to the observer's left (clockwise) or right (counter clockwise). In the experimental condition, another virtual head (distractor head) was additionally presented on the secondary display. Three factors were varied in a repeated-measures design: (1) the orientation of the primary virtual head was altered using the same factor levels as in the control condition. (2) The distractor head on the secondary display was either directly facing the observer or it was diverted to point beside the observer's right shoulder. (3) The eyes of the distractor head were either gazing straight at the observer or the gaze was directed away from her/him, approximately 35 cm to her/his right (see Figure 1). Trials from both conditions were randomly intermixed and assigned to one of two measurement sessions with a short break between the blocks.

On each trial, participants were instructed to accomplish one of two adjustment tasks (centring or decentring task; see Gamer & Hecht, 2007, for further details) to allow for a quantitative measurement of the gaze cone's width and direction as a function of the experimental manipulations. To this end, the observer could freely rotate the virtual eyes of the head on the primary display in steps of 0.1° using the cursor keys of a computer keyboard. On centring trials (indicated by the letter c in the upper corner of the primary display), the virtual eyes initially gazed at a point around 10° to the left or to the right of the observer. This value was randomly varied by ± 1° to avoid a constant starting position and at the same time to leave sufficient room for adjustment. The observer was instructed to adjust the eyes of the virtual head on the primary display such that it gazed directly at her/him (centring task). On decentring trials, the virtual head initially gazed directly at

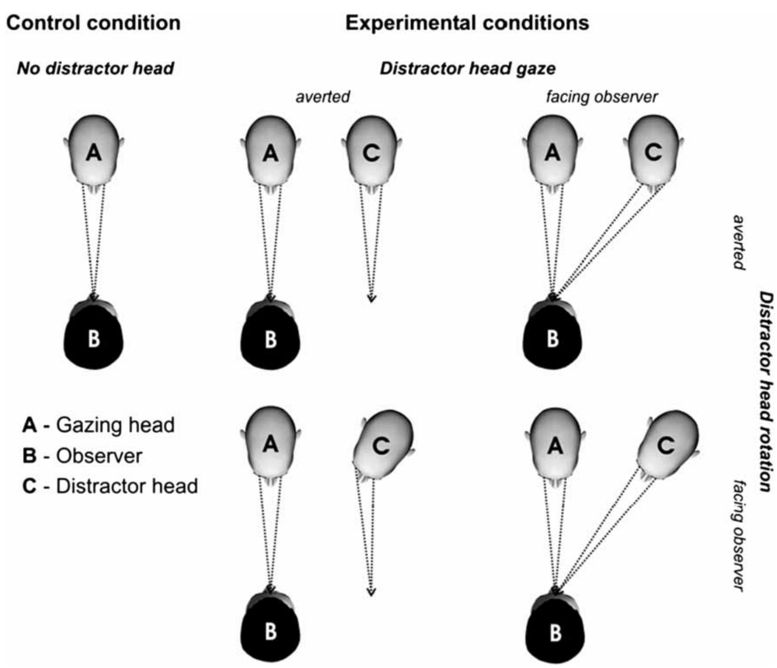

Figure 1. *Schematic design of the experiment. In all conditions, the rotation of the target head was varied as an additional experimental factor (see main text).*

the observer and he/she was instructed to rotate the head's eyes either to the left or to the right (indicated by the letters l or r) until the virtual head just stopped gazing at the observer (decentring task).

The order of the trials was randomly determined for each observer and participants were instructed to press the Enter key when they were satisfied with their setting. No time limit was specified. Each adjustment was accomplished twice, resulting in a total of 120 trials for each participant.

Two indices were computed for each condition: (1) The direction of the gaze cone as a function of the experimental manipulations was calculated as the average of all adjustments in the centring task of each condition expressed in degrees from the observer's straight ahead. (2) The width of the gaze cone was measured by the decentring task. It amounted to the angular difference between the leftward and rightward boundary of the sector within which gaze directions were considered as looking at the observer (cf. Gamer & Hecht, 2007).

Statistical analyses

Effects of the experimental manipulations were tested separately for the control and the experimental conditions by calculating analyses of variance (ANOVAs) on the direction and the width of the gaze cone. The Greenhouse–Geisser procedure was applied to correct for potential violations of the sphericity assumption. For each statistically significant effect in the ANOVAs, Cohen's *f* is reported as an effect-size estimate.

RESULTS

Control condition

A 2×3 ANOVA on the direction of the gaze cone using Group (patients vs. controls) and Head Orientation ($-10°$, $0°$ or $10°$) as factors revealed a significant main effect of Head Orientation, $F(2, 28) = 10.26$, $\varepsilon = 0.69$, $p < .01$, $f = .66$. Neither the group factor nor the interaction of both factors reached statistical significance. Thus, for patients and controls, the gaze cone shifted towards the direction to which the virtual head was rotated (see Figure 2, left panel). A similar ANOVA on the gaze cone's width did not reveal any significant effect. Across groups and conditions, the width amounted to $11.92°$ ($SD = 5.71°$), and differed significantly from 0, $t(15) = 8.35$, $p < .001$.

Experimental conditions

We first conducted a $2 \times 2 \times 2 \times 3$ ANOVA on the direction of the gaze cone using Group

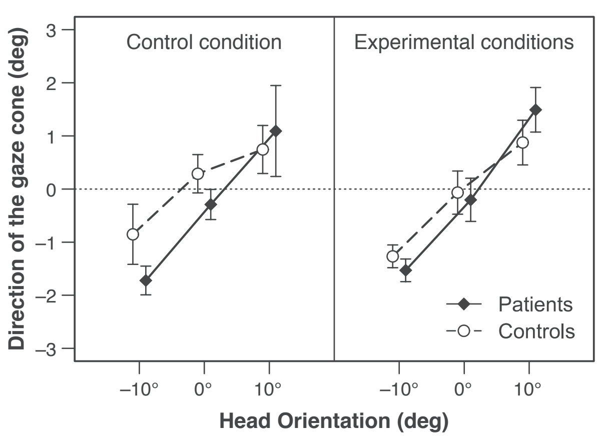

Figure 2. *Average positions of judged gaze direction for patients with social phobia and matched controls as a function of head rotation in the control and the experimental conditions. Error bars indicate standard errors of the mean.*

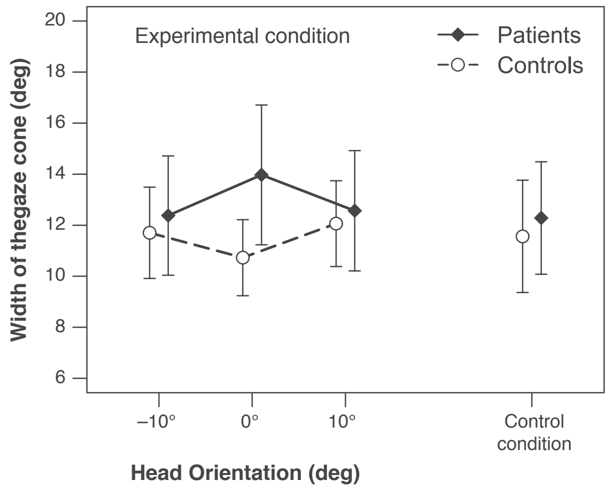

Figure 3. *Width of the gaze cone for patients with social phobia and matched controls as a function of head rotation in the experimental conditions. For comparison purposes, the mean values of the control condition are displayed on the right side of the figure. Error bars indicate standard errors of the mean.*

(patients vs. controls), Orientation of the Distractor Head (direct vs. averted), Gaze of the Distractor Head (direct vs. averted) and Head Orientation ($-10°$, $0°$ or $10°$) as factors. This analysis only revealed a significant main effect of the Head Orientation, $F(2, 28) = 21.65$, $\varepsilon = 0.55$, $p < .001$, $f = .72$, which was highly similar to the control condition (see Figure 2). In a comparable ANOVA on the width of the gaze cone we obtained a significant main effect of the Orientation of the Distractor Head, $F(1, 14) = 6.81$, $\varepsilon = 0.55$, $p < .05$, $f = .07$. The gaze cone was slightly larger when the distractor head was averted ($M = 12.69°$, $SD = 6.09°$) in comparison to the direct orientation ($M = 11.78°$, $SD = 5.45°$). Furthermore, the ANOVA revealed a significant interaction of the Group factor and the Rotation of the Target Head, $F(2, 28) = 5.36$, $\varepsilon = 1.00$, $p < .05$, $f = .10$. As can be seen in Figure 3, the gaze cone tended to be smaller when the target head was directed towards the participant in the control group. In stark contrast, for patients with social phobia, the sector where they felt looked at widened in this condition. To examine whether this differential effect of target head rotation on gaze cone's width correlates with the severity of social anxiety, we calculated the difference between the gaze cone's width in the 0° condition (i.e., when the target head was squarely facing the participant) and the average of the $-10°$ and $10°$ condition where the target head was averted. Non-parametric bootstrap techniques revealed that this value correlated significantly with the SPAI scores across all participants, $r = .57$ (95% confidence interval ranging from .19 to .76). Thus, the specific effect of social phobia on the gaze cone's width that was revealed by the ANOVA above was more pronounced for higher than for lower SPAI scores.

After the experiment, participants were instructed to report the perceived distraction that resulted from the presentation of the second head in the experimental conditions on a 6-point Likert scale ranging from 1 (*no distraction*) to 6 (*strong distraction*). Patients ($M = 2.38$, $SD = 1.60$) and controls ($M = 1.75$, $SD = 1.39$) reported very similar values indicating that the second looker did not distract them, $t(14) < 1$.

DISCUSSION

The current study tested a quantitative measure for the perceived gaze of others in social phobia.

We implemented a psychophysical task that allowed us to characterise how an observer perceives the gaze directions of another person. The task involved a measurement of direction and width of the cone of gaze (Gamer & Hecht, 2007). In line with previous studies, we found that the orientation of the looker's head attracted the perceived direction of the gaze cone toward the head direction (Anstis et al., 1969; Gibson & Pick, 1963). This effect was comparable between patients and controls and it was not modulated by the presence of a second virtual head.

Regarding the gaze cone's width, we replicated previous findings showing that a considerable range of gaze directions is capable of evoking the feeling of being looked at (Gamer & Hecht, 2007; Gibson & Pick, 1963). Again, healthy controls and people with social phobia did not differ with respect to the gaze cone's width in the one-on-one situation (control condition). In the experimental condition, however, where a second looker was present, we observed a significantly widened gaze cone for patients with social phobia when the primary looker was squarely facing them. Interestingly, this effect was independent of the orientation and the eye contact of the second (task-irrelevant) head. The magnitude of this effect correlated with the severity of social anxiety as determined by the SPAI. Thus, patients with social phobia have a higher tendency to perceive a person's gaze to be directed at them while another individual is simultaneously present. Healthy participants on the other hand seem to show a small reduction of their gaze cone's width in this situation.

One may speculate that this effect is related to information-processing biases that have been previously reported for patients with social phobia (Clark & McManus, 2002). For example, it was found that socially anxious individuals are more sensitive to negative social events than are healthy participants (Veljaca & Rapee, 1998). Anxious people are also more likely to interpret ambiguous social events in a negative fashion (Amin, Foa, & Coles, 1998). In the current study, the presence of the second (task-irrelevant) head might have enhanced negative thoughts about the self and thereby increased the detection of potentially negative social signals such as being observed by others. As a consequence, these patients might have been more sensitive to the gaze of the primary virtual person when such an increased eye contact was most plausible, i.e., when he was squarely facing them.

Taken together, the perception of mutual gaze seems to rely on integrating head rotation and gazing direction. On the one hand, the orientation of the looker's head attracts perceived gaze direction toward the head direction (cf. Gibson & Pick, 1963). On the other hand, head rotation is also capable of influencing the range of gaze directions which are taken as being directed at the observer. This modulating effect seems to be particularly enhanced in social phobia in situations with slight social pressure (e.g., when a second looker is present). In this case, patients with social phobia were more prone to assume mutual gaze when the head of the primary looker was directed at them. Thus, the integration of head rotation and gaze direction appears to be biased in social phobia to perceive mutual gaze in such situations.

Some limitations of the current study are worth mentioning. First, we examined only small samples of patients with social phobia and healthy controls. However, the results of our control group were highly similar to our recent study (Gamer & Hecht, 2007), and patients and controls were carefully matched. The fact that we found a significant group difference with respect to the width of the gaze cone indicates that the size of this onlooker effect is large enough to be revealed even with such small sample size. A second limitation concerns the experimental setting itself, which was highly controlled and only incorporated virtual lookers. In a way, this is more a strength than a weakness of the current study since we intentionally avoided constructing a situation that enhances social anxiety such as an interaction with a real person (Daly, 1978; Farabee et al., 1993) or being observed by a larger group of people (Rapee & Lim, 1992). The widening of the gaze cone might be even more pronounced in such situations of greater social pressure.

The differences between patients with social phobia and healthy controls were found in a highly controlled psychophysical task with a virtual looker. This static and artificial environment may have diminished other potential effects of social phobia on gaze perception. In future studies, the perceived direction of gaze may have to be couched within a dynamic framework. A given gaze direction has a strong influence on a subsequent gaze in that the first gaze sets a reference point or causes adaptation (Jenkins, Beaver, & Calder, 2006). As gaze after-effects are strong and potentially amenable to cognitive control we suspect such dynamic effects to be even stronger than the stationary effects reported here.

In sum, our laboratory experiment indicates that the enhanced gaze sensitivity in social phobia represents a fundamental mechanism that is not directly related to higher level cognitive functions such as the fear of being observed and evaluated by others. It is an interesting question for future research to track potential changes of gaze sensitivity during the course of pharmacological or cognitive behavioural therapy.

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