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The effects of social pressure and emotional expression on the cone of gaze in patients with social anxiety disorder

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ABSTRACT

Background and objectives: Patients with social anxiety disorder suffer from pronounced fears in social situations. As gaze perception is crucial in these situations, we examined which factors influence the range of gaze directions where mutual gaze is experienced (the cone of gaze).
Methods: The social stimulus was modified by changing the number of people (heads) present and the emotional expression of their faces. Participants completed a psychophysical task, in which they had to adjust the eyes of a virtual head to gaze at the edge of the range where mutual eye-contact was experienced.
Results: The number of heads affected the width of the gaze cone: the more heads, the wider the gaze cone. The emotional expression of the virtual head had no consistent effect on the width of the gaze cone, it did however affect the emotional state of the participants. Angry expressions produced the highest arousal values. Highest valence emerged from happy faces, lowest valence from angry faces.
Conclusion: These results suggest that the widening of the gaze cone in social anxiety disorder is not primarily mediated by their altered emotional reactivity. Implications for gaze assessment and gaze training in therapeutic contexts are discussed.
Limitations: Due to interindividual variability, enlarged gaze cones are not necessarily indicative of social anxiety disorder, they merely constitute a correlate at the group level.

1. Introduction

Gaze plays a crucial role in human interaction. The aim of the work described in this article was to examine which social factors influence the perception of gaze and in particular the region of mutual gaze. Patients suffering from social anxiety disorder experience an amplified feeling of being looked at, amounting to an extension of the region taken to constitute mutual gaze (the gaze cone's width; Gamer & Hecht, 2007; Gamer, Hecht, Seipp, & Hiller, 2011; Harbort, Witthöft, Spiegel, Nick, & Hecht, 2013). Here, we investigated possible contributing factors, such as social pressure and the emotion conveyed by the gazing person. Before reporting two experiments, we introduce current findings about the relations between gaze and social anxiety disorder.

1.1. Gaze in social interaction

The information transmitted by gaze direction cues facilitates adequate communication to a large extent (Baron-Cohen, 1995; Gibson & Pick, 1963). Thus, it comes as no surprise that the estimation accuracy of gaze perception is generally high (Gale & Monk, 2000; Symons, Lee, Cedrone, & Nishimura, 2004). We have no trouble detecting where the attention of another person is focused, and we are able to tell the gaze direction of others even when they do not look at us directly (Gibson & Pick, 1963). Accordingly, Gamer and Hecht (2007) found that eye visibility had no effect on the width of the so called “gaze cone” (i.e., the area where mutual gaze is experienced).

The metaphor of a cone captures the fact that the range of eye-orientations conveying mutual gaze grows with the onlooker's distance. In order to fully assess the gaze cone, Gamer and Hecht (2007) devised two tasks. The “centering task” gauges the direction of the gaze cone. In the “decentering task” participants are instructed to adjust the onlooker's gaze to the very limit where they cease to feel looked at, which allows one to determine its left and

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rightward thresholds and thereby calculate the cone's width, indicating the readiness to feel looked at (see Task and Design section also). The width of the cone remained invariant under manipulations such as the onlooker's head orientation, the observer distance, and the presence of a second head. Harbort et al. (2013) demonstrated excellent reliability indices for the gaze cone measure with an internal consistency of ($\alpha = 0.99$) and a retest reliability score of $r = 0.745$. Furthermore, they demonstrated that the widening of the gaze cone in social anxiety disorder occurred both using a virtual head and a real person as a stimulus.

1.2. Social anxiety disorder

Social anxiety disorder is a rather common mental disorder. One-year prevalence estimates range from 3.2% (Narrow, Rae, Robins, & Regier, 2002) up to 6% (Wittchen & Fehm, 2001, 2003). The lifetime risk is about 7–13%. Without adequate psychotherapeutic treatment, the risk of chronic persistence is higher than for other anxiety disorders (Wittchen & Fehm, 2001). It is thus important to investigate correlates of social anxiety disorder that might further the development of new techniques for diagnosis and therapy. We suggest that the width of the gaze cone might constitute such a promising correlate.

The cognitive behavioral models of social anxiety proposed by Clark and Wells (1995) and Rapee and Heimberg (1997; Heimberg, Brozovich, & Rapee, 2010) represent the two most important explanatory approaches to account for the pathogenesis of severe social anxiety. Whereas both models agree on the central role of dysfunctional representations of the self and the perpetuating role of an attentional bias toward negative self-related cognitions and mental images, the Rapee and Heimberg model further proposes an attentional bias toward external social threat related cues in the environment and difficulties to disengage attention from these cues, which operate in combination with an internal self-focused attentional bias to maintain social anxiety (e.g., Schultz & Heimberg, 2008). Thus, abnormalities in the allocation of visual attention to potential external threat cues in patients with social anxiety disorder as, for example, assessed in the gaze cone paradigm, would be more in line with the theoretical predictions of the Rapee and Heimberg model compared to the Clark and Wells model, which rather exclusively focuses on a biased attention allocation to internal threat cues (i.e., negative self-related cognitions and biased mental images of the self in social situations) and predicts the avoidance of external threat cues.

Within the literature that focuses on a possible link between social anxiety disorder and gaze patterns, we discern two general approaches. The first focuses on altered gaze patterns within the active behavior of social anxiety disorder patients. Studies conducted within this approach found a significant correlation between the severity of social anxiety and gaze avoidance (Moukheiber et al., 2010; Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz, 2011). Avoidance has been found for entire facial features (reduced foveal fixations), especially of the eyes (Garner, Mogg, & Bradley, 2006; Horley, Williams, Gonsalvez, & Gordon, 2003). Horley, Williams, Gonsalvez, and Gordon (2004) demonstrated that this avoidance behavior is especially evident for angry faces. These findings are in line with the Clark and Wells (1995) model suggesting avoidance of external social threat.

The second approach focuses on potential differences in the social anxiety disorder patient's perception of another's gaze (the onlooker's gaze), thus it is concerned with the feeling of being looked at. For example, Roelofs et al. (2010) found that people with high social anxiety were faster in avoiding angry or happy faces as compared with people with low social anxiety in an approach-avoidance task. Interestingly, this result emerged for the angry faces only if they displayed a conspicuous direct gaze but not if they exhibited an averted gaze. It has to be acknowledged, however, that the existing empirical evidence regarding gaze avoidance in social interactions in patients with social anxiety disorder is rather inconclusive (Weeks, Heimberg, & Heuer, 2011; Schulze, Renneberg, & Lobmaier, 2013).

Regarding the size of the gaze cone in social situations, we found that the cone is generally widened in patients with social anxiety disorder (Harbort, Witthöft, Spiegel, Nick, & Hecht, 2013), and that this effect is particularly strong when social pressure (by means of another head directed toward the subject) is increased (Gamer et al., 2011). Furthermore, the degree of gaze cone enlargement was shown to be correlated with the severity of social anxiety disorder. These findings are, at first glance, more compatible with the predictions of the Rapee and Heimberg model suggesting sustained vigilance for external social threat cues. In this sense, wider gaze cones might represent an indicator of an external threat monitoring process according to the Rapee and Heimberg (1997) model. This threat monitoring process serves to detect and avoid possible social threats (e.g., signs of negative evaluations by others) and might operate in a hyper-vigilant state in case of social anxiety disorder. However, a wider gaze cone could also be the result of an avoidance reaction toward social threat cues as suggested by Clark and Wells. As a consequence of avoidance, information accumulation could be impaired leading to a less detailed processing of socially relevant information, which is based more on internal anxiety relevant schemata and 'emotional reasoning' than on external sensory stimulus properties. Consequently, a larger gaze cone might be the product of such noisy processing of external socially relevant information.

The present work aims to further explore gaze perception in social anxiety disorder with two primary goals. Firstly, if social anxiety disorder leads to a widened gaze cone, then increasing the degree of social pressure might moderate this effect (i.e., should widen the cone even more). In Experiment 1, we varied social pressure by adding other heads and presenting them in 3D. Secondly, we assumed that negative expressed emotion should widen the gaze cone, in particular for people with social anxiety disorder. This prediction would be compatible with the recent finding that observers are more accurate when determining the gaze direction of faces with neutral emotional expression, as opposed to happy, angry, or fearful expressions (Lobmaier, Hartmann, Volz, & Mast, 2013). In Experiment 2, we therefore varied the emotional expression of the virtual heads.

2. Material and method of experiment 1: Does social pressure influence the width of the gaze cone?

People with social anxiety disorder have more anxiety during public speeches than people without social anxiety (Hofmann, Gerlach, Wender, & Roth, 1997). Cornwell, Johnson, Berardi, and Grillon (2006) confirmed that anxiety can be caused both by speaking and anticipation of speaking in front of an audience, even if the audience is virtual. Furthermore, social anxiety disorder patients are more accurate in detecting positive (for example smile) and negative (for example raised eyebrows) signs of behavior from the audience, with the latter being detected with particular ease (Veljaca & Rapee, 1998). We hypothesize that increasing the number of people who also look at the patients should augment the perceived risk that humiliating or embarrassing events could happen and thereby increase their level of anxiety. This in turn should widen the cone of gaze.

2.1. Method

2.1.1. Participants

The sample consisted of twenty patients fulfilling the social anxiety disorder criteria of the DSM-IV (Saβ, 2003) (14 female, 6 male, aged between 18 and 67 years, $M = 32.45$, $SD = 13.05$) and 21 control participants without any current mental disorder (15 female, 6 male, aged between 18 and 61 years, $M = 31.95$, $SD = 12.65$). All social anxiety disorder participants were diagnosed with the Structured Clinical Interview for DSM-IV (SCID; Wittchen, Zaudig, & Fydrich, 1997) by specially trained raters. Control participants were pairwise matched to the patients regarding gender, age, and education. All patients were recruited before the beginning of a psychotherapeutical treatment at the outpatient clinic of the University of Mainz. The study took place with approval of the local ethics committee. The participants gave informed consent that their participation was voluntary and that they could withdraw from the study any time. Four participants had problems with the adjustment task (three patients, one control). They produced average gaze angles more than two standard deviations above or below the mean and were excluded from the analysis.

2.1.2. Task and design

The between-subjects factor *Group* had two levels: the social anxiety disorder group and a healthy control group. The *Number of Heads* was varied as a within-subjects factor. The number of heads ranged from one to five heads: the target head whose eyes had to be adjusted and zero to four additional distractor heads (see Fig. 1).

The target head was always present in the middle of the screen. All distractor heads were either directly facing the observer or were rotated straight into the room. Likewise, the same variations were applied to the eyes, i.e., the eyes of the distractor head were aligned with the head. The implementation of these variations was made equally for all distractor heads. All heads were presented three-dimensionally using a stereoscopic projection. In order to minimize eye strain on participants, we refrained from using both male and female heads, which would have doubled the duration of the experiment to last approximately three hours, and used only male heads.

The participants had to perform the so-called decentering task upon the target head, which measures the width of the gaze cone. The target head was initially looking straight at the participant, who was instructed to rotate the eyes to the left or to the right until the participant ceased to feel looked at. The virtual eyes were adjusted to converge at the interpupillary point of the subject when looking straight ahead and could be rotated in 0.1° steps by pressing the arrow keys on a keyboard. Thus, in each trial the participant had to adjust the eyes either leftwards or rightwards until they subjectively reached the point where the gaze stopped to be directed at the subject. This allowed us, by combining the left and the right thresholds, to determine the width of the gaze cone, which constitutes the first dependent variable. As a second dependent measure, after each trial participants had to rate their emotional state on the Self-Assessment Rating Scales (SAM; Lang, 1980). SAM is a language-independent instrument to measure emotions with a 9-point rating scale. We measured the scales *Arousal* and *Valence*. Both are graded into nine levels represented graphically by a so-called “manikin”, a figure indicating an emotional state (see Fig. 2).

From left to right the valence scale begins with “unhappy, annoyed, sad” and ends with “comfortable, happy, cheerful”. For arousal, the scale begins with “relaxed, calm” and ends with “excited, nervous”. The participants indicated their emotional state by marking the figure that best corresponded to their emotional state.

A total of 68 trials were run. The target head by itself and the target head supplemented with 1–4 distractor heads (each with 2 possible orientations crossed with 2 gaze directions) amounted to 17 stimuli. All these stimuli were presented once with the request to decenter to the left and once with the request to decenter to the right. The resulting 34 trials were repeated once in separate random orders for each subject.

2.1.3. Apparatus

The participants were seated on a height-adjustable chair in front of a 1.93 × 1.06 m flat screen, with an aspect ratio of 16:9. The stimuli were presented by a 3D projector (Depth Q Stereoscopic WXGA) with a resolution of 1280 × 720 pixels and a color depth of 32 bits. LCD shutter glasses (CrystalEyes 3 Eyewear) allowed for a display rate of 60 Hz for each eye. We used the 3D Software WinVizard 3.12 (2009) to render natural-looking human heads of Caucasian male adults. Their size matched that of an average adult human head at screen distance (width of 19 cm and height of 34 cm). During the experiment, participants placed their head on a chin rest, which was adjusted so that the eyes of the target head were at the same level as the eyes of the subject, that is, 1.2 m above the floor. The participants' eye-point was centered with respect to the screen at a distance of 2 m and thus directly in front of the target head.

2.1.4. Procedure

In a separate session before the experiment subjects were screened for mental disorders. Only participants without comorbid disorders were included in the experiment. No time limit was given. After each trial, the SAM manikins were presented and rated on the same display screen. The trials were separated into two blocks, with a facultative short break in between. The entire experiment lasted about 1.5 h on average.

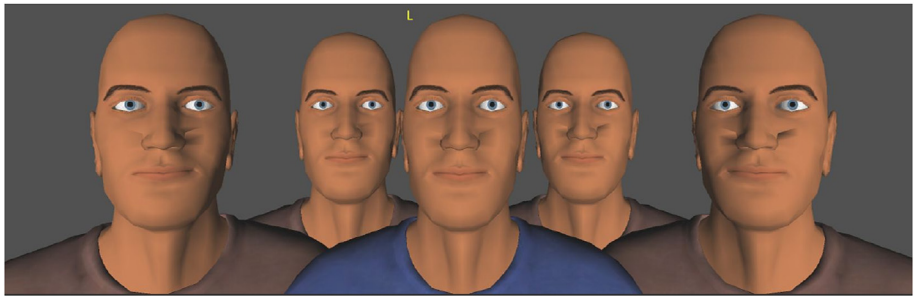

Fig. 1. Five virtual people, presented in 3D in Experiment 1. The one with the blue shirt (in the middle) is the target head, the ones with the brown shirts are the distractor heads. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

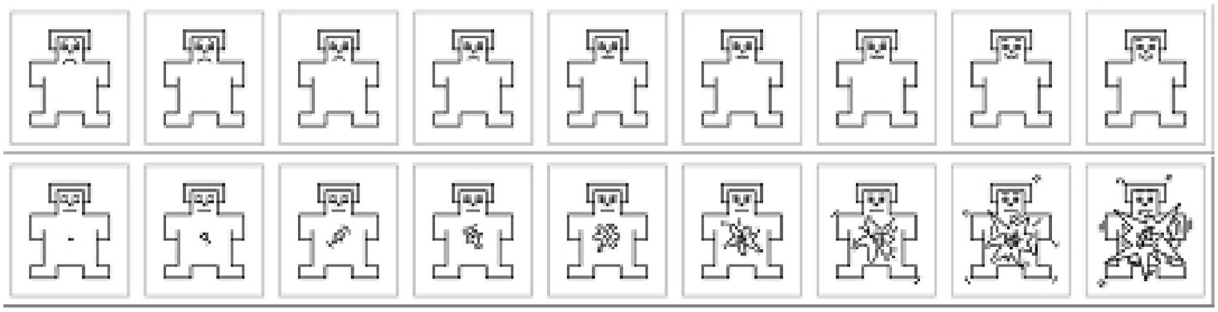

Fig. 2. Experiments 1 and 2: The items of the Self-Assessment-Manikin scales (SAM), Valence (upper picture) and Arousal (lower picture).

3. Results

3.1. Gaze cone

A mixed analyses of variance (ANOVA) on the width of the gaze cone with the factors *Group* (between-subjects) and *Number of Heads* (repeated-measures) and was conducted. A main effect of *Group* was found on the width of the gaze cone, $F(1, 35) = 20.389$, $p < 0.001$, $\eta^2 = 0.368$, 95% CI [0.16, 0.52]. Social anxiety disorder patients ($M = 15.4$, $SD = 1.166$) had larger gaze cones than healthy controls ($M = 8.27$, $SD = 1.075$; see Fig. 3).

The ANOVA revealed a significant effect of *Number of Heads* on the width of the gaze cone: $F(1.94, 67.78) = 6.895$, $p = 0.002$, $\eta^2 = 0.165$, 95% CI [0.04, 0.28]. The more virtual onlookers, the wider was the gaze cone. The pairwise comparison of means (see Table 1) revealed significant differences between the presence of five versus one, two and three heads.

This result supports our hypothesis that social pressure enlarges the cone of gaze. Finally, this effect was not moderated by social anxiety disorder, as disclosed by a non-significant *Group* × *Number of Heads* interaction, $F(1.97, 67.78) = 2.191$, $p = 0.121$, $\eta^2 = 0.059$, 95% CI [0.00, 0.15]. Similarly, the orientation of the head and the eyes of the distractor heads failed to reach statistical significance.

3.2. Emotion ratings

A second ANOVA was conducted on the arousal ratings and a third one on the valence ratings. For arousal, a main effect of *Group* was found, $F(1, 35) = 11.576$, $p = 0.002$, $\eta^2 = 0.249$, 95% CI [0.07, 0.42]. Social anxiety disorder patients ($M = 3.182$, $SD = 1.619$) were overall more aroused than healthy controls ($M = 1.643$, $SD = 1.12$) during the entire experiment. The difference of the means (patients vs. controls) amounted to 1.538, $SEM = 0.452$, $p = 0.002$. *Number of Heads* had no significant main effect, $F(3.28, 114.67) = 2.151$, $p = 0.092$, $\eta^2 = 0.058$, 95% CI [0.00, 0.12]. However, it did interact significantly with *Group*, $F(3.28, 114.67) = 4.062$, $p = 0.007$, $\eta^2 = 0.104$, 95% CI [0.02, 0.18]. That is, only social anxiety disorder patients' arousal significantly increased with increasing number of heads.

With regard to valence, social anxiety disorder patients ($M = 5.629$, $SD = 1.267$) had lower valence scores than healthy controls ($M = 7.321$, $SD = 1.721$), this *Group* factor being significant at $F(1, 35) = 11.233$, $p = 0.002$, $\eta^2 = 0.243$, 95% CI [0.04, 0.44]. For *Number of Heads*, there was a null effect $F(3.28, 114.8) = 0.292$, $p = 0.848$, $\eta^2 = 0.008$, 95% CI [0.00, 0.04]. Finally, the interaction *Number of Heads* × *Group* was non-significant.

The arousal scores revealed a strong negative correlation with

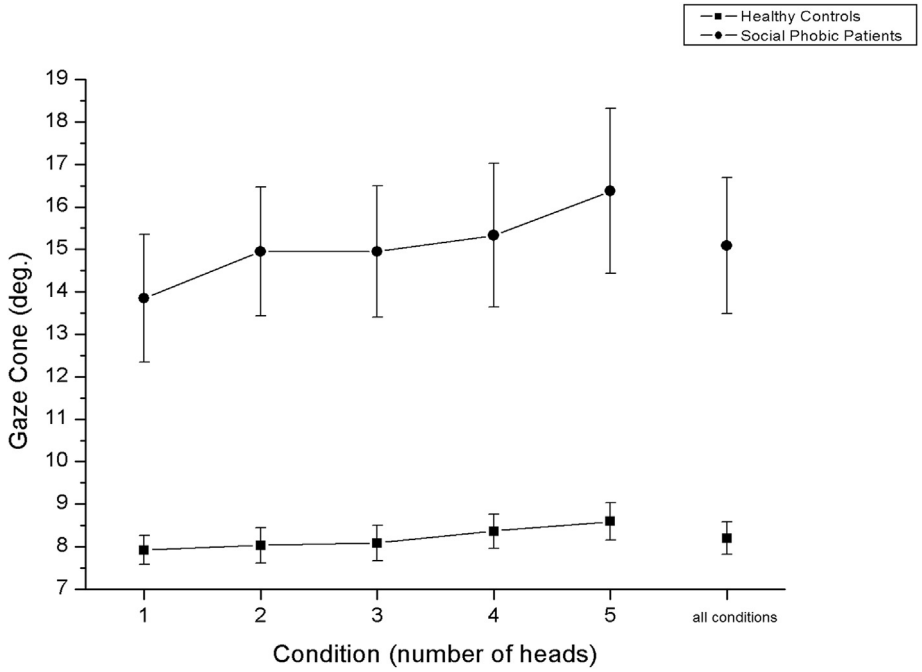

Fig. 3. Experiment 1: Width of the gaze cone (in degrees) for both experimental groups (social anxiety disorder patients, healthy controls) as a function of number of total heads (1–5). Note that 1 head indicates the target-head only condition.

Table 1
Experiment 1: Pairwise comparisons of the mean values (difference), standard error of the mean, and significance (p) for the width of the gaze cone for the various numbers of heads.

Number of heads (I)	Number of heads (J)	Mean difference (I-J)	Standard error of mean	*p*
1	2	-0.605	0.360	1.000
	3	-0.632	0.347	0.770
	4	-0.964	0.406	0.230
	5	−1.599	0.506	0.032
2	1	0.605	0.360	1.000
	3	-0.027	0.152	1.000
	4	-0.360	0.192	0.693
	5	-0.995	0.268	0.007
3	1	0.632	0.347	0.770
	2	0.027	0.152	1.000
	4	-0.332	0.179	0.717
	5	-0.967	0.299	0.027
4	1	0.964	0.406	0.230
	2	0.360	0.192	0.693
	3	0.332	0.179	0.717
	5	-0.635	0.256	0.179
5	1	1.599	0.506	0.032
	2	0.995	0.268	0.007
	3	0.967	0.299	0.027
	4	0.635	0.256	0.179

valence, $r = -0.824$, $p < 0.001$, for both the social anxiety disorder patients, $r = -0.751$, $p = 0.001$, and the control group, $r = -0.812$, $p < 0.001$. Thus, in general, participants who reported more negative feelings also felt more aroused by those same emotions.

4. Discussion

The primary aim of Experiment 1 was to test whether social pressure would be able to increase arousal and the size of the gaze cone in patients with a social anxiety disorder. First, these patients did produce wider gaze cones compared to healthy control participants, replicating previous findings (Gamer et al., 2011; Harbort et al., 2013). Second, the larger the social pressure putatively induced by the additional heads, the larger was the gaze cone. However, this effect was not significantly stronger in patients than in healthy subjects. Although we observed a medium effect size for the most important interaction effect between the group factor and the number of heads for the width of the gaze cone, this effect failed to reach significance. Thus, our initial hypothesis that patients with social anxiety disorder would be particularly amenable to social pressure could not be confirmed as there was no sizable interaction. In contrast, our experimental manipulation of social pressure by increasing the number of heads was obviously successful.

A limitation of Experiment 1 constitutes the lack of systematic manipulation of the emotional expression. Thus, it is impossible to decide whether the observed wider gaze cones in patients with a social anxiety disorder are ubiquitous for the whole spectrum of positive and negative emotional expressions. We designed Experiment 2 to test whether emotional expression modulates the gaze cone width.

5. Introduction experiment 2: Does facial emotion influence the width of the gaze cone?

Social anxiety disorder patients dislike social situations for fear they might behave in embarrassing or humiliating ways (Saβ, 2003; World Health Organization, 2006). The emotion displayed by the person with whom they interact might thus modulate their appraisal of how threatening the social situation is. Accordingly, the cone of gaze could reflect the degree of threat experienced by the patient.

Lundh and Öst (1996) reported that individuals with social anxiety disorder were more accurate in recognizing previously seen critical faces as compared to friendly faces, while normal controls showed the inverse pattern (see also Coles & Heimberg, 2005). Despite a wealth of research on the perception, processing, and memory for emotional faces in patients with social anxiety disorder (see Staugaard, 2010; for a review), the results remain inconclusive, for the most part due to the diversity in methods and stimuli.

It may be possible to reconcile the above findings when factoring in whether the processing times would have allowed for an engagement of higher-level perceptual processes, which may be inhibited in socially anxious participants for short stimulus presentations (Staugaard, 2010). In other words, this pattern could be accounted for by the avoidance *versus* vigilance hypothesis, with the former being elicited in later processing stages. In support of this claim, when patients were confronted with photos of threatening faces, they exhibited increased activation in brain areas associated with earlier emotional processing (Brühl et al., 2011). An increased activity of the amygdala, insula, medial prefrontal cortex, and rostral anterior cingulate cortex emerged when social anxiety disorder patients were confronted with negative emotions (Amir et al., 2005; Blair et al., 2008, 2011; Campbell et al., 2007; Etkin & Wager, 2007; Stein, Simmons, Feinstein, & Paulus, 2007). Campbell et al. (2007) reported amygdala responses to be delayed for people with generalized social anxiety disorder if happy, angry, or fearful faces were presented.

Other social cues which might modulate the impact of emotional expression have rarely been considered. One exception is a study by Roelofs et al. (2010). In an approach-avoidance task, they manipulated both the emotional facial expression (anger or happiness) and the direction of gaze of the stimulus face (towards or away from the participant). Social anxiety patients were faster in avoiding both angry and happy faces, but the former only when the face was conspicuously looking at them. This dissociation was taken to reflect the fact that gaze direction modulates the importance and meaning of a facial expression, similar to the effect that positive mood broadens the attentional focus (e.g., Rowe, Hirsh, & Anderson, 2007). If the widening of the gaze cone with social anxiety disorder is mediated by such altered processing of emotional stimuli, then patients should react to and interpret emotional expressions differently than healthy subjects. Experiment 2 sought to test this hypothesis. We expected to find wider gaze cones for angry, compared to neutral and happy faces. We further hypothesized that this valence effect would be moderated by the diagnosis of social anxiety disorder. That is, patients with social anxiety disorder should show disproportionally wider gaze cones in light of angry compared to neutral and happy expressions.

6. Method

6.1. Participants

The recruitment criteria were the same as in Experiment 1. Twenty patients with social anxiety disorder (13 female, 7 male; aged between 18 and 55 years, $M = 29.10$, $SD = 9.86$ years) and twenty healthy controls (13 female, 7 male; aged between 18 and 66 years, $M = 30.05$, $SD = 12.03$ years) participated in this experiment. Two additional subjects were excluded for failure to follow instructions as they had produced average gaze angles more than two standard deviations above or below the mean (one patient, one control).

6.2. Task and design

As before, we used stereoscopic 3D-animations of virtual target heads. The between-subjects factor *Group* had two levels, the social anxiety disorder group and the healthy control group. *Emotion* conveyed by the onlooker was varied as a within-subject factor among neutral, happy, and angry (see Fig. 4).

As before, the subject had to adjust the gaze direction of the target head to indicate the edges of the gaze cone. Either just the target head was present, or it was supplemented with a distractor head. The head and eye orientation of the distractor head was the same as in Experiment 1. The target head, whose eyes had to be adjusted, was always present in the middle of the screen. The distractor head, if present, exhibited the same emotion as the target head.

As in Experiment 1, participants had to perform the decentering task; the conditions, configuration, self-report-measures, and instructions were the same. The factors emotion (3) and decentering direction (2) were fully crossed with the 5 head conditions (target head only, additional distractor head with two possible orientations times two possible eye-directions). The resulting 30 trials were presented twice in different random orders for each subject.

6.3. Apparatus and procedure

The same apparatus and procedure of Experiment 1 was used here.

7. Results

7.1. Gaze cone

A mixed analyses of variance (ANOVA) on the width of the gaze cone with the factors *Group* (social anxiety disorder vs. control), *Number of Heads* (1 vs. 2), and *Emotional expression* (neutral vs. happy vs. angry) was conducted. A main effect of *Group* was found on the width of the gaze cone, $F(1, 36) = 11.075$, $p = 0.002$, $\eta^2 = 0.235$, 95% CI [0.04, 0.44], suggesting that social anxiety disorder patients had larger gaze cones than healthy controls (Fig. 5).

No main effects for the *Number of heads*, $F(1, 36) = 2.409$, $p = 0.129$, $\eta^2 = 0.063$, 95% CI [0.00, 0.25], or the *Emotional expression*, $F(1, 36) = 2.130$, $p = 0.126$, $\eta^2 = 0.056$, 95% CI [0.00, 0.24], were observed and none of the interaction effects reached the significance level, all Fs < 1.420, all ps > 0.243.

7.2. Emotion ratings

In case of arousal, an ANOVA with the factors *Group* and *Emotion* revealed a significant main effect of *Group* $F(1, 36) = 13.263$, $p = 0.001$, $\eta^2 = 0.269$, 95% CI [0.06, 0.47]. Social anxiety disorder patients had higher arousal ratings than healthy controls, the difference of the means (patients vs. controls) amounting to 1.514, $SEM = 0.416$, $p = 0.001$. However, the interaction *Emotion* × *Group* was not significant, $F(1.16, 41.83) = 0.600$, $p = 0.467$, $\eta^2 = 0.016$, 95% CI [0.00, 0.15]. The *Emotion* also had a significant effect on arousal $F(1.16, 41.83) = 7.475$, $p = 0.007$, $\eta^2 = 0.172$, 95% CI [0.02, 0.36]. Arousal was highest when the presented head looked angry, it was lower when the target head looked neutral, and it was lowest when the head looked happy. This pattern was not modulated by the number of heads present. The pairwise comparison showed a significant difference between the mean of happy and angry faces (difference of the means = −0.434, $p = 0.015$, $SEM = 0.146$), and a marginally significant difference between neutral and angry faces (difference of the means = −0.335, $p = 0.053$, $SEM = 0.135$). The difference between neutral and happy faces did not reach the significance level (difference of the means = 0.099, $p = 0.127$, $SEM = 0.047$).

A separate ANOVA conducted on the valence ratings revealed a significant main effect of *Group* across all conditions, $F(1, 36) = 16.267$, $p < 0.001$, $\eta^2 = 0.311$, 95% CI [0.08, 0.50]. Healthy controls had higher (i.e., more positive) valence scores than social anxiety disorder patients; pairwise comparisons of mean values revealed a significant mean difference (controls vs. patients) of 1.737 ($SEM = 0.431$, $p < 0.001$). The ANOVA also yielded a significant main effect of *Emotion*, $F(1.1, 39.48) = 11.702$, $p = 0.001$, $\eta^2 = 0.245$, 95% CI [0.05, 0.44]. Highest valence scores emerged with happy faces, lowest valence scores with angry faces. Neutral and happy faces differed by −0.206 (*SEM* 0.051, $p = 0.001$), neutral − angry faces by 0.334 (*SEM* 0.114, $p = 0.018$) and for happy − angry faces a mean difference of 0.539 (*SEM* 0.150, $p = 0.003$) was found. The orientation of the head and the eyes of the distractor heads had no effect.

Finally, the arousal scores correlated significantly with the valence scores across all conditions (range from $r = -0.637$, $p < 0.001$ to $r = -0.847$, $p < 0.001$). That is, participants reported higher well-being for low-arousal trials and vice-versa.

8. Discussion

The primary aim of Experiment 2 was to test whether the width of the gaze cone changes as a function of the emotional expression of the respective face stimulus. Based on previous findings (Harbort et al., 2013), we hypothesized that angry facial expressions widen the gaze cone more than happy and neutral expressions, in particular in patients with a social anxiety disorder. This was not supported by the data. Patients clearly differed in the emotional response from the healthy controls. Patients were more easily aroused and they experienced the emotion as more negative. This experience, however, did not produce a straight-forward effect on the width of the gaze cone. Thus, the widening of the gaze cone in patients does not seem to be mediated by their emotional response. Additionally, the findings suggest that the manipulation of social pressure by increasing the number of heads does not affect the width of the gaze cone.

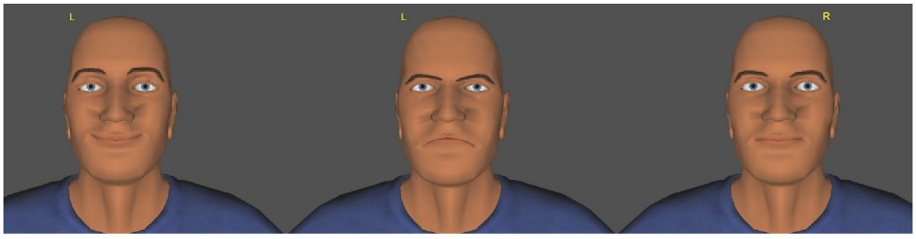

Fig. 4. Experiment 2: The different emotions: happy, angry, neutral.

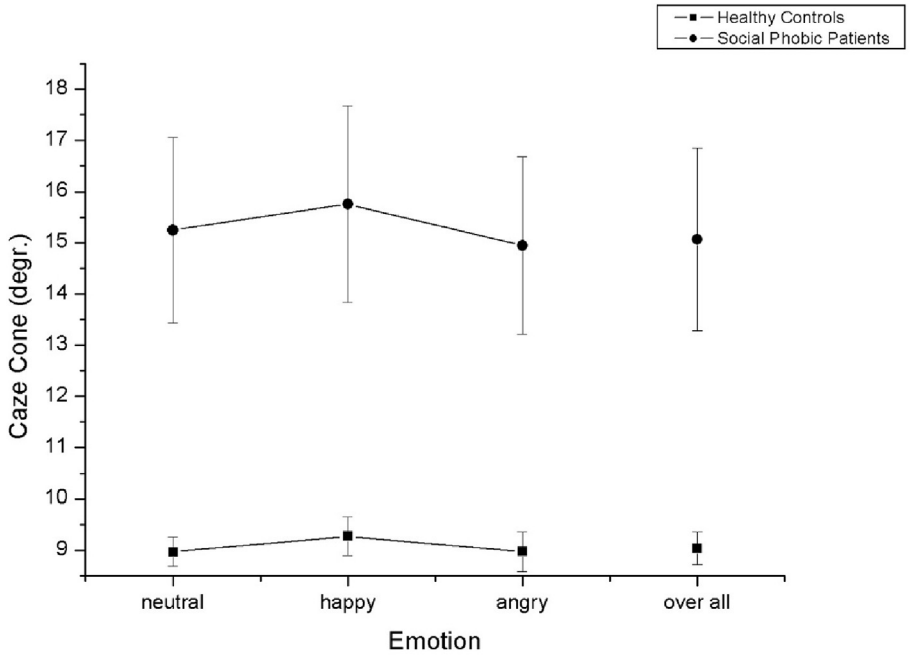

Fig. 5. Experiment 2: Width of the gaze cone (in degree) for both experimental groups (social anxiety disorder patients, healthy controls) across the three emotions (neutral, happy, angry) and for all conditions together.

9. General discussion

The aim of this study was to further investigate the cone of gaze – the area of perceived mutual gaze – as a correlate of social anxiety disorder. In agreement with previous research, we found a robust effect of social anxiety disorder to widen the gaze cone. In two experiments, we varied the social pressure as induced by the number of virtual heads and the expressed emotions. We also assessed the emotional state of the participants.

Healthy control subjects exhibited normal gaze cones with an average width of about 9°. Patients exhibited gaze cones that were almost doubled in width. Experiment 1 revealed that the gaze cone widens as a function of the number of onlookers. That is, significantly larger gaze cones were observed when facing the maximum number of 5 heads, as compared to a smaller number of one to three heads. Note, however, that the effect regarding the number of heads was considerably smaller than the effect of social anxiety disorder per se. Interestingly, a relatively slight increase of the cone with social pressure appears to be reflected in the healthy controls as well, albeit below the level of statistical significance. In other words, social pressure does not seem to enlarge the cone of gaze disproportionally in case of social anxiety disorder. This conclusion is, however, limited by the comparatively small sample size and it cannot be ruled out that the use of larger sample sizes would have resulted in a significant interaction effect between social anxiety and social pressure regarding the width of the gaze cone.

In Experiment 2, the gaze cone width unexpectedly appeared rather independent of the facial expression. As large as the differences were between the social anxiety and the control group, it remained largely unaffected by the manipulation of the facial expression. The emotion of the faces came across clearly (as reflected in the arousal ratings), thus, the lack of an effect cannot be attributed to deficiencies in the facial expressions of the virtual head.

At first sight, our finding that the gaze cone width was independent of the emotional expression of the target face contradicts Schulze, Lobmaier, Arnold, and Renneberg (2013). They had used a large sample of n = 174 participants recruited via the internet. The feeling of being looked at (i.e., stronger self-directed perception of the gaze of other person) was positively associated with social anxiety, particularly when using neutral and negative facial expressions (but not in case of happy facial expressions). At second sight, the differences between our paradigm using leisurely adjustment of the avatar's eyes and Schulze et al.'s paradigm (using very brief presentations of a static stimulus) might explain the difference. Most importantly, we have varied the number of heads present in the stimulus. The social pressure exerted by the additional lookers did increase the cone width and may well have drowned any potential effect of emotion. Note that Schulz, Lobmaier et al. (2013), –by virtue of the large number of subjects used – were able to detect influences of facial expression too small for our design. Another interpretation of the discrepancy, going beyond the fundamental methodological differences could be sought in the different subject populations (the general population vs. patients with social anxiety disorder). An inferior ability to correctly identify emotional expression could have prevented the effect to surface in our patient population.

Across Experiments 1 and 2, self-assessed arousal was systematically higher for patients with social anxiety disorder than for healthy controls. Similarly, the ratings of valence were overall more negative for social anxiety disorder patients. Importantly, the number of heads modulated the reported arousal for patients but not for healthy participants (Experiment 1). However, the conveyed facial emotion did affect both valence and arousal ratings. Altogether, both arousal and the width of the gaze cone were higher the more heads were shown. Our hypothesis that emotion predominantly increases the subjective social pressure in patients with social anxiety disorder was not supported (Experiment 2). Also, healthy controls had higher valence scores than social anxiety disorder patients. Taken together, this could indicate that patients use coping strategies. This does not, however, take away from the sizable initial widening of the gaze cone as related to social anxiety disorder.

A number of caveats should be considered. Firstly, the experimenter was present during the experiment at all times and might have had an additive effect on the judged width of the cone. After

giving the instructions and overseeing the practice trials, she remained in the experiment room. This was deemed appropriate for general supervision of the experiment. The researcher turned her back towards the subject as to be as unobtrusive as possible. This social contact might nonetheless have influenced the performance of social anxiety disorder patients. It is not clear, however, in which direction such an influence would have changed the results, if at all. The experimenter could have put some degree of social pressure on the patients or she could have been a source of comfort, as she kept close ties to the outpatient service and the therapists. We surmise that it is unlikely that patients who volunteered for the study felt undue social pressure exerted by the experimenter – no participant mentioned any discomfort after the experiment.

Another caveat regards the legitimacy of diagnostic inferences from the increased cone of gaze. It is necessary to assess the cone of gaze along with the standard diagnostic tools as there is interindividual variability. For instance, a gaze cone of 13° is by itself not necessarily indicative of social anxiety disorder. However, it is easy to see how the measure could be used to supplement diagnostic tools when it comes to assess the progress or success of a therapeutic intervention. The cone of gaze should become smaller along the road of recovery (see Harbort et al., 2013). Another limitation of the current study represents the lack of a clinical control group. The question of specificity of the observed findings for patients with social anxiety disorder compared to patients with other anxiety or affective disorders therefore remains unanswered and future studies have to test whether the observed alterations in gaze perception are specific to social anxiety disorder or whether they represent a broader transdiagnostic aspect of psychopathology.

From a clinical perspective, it appears promising to use the cone of gaze measure as a therapeutic instrument itself. Knowing that it enlarges in states of social pressure, one could demonstrate this to patients. They could be exposed to virtual people gazing at them for periods of time long enough for a significant drop of anxiety and arousal – in other words, allowing for a desensitization exercise in a controlled setting. Likewise, different fears can be assessed within such a protected frame, in which the therapist is present or available. Promising as it is, these prospects should be of paramount focus in future research.

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