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Look at me: The relation between empathy and fixation on the emotional eye-region in low vs. high social anxiety

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ABSTRACT

Background and objectives: Fixation on another person's eye-region may be an effective measure of one's level of empathy. In the present study, we tested the hypothesis that this type of empathy measure may not be appropriate for individuals with high levels of social anxiety, since avoidance or hypervigilance attentional biases towards emotional faces are frequent in this condition.

Methods: Using eye-tracking, we measured fixation time on the eye-region of another person in participants with low vs. high social anxiety, and we correlated this measure with empathy levels. In a second eye-tracking task, the two groups of participants were presented with pairs of emotional-neutral faces to determine the presence of attentional biases.

Results: While participants with low social anxiety showed an association between empathy and fixation time on the other person's eyes, the association was null for participants with high social anxiety. Attentional biases towards emotional faces were absent in high social anxiety, but social anxiety correlated negatively with fixation on the eye region.

Limitations: Our sample was made up of Psychology undergraduates, and this may have had an influence on gaze behavior towards the eye region.

Conclusion: Fixation on the eye region is not a valid measure of empathy in high social anxiety, possibly due to systematic eye-region avoidance.

1. Introduction

Empathy – the ability to resonate with other people's emotions (Aragno, 2008; Baron-Cohen, 2012; Goldman, 2006; Kohut, 1971; Racker, 1968; Stueber, 2006) – is a psychological trait that can be measured using self-report questionnaires (e.g., Davis, 1980) or facial indices (Eisenberg & Fabes, 1990). Recent research results suggested that eye-tracking measures may be an alternative, in that the amount of time a healthy participant spends fixating on another person's eye-region correlates positively with her/his degree of trait-empathy (Cowan, Vanman, & Nielsen, 2014). Cowan and colleagues asked 69 healthy adults (age range 18–33) to visualize two videos of an actress telling either a neutral or a sad story as their eye movements were recorded. Participants also filled in the Interpersonal Reactivity Index (IRI), a self-report questionnaire of empathy (Davis, 1983). The proportion of time participants spent fixating the eye-region of the actress (relative to fixation time on the whole image) was computed, and then correlated with individual IRI scores. The results showed a positive correlation between fixation on the eye-region (mostly for the sad video) and IRI scores.

Unlike questionnaires, eye-tracking measures of empathy are neither falsifiable nor subject to self-interpretation biases (Zhou, Valiente, & Eisenberg, 2003), which makes them a preferred alternative. Despite these advantages, the use of eye-tracking measures of empathy may not be a universal solution. For instance, individuals with biased attentional processing of emotional human faces – abnormally high or low visual attention – may have deviant fixation patterns on others' eye-region (Fernandes et al., 2017) due to reasons other than empathy itself. This may be the case of individuals with high social anxiety (Hirsch & Clark, 2004; Hofmann, 2007; Rapee & Heimberg, 1997), who tend to show attentional biases towards emotional faces. In the present study, we investigated whether eye-tracking measures of empathy are valid for individuals with high social anxiety.

Social Anxiety (Kessler, McGonagle, & Zhao, 1994; Kessler, Stein, & Berglund, 1998; Ruscio et al., 2008; Turk, Heimberg, & Magee, 2008) is a pathological condition defined by the constant fear of being negatively

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judged (embarrassed, humiliated) in situations of social interaction or performance (American Psychiatric Association, 1994). Since socially-anxious individuals are highly focused on their negative self-perceptions, they tend to perceive social situations as dangerous (Ranta, Tuomisto, Kaltiala-Heino, Rantanen, & Marttunen, 2014; Tuomisto, Kaltiala-Heino, Rantanen & Marttunen, 2014) and to confirm dysfunctional beliefs about themselves after going through these situations (Roberts, Hart, & Eastwood, 2010). The psychophysiological and behavioural symptoms of social anxiety (e.g., shortened breaths, sweat, self-defeating cognitions, anticipation of fearful situations, see American Psychiatric Association, 2000; Heimberg, Brozovich, & Rapee, 2010) can severely affect the individual's professional and social life (Aderka et al., 2012; Wittchen & Beloch, 1996). These symptoms generate discomfort and, in some cases, lead to the avoidance of social situations (Morrison et al., 2016). Avoidance tends to increase as social anxiety is experienced for a long period (Fernandes et al., 2017). Two big types of models have attempted to explain the origins of social anxiety: *emotional-evolutional models*, which focus on the role of early interpersonal relations (Eng, Heimberg, Hart, Scheneier & Liebowitz, 2001; Leary, 1986; Leary, Kowalski & Campbell, 1988; Móran, Olaz, Pérez & Del Prette, 2018; Sroufe, 2009), and *cognitive models* (e.g., Clark & Wells, 1995; Mathews & Mackintosh, 1998; Rapee & Heimberg, 1997), which emphasize the impact of distorted attention patterns on creating and maintaining social anxiety. These distorted attention patterns are known as *attentional biases* (Grant & Beck, 2006; Roberts et al., 2010).

Attentional biases seem to be a defense mechanism of socially-anxious people: they are extremely focused on the social environment around them, which they tend to perceive as a threat source (Beck, Rush, Shaw, & Emery, 1979). In social circumstances, socially-anxious individuals pay increased attention to the information that confirms their negative perceptions (Beck, 1987; Clark & Wells, 1995; Rapee & Heimberg, 1997), showing deviant eye-movement patterns that substantiate attentional biases. At least two types of attentional biases seem to be present in social anxiety - *the avoidance bias* and the *hypervigilance bias*. The first one occurs when the individual avoids fixating stimuli that s/he finds negative or threatening (Pineles & Mineka, 2005). The second one occurs when the individual stares at the threatening stimuli (Rapee & Heimberg, 1997). Given that negative emotions (e.g., anger) provide higher threat levels, attentional biases appear to be mostly related with negative emotions (Schmitz, Scheel, Rigon, Gross, & Blechert, 2012). Nevertheless, there is evidence that socially-anxious individuals may also run away from positive (happy) facial expressions, possibly because they interpret other people's smiles as an invitation to interact and/or a moment of judgement (Mansell, Clark, Ehlers, & Chen, 1999). Experimental approaches to attentional biases have mostly relied on the presentation of emotional (threatening) vs. neutral (non threatening) faces side-by-side (Lange at al., 2011; Schofield, Johnson, Inhoff, & Coles, 2012).

In the present study, we used Cowan et al. (2014) video-watching paradigm (see above) to test whether the positive correlation between empathy and fixation on the eye-region of the actor is disrupted by high levels of social anxiety, specifically by the presence of attentional biases. To that end, we split a sample of young adults into two groups – *low social anxiety* (LSA) vs. *high social anxiety* (HSA). We analyzed the correlation between empathy (IRI scores) and fixation on the eye-region (eye-tracking video-watching task) for each group, and we investigated whether HSA showed attentional biases (as indicated by a second eye-tracking, face-viewing task). We expected the LSA group to replicate the positive correlation observed by Cowan et al. (2014). Concerning HSA individuals, we expected to see either avoidance or hypervigilance biases, which might disrupt the correlation between empathy and fixation on the eye-region in two possible ways: in case of an avoidance bias, HSA participants would avoid emotional faces and, consequently, the emotional eye-region. Therefore, no matter how empathic these individuals might be, they would not seek other persons' eyes. In case of a hypervigilance bias, HSA participants would fixate emotional faces persistently, regardless of their empathy levels and with the sole purpose of controlling social threat. In any of these scenarios, LSA and HSA should differ in the correlation between empathy and fixation on the other's eye-region.

2. Material and methods

2.1. Participants

Thirty-five undergraduate students with normal or corrected-to-normal vision participated in the study. Due to excessive eye-tracking artefacts, seven participants were excluded. The final sample comprised 28 participants (all women) with ages ranging between 19 and 26 years ($Mage + SD = 21.07 + 2.75$). Participants filled in informed consent in accordance with the Declaration of Helsinki.

2.2. Materials

To measure participants' fixation on the eye-region, we presented two video stimuli — neutral and sad. In the neutral video, an amateur actress described her wait at an airport before visiting her grandparents (Fig. 1). In the sad one, the same actress described the evolution of her grandmother's Alzheimer's disease. The videos lasted for 29 and 60 s, respectively. The selected videos were validated by four impartial judges, who rated two takes from each video on a Likert scale of −7 to 7, -7 meaning *very sad* and 7 *very happy*. The selected takes obtained average scores of 0.7 (neutral video) and −2.2 (sad video).

For measuring individual levels of empathy, we used the Interpersonal Reactivity Index (IRI, Davis, 1980, validated for Portuguese by Limpo, Alves, & Castro, 2010). This self-report questionnaire consists of 4 subscales (Fantasy, Perspective Taking, Personal Discomfort and Empathic Concern), totaling 28 items. Each item is rated on a 5-point scale (0–4), ranging from *totally disagree* to *totally agree*. The IRI

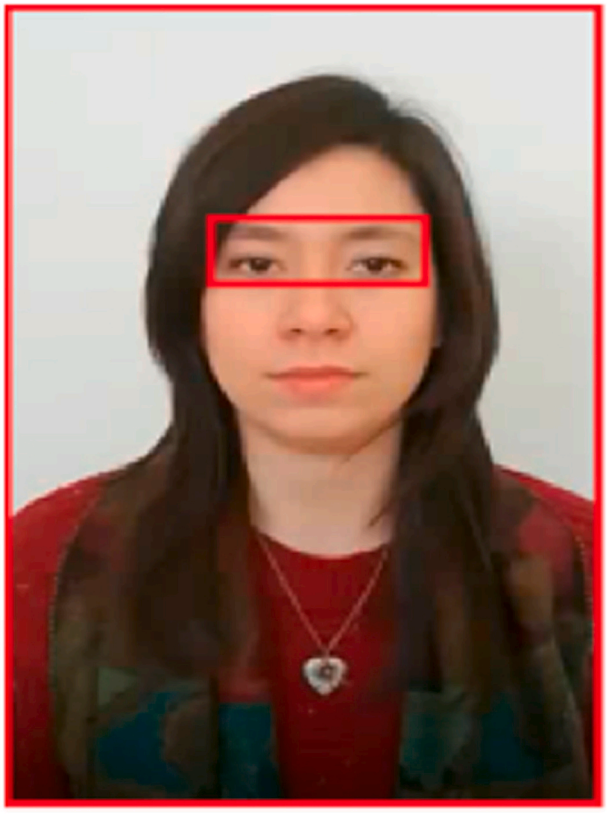

Fig. 1. Neutral video, with area of interest around the eye-region.

questionnaire is scored by averaging scores for each subscale, and then summing these four average scores. The total maximum score is 16. The mean empathy level for the whole sample was 10.96 ($SD = 2.02$).

In order to differentiate low-vs. high-social-anxiety (LSA vs. HSA) participants, we used the Social Interaction and Performance Anxiety and Avoidance Scale (SIPAAS; Pinto-Gouveia, Cunha, & Salvador, 2003), a self-report questionnaire validated for the Portuguese population. This instrument includes 44 scalar items, organized into two subscales: discomfort and anxiety (anxiety, hereafter) and avoidance. Each subscale is rated separately, through the sum of the composing items. In order to classify participants as either LSA or HSA, we did a median-split of our sample (94.5 for anxiety; 86 for avoidance; please note that both values stand below the clinical cut-off scores – 115 for anxiety and 105 for avoidance). Given that avoidance does not necessary imply social anxiety (Heeran & McNally, 2018), we created two sample-splits – one based on the anxiety subscale and the other on the avoidance subscale. Accordingly, analyses engaging group comparisons were ran twice (see below).

In order to investigate attentional biases in the HSA group, we used 40 faces representing joy, anger, sadness and neutrality (10 faces per emotion, portrayed by 5 female and 5 male actors). Faces were selected from the Karolinska Database of Emotional Faces (Lundqvist, Flykt, & Öhman, 1998) and validated for the Portuguese population by Fernandes (2013). Each non-neutral face (n = 10 + 10+10) was paired twice with a neutral one (n = 10): once, with neutral on the left side of the picture; twice, with neutral at the right side (Fig. 2). In total, we had 60 stimuli. Along the experiment, each non-neutral face was shown twice, and each neutral one appeared four times.

2.3. Procedure

The experiment started with the two eye-tracking sessions – visualizing sad vs. neutral videos for measuring participants' fixation on the eye-region, and visualizing face pairs for determining potential attentional biases in the HSA group. Following the established paradigms (e.g., Cowan et al., 2014; Fernandes et al., 2017), participants received no instruction other than looking at the image. They were asked to blink preferably during the fixation cross preceding each stimulus. The order of the two eye-tracking sessions was counterbalanced across participants.

In the face-pairs-viewing session, each stimulus was presented for 1500 ms, preceded by a fixation cross of 500 ms. The presentation order of the 60 face pairs was randomized. The presentation of each video stimulus (29 sec 60 sec) was also preceded by a 500 ms fixation cross. The presentation order (sad vs. neutral) was counterbalanced.

At the end of eye-tracking sessions, participants were asked to fill in the IRI and SIPAAS questionnaires. The order of administration of the two questionnaires was also counterbalanced.

2.4. Eye movement recording and preprocessing

Eye movements were recorded with the SMI RED 250 eye-tracking system (www.smivision.com). Each recording session was preceded by a 5-point calibration process. Tracking errors greater than 1° were followed by a new calibration.

Recordings were monocular (right eye) with a sampling frequency of 250 Hz. Participants sat away from the monitor (46 × 30 cm) at a distance of 60 cm. Under these circumstances, each individual face region in face pairs occupied a horizontal angle of (14.7°) and a vertical angle of 21.2°. The eye-region in each video corresponded to a horizontal angle of 6.8° and a vertical angle of 2.8°.

Trials were visually inspected for artefacts. Those containing signal loss (blinks, tracking errors) above 30% of their duration (450 ms for face pairs, 18000 ms for the sad video, 8700 ms for the neutral video) were signaled and then excluded from the analysis. Participants with more than 50% of contaminated trials (n = 6) were excluded from analysis. Valid trials for the face-pairs task (n = 28 participants) corresponded to 82% of all trials (18% excluded). All videos were non-contaminated (artefacts below 30% of the trial).

We used dwell time (sum of fixation and saccade time) to measure both the fixation on the eye-region (videos) and potential attentional biases (face pairs). To that end, we defined two areas of interest (AOIs) for videos (Fig. 1): the whole image and the eye-region. This allowed us to compute the proportion of fixation on the eye-region. For face pairs, we had three areas of interest (Fig. 2): the whole image, the left face and the right face. With this, we computed the proportion of dwell time on each face relative to the whole image.

2.5. Statistical analysis

We have first performed two social-anxiety-related sample splits, based on the medians of the anxiety and avoidance subscales of SIPAAS

Fig. 2. Example of a pair of faces (neutral vs. sad), with area of interest around each face.

and giving origin to LSA groups. We then checked whether groups differed significantly in SIPAAS scores while matching for age and empathy levels.

To test the hypothesis of a positive correlation between empathy and fixation on the eye-region in LSA but not in HSA, we correlated IRI scores and an eye-tracking measure based on the proportion of dwell time on the eye-region of the actor relative to the whole video image. Taking into account the concept of empathy – which implies the detection of (non-neutral) emotions in the other person – we computed the *difference* between the proportion of dwell time on the eye-region relative to the whole image as obtained in the sad (emotional) video and the equivalent proportion in the neutral video, so that we could get a measure that was strictly related to others' emotions. For that reason, hereafter we refer to this eye-tracking measure as the *fixation on the emotional eye-region.* We computed the zero-order correlation between empathy and fixation on the emotional eye-region for the whole sample, together with partial correlation using social anxiety as covariable. Differences between zero-order and partial correlations were followed by separate correlations between empathy and fixation on the emotional eye-region for each group – LSA vs. HSA. We then ran a Fisher's Z test (see Diedenhofen & Musch, 2015) to compare the two correlation coefficients.

To determine possible attentional biases in HSA, we ran a mixed ANOVA on the proportion of dwell time on each face (in face pairs), using emotionality (emotional vs. neutral face) and type of emotion (anger, happiness, sadness) as within-subjects factors, and social anxiety (LSA vs. HSA) as between-subjects factor. Significant positive differences between emotional and neutral faces would indicate increased attention to emotional faces, and negative differences increased attention to neutral ones. Whatever the direction, we were concerned with the interaction between emotionality and social anxiety (LSA vs. HSA), which would indicate attentional biases in HSA. Increased differences between emotional and neutral faces in HSA compared to LSA would point to hypervigilance, and the reverse to avoidance.

In order to better understand the meaning of our main results, we have further investigated the relation between social anxiety scores (anxiety vs. avoidance scores) with fixation on the emotional eye-region in videos, using both group-based (independent samples t-tests) and correlational analyses. In all analyses, we adopted a critical level of significance of .05. Bonferroni corrections were applied for multiple comparisons.

3. Results

3.1. LSA vs. HSA and empathy levels

Table 1 describes the characteristics of LSA vs. HSA groups, considering two different sample-splits: one based on the median of the anxiety subscale of SIPAAS and the other based on the median of the avoidance subscale. As expected, the resulting groups differed significantly in anxiety and avoidance scores. There were age differences for the avoidance-based split, but not for the anxiety-related one.

Surprisingly, cross-group differences in empathy levels were significant, with the HSA group showing higher values both for the anxiety (see Table 1) and the avoidance subscale. Continuous-variable approaches to social anxiety corroborated this, in that empathy correlated significantly with both anxiety (r (26) = 0.631, $p < .001$) and avoidance scores (r (26) = 0.673, $p < .001$, Fig. 3*),* significance unchanged after Bonferroni-correcting for multiple comparisons (n = 2). We took this into account when comparing LSA and HSA for the correlation between empathy and fixation on the emotional eye-region, in that a null correlation for HSA could be due to ceiling effects, i.e., top-high levels of empathy with little variability precluding the expression of empathy into fixation on the eye (see Smoleń & Chuderski, 2015).

Table 1
Characteristics of low (LSA) vs. high (HSA) social anxiety participants (SIPPAS = social anxiety and avoidance measure; IRI = empathy measure).

	LSA (n = 14)	HSA (n = 14)	
	Split based on SIPAAS anxiety subscale (*Mdn* = 94.5) *M* ± *SD*		*t, p, d*[a]
Age	21.50 ± 3.28	20.64 ± 2.13	0.84, .420, .32
SIPAAS	79.79 ± 11.49	113.36 ± 17.75	−3.98, <.001, - 2.33
IRI	9.75 ± 1.96	12.19 ± 1.20	−3.978, <.001, - 1,56
	Split based on SIPAAS avoidance subscale (*Mdn* = 86)		
Age	20.00 ± 1.30	22.14 ± 3.39	2.21, .042, 0.17
SIPAAS	70.93 ± 10.12	102.93 ± 13.86	−2.84, .009, −2.74
IRI	10.00 ± 1.96	11.94 ± 1.64	−2.843, .009, - 1.11

[a] *t, p, d* – *t*-test result, significance level, Cohen's d effect size.

3.2. Empathy and fixation on the emotional eye-region for LSA vs. HSA

The mean proportion of fixation on the emotional eye-region was 0.319 (SD = 0.326) for the neutral video and 0.332 (SD = 0.265) for the sad one. These values are lower than those reported in the literature (around 0.40, see McDonnell et al., 2014), but they may be accounted for by the fact that our actress was speaking (drawing attention to the mouth area), and that the upper body part was also visible (the literature typically focuses on faces only). Given that neutral vs. sad videos had different durations (29 vs. 60 sec., respectively) and could thus provide different opportunity for expressing attention to the eye-region, we compared fixation on the eye-region across the two videos. The analysis showed a positive (M + SD = 0.012 + .186), but non-significant difference (p = .729). Therefore, the participant-level measure of fixation on the emotional eye-region (fixation on sad – fixation on neutral), that we investigated in relation to empathy did not seem to result from stimulus-length-related artefacts.

The correlation between empathy and fixation on the emotional eye-region in videos for the whole sample was non-significant (r (26) = 0.103, p = .60). However, when controlling anxiety levels as measured by the anxiety subscale of SIPAAS, we found a positive, moderate correlation (r (25) = 0.562, p = .002). We then did separate correlations for the two groups, as defined by the anxiety subscale. We found a moderate positive value for LSA (r (12) = 0.665, p = .009), and a non-significant negative correlation for HSA (r (12) = - 0.180, p = .54, see Fig. 4). Bonferroni corrections for multiple comparisons (n = 2) did not change the significance of the LSA correlation (p = .018). Moreover, Fisher's Z test indicated significant differences between the two correlation coefficients (Z = 2.29, p = .011).

The pattern of correlations was not compatible with a ceiling effect related to elevated empathy in HSA: if it were the case, we should expect to see little dispersion for empathy and fixation on the emotional eye-region, both showing high levels in HSA. This was clearly not the case, so HSA participants appeared unable to express empathy by fixating the emotional eye-region. We moved on to check whether this could be due to attentional biases towards emotional faces.

When controlling avoidance levels (SIPAAS avoidance subscale), the correlation was positive and marginal (r (25) = 0.350, p = .073). Correlations for each group were non-significant (LSA: r (12) = 0.378, p = .182; HSA: r (12) = 0.089, p = .761). Therefore, we focused on the anxiety-based sample split.

Social anxiety and attentional biases in face pairs

We started with cross-group comparisons of dwell time on face types (emotional vs. neutral, anger vs. happiness vs. sadness) based on the anxiety subscale. The mixed ANOVA showed a significant main effect of emotionality and no effect from type of emotion (p = .695): Overall,

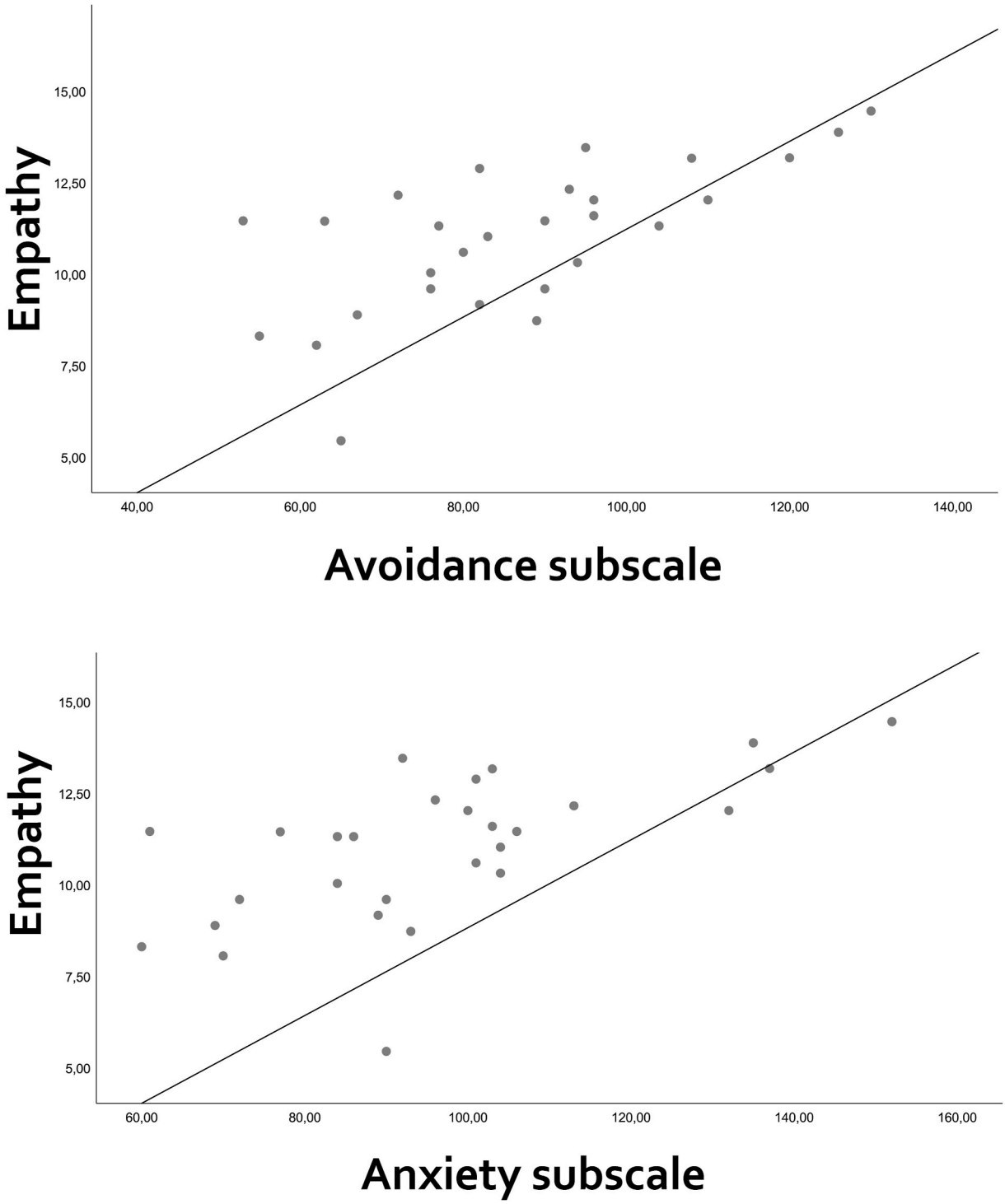

Fig. 3. Correlation between empathy (IRI) and the subscales of the social anxiety (SIPAAS) questionnaire (below, anxiety, above, avoidance).

emotional faces elicited increased dwell time compared to neutral ones (F (1,26) = 26.71, $p < .001$, $\eta^2p = .507$, Fig. 5). The critical interaction - emotionality x social anxiety - was non-significant ($p = .205$, $\eta^2p = .061$), indicating no evidence of attentional biases in the HSA group as defined by the anxiety subscale.

Given that attentional biases towards emotional faces did not account for the lack of correlation between empathy and fixation on the emotional eye-region in HSA, we were left with the possibility that social anxiety engages eye-region-specific avoidance, which remains uncaptured when whole faces are analyzed. To test this, we returned to fixation on the emotional eye-region, as measured with videos.

3.3. Social anxiety and fixation on the emotional eye-region in videos

Cross-group comparisons showed no significant differences between LSA and HSA groups concerning fixation on the emotional eye-region of the video actress (anxiety subscale: $p = .365$). However, a continuous-variable approach to anxiety showed a significant, negative and moderate correlation between anxiety-subscale scores and fixation on the emotional eye-region: r (26) = −0.453, $p = .016$ (see Fig. 6): socially-

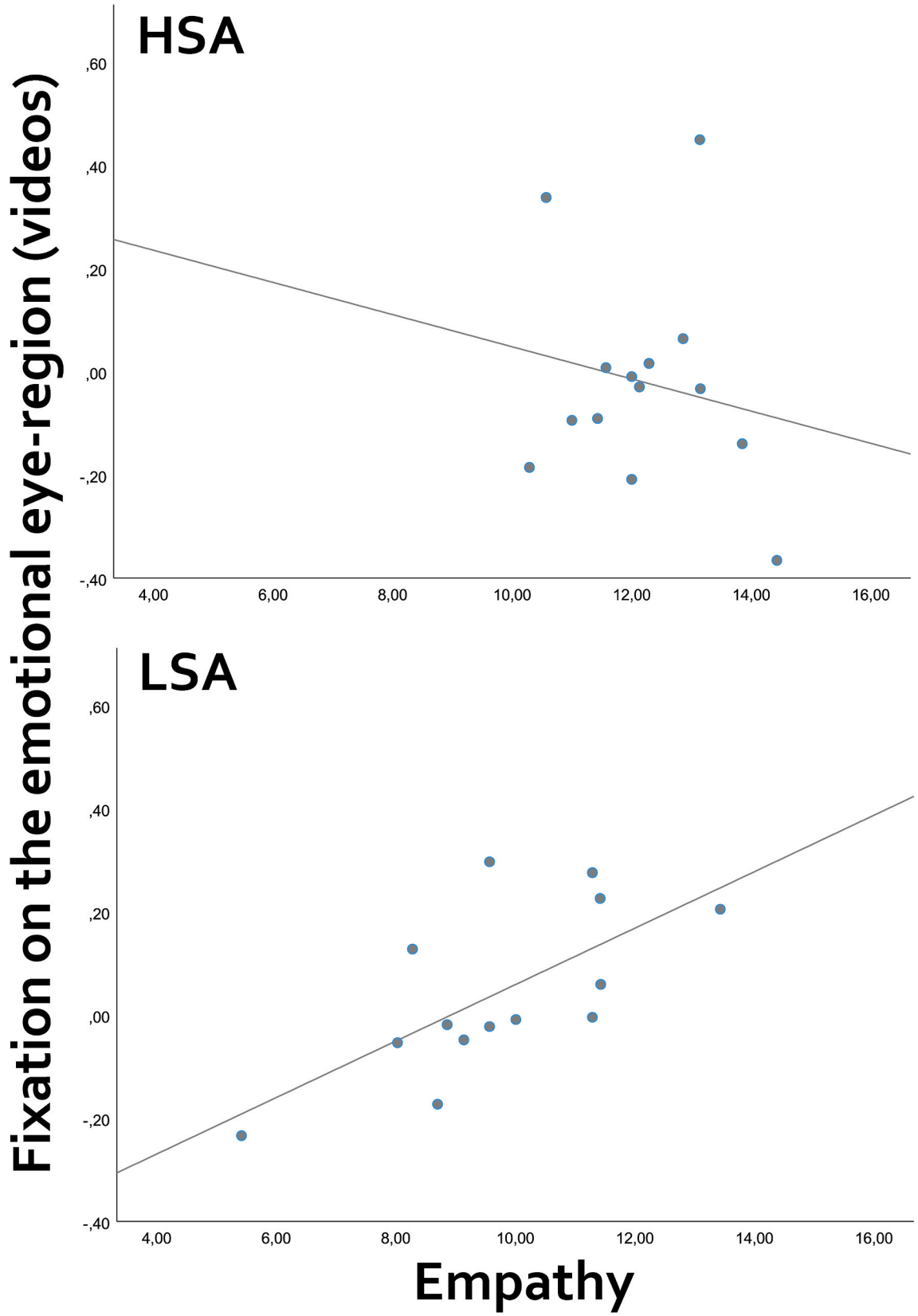

Fig. 4. Correlation between fixation on emotional eye-region in videos and empathy for Low Social Anxiety (below) and High Social Anxiety groups (above), defined according to the anxiety subscale of SIPAAS questionnaire.

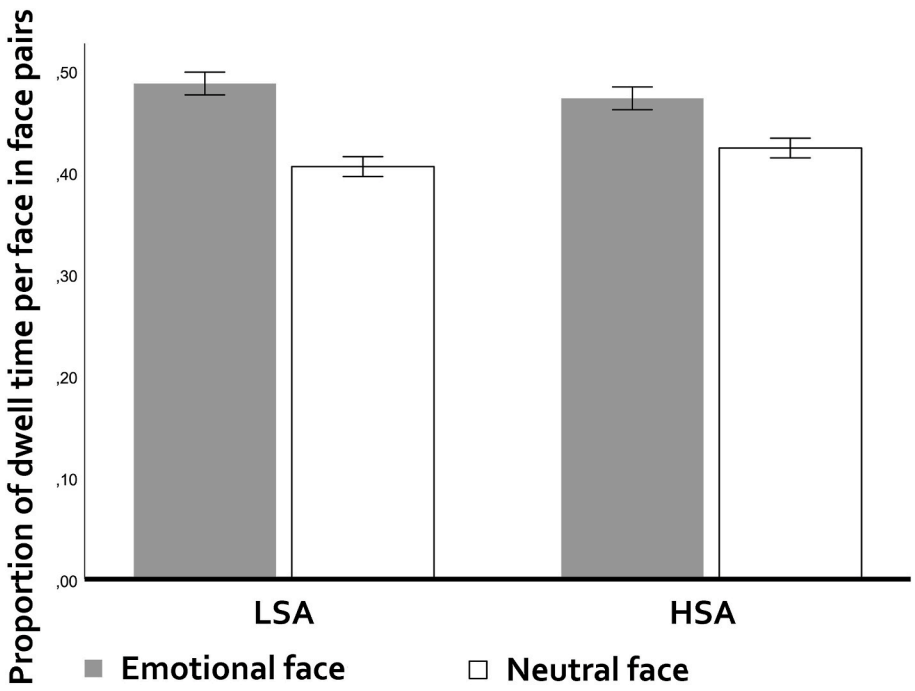

Fig. 5. Mean dwell time (proportion relative to whole image) differences between emotional and neutral faces for LSA vs. HSA, defined according to anxiety subgroups Error bars indicate the standard error of the mean.

anxious participants tend to fixate less on the eye-region. Therefore, one reason why anxiety-defined HSA individuals do not express their empathy levels by fixating on the emotional eye-region may be that they avoid looking at this area of the face, even though they do not avoid faces as a whole (no attentional biases towards faces, see 3.3).

4. Discussion

We tested the hypothesis that empathy correlates positively with fixation on the other's emotional eye-region in low social anxiety (LSA), but not in high social anxiety (HSA), and that such a correlation would be due to the presence of attentional biases towards emotional faces in HSA individuals. To that end, we collected three types of data from LSA vs. HSA participants: empathy levels, fixation on the eye-region of an

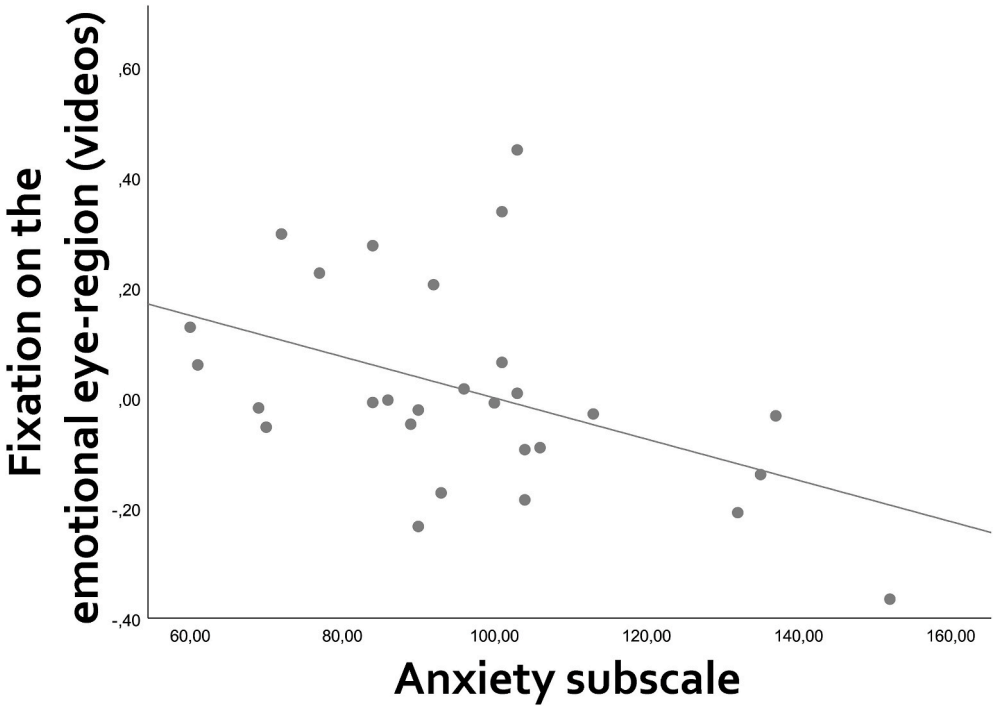

Fig. 6. Correlation between emotional fixation on the other's eye-region (vídeos) and the anxiety subscale scores of the social anxiety questionnaire for the entire sample.

actress performing in neutral vs. sad videos, and dwell time on pairs of neutral vs. emotional still faces. By analyzing eye movements on the video materials, we did find a significant correlation between empathy and fixation on the eye-region in LSA but not in HSA, as well as significant differences between two correlations. However, HSA individuals did not show evidence of attentional biases in the still-face-viewing task: the difference in fixation time for neutral vs. emotional faces was similar in both groups.

Although attentional biases towards emotional still faces did not account for cross-group differences in the association empathy-fixation on the eye-region of the video actress, we saw that high social anxiety *per se* decreases fixation on the emotional eye-region, in line with findings of eye-specific avoidance in high social anxiety, namely for anger and sadness (Farabee, Holcolm, Ramsey, & Cole, 1993; Horley et al., 2003, 2004). This may be enough to explain why HSA participants did not express their high empathy by fixating the other's eye-region: although HSA did not show deviant attentional patterns for emotional faces as wholes, they avoided the emotional eye-region.

The effects of social anxiety we have just reviewed were all associated to the anxiety (intense discomfort) dimension of social anxiety, and not to the avoidance dimension. This strengthens the idea that, although anxiety/discomfort and avoidance may coexist in social anxiety, they may also dissociate (Heeran & McNally, 2018). The reason why anxious, but not avoiding, participants showed specific avoidance of the emotional eye-region in our study may be related to strategies for managing safety behaviors (Cumming et al., 2009): while the avoidant subtype keeps him/herself safe by staying away from social situations, the anxious subtype undergoes social situations with the cost of being led to adopt safety behaviors such as looking away from the emotional eye-region.

Marginally to our main goal, we found that empathy increases with social anxiety whatever the dimension of social anxiety (anxiety/discomfort or avoidance). The literature is mixed regarding this matter (Aragno, 2008; Batson, 1987b; Goldman, 2006; Kohut, 1971; Racker, 1968; Stueber, 2006): high social anxiety participants have been characterized as more empathic than low social anxiety ones (Davis, 1983), but there are also reports of empathic dysfunction in high social anxiety (O'Toole, Hougaard, & Mennin, 2013), as well as evidence that high social anxiety individuals are less empathic only when facing social threat situations (Auyeung & Alden, 2016). One possible explanation for the positive association between social anxiety and empathy may lie in a social desirability effect (Latkin, Edwards, Davey-Rothwell, & Tobin, 2017; Joinson, 1999): given their strong focus on external judgements, it is likely that HSA individuals were particularly concerned with the experimenter's judgement on his/her empathy levels. This may have biased HSA responses in the empathy questionnaire, where participants easily become aware of the target of the evaluation. Future studies could control the social desirability effect by administering, for example, Marlowe–Crowne Social Desirability Scale (Crowne & Marlowe, 1960). The possibility that social anxiety correlates with empathy regardless of confounds such as social desirability may be of interest to differential diagnosis between autism and social anxiety. It is known that social anxiety features are present in autism, although as a secondary symptom (Spain, Sin, Linder, McMahon, & Happé, 2018) and with different attention-related manifestations from primary social anxiety disorder (Kleberg et al., 2017). Empathy levels could help differentiate between these two conditions: so far, the literature has pointed to decreased empathy in autism compared to social anxiety disorder (Pepper et al., 2019), but still with evidence that both pathologies show decreased empathy than healthy controls. Establishing an empathy advantage relative to controls in primary social anxiety could help clarify the boundaries between social anxiety and autism.

Considering that HSA participants avoided the emotional eye-region of the video actress, it may look inconsistent that fixation patterns for still faces (face-pairs viewing task) showed increased dwell time for emotional than neutral faces – in HSA as well as in LSA, suggesting that emotional faces were vigilance targets rather than something to avoid. One explanation may relate to methodological issues: neutral faces were presented three times during the experiment (once with happy, twice with angry, three times with sad faces), while emotional faces appeared once only. Therefore, participants may have got more habituated to neutral faces than to emotional ones, leading to increased dwell time on the latter.

The main practical contribution of our findings is to pinpoint the limitations of eye-tracking techniques as an alternative tool for measuring empathy: while eye-tracking data concerning fixation on the other's emotional eye-region seems to be an effective way to measure empathy levels in low social anxiety, such efficacy may be lost as social anxiety levels increase. Fixation patterns on the emotional eye-region as an index of empathy may be meaningless in high social anxiety, as they will tend to underestimate empathy levels.

On the other hand, the fact that individuals with high social anxiety, though highly empathic, tend to avoid the emotional eye-region points to new (and possibly undiscussed) complications in the lives of these individuals: as they avoid gazing at the emotional eye-region, other people may perceive them as less empathic and thus avoid interacting with them; as a result, these individuals will tend to have difficulties in their social relationships (being rejected) that add to the ones inherent to social anxiety *per se* (rejecting others). A possible way of intervening in this cycle of mutual rejection could be, for example, training high-social-anxiety individuals to fixate on the other's emotional eye-region, beginning with close people and social situations and then, gradually, expand to less familiar contexts.

According to sensitivity power analyses carried out with G × Power (Faul, Erdfelder, Lang, & Buchner, 2007) the minimum effect sizes that our tests were able to detect reliably (Perugini, Gallucci, & Costantini, 2018) with 80% power (alpha = .05) were overall realistic (Faul et al., 2007): the minimum detectable correlation would be $r = 0.614$ with a sample of 14 participants (correlation between empathy and fixation on the emotional eye region in LSA), and it would be $r = 0.451$ with 28 participants (correlations between social anxiety and empathy, and between social anxiety and fixation on the emotional eye-region, LSA and HSA collapsed). Consistent with the sensitivity power analyses, we found significant effects above those thresholds.

In the mixed ANOVA for determining attentional biases, the minimum detectable effect size for the critical interaction (between group, LSA vs. HSA, and emotionality of faces, emotional vs. neutral) with 14 + 14 participants (80% power, alpha = .05) was $\eta^2p = .070$. Although realistic (medium effect), the size of this effect was slightly above the one observed in our study ($\eta^2p = .061$), where results were non-significant. Therefore, we cannot exclude the possibility that attentional biases existed in the HSA group, but our study was unable to capture these effects as significant due to its relatively small sample size. Although this is an important methodological issue to be considered in future studies, uncertainty relating to the presence or absence of attentional biases towards faces in HSA participants does not threaten the main findings of the present study: whatever their attentional biases towards faces (about which we remain uncertain), these participants – unlike LSA - did not express their empathy by looking at other people's eyes, which they seem to have avoided. Therefore, what remains to be further investigated is the scope of HSA participants' avoidance – eyes vs. whole face.

Beyond sample size, another limitation of the present study concerns the generality of our findings: we collected data from Psychology students, who may be more aware of their eye-gaze behavior towards people, and therefore may show patterns of fixation on the other's eye region guided by self-directed and conscious influences.

Despite their limitations, our preliminary findings help define challenges for future research, namely the mechanisms subtending eye-region-specific avoidance in high social anxiety, and possible ways of counteracting this, as well as bias-free alternatives for measuring empathy in these individuals. This could allow adjusting

psychotherapeutic processes to individual levels of empathic functioning and, consequently, to the improvement of psychotherapeutic processes for socially anxious individuals (Coll et al., 2017; Morrison et al., 2016). Finally, the hypothesis of increased empathy in social anxiety deserves further investigation.

Dataset

The dataset of this study is available for download at https://drive.google.com/open?id=1tPEXXb3yP27LzcSi6Yjh0dLXTeK2JQyP.

CRediT authorship contribution statement

Raquel Moutinho: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing - original draft. **São Luís Castro:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing - original draft, Writing - review & editing. **Susana Silva:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare no conflict of interest.

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