the british psychological society
promoting excellence in psychology

British Journal of Psychology (2020), 111, 233–245

www.wileyonlinelibrary.com

Social anxiety modulates visual exploration in real life – but not in the laboratory

Marius Rubo*, Lynn Huestegge and Matthias Gamer
Department of Psychology, Julius Maximilian University of Würzburg, Germany

In clinical reports, individuals high on social anxiety are often described to avoid gaze at other people, whereas several experimental studies employing images of persons yielded conflicting results. Here, we show that gaze avoidance crucially depends on the possibility of social interactions. We examined gaze behaviour in individuals with varying degrees of social anxiety in real-life and in a second group of participants using a closely matched laboratory condition. In the real-life situation, individuals with a higher degree of social anxiety had a reduced bias to look at near persons compared to individuals with a lower degree of social anxiety, while gaze behaviour in the laboratory group was not modulated by social anxiety. This effect was specific to social attention since there was no corresponding effect regarding fixations on objects. The presence of anxiety effects in real-life but not in the laboratory condition, where participants do not expect to be evaluated by gazed-at conspecifics, points to critical deficits of current laboratory research paradigms in eliciting authentic social attentional mechanisms, possibly leading to spurious results.

A large proportion of people in the community exhibit signs of social anxiety such as fear of speaking to an audience or talking to persons in authority (Stein, Walker, & Forde, 1994), and a subgroup of these individuals suffers so severely from their fear of other people's scrutiny that they may receive a diagnosis of *social anxiety disorder* (SAD) or *social phobia* (American Psychiatric Association, 2013). Cognitive models of SAD (Rapee & Heimberg, 1997) propose biases in evaluating social information that provoke anxiety in social situations and contribute to the aetiology and maintenance of the disorder. For instance, individuals high on social anxiety show a tendency to interpret ambiguous social information negatively (Huppert, Pasupuleti, Foa, & Mathews, 2007) and preferentially memorize negative social cues (Lundh & Öst, 1996). Clinical reports of individuals with SAD furthermore emphasize an avoidance of other people's gaze (Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz, 2011). This specific effect, however, could not be robustly replicated in laboratory settings, with some studies reporting reduced (Moukheiber *et al.*, 2010; Weeks, Howell, & Goldin, 2013), but other studies reporting heightened amounts of fixation on faces or eyes in social phobic adults and shy children (Boll, Bartholomaeus, Peter, Lupke, & Gamer, 2016; Brunet, Heisz, Mondloch, Shore, & Schmidt, 2009; Wieser, Pauli, Alpers, & Mühlberger, 2009).

Correspondence should be addressed to Marius Rubo, Department of Psychology, Julius Maximilian University of Würzburg, Marcusstr 9-11, 97070 Würzburg, Germany (email: marius.rubo@uni-wuerzburg.de).

DOI:10.1111/bjop.12396

Note that such laboratory-based studies on attentional biases in social anxiety typically rely on passively viewing images of persons and do not incorporate any interaction with real people. This approach is problematic since gaze behaviour is known to be modulated by the presence of other people, even in the general population. For instance, Laidlaw, Foulsham, Kuhn, and Kingstone (2011) found participants to frequently look at the videotape of a confederate, but to avoid looking at a live confederate when she was present in the room. Along these lines, Gobel, Kim, and Richardson (2015) found participants to avoid looking at the eyes of higher ranked individuals in a videotape when they believed the depicted person would in return later see a videotape of them. These effects of the (real or imagined) presence of another person on one's gaze behaviour are typically explained by a dual function of gaze, that is by the fact that orienting one's gaze serves both to redirect overt attention and to signal one's intentions to others (Gobel *et al.*, 2015; Risko, Richardson, & Kingstone, 2016). Additionally, well-established effects like the facilitation or impediment of certain tasks in social situations (Guerin, 2010) highlight the important distinction between viewing an image of another person and locating oneself in his or her presence. We therefore believe that the distinction between real-life and laboratory situations, which is beginning to be acknowledged in the literature on social attention in the general population, might explain conflicting findings in social anxiety research and should be considered. The present study is therefore informed by a *cognitive ethology* approach (Kingstone, Smilek, & Eastwood, 2008), where behaviour is first investigated in a situation in which it naturally occurs, and only then transferred to a laboratory situation.

In the current study, a first group of participants varying in pre-screened social anxiety traits walked a specified path in a public train station while their gaze was tracked. A second group matched for gender and social anxiety viewed video recordings of these itineraries in the laboratory. In both conditions, we quantified the time in which gaze was directed towards another person and object, or the path and furthermore registered when gaze was directed towards the vicinity or the distance (Foulsham, Walker, & Kingstone, 2011). This approach allows us to investigate how the presence of other people influences social gaze in participants, and how participants' social anxiety modulates this effect. The real-life situation in the present study poses few restrictions on participants' behaviour and employs no scripted situations (e.g., carried out by a confederate of the experimenter), allowing for an ecologically more valid assessment of behaviour. We attempted to control for the higher variance which is naturally introduced in such paradigms by implementing a side-by-side comparison with a tallied laboratory situation involving a matched participant group. This enables us to more clearly carve out the effect of the physical presence of other people on participants' gaze behaviour. We expected social anxiety to influence gaze on other individuals in the real-life situation more strongly as compared to the laboratory group.

Materials and methods

Participants

Among several hundred persons who completed an online pre-screening, we recruited an *a priori* defined number of 60 participants based on medium to high social anxiety scores (M = 26.58 years, SD = 6.82 years, 43 females, 49 students, see Appendix S1 for further details). Participants were either assigned to a real-life group (30 participants) or a laboratory group (30 participants) while ensuring a matching between groups regarding gender and social anxiety pre-screening scores (matching for gender was not possible in one pair). Groups did not differ significantly in age, depression, general or social anxiety (see Table 1). Note that in the present study, each participant in the laboratory group viewed scenes recorded from the perspective of their partner in a real-life situation. Matching partners on gender and social anxiety served to reduce systematic effects of moving behaviour on comparisons of gaze behaviour between the two groups. For instance, if gender or social anxiety systematically influence walking speed, straightness of walking, or any other relevant variable, such effects will be equally present in the real-life and the laboratory situation and will therefore not distort comparisons between groups. All participants had normal or corrected to normal vision and did not wear glasses in everyday situations. The study conformed to the principles expressed in the Declaration of Helsinki and was approved by the local ethics committee.

Following data acquisition, one participant in the real-life group (together with the corresponding partner in the laboratory group) was excluded from the analysis due to substantial discrepancies between pre-screening and detailed assessment of social anxiety (for details, see Appendix S1), which made it impossible to estimate the quality of the matching between the partners. For the remaining 29 pairs, pre-screening scores were highly correlated, $r(29) = .82$, $p < .001$, thus indicating successful matching. Three further participants, all in the real-life group, were excluded due to technical problems with the mobile eye tracking device resulting in <75% valid data. Here, matching partners in the laboratory group were not excluded since matching was not affected by the technical problems in the matching partner's data acquisition. Altogether, 26 participants (20 females) in the real-life group and 29 participants (21 females) in the laboratory group remained in the analysis.

These participants were characterized regarding symptoms of depression (Beck Depression Inventory, BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), trait anxiety (trait part of the State-Trait Anxiety Inventory, STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), and social anxiety (Social Interaction Anxiety Scale, SIAS, Mattick & Clarke, 1998, and the Social Phobia and Anxiety Inventory, SPAI; Turner, Beidel, Dancu, & Stanley, 1989) by means of self-report questionnaires that were completed (German versions) after the experiment (see Appendix S1). The SPAI aims at representing the entire continuum of socially anxious concerns and serves as the most comprehensive

Table 1. Sociodemographic and questionnaire data of participants in the real-life and the laboratory group

	Real life			Laboratory			
	Range	*M*	*SD*	Range	*M*	*SD*	Group comparison
Age	[19, 46]	26.04	6.69	[18, 48]	26.21	5.97	$t(53) = 0.10, p = .92$
Pre-screening	[3.0, 4.6]	3.53	0.38	[3.0, 5.0]	3.63	0.59	$t(53) = 0.77, p = .45$
BDI	[2, 35]	11.46	8.93	[1, 40]	11.34	9.62	$t(53) = 0.05, p = .96$
STAI-T	[29, 77]	50.54	13.43	[28, 74]	46.69	12.15	$t(53) = 1.12, p = .27$
SIAS	[10, 52]	29.92	11.48	[13, 61]	35.69	13.99	$t(53) = 1.66, p = .10$
SPAI	[76, 169]	119.82	27.37	[77, 177]	133.25	30.98	$t(53) = 1.70, p = .10$

Note. BDI = Beck's Depression Inventory; Pre-screening = Social anxiety assessment; SIAS = Social Interaction Anxiety Scale; SPAI = Social Phobia and Anxiety Inventory; STAI-T = State-Trait Anxiety Inventory.

account of social anxiety in the present study. Therefore, the SPAI was defined as the primary measure for characterizing social anxiety traits and all analyses rely on these scores. The SIAS specifically, and more briefly, focuses on fear of interacting with other people. Exploratory analyses on this measure are reported in the Appendix S1.

Apparatus and stimuli

For the real-life group, we recorded gaze of both eyes using SMI Eye Tracking Glasses 2.1 (SensoMotoric Instruments, October 2014) with iViewETG software at a sampling rate of 60 Hz. A video capturing the participants' field of view was recorded at 30 Hz with a resolution of 960 × 720 pixels. For the laboratory group, video clips were presented centrally on a 24-inch LCD monitor (LG 24MB65PY-B, resolution of 1,920 × 1,200 pixels). Viewing distance amounted to approximately 50 cm, resulting in a visual angle for the videos of 28.98° horizontally × 21.94° vertically. In the laboratory, eye movement data were recorded from the right eye using an EyeLink 1000 Plus system (SR Research, Kanata, ON, Canada) at a sampling rate of 250 Hz. Head location was fixed using a chin rest and a forehead bar.

Procedure

Upon completion of an informed consent form and a brief sociodemographic questionnaire, participants in both groups were given information on the experiment, and the routes they were going to walk or see, as well as the erroneous information that the eye tracking device would be installed in order to measure their pupillary response to varying lighting conditions. When later asked to comment on their experiences and thoughts concerning the experiment, none of the participants reported being aware that our primary research focus was on (social) gaze orienting and not on changes in pupillary responses as a function of lighting conditions.

In the real-life group, the eye tracker was calibrated using a 3-point calibration, then validated, and, if validation failed, calibrated again until validation yielded a positive result. All participants wore a hat to protect the eye tracking measurements from direct sunlight. Participants then walked the predefined paths both in a populated train station (social condition) and in a close-by parking garage where other people were largely absent (non-social condition) in a randomized order. As this study's main interest is in social attention, only analyses concerning the social condition will be described here. The experimenter unobtrusively followed the participant at a distance of at least 10 m and intervened in four cases when participants were getting off the defined path. After a walk of approximately 4–5 min, participants reached the end of the route and waited standing for approximately 5 min until they were picked up by the experimenter. Calibration was validated, and, if necessary, performed again after the first condition.

In the laboratory group, participants were presented with the videos obtained from their matched participants in the real-life group, with both conditions presented in the same order as for the real-life participant. Before each condition, the eye tracking system was calibrated and validated using a 9-point calibration grid. Participants were given the instruction to watch the videos as if they were watching television. Stimulus presentation and data collection were controlled using the Psychophysics Toolbox (Brainard, 1997) on MATLAB R2011b (MathWorks, Natick, MA, USA).

Upon completing the experiment, participants in both groups filled out questionnaires to allow for participant characterization regarding symptoms of depression, trait anxiety, and social anxiety (see Appendix S1).

Data processing

We extracted videos displaying the participants' field of view over the duration of the experiment as well as the same videos with gazed-at locations indicated as coloured rings using the SMI BeGaze (version 3.5) software. Parallel to the real-life group, we produced videos displaying the mean gazed-at location in each frame as coloured rings for the laboratory group using MATLAB R2011b (MathWorks). Matched participants in both groups were assigned the same video ID.

Using the videos displaying the gazed-at locations, gaze was manually coded at 6 Hz (i.e., every fifth frame) using in-house software written in MATLAB by raters who were not aware of the experimental group assignment (see Figure S2 in supplementary methods). Overall, 183,753 frames were coded. For each frame, raters noted whether or not a person was present in the frame, if a person, the path, an object, or nothing particular was being gazed at (*category*) and if the frame could be considered as valid (see Appendix S1 for details on coding). We furthermore noted whether gaze was located within (vicinity) or beyond (distance) the near-distant action space – a space of approximately 8 metres around a person characterized by the effective use of eye accommodation, visual convergence, and retinal disparity in distance estimation (Daum & Hecht, 2009; Grüsser, 1983). Two raters each coded videos from 15 matched pairs (inter-rater reliability was checked for a subset of these videos, see Appendix S1). For the analyses, we removed all frames in the data set in which no persons were visible (M = 15.23%, SD = 10.61% in the laboratory group, M = 15.30%, SD = 11.30% in the real-life group), all invalid frames (M = 3.72%, SD = 4.47% in the laboratory group, M = 11.60%, SD = 5.40% in the real-life group), and all frames in which gaze location was coded as undefined (M = 0.14%, SD = 0.29% in the laboratory group, M = 0.13%, SD = 0.20% in the real-life group). We then produced a data set for each participant, listing the relative frequencies of frames for which gaze was labelled to rest on each of the six coding categories (i.e., person, path, or object in the vicinity or in the distance). The sum of gaze frequencies was normalized to add up to a value of 1 within each participant.

Statistical analysis

All statistical analyses were performed using *R software for statistical computing* (version 3.2; R Core Team, 2015). We first compared the fixation time on different categories in both conditions using a 2 × 2 × 3 mixed ANOVA with group (real-life vs. laboratory) as between-subject factor and distance (vicinity vs. distance) as well as category (person, object or path) as within-subject factors.

We furthermore investigated the stability of gaze preferences throughout the time course of the experiment. To this end, we separated gaze data from each participant into 20 bins of equal length (M = 23.39s, SD = 4.63s), computed relative gaze frequency for each category (person, object or path) and distance (vicinity vs. distance), and tested the stability of differences between participants across the individual bins using Cronbach's α. Cronbach's α varies between 0 and 1 and is commonly employed to quantify the intra-individual consistency of responses along a set of items (Cortina, 1993).

In order to investigate the influence of social anxiety on fixation on persons, we computed linear mixed models using the *lme* function of the *nlme* package (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2018) with group (real-life vs. laboratory), distance (near vs. far), and the SPAI score included as fixed effects and the Video ID included as random effect. We chose to rely on the SPAI score in these analyses since this questionnaire allows for a comprehensive characterization of social anxiety across a variety of situations. In order to better interpret a group × distance × SPAI interaction, we computed a corresponding linear mixed model for each of the two groups separately. To ensure the social specificity of attentional effects of social anxiety, we furthermore computed a corresponding linear mixed model across both groups with gaze on objects as a dependent variable.

In all statistical analyses, α was set to .05. For ANOVAs and regression models, η_p^2 and R^2 are reported as effect size estimates, respectively. For ANOVAs, degrees of freedom were adjusted using the Greenhouse–Geisser procedure to account for possible violations of the sphericity assumption, and corresponding ε values are reported. *Post-hoc* pairwise comparisons were performed using Tukey's HSD test, and Cohen's *d* values are reported to display effect sizes in *post-hoc* comparisons. Parameters in linear mixed models were estimated using the restricted maximum likelihood (*REML*) approach and tested for significance using *F*-tests.

Results

Distribution of gaze in real life and in the laboratory

The three categories (person, object, and path) were gazed at for a different proportion of time, $F(2, 106) = 161.80$, $p < .001$, $\eta_p^2 = .75$, $\varepsilon = .59$, see Figure 1. Gaze was directed more frequently towards the vicinity than the distance, $F(1, 53) = 443.27$, $p < .001$, $\eta_p^2 = .89$, and there was a significant distance × category interaction, $F(2, 106) = 82.67$, $p < .001$, $\eta_p^2 = .61$, $\varepsilon = .80$, as well as a significant group × distance interaction, $F(1, 53) = 15.24$, $p < .001$, $\eta_p^2 = .22$. The group × category interaction, $F(2, 106) = 2.06$, $p = .154$, $\eta_p^2 = .04$, $\varepsilon = .59$, as well as the group × distance × category interaction, did not reach statistical significance, $F(2, 106) = 3.02$, $p = .065$, $\eta_p^2 = .05$, $\varepsilon = .80$. Across both groups, both objects ($p < .001$) and persons ($p < .001$) were gazed at more often than the path, while there was no difference between objects and persons ($p = .889$). The preference for the vicinity was present in all three categories, but more pronounced for objects ($p < .001$, $d = 2.65$) and persons ($p < .001$, $d = 2.48$) than for the path ($p = .043$, $d = 1.02$). The preference for the vicinity was furthermore present in both groups, but more emphasized in the laboratory ($p < .001$, $d = 1.55$) than in the real-life group ($p < .001$, $d = 0.98$).

Consistency of gaze behaviour along the experiment's time course

Table 2 displays internal consistency (represented as Cronbach's α) in gaze towards each category (person, object, or path) and distance (vicinity vs. distance), separately for participants in the real-life group and laboratory group as well as for all participants combined. The interpretation of Cronbach's α was argued to depend on the research question, but one influential report recommended .70 as a goal for early stages of research and noted that values above .90 may be hinting more towards unnecessary redundancy in the measurement rather than consistency (Streiner, 2003). In the present study,

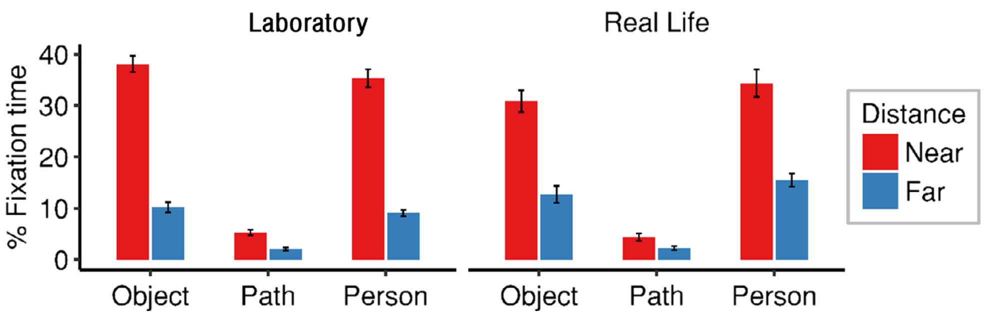

Figure 1. Percentage of time gaze was directed at objects, the path, or persons, in the vicinity or distance, for both the laboratory and the real-life groups. Error bars indicate SEM. [Colour figure can be viewed at wileyonlinelibrary.com]

consistency in gaze behaviour was moderate or high for all categories and distances (values between .71 and .91). For all participants, α for gaze at near people was .88 and α for gaze at distant people was .86, highlighting high intra-individual stability in gaze towards other people throughout the experiment.

Effects of social anxiety on gaze at persons

When incorporating social anxiety (SPAI) scores into a linear mixed model predicting fixations on persons for the real-life and the laboratory group (Figure 2), we again found a main effect of distance, $F(1, 74) = 207.93$, $p < .001$, a group × distance interaction, $F(1, 74) = 7.22$, $p = .009$, and a group × distance × SPAI interaction, $F(1, 74) = 4.43$, $p = .039$. None of the other main or interaction effects reached the level of significance, SPAI: $F(1, 74) = 0.12$, $p = .729$, group: $F(1, 74) = 2.89$, $p = .093$, distance × SPAI: $F(1, 74) = 1.79$, $p = .185$; group × SPAI: $F(1, 74) = 0.05$, $p = .820$.

To follow up on the significant three-way interaction, we calculated separate mixed models within each group, again selectively focusing on fixations on persons. In the real-life group alone, we found a significant main effect for distance, $F(1, 24) = 50.19$, $p < .001$, and, importantly, a distance × SPAI interaction, $F(1, 24) = 5.97$, $p = .022$, but no significant main effect for SPAI, $F(1, 24) = 0.10$, $p = .753$. In the laboratory group alone, we found a significant main effect for distance, $F(1, 27) = 188.73$, $p < .001$, but no main effect for SPAI, $F(1, 27) = 0.14$, $p = .715$, and no distance × SPAI interaction, $F(1, 27) = 0.02$, $p = .892$. Specifically, participants in the real-life group, but not the laboratory group, showed a reduced bias to gaze at near compared to distant people when high on social anxiety. This pattern of results was similar when relying on the SIAS score

Table 2. Consistency (measured as Cronbach's α) of participants' viewing preferences along the experiment's time course

	Real life		Laboratory		Combined	
	Near	Far	Near	Far	Near	Far
Persons	.91	.84	.84	.71	.88	.86
Objects	.86	.91	.84	.89	.87	.91
Path	.84	.79	.84	.83	.84	.81

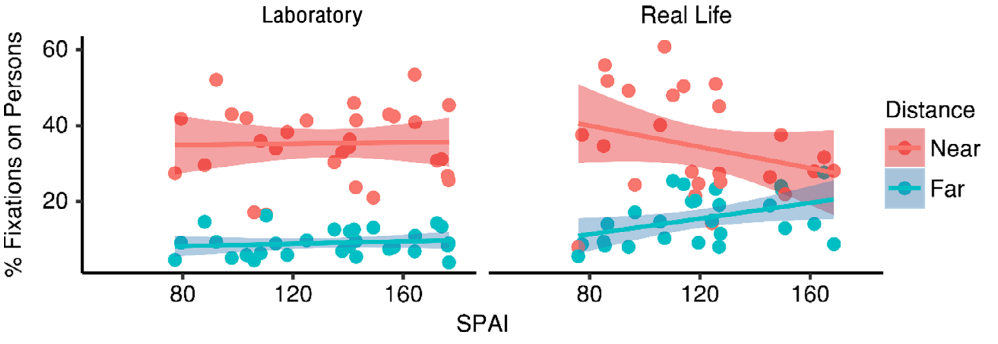

Figure 2. Frequency of gaze at persons as a function of group, distance, and SPAI. Shaded areas represent 95% confidence intervals of the linear regression. [Colour figure can be viewed at wileyonlinelibrary.com]

instead, while general anxiety as measured by the STAI did not modulate gaze behaviour (see Appendix S1). In a parallel model across both groups with fixations on objects (instead of persons) as dependent variable, SPAI scores were in no way related to the frequency of fixations on objects in real life or in the laboratory (see Appendix S1: Figure S3).

Discussion

The present study found several general similarities and differences in viewing behaviour between matched participants in a real-life and a laboratory group. Specifically, participants looked at objects and persons more frequently than at the path in both groups and exhibited a general preference for looking into the vicinity (vs. distance), which was, however, enhanced in the laboratory group. Unlike other studies that utilized gaze monitoring in naturalistic conditions (Foulsham *et al.*, 2011), we did not find a general avoidance of gaze at other persons in real life, but rather more fixations on near as compared to distant persons in laboratory as well as in field conditions.

Interestingly, we found moderate to high stability in participants' viewing preferences for all categories and distances, both in the laboratory group and in the real-life group. Given the high variability in viewing conditions between participants, this consistency seems surprising but similar results have been reported for participants watching videos on a computer screen (Rubo & Gamer, 2018). To the best of our knowledge, such consistency in viewing patterns has not yet been documented in a naturalistic situation outside the laboratory but it confirms that the current findings were not driven by a small number of exceptional samples in individual recordings. Crucially, extensive measurements of stable response patterns were argued to partially provide self-replication within a single experiment and can explain why certain fields relying on experiments with small sample sizes never faced a replication crisis (Smith & Little, 2018). Nonetheless, while high intra-personal stability does highlight the robustness of observations made within the present sample, future research will need to test a different group of individuals to better estimate the generalizability of between-subject effects.

Regarding the influence of social anxiety on viewing patterns, we found a bias to look more frequently at near compared to distant people, which was not modulated by social anxiety in the laboratory group. In the real-life group, by contrast, the bias to look at near people was reduced with increasing levels of social anxiety; that is, while individuals high on social anxiety did not generally avoid looking at other people in real life, they had a reduced preference to do so when conspecifics were near compared to less socially anxious individuals. This compensatory pattern was furthermore specific to social attention and was not present in attention towards objects, showing that social anxiety specifically affected attention to persons, not attention in general. While clinical observations and self-reports (Schneier *et al.*, 2011) canonically report an avoidance of gaze at other persons in socially anxious individuals, the present study extends these observations by showing that socially anxious observers may instead prefer to gaze at others at a greater distance compared to less socially anxious individuals. In our opinion, this observation seems plausible from a theoretical point of view considering that conspecifics' scrutiny – the target of fear in social anxiety (Stein & Stein, 2008) – might be preferentially elicited when the conspecific is near enough to detect and reciprocate one's gaze or to even initiate a conversation following eye contact. Since socially anxious individuals are not thought to be less interested in the social world per se, they may, compared to less socially anxious individuals, preferentially allocate overt attention towards people when they are located in the distance, thereby satisfying their need for social information while anticipating (and thereby coping with) their fear of scrutiny. However, we would like to stress that future research will need to address this proposed mechanism more directly by investigating gaze behaviour in social situations in which the distance of other people varies systematically.

By providing the first direct comparison of gaze behaviour in two participant groups matched on social anxiety viewing the same stimulus material in real-life and in a laboratory situation, the present study resolves a long-standing conflict between clinical practitioners' observations and laboratory-based research. Critically, the absence of gaze modulation by social anxiety in the laboratory group substantiates previously expressed concerns (Risko *et al.*, 2016) that laboratory-based passive viewing tasks may not provide an appropriate proxy for real-world social attentional phenomena in humans, likely because participants are aware that persons in a video will not be able to evaluate them. Interestingly, absence of atypical viewing behaviour towards images of persons was also reported in autism (Rutherford & Krysko, 2008), although a substantial amount of clinical reports document deviations in social attention in real-world social situations in these patients as well (Senju & Johnson, 2009).

Further support for the hypothesis that the presence of real persons may stimulate distinctly different attentional processes compared to the presence of images comes from related fields (Risko & Kingstone, 2011). For instance, it was shown that compared to averted gaze, direct gaze elicited enhanced visual brain responses (Pönkänen, Alhoniemi, Leppänen, & Hietanen, 2011), stronger left-sided frontal EEG alpha-asymmetry (Pönkänen, Peltola, & Hietanen, 2011), and a larger skin conductance response (Pönkänen, Peltola, *et al.*, 2011), but only in a live condition and not when participants viewed images of the same faces gazing at them.

By recruiting a stratified sample of participants on the basis of a pre-screening procedure, we were able to cover a broad range of social anxiety traits ranging from low to medium levels to (sub)clinical symptoms. This approach complies with the conceptualization of social anxiety as a continuum (Rapee & Spence, 2004) with subjects at the upper end representing high degrees of social fear (commonly diagnosed as SAD). Nevertheless, future studies should examine the stability and generalizability of the current findings to individuals who received the formal diagnosis of a social anxiety disorder or to compare such persons to other patient groups to elucidate the specificity of the current findings. Another aspect calling for a more detailed inquiry is the precise distance at which gaze at other persons is reduced or enforced in social anxiety. Grounded in basic models of visual perception (Daum & Hecht, 2009), we classified gaze as falling either in the vicinity (8 m or nearer) or distance (beyond 8 m) of the participants. This data aggregation strategy was also motivated by technical boundaries, as present eye tracking devices do not measure the distance to the looked-at object. Future studies may achieve more fine-grained data acquisition either by employing virtual reality technology, where precise distance measures are easily available (Ben-Moussa, Rubo, Debracque, & Lange, 2017), or by installing identification marks in the test environment to allow for a more precise estimation of distances.

Future research should furthermore aim at examining the generalizability of the current findings by comparing viewing behaviour across different situations within the same participants. In the present study, viewing behaviour was investigated in only one type of social situation, a populated train station. To avoid an influence of memory effects, the laboratory condition was not presented to the same persons as the real-life condition, but to other participants matched on gender and social anxiety. In order to better estimate the generalizability of the present findings, participants in future research should be confronted with a larger variety of everyday situations (e.g., pedestrian zones, supermarkets, waiting rooms, concerts, sports events). This will allow to better highlight the specificity or generalizability of gaze patterns across environments, and, by randomly assigning participants to a real-life or laboratory version of the same scenes, will help to better understand influences of social presence (as manipulated via different scene types) on viewing behaviour within the same individuals.

Summing up, the present study is the first to directly compare gazing behaviour of persons with a high range of social anxiety symptoms both in a real-life group and a closely matched laboratory group. Extending on clinical observations, we found high social anxiety to be associated with a relative avoidance of gaze at near compared to distant people in real life, but no such modulation of gaze behaviour by social anxiety in the laboratory group. Our findings furthermore provide a basis for recently expressed assertions that the field of social attention needs to move beyond laboratory research and into real-world situations to do justice to all basic social mechanisms that are at the heart of social attention (Schilbach *et al.*, 2013). This applies all the more to research on impairments of social functions in psychiatric conditions.

Acknowledgements

This work was supported by the European Research Council (ERC-2013-StG #336305) and the German Research Foundation (Collaborative Research Center 'Fear, Anxiety, Anxiety Disorders', SFB-TRR 58 project C10). The authors thank Anna-Sophia Kotulla, Katharina Kurz, and Michael Strunz for their help during data collection and analysis.

Data availability

The data that support the findings of this study are available at https://osf.io/h7pf2/.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing. Retrieved from https://doi.org/10.1176/appi.books.9780890425596

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*, 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004

Ben-Moussa, M., Rubo, M., Debracque, C., & Lange, W.-G. (2017). DJINNI: A novel technology supported exposure therapy paradigm for SAD combining virtual reality and augmented reality. *Frontiers in Psychiatry*, *8*(26), 1–12. https://doi.org/10.3389/fpsyt.2017.00026

Boll, S., Bartholomaeus, M., Peter, U., Lupke, U., & Gamer, M. (2016). Attentional mechanisms of social perception are biased in social phobia. *Journal of Anxiety Disorders*, *40*, 83–93. https://doi.org/10.1016/j.janxdis.2016.04.004

Brainard, D. H. (1997). The psychophysics toolbox. *Spatial Vision*, *10*, 433–436. https://doi.org/10.1163/156856897x00357

Brunet, P. M., Heisz, J. J., Mondloch, C. J., Shore, D. I., & Schmidt, L. A. (2009). Shyness and face scanning in children. *Journal of Anxiety Disorders*, *23*, 909–914. https://doi.org/10.1016/j.janxdis.2009.05.009

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, *78*(1), 98–104.

Daum, S. O., & Hecht, H. (2009). Distance estimation in vista space. *Attention, Perception, & Psychophysics*, *71*, 1127–1137. https://doi.org/10.3758/APP

Foulsham, T., Walker, E., & Kingstone, A. (2011). The where, what and when of gaze allocation in the lab and the natural environment. *Vision Research*, *51*, 1920–1931. https://doi.org/10.1016/j.visres.2011.07.002

Gobel, M. S., Kim, H. S., & Richardson, D. C. (2015). The dual function of social gaze. *Cognition*, *136*, 359–364. https://doi.org/10.1016/j.cognition.2014.11.040

Grüsser, O. J. (1983). Multimodal structure of the extrapersonal space. In A. Hein & M. Jeannerod (Eds.), *Spatially oriented behavior* (pp. 327–352). New York, NY: Springer.

Guerin, B. (2010). Social facilitation. In I. B. Weiner & W. E. Craighead (Eds.), *The Corsini encyclopedia of psychology*. Hoboken, NJ: John Wiley & Sons, Inc.

Huppert, J. D., Pasupuleti, R. V., Foa, E. B., & Mathews, A. (2007). Interpretation biases in social anxiety: Response generation, response selection, and self-appraisals. *Behaviour Research and Therapy*, *45*, 1505–1515. https://doi.org/10.1016/j.brat.2007.01.006

Kingstone, A., Smilek, D., & Eastwood, J. D. (2008). Cognitive ethology: A new approach for studying human cognition. *British Journal of Psychology*, *99*, 317–340. https://doi.org/10.1348/000712607x251243

Laidlaw, K. E. W., Foulsham, T., Kuhn, G., & Kingstone, A. (2011). Potential social interactions are important to social attention. *Proceedings of the National Academy of Sciences of the United States of America*, *108*, 5548–5553. https://doi.org/10.1073/pnas.1017022108

Lundh, L. G., & Öst, L. G. (1996). Recognition bias for critical faces in social phobics. *Behaviour Research and Therapy*, *34*, 787–794. https://doi.org/10.1016/0005-7967(96)00035-6

Mattick, R. P., & Clarke, J. C. (1998). Development and validation of measures of social phobia scrutiny fear and social interaction anxiety. *Behaviour Research and Therapy*, *36*, 455–470. https://doi.org/10.1016/s0005-7967(97)10031-6

Moukheiber, A., Rautureau, G., Perez-Diaz, F., Soussignan, R., Dubal, S., Jouvent, R., & Pelissolo, A. (2010). Gaze avoidance in social phobia: Objective measure and correlates. *Behaviour Research and Therapy*, *48*, 147–151. https://doi.org/10.1016/j.brat.2009.09.012

Pinheiro, J., Bates, D., DebRoy, S., Sarkar, D., & R Core Team. (2018). *nlme: Linear and nonlinear mixed effects models. R package version 3.1-137*. Retrieved from https://CRAN.R-project.org/package=nlme

Pönkänen, L. M., Alhoniemi, A., Leppänen, J. M., & Hietanen, J. K. (2011). Does it make a difference if I have an eye contact with you or with your picture? An ERP study. *Social Cognitive and Affective Neuroscience*, *6*, 486–494. https://doi.org/10.1093/scan/nsq068

Pönkänen, L. M., Peltola, M. J., & Hietanen, J. K. (2011). The observer observed: Frontal EEG asymmetry and autonomic responses differentiate between another person's direct and averted gaze when the face is seen live. *International Journal of Psychophysiology*, *82*, 180–187. https://doi.org/10.1016/j.ijpsycho.2011.08.006

R Core Team. (2015). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.r-project.org/

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*, 741–743. https://doi.org/10.1016/s0005-7967(97)00022-3

Rapee, R. M., & Spence, S. H. (2004). The etiology of social phobia: Empirical evidence and an initial model. *Clinical Psychology Review*, *24*, 737–767. https://doi.org/10.1016/j.cpr.2004.06.004

Risko, E. F., & Kingstone, A. (2011). Eyes wide shut: Implied social presence, eye tracking and attention. *Attention, Perception, & Psychophysics*, *73*, 291–296. https://doi.org/10.3758/s13414-010-0042-1

Risko, E. F., Richardson, D. C., & Kingstone, A. (2016). Breaking the fourth wall of cognitive science: Real-world social attention and the dual function of gaze. *Current Directions in Psychological Science*, *25*(1), 70–74. https://doi.org/10.1177/0963721415617806

Rubo, M., & Gamer, M. (2018). Social content and emotional valence modulate gaze fixations in dynamic scenes. *Scientific Reports*, *8*(1), 1–11. https://doi.org/10.1038/s41598-018-22127-w

Rutherford, M. D., & Krysko, K. M. (2008). Eye direction, not movement direction, predicts attention shifts in those with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *38*(10), 1958. https://doi.org/10.1007/s10803-008-0592-4

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). A second-person neuroscience in interaction. *Behavioral and Brain Sciences*, *36*, 441–462. https://doi.org/10.1017/s0140525x12002452

Schneier, F. R., Rodebaugh, T. L., Blanco, C., Lewin, H., & Liebowitz, M. R. (2011). Fear and avoidance of eye contact in social anxiety disorder. *Comprehensive Psychiatry*, *52*(1), 81–87. https://doi.org/10.1016/j.comppsych.2010.04.006

Senju, A., & Johnson, M. H. (2009). Atypical eye contact in autism: Models, mechanisms and development. *Neuroscience & Biobehavioral Reviews*, *33*, 1204–1214. https://doi.org/10.1016/j.neubiorev.2009.06.001

Smith, P. L., & Little, D. R. (2018). Small is beautiful: In defense of the small-N design. *Psychonomic Bulletin & Review*, *25*, 2083–2101. https://doi.org/10.3758/s13423-018-1451-8

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press. https://doi.org/10.1037/t06496-000

Stein, M. B., & Stein, D. J. (2008). Social anxiety disorder. *The Lancet*, *371*, 1115–1125. https://doi.org/10.1016/s0140-6736(08)60488-2

Stein, M., Walker, R., & Forde, R. (1994). Setting diagnostic thresholds for social phobia. *American Journal of Psychiatry*, *151*, 408–412. https://doi.org/10.1176/ajp.151.3.408

Streiner, D. L. (2003). Starting at the beginning: An introduction to coefficient alpha and internal consistency. *Journal of Personality Assessment*, *80*(1), 99–103.

Turner, S. M., Beidel, D. C., Dancu, C. V., & Stanley, M. A. (1989). An empirically derived inventory to measure social fears and anxiety: The social phobia and anxiety inventory. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, *1*(1), 35–40. https://doi.org/10.1037/1040-3590.1.1.35

Weeks, J. W., Howell, A. N., & Goldin, P. R. (2013). Gaze avoidance in social anxiety disorder. *Depression and Anxiety*, *30*, 749–756. https://doi.org/10.1002/da.22146

Wieser, M. J., Pauli, P., Alpers, G. W., & Mühlberger, A. (2009). Is eye to eye contact really threatening and avoided in social anxiety?–An eye-tracking and psychophysiology study. *Journal of Anxiety Disorders*, *23*(1), 93–103. https://doi.org/10.1016/j.janxdis.2008.04.004

Received 8 August 2018; revised version received 22 February 2019

Supporting Information

The following supporting information may be found in the online edition of the article:

Appendix S1. Methods and results.