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From face to hand: Attentional bias towards expressive hands in social anxiety

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ABSTRACT

The eye-region conveys important emotional information that we spontaneously attend to. Socially submissive individuals avoid other's gaze which is regarded as avoidance of others' emotional face expressions. But this interpretation ignores the fact that there are other sources of emotional information besides the face. Here we investigate whether gaze-aversion is associated with increased attention to emotional signals from the hands. We used eye-tracking to compare eye-fixations of pre-selected high and low socially anxious students when labeling bodily expressions (Experiment 1) with (non)-matching facial expressions (Experiment 2) and passively viewed (Experiment 3). High compared to low socially anxious individuals attended more to hand-regions. Our findings demonstrate that socially anxious individuals do attend to emotions, albeit to different signals than the eyes and the face. Our findings call for a closer investigation of alternative viewing patterns explaining gaze-avoidance and underscore that other signals besides the eyes and face must be considered to reach conclusions about social anxiety.

1. Introduction

The eyes play a very important role in social interactions. Infants as well as adults spontaneously look at the eyes, they grasp emotion signals provided by the eyes and they follow the others' gaze (Farroni, Csibra, Simion, & Johnson, 2002; Tomasello, Hare, Lehmann, & Call, 2007). The human eye is not just designed for seeing, but also to be seen and to communicate, fostering smooth social interactions (Kobayashi & Kohshima, 1997; Kret, Tomonaga, & Matsuzawa, 2014; Kret, Fischer, & de Dreu, 2015). Eye contact is important for establishing secure attachment between mothers and infants (Robson, 1967), it positively impacts on the quality of social interactions later in life (Scherer, 1974), yet it also increases bodily self-awareness (Baltazar et al., 2014) and arousal (Hietanen, Leppanen, Peltola, Linna-Aho, & Ruuhiala, 2008).

Despite the importance of eye contact, research has shown large individual differences in how much attention is drawn towards the eye-region. For example, patients with social anxiety disorders *avoid* others' facial expressions during social interactions more than non-anxious individuals (Garner, Mogg, & Bradley, 2006; Horley, Williams, Gonsalvez, & Gordon, 2003, Horley, Williams, Gonsalvez, & Gordon, 2003; Moukheiber et al., 2010; Terburg, Aarts, & van Honk, 2012; Weeks, Howell, & Goldin, 2013). It is thought that this avoidance is caused by a heightened self-focus during social interactions due to expectations that others will evaluate them negatively (Alden & Mellings, 2004; Clark & Wells, 1995; Mellings & Alden, 2000; Rapee & Heimberg, 1997). How then do these individuals gather insight into another's emotions? The hypothesis we put forward here is that they attend to information sources other than the face as well. Socially anxious individuals may attend to "safe", "non-monitoring" information sources such as other body parts, for instance the hands, more than non-anxious individuals do, and this may serve as a compensatory mechanism for the information missed from the face. Testing this hypothesis requires rethinking about how socially anxious people, and possibly individuals with other disorders as well, process emotions and specifically asks for experiments with stimulus material other than facial expressions. We here test this in a group of participants who are known to avoid eye contact and we study fixation patterns on stimulus material

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Table 1
Participant characteristics.

	Low social anxiety		High social anxiety	
	Mean	SD	Mean	SD
Age	22.29	2.80	21.87	3.05
Sex*	N = 11 ♂; N = 10 ♀		N = 4 ♂; N = 19 ♀	
LSAS anxiety*	9.00	4.94	43.22	9.22
LSAS avoidance*	6.76	5.69	34.87	10.72
LSAS social interaction total*	7.10	5.20	36.65	10.66
LSAS performance total*	8.67	4.37	41.43	9.78
STAI state	50.62	2.20	50.91	2.61
STAI trait	51.57	2.13	51.57	3.57
Beck depression inventory*	2.86	3.12	11.61	6.91
STAXI	10.10	0.30	11.22	2.66
AVL (agression) total	62.43	16.80	65.78	16.00
AVL physical agression*	20.95	7.57	15.83	5.75
AVL verbal agression*	12.95	3.25	10.74	3.31
AVL anger	13.76	4.87	15.87	5.65
AVL hostility*	14.76	5.22	23.35	5.81
Social inhibition (Type D questionnaire)	5.95	4.75	15.52	6.18
Negative affectivity (Type D questionnaire)	5.86	5.11	14.39	4.90
Type D	N = 1		N = 13	
BIS*	18.71	3.38	12.35	4.89
BAS*	22.33	5.33	29.83	6.23
BAS drive*	7.67	2.50	10.00	2.24
BAS fun seeking*	6.76	2.02	9.91	2.37
Bas reward responsiveness*	7.90	2.00	9.91	3.23
VAS tense state*	3.90	2.98	8.04	5.29
VAS tired state	8.24	4.43	9.43	4.70
VAS gloomy state*	2.14	1.59	5.61	3.69
VAS anxious state*	1.38	0.74	5.30	4.77
VAS active state	10.10	4.57	9.83	4.55
Motivation state	13.48	3.31	13.43	4.13
Attention state	8.71	5.29	9.39	4.73

*$p < .05$; AVL = algemene vragenlijst (general questionnaire); BAS = behavioral activation scale; BIS = behavioral inhibition scale; STAXI = state trait anger expression inventory; Type D = distressed personality type; VAS = visual analogue scale.

that shows emotional expressions from the whole body including the face.

In everyday life, bodily postures and movements express our affective state, revealing it, in turn, to the observer. Clearly, in order to grasp another's emotion or intention, humans not only attend to the others' face but also attend to the others' whole body (Atkinson, Dittrich, Gemmell, & Young, 2004; Atkinson, Herberlein, & Adolphs, 2007; Aviezer, Trope, & Todorov, 2012; de Gelder, Snyder, Greve, Gerard, & Hadjikhani, 2004; Kret & de Gelder, 2010; Kret & de Gelder, 2013; Mondloch, Nelson, & Horner, 2013; for a review, see de Gelder et al., 2010). The hands are probably the most expressive components of the human body and provide a rich source of information for observers; the movements we make with our hands, our actions and gestures (Cartmill, Beilock, & Goldin-Meadow, 2012) and emotional expressions (Wallbott & Scherer, 1986; Grosbras & Paus, 2006; Hietanen, Leppänen & Lehtonen, 2004). Research has shown that the perception of facial expressions of emotions can be affected by the expressive qualities of hand movements (Hietanen & Leppänen, 2008). There is of course a striking difference between faces and hands in conveying emotion. When looking into someone's face, most attention goes to the eyes. In contrast to eyes that can see, hands disclose information without being able to judge. For that reason, for socially anxious individuals, attending to the hands may serve as an alternative source of information during interactions with others.

To test this hypothesis, we pre-selected high and low socially anxious university students based on their Liebowitz Social Anxiety Scale (LSAS) scores (Fresco et al., 2001). In three experimental paradigms, we investigated their fixation patterns on bodily expressions of anger, fear and happiness with the facial features blurred, or the combined percept from these emotions expressed by the body and the face simultaneously. We opted for these specific expressions for three reasons. First, these three emotions can be expressed equally well via the body and the face, contrary to surprise and disgust that are not well recognized from body expressions alone (de Gelder et al., 2010). Second, these three emotions are similarly arousing and contain a clear action component (in contrast to a sad body expression) (Pichon, de Gelder, & Grèzes, 2008; Kret, Pichon, Grèzes, & de Gelder, 2011a; Kret, Pichon, Grèzes, & de Gelder, 2011b). Third, by including these specific emotions, we included two negative emotions (fear and anger) and two approach-driven emotions (happiness and anger) and therewith take into account that the anxiety literature is somewhat inconclusive as to whether anger or fear show stronger gaze-avoidance than happiness or not (Adams & Kleck, 2003; Garner et al., 2006; Horley et al., 2004).

In the first experiment, participants viewed angry, fearful and happy bodily expressions with blurred face and labeled the emotions. The aim of this study was to investigate whether bodily expression of emotion, completely independent of any facial characteristics, could drive fixation patterns towards the face and hands. In the second experiment, participants labeled the bodily expressions that were part of face-body compounds consisting of emotionally congruent or incongruent signals of emotion. The reason for including emotionally incongruent combinations was to follow up on the previous experiment by investigating effects of the emotions anger, fear and happiness, and to pull apart the emotion effects from the source through which these emotions were expressed. The third experiment used the same stimuli as Experiment 2, but participants passively viewed the images. This experiment was included because it most closely reflects a real world scenario where individuals are being confronted with emotional others but are not asked to explicitly label emotions. Again, emotionally incongruent stimuli were included as these allow us to disentangle the effects of emotion and effects of the face and body on fixation patterns.

Our main hypothesis is that when confronted with a full body stimulus, high as compared to low socially anxious individuals will attend more to expressive hands, especially when these express anger (negative and approaching the participant). Our previous research showed that angry expressions from the face and body attracted most attention, relatively independent of whether the face and body expressed the same emotion or not (Kret, Roelofs, Stekelenburg, & de Gelder, 2013a; Kret, Stekelenburg, Roelofs, de Gelder, 2013b). This is in line with a large literature showing preferential processing of threatening information, and may be explained by evolutionary adaptations to quickly attend to and respond to threat. We here hypothesize that the expected attentional bias to hands expressing anger in the high anxiety group, is independent from the facial expression. Based on research showing that gaze-avoidance in social anxiety disorders is observed during passive and active labeling tasks alike (Garner et al., 2006; Horley et al., 2003, 2004; Moukheiber et al., 2010), we predict that this pattern will be present independent of the specific task instructions and thus observed across the three experiments.

2. Method

2.1. Participants

2.1.1. Pre-screening

Students at Tilburg University were emailed with the request to fill out a short questionnaire. In case they did not reply, up to three reminders were sent. This resulted in a total of 1088 students at Tilburg University filling out the LSAS anxiety scale (24 items, 0–3 scale: none, mild, moderate, severe social anxiety; range 0–72). Participants who scored below 6 ($N = 106$) or above 36 ($N = 56$) (the latter being indicative for at least "marked social phobia") were invited to take part in this study. Finding low anxious students and getting them into the lab was much easier than convincing the 56 anxious students to take part. After sending them several requests via email, we finally had a group of 23 high anxious students. Consequently, we also approached the 23 students who scored lowest on anxiety.

2.2. The current study

Participants were thus pre-selected on their LSAS anxiety score, but on the day of testing, were asked to fill out this scale again, in addition to several other questionnaires that are listed in Table 1. This package of questionnaires was given at the end of the testing session to keep them maximally focused on the main task. We calculated Cronbach's alpha as the reliability statistic for the LSAS anxiety score that we used for the pre-selection and the score on the day of testing (Cronbach's $\alpha = 0.769$ with a correlation of 0.624, $p = 000006$). Unfortunately, on retesting the LSAS on the day of testing, two "low anxious" students actually scored much higher than during their pretest (during which they for each question always circled the lowest value). Because these two were not highly anxious and not low anxious and we doubted about the reliability of their questionnaire scores, they were excluded from the analyses. Therefore, the final group (fifteen male and twenty-nine female, on average 22.07 years old, ranging from 19 to 27 years old) consisted of twenty-one low socially anxious and twenty-three high socially anxious participants.

On the day of testing, participants were asked to report past/present medical conditions including psychological disorders and medication use. In the low socially anxious group, one participant took an antidepressant (amitriptyline) for psychological problems. Another participant reported to have sought psychological help in the past for sexual abuse but was not currently seeing a psychologist or psychiatrist and did not report to experience psychological problems. Both participants were kept in the analyses and were no outliers on any of our measures. No other medical conditions were reported.

As is common in a preselected group of high socially anxious individuals, we also observed higher scores on depression, Type D personality traits, behavioral inhibition, hostility, and different states including tension, gloominess and anxiety (see Table 1). High socially anxious participants scored lower on the behavioral activation scale, and on physical and verbal aggression than the low socially anxious group. Within our student population, it was not possible to find more high socially anxious males who were willing to come to the lab and therefore the high social anxiety group contained more females and fewer males than the low social anxiety group (high socially anxious group $N = 23$, 19 ♀; low socially anxious group $N = 21$, 10 ♀). Importantly, students in both groups did not differ on the State Trait Anxiety Inventory (STAI), which indicates that the social anxiety measure on the basis of which they were preselected was specifically related to anxiety for social interactions and not generalized anxiety. Moreover, the two groups were equally motivated and attentive in the task and did not differ in age. See Table 1.

All participants filled out an informed consent before taking part in the experiments. Participants had normal or corrected-to-normal vision. The study was performed in accordance with the Declaration of Helsinki and approved by the local medical ethical committee. One highly anxious participant only took part in Experiment 1 as after that she had indicated that she wanted to stop.

2.3. Materials

The study used stimulus material consisting of facial expressions of emotion and body postures. In Experiment 1, body postures were presented with blurred facial features, in Experiment 2 and 3, the facial expressions were visible. Fearful, happy and angry facial expressions of six male individuals that were correctly recognized above 80% were selected from the NimStim set (Tottenham et al., 2009). The body expressions were taken from our own published and well-validated stimulus database containing 254 digital pictures. The pictures were shot in a professional photo studio under constant lighting conditions. Non-professional actors were individually instructed in a standardized procedure to display different expressions with the whole body. The instructions provided a few specific and representative daily events typically associated with each emotion (for more details, see de Gelder & van den Stock, 2011). For the current study, we selected images with recognition scores above 80% correct. Only male actors were chosen because we previously found that angry and fearful expressions evoke stronger arousal reactions in participants than when these emotions are expressed by females (Kret & de Gelder, 2013; Kret et al., 2011b). Pictures were presented in greyscale, against a grey background. Using Adobe Photoshop the luminance of each stimulus was modified to the average luminance. A final check was made with a light meter on the test computer screen. The exact same stimuli have been used before in a different, random sample of university students (Kret et al., 2013a, 2013b) and also in violent offenders and matched control participants (Kret & de Gelder, 2013). In the university students, it was found that happy bodies were recognized with 75% accuracy, anger with 95% accuracy and fear with 91% accuracy. If the facial expression matched the bodily expression, these percentages went up to 96%, 99% and 95% respectively.

2.4. Procedure

After reading the information brochure and signing the informed consent, the eye-tracking device was positioned on the participant's head. Next, a 9-point calibration was performed which was repeated before each block. Stimuli were presented using E-prime software on a PC screen with a resolution of 1024 by 768 and a refresh rate of 100 Hz. Each trial started with a fixation-cross, shown for minimally 3000 ms until the participant fixated and a manual drift correction was performed by the experiment leader, followed by a picture presented for 4000 ms and a grey screen (3000 ms).

The study consists of three experiments. In Experiment 1, the task was to label bodily expressions in a three-alternative forced choice task consisting of 36 trials. Experiment 2 and 3 consisted of two blocks containing 36 trials each with 18 emotionally congruent and 18 incongruent stimuli (for example, a happy face paired with an angry body). In Experiment 2, participants were asked to recognize the body posture while ignoring the face. In Experiment 3, they had to observe the images without giving a response. Although reported last, Experiment 3 was in fact always given first because we wanted participants to enter this experiment completely unbiased. In Experiment 3, in the instructions, we did not refer to emotions and we simply instructed them to look at the images as they would normally do. At that point, they did not know that in the following experiments they would be asked to label expressions. The order of Experiment 1 and 2 was counterbalanced.

After the experiments, participants were asked to describe what they had seen. All mentioned having seen emotional expressions but that sometimes the facial and body expressions did not match.

2.5. Eyetracking measurement

Participants were comfortably seated at a distance of 65 cm from the computer screen. With the head-mounted system, a chin-rest was not required, but we nonetheless asked participants to rest their head against the headrest of the seat. Eye movements were recorded with a sample-rate of 250 Hz using an EyeLink system (SensoMotoric Instruments GmbH, Germany). A drift correction was performed on every trial to ensure that data was adjusted for movement. We used the default Eyelink settings which defines a blink as a period of saccade-detector activity with the pupil data missing for three or more samples in a sequence. A saccade was defined as a period of time where the saccade detector was active for 2 or more samples in sequence and continued until the start of a period of saccade detector inactivity for 20 ms. The configurable acceleration (8000°/s) and velocity (30°/s) threshold were set to detect saccades of at least 0.5° of visual angle. A fixation was defined as any period that was not a blink or saccade. Analyses were performed on the proportion of time spent looking at each region of interest (ROI: hands and face) within the time spent looking on the screen, with the first 200 ms discarded due to the fixed position of the fixation cross.

2.6. Statistical analyses

Fixations were always analyzed in three Repeated Measures ANOVAs. In the first analysis, region of interest (ROI) was included as a within-subject factor, to specifically look for an interaction between group and ROI. In the second analysis we analyzed fixations within the face region. Most importantly, in the third analysis we investigated fixation durations on the hands. Facial expression and/or Body expression were entered as within-subject factors, and Group[1] was entered as a between-subject variable. Significant main effects were followed up by Bonferroni-corrected pairwise comparisons. The exact p-value is always reported but p-values smaller than .001 are reported as $p < .001$.

3. Results

3.1. Experiment 1. Recognition of body expressions

Participants categorized bodily expressions of fear, anger and happiness. The facial features were blurred.

3.1.1. Fixations on the hands or head

A $2 \times 2 \times 3$ repeated measures ANOVA (with ROI (head/hands), group (low anxious, high anxious) and emotion (anger, fear, happy)) revealed a trend towards an interaction between ROI and group $F(1,41) = 3.130$, $p = .084$, $\eta p.^2 = .071$.

3.1.2. Fixations on the hands

In line with our prediction, a 2×3 Repeated Measures ANOVA (with group (low anxious, high anxious) and emotion (anger, fear, happy)) revealed a main effect of group $F(1,41) = 5.125$, $p = .029$ $\eta p.^2 = .111$ showing that high socially anxious participants fixated longer on the hands than low socially anxious participants. See Fig. 1.

A main effect of emotion ($F(2,82) = 12.336$, $p < .001$, $\eta p.^2 = .231$) showed that independently of group, fixations were longest on negative (angry and fearful versus happy) hands (p s < .001). There was no significant interaction between group and emotion ($p = .794$).

3.1.3. Fixations on the head (blurred facial features)

A similar 2×3 repeated measures ANOVA (with group (low anxious, high anxious) and emotion (anger, fear, happy)) revealed a main effect of body expression $F(2,82) = 61.336$, $p < .001$, $\eta p.^2 = .599$. In line with the expectations, participants attended shorter to the head-region (non-expressive as all features were blurred) when the body expressed fear or anger compared to happiness (p s < .001). In addition, there was an emotion by group interaction $F(2,82) = 5.407$, $p = .006$, $\eta p.^2 = .117$. Follow-up tests did not reveal any significant effects although one trend towards significance was observed, showing that low as compared to high socially anxious participants paid somewhat more attention to the head-region of happy bodies $t(41) = 1.829$, $p = .075$.

3.1.4. Accuracy

A 2×3 repeated measures ANOVA, with the variables emotion (anger, fear, happy) and group (low anxious, high anxious) showed there were no main or interactions effects of group. Both groups could easily recognize bodily expressions of emotion. There was a main effect of Emotion, $F(2,84) = 30.246$, $p < .001$, $\eta p.^2 = .419$. Post-hoc tests revealed that independent of group, happy body expressions were least well recognized, (happy (73.4% correct) vs. fear (91.6%), $p = .048$) or vs. anger (96.4%), all p s < .001.

[1] In additional control analyses we ruled out that the differences in fixations on the hands could be explained by sex differences. Although the interaction between ROI and group was not significant, it was not significantly different from the interaction as observed in Experiment 2. This was tested in an ANOVA with the factors Experiment, ROI, body emotion, facial emotion and group. The interaction between Experiment, ROI and group was not significant $F(1,41) = .875$, $p = .355$, $\eta p.^2 = .021$ and for consistency with Experiment 1 and 2, we analyzed effects of facial expression, bodily expression and group also within the face and body ROIs. In additional control analyses we ruled out that the differences in fixations on the hands could be explained by sex differences.

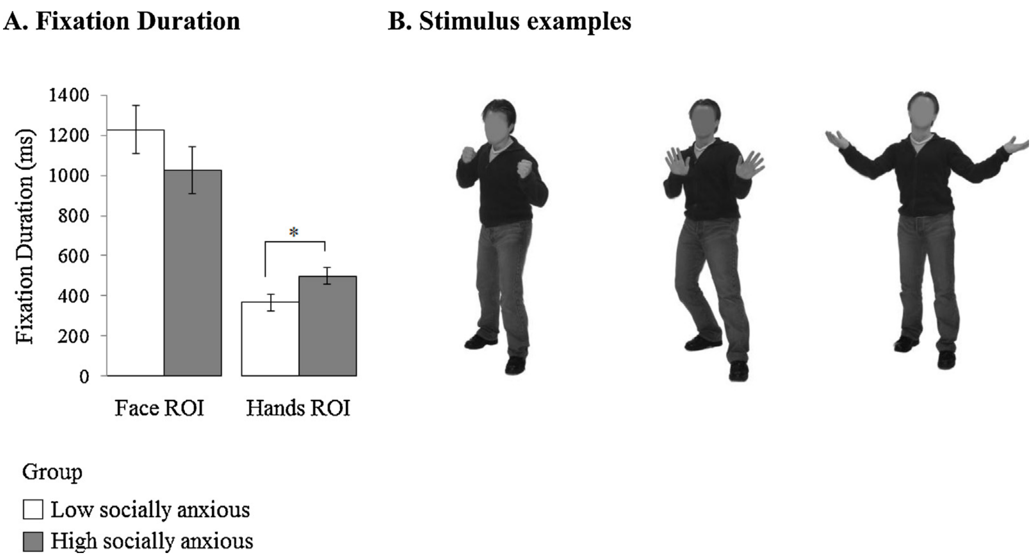

Fig. 1. Fixation duration on whole body expressions of emotion.
(A) High as compared to low socially anxious participants spend more time observing the hand region in order to label the expression. (B) A stimulus example of a happy, fearful, and angry posture. Error bars represent the standard error of the mean.

3.1.5. Conclusion

In line with our prediction, high socially anxious participants attended more to the hands than low socially anxious participants. Furthermore, the hands attracted more gaze when they expressed anger or fear, than happiness, irrespective of group. Usually, an authentic facial expression is accompanied by a body posture that reflects the same emotion as expressed in the face. However, in many situations, people control their facial expression, they may force a smile when necessary, but they are not able to fully control their body posture, leading to an incongruence between the body and the face. Therefore, in the next experiment we additionally made use of face-body composite images showing not only congruent, but also emotionally incongruent expressions. We predicted that high socially anxious would pay more attention to the hand regions than their low socially anxious counterparts.

3.2. Experiment 2. Recognition of body expressions in face–body composite images

Similar to Experiment 1, participants were requested to categorize angry, fearful and happy bodily expressions. In the current experiment however, the postures were paired with facial expressions showing either the same or a different expression in all combinations (angry face with angry, happy and fearful body, happy face with angry, happy and fearful body, fearful face with angry, happy and fearful body). As in Experiment 1, participants were asked to label the bodily expression. As in this experiment facial expressions were visible too, participants were told to ignore these and for the emotion recognition task, to purely rely on the body.

3.2.1. Fixations on the hands or face

In line with our prediction, a $2 \times 2 \times 3 \times 3$ repeated measures ANOVA (with ROI (face, hands), group (low anxious, high anxious), body emotion (anger, fear, happy) and facial emotion (anger, fear, happy)) revealed an interaction between ROI and group F (1,41) = 7.375, $p = .010$, $\eta p.^2 = .152$. In addition, there was a four-way interaction $F(4,164) = 2.630$, $p = .036$, $\eta p.^2 = .060$. These effects were followed up in two separate ANOVAs per ROI.

3.2.2. Fixations on the hands

A $2 \times 3 \times 3$ (group (low anxious, high anxious) $\times$ body expression (anger, fear, happy) $\times$ face expression (anger, fear, happy)) Repeated Measures ANOVA within the hand-ROI revealed a main effect of group F (1,41) = 8.755, $p = .005$, $\eta p.^2 = .176$. High socially anxious participants paid more attention to the hands than low socially anxious participants. Moreover, an interaction between group, facial expression and body expression F (4,164) = 3.209, $p = .014$, $\eta p.^2 = .073$ indicated that group differences were different across conditions. They were largest when threat was maximally presented, i.e., when angry faces were paired with angry bodies t (41) = 3.656, $p < .001$ or when fearful faces were presented above fearful bodies t (41) = 3.601, $p < .001$ and not for maximally positive(happy–happy t (41) = 1.736, $p = .09$ and the incongruent composite of an angry face with a fearful body t (41) = 0.390, $p = .699$ (see Fig. 2).

Regardless of group, there were main effects of bodily expression F (2,82) = 4.354, $p = .016$, $\eta p.^2 = .096$ and facial expression F (2,82) = 50.779, $p < .001$, $\eta p.^2 = .553$. Participants attended more to hands when the body expressed fear or anger as compared to happiness ($p\,s < .001$) and when the face expressed fear as compared to anger ($p = .035$).

3.2.3. Fixations on the face

A $2 \times 3 \times 3$ (group (low anxious, high anxious) $\times$ body expression (anger, fear, happy) $\times$ face expression (anger, fear, happy)) repeated measures ANOVA revealed a main effect of group F (1,41) = 4.527, $p = .039$, $\eta p.^2 = .099$. High as compared to low socially anxious participants attended less to the face.

Regardless of group, there was a main effect of facial expression $F(2,82) = 6.251$, $p = .003$, $\eta p.^2 = .132$ showing shortest fixations on a fearful face, as compared to both an angry and a happy face ($p = .006$; $p = .005$, respectively). None of the interactions was significant ($p > .325$).

3.2.4. Accuracy

A $2 \times 3 \times 3$ (group (low anxious, high anxious) $\times$ body expression (anger, fear, happy) $\times$ face expression (anger, fear, happy)) repeated measures ANOVA revealed no main or interaction effects of group (all $p\,s > .336$). An interaction between body expression and face expression F (2,80) = 13.165, $p < .001$, $\eta p.^2 = .248$ showed

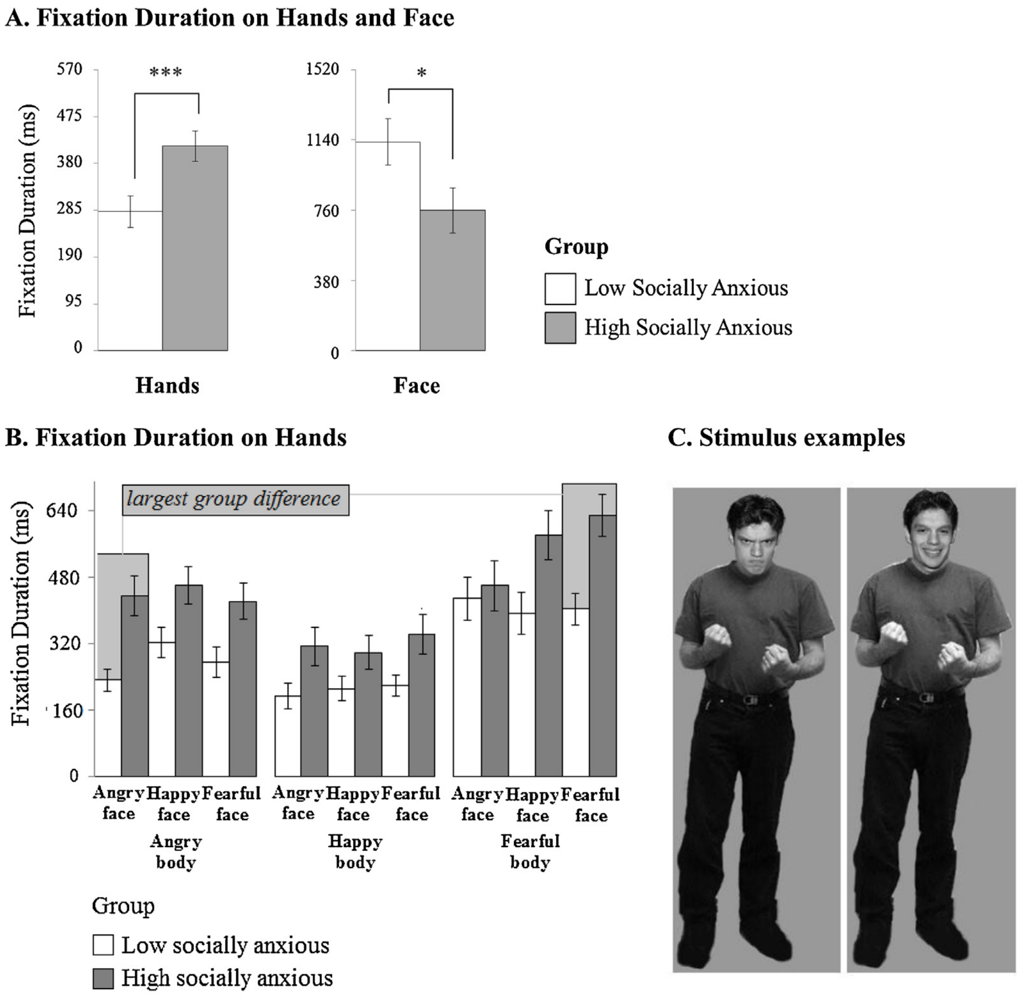

Fig. 2. A fixation duration on hands and face. (B) Fixation duration on hands.
(A) High socially anxious observers had longer fixations on the hands (left) and shorter fixations on the face (right) than low socially anxious observers. (B) The attentional bias towards the hands in the high anxiety group was consistent across conditions, but strongest in the most negative conditions (angry and fearful expressions displayed by congruent composite stimuli). (C) Stimulus examples showing an angry body with an angry face (congruent on the left) and with a happy face (incongruent on the right). Error bars represent the standard error of the mean.

that happy bodies were better recognized when paired with happy than with angry or fearful faces, respectively $t\,(41) = 4.749$, $p < .001$; $t\,(41) = 3.304$, $p = .002$. Fearful bodies were better recognized when paired with fearful rather than angry or happy faces, respectively $t\,(41) = 3.143$, $p = .003$; $t\,(42) = 3.517$, $p = .001$.

3.2.5. Conclusion

In line with our prediction, we observe that high socially anxious participants attend longer to expressive hands, and less to the face than low socially anxious participants. In the current experiment, where participants were told to ignore the face and focus on the body and label that expression, effects of emotion emerged. More specifically, the largest effect of group was observed in the conditions where negative (angry and fearful) emotions were expressed by congruent composite stimuli. In Experiment 3, we test whether these tendencies hold in a free-viewing paradigm in which participants were not forced to think about emotion labels or worry about their performance.

3.3. Experiment 3. Passive viewing of face-body composite images

Participants freely viewed angry, happy and fearful facial expressions paired with body expressions in all combinations (angry face with angry, happy and fearful body, happy face with angry, happy and fearful body, fearful face with angry, happy and fearful body).

3.3.1. Fixations on the hands or face

In contrast to the two previous emotion recognition tasks, a $2 \times 2 \times 3 \times 3$ Repeated Measures ANOVA (with ROI (face, hands), group (low anxious, high anxious), body emotion (anger, fear, happy) and facial emotion (anger, fear, happy)) did not reveal an interaction between ROI and group ($p = .278$).[2]

[2] Although the interaction between ROI and group was not significant, it was not significantly different from the interaction as observed in Experiment 2. This was tested in an ANOVA with the factors Experiment, ROI, body emotion, facial emotion and group. The interaction between Experiment, ROI and group was not significant $F\,(1,41) = .875$, $p = .355$, $\eta p.^2 = .021$ and for consistency with Experiment 1 and 2, we analyzed effects of facial expression, bodily expression and group also within the face and body ROIs.

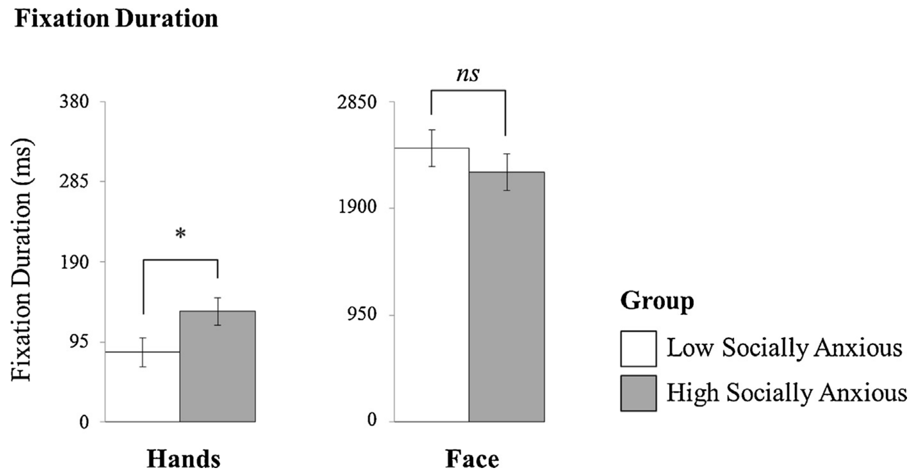

Fig. 3. High as compared to low socially anxious participants spend more time observing the hand region while passively viewing images of emotional others. Error bars represent the standard error of the mean.

3.3.2. Fixations on the hands

As expected, a $2 \times 3 \times 3$ (group (low anxious, high anxious) $\times$ face expression (anger, fear, happy) $\times$ body expression (anger, fear, happy)) repeated measures ANOVA again showed that high socially anxious individuals focus more on the hands than low socially anxious individuals $F(1,41) = 4.113$, $p = .049$, $\eta p.^2 = .091$ (see Fig. 3). In addition, fixations on the hands were modulated by body posture $F(2,82) = 18.745$, $p < .001$, $\eta p.^2 = .314$. The hands attracted most fixations when the body expressed fear (vs. happy, $p < .001$; vs. anger $p < .001$). There was also an effect of facial expression $F(2,82) = 4.318$, $p = .016$, $\eta p.^2 = .095$ but none of the post-hoc comparisons reached significance and groups did not differ in how facial expressions modulated hand fixations ($p\,s > .07$).

3.3.3. Fixations on the face

A $2 \times 3 \times 3$ (group (low anxious, high anxious) $\times$ face expression (anger, fear, happy) $\times$ body expression (anger, fear, happy)) repeated measures ANOVA showed that fixations on the face were modulated by the facial expression $F(2,82) = 9.951$, $p < .001$, $\eta p.^2 = .195$. The face attracted most fixations when it expressed fear (vs. happy, $p < .001$; vs. anger $p = .057$) but there was no main effect of or interaction with group ($p\,s > .304$).

3.3.4. Conclusion

Although the interaction between ROI and group was not significant, we again observe that high socially anxious participants attend longer to expressive hands than low socially anxious participants. In this experiment, participants had no specific task than to observe the images. Although in real life it is often important to judge another's emotional state from bodily signals and give a proper response, in this final experiment, discriminating the emotional expression or not had no consequence for directing gaze. Even in this experiment, the attentional bias towards hands was observed, showing the robustness of the effect, which held independent of the task.

4. Discussion

The present study used naturalistic stimuli of whole body expressions of emotion to investigate the relation between emotion perception and social anxiety. High socially anxious individuals perceive emotional expressions by gazing at the hands instead of the head more than low anxious participants. This finding contrasts with theories suggesting that high socially anxious individuals avoid others' emotional expressions because they are more focused on the self (Alden & Mellings, 2004; Mellings & Alden, 2000). The results show that correct performance in emotion recognition is guaranteed by the fact that avoidance of eye-contact is compensated for by increased attention to body-regions.

In three experiments, we consistently found that high socially anxious individuals paid more attention to expressive hands than low socially anxious individuals, and especially so when the whole body expressed fear or anger. Previous emotion perception research in social anxiety has largely focused on emotional face processing and has consistently shown gaze aversion in high socially anxious individuals (Garner et al., 2006; Horley et al., 2003, 2004; Moukheiber et al., 2010; Weeks et al., 2013). Although the aim of the study was not to study gaze avoidance, as that would have required different stimulus material with larger eye-regions, the results of the current study can partly be interpreted in line with that earlier work. For example, the results of our Experiment 2 demonstrate shorter fixations on the face in high as compared to low anxious students. Experiment 1 showed a trend towards this effect for happy body expressions with blurred facial features. This group difference was no longer present in the free-viewing paradigm of Experiment 3 when no task performance was required, although the pattern was similar to the pattern observed in Experiment 1–2. Future studies should rule out whether performance and the associated risk of being evaluated on the basis of performance provide a context for these effects to occur.

The present findings call for rethinking about how different people process emotions differently, which might have important implications for social interaction research (also beyond the field of social anxiety). To date, most studies use faces as stimulus material. In social anxiety research, this has led many researchers to conclude that individuals with social anxiety avoid others' emotional expressions. We show that this is not the case. By using naturalistic stimulus material, we show that high socially anxious individuals direct more attention to expressive hands than low socially anxious individuals, suggesting that they have found an adaptive compensation strategy that they may apply during social interactions where they avoid eye-contact, but still keep track of the others' emotions by paying close attention to their hand gestures. It is possible that this strategy helps them cope with their social anxiety, allowing them despite their clear handicap, to be relatively successful in situations where social interaction is required. The current study cannot rule out that the observed effects are limited to a relatively high functioning population with social anxiety traits and extend to clinically anxious populations.

The current study extends previous research by providing an alternative interpretation of gaze-avoidance. A large number of studies have shown that when looking at someone's face, it's the eyes that attract most attention and it's the eyes that are mostly used to infer another's emotional state (Adolphs et al., 2005). However, in a natural social interaction, we are communicating with full persons, not just with their faces (de Gelder et al., 2010). Moreover, the body posture influences how the facial expression is perceived (Kret & de Gelder, 2013; Kret et al., 2013a, 2013b; Meeren, van Heijnsbergen, & de Gelder, 2005; Van den Stock & de Gelder, 2006; Van den Stock, Righart, & de Gelder, 2007). Wallbott and Scherer's (1986) examination of body expressions indicated that hand gestures and movements are one of the most significant characteristics for distinguishing between emotional expressions. This is not surprising given that most of our gestures come from the hands, and humans are very adept at making and understanding (emotional) signals through them (Hietanen, Leppänen & Lehtonen, 2004). On the neural level, Grosbras and Paus (2006) found that observing angry as compared to neutral hand movements activated the temporo-parietal junction, an area consistently shown to be implicated in perspective-taking, theory of mind, and empathy. In an earlier study we showed that this region, in line with other regions, was over-activated in socially inhibited individuals when observing emotional body movements (Kret, Denollet, Grèzes, de Gelder, 2011). With the help of more naturalistic stimulus material including the whole body, we were here able to show that socially anxious are as much interested in others emotions and recognize them equally well as low anxious participants, but that they retrieve emotional information more from sources beyond the face, from expressive hands.

Our study has a limitation in that the two groups that were studied here not just differed on their level of social anxiety, but on depression scores and other personality aspects as well. This is also commonly observed in the clinical population: epidemiological studies have revealed that up to 30% of the adult population in the United States has a mental disorder and that almost half of them have a comorbid disorder. Especially substance use, mood and anxiety disorders are very often intermixed. In the case of anxiety, depressive symptoms are often the *consequence* of the anxiety symptoms (Kessler et al., 2005). Recently, disrupted emotion processing has been proposed as a liability spectrum that underlies various mental disorders (Kret & Ploeger, 2015). Emotion processing deficits have been reported in different disorders and result in difficulties in regulating emotions and at the perceptual level in attentional biases, gaze avoidance and impaired recognition of emotional expressions. In addition, in many different disorders, amygdala dysfunction has been observed. The amygdala plays an important role in how affective signals are processed and is important in guiding attention and eye gaze to faces and particularly to the eyes (Adolphs et al., 2005; Kennedy & Adolphs, 2010; Gamer & Büchel, 2009). Recently, it was shown that bilateral calcification of the basolateral nucleus of the amygdala results in prolonged gaze at the eyes of fearful faces (Terburg et al., 2012) and in difficulties in ignoring task-irrelevant bodily threat signals when recognizing briefly presented facial expressions (de Gelder et al., 2004). Importantly, the point we are trying to make here is not that the attentional bias towards hands that we observed in the three experiments is specific for social anxiety, but rather, that gaze avoidance across several other disorders, may well be explained too by alternative viewing patterns, and not by a lack of interest in others social or emotional behavior. Future studies should therefore investigate different clinical and sub-clinical samples, especially those characterized with gaze-avoidance such as for example autism in order to test whether these individuals are really avoiding the eyes, or are using a different emotion recognition strategy (see also Atkinson, 2009; Hadjikhani et al., 2009). If these studies include a larger sample size than the current study, then it will be possible to use alternative statistics such as path analysis to investigate the relationship of different clinical conditions and/or personality traits with gaze avoidance.

Another limitation of this study is the overall high accuracy in emotion recognition. Due to ceiling effects, possible group differences were rendered invisible and the small variance also prohibited a test for correlations with fixation duration. Future studies could consider increasing task difficulty, for example by asking participants to respond as quickly as they can during the presentation of the stimulus. Such a manipulation would also allow for the analysis of reaction times.

To conclude, the current study is the first to investigate fixation patterns on emotional face versus emotional hand expressions in the natural context of the whole body and relate these patterns to participant's social anxiety. We show that individuals who have a tendency to avoid gaze use compensatory strategies to perceive emotional information from the hands. Our findings call for closer investigation of alternative viewing patterns explaining gaze-avoidance and plead in favor of investigating social and emotional skills with naturalistic stimulus materials including images of the whole body.

Author contribution

MEK was involved in data collection, analyzed the data and prepared figures. MEK, KR, JJS and BdG contributed in designing the study, interpreting the data and writing the main manuscript text.

Additional information

The authors declare no competing financial interests. Development of the MacBrain Face Stimulus Set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set.

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References

Adams, R. B., & Kleck, R. E. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science*, *14*(6), 644–647.

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature*, *433*(7021), 68–72.

Alden, L. E., & Mellings, T. M. (2004). Generalized social phobia and social judgments: the salience of self- and partner-information. *Journal of Anxiety Disorders*, *18*(2), 143–157.

Atkinson, A. P. (2009). Impaired recognition of emotions from body movements is associated with elevated motion coherence thresholds in autism spectrum disorders. *Neuropsychologia*, *47*(13), 3023–3029.

Atkinson, A. P., Dittrich, W. H., Gemmell, A. J., & Young, A. W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception*, *33*(6), 717–746.

Atkinson, A. P., Herberlein, A. S., & Adolphs, R. (2007). Spared ability to recognise fear from static and moving whole-body cues following bilateral amygdala damage. *Neuropsychologia*, *45*(12), 2772–2782.

Aviezer, H., Trope, Y., & Todorov, A. (2012). Body cues, no facial expressions, discriminate between intense positive and negative emotions. *Science*, *338*, 1225. http://dx.doi.org/10.1126/science.1224313

Baltazar, M., Hazem, N., Vilarem, E., Beaucousin, V., Picq, J. L., & Conty, L. (2014). Eye contact elicits bodily self-awareness in human adults. *Cognit*, *133*(1), 120–127.

Cartmill, E. A., Beilock, S., & Goldin-Meadow, S. (2012). A word in the hand: action, gesture and mental representation in humans and non-human primates. *Philosophical transactions of the Royal Society of London. Series B, Biological Sciences*, *367*(1585), 129–143.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. Heimberg, M. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), *Social phobia: diagnosis, assessment and treatment*. New York: Guilford Press.

de Gelder, B., & van den Stock, J. (2011). The bodily expressive action stimulus test (BEAST). Construction and validation of a stimulus basis for measuring perception of whole body expression of emotions. (BEAST). *Frontiers in Psychology*, *9*(2), 181

de Gelder, B., Snyder, J., Greve, D., Gerard, G., & Hadjikhani, N. (2004). Fear fosters flight: a mechanism for fear contagion when perceiving emotion expressed by a whole body. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(47), 16701–16706.

de Gelder, B., Van den Stock, J., Meeren, H. K., Sinke, C. B., Kret, M. E., & Tamietto, M. (2010). Standing up for the body. Recent progress in uncovering the networks involved in the perception of bodies and bodily expressions. *Neuroscience and Biobehavioral Reviews*, *34*(4), 513–527.

Farroni, T., Csibra, G., Simion, F., & Johnson, M. H. (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(14), 9602–9605.

Fresco, D. M., Coles, M. E., Heimberg, R. G., Liebowitz, M. R., Hami, S., Stein, M. B., & Goetz, D. (2001). The Liebowitz Social Anxiety Scale: a comparison of the psychometric properties of self-report and clinician-administered formats. *Psychological Medicine*, *31*(6), 1025–1035.

Gamer, M., & Büchel, C. (2009). Amygdala activation predicts gaze toward fearful eyes. *Journal of Neuroscience*, *29*(28), 9123–9126.

Garner, M., Mogg, K., & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology*, *115*(4), 760–770.

Grosbras, M. H., & Paus, T. (2006). Brain networks involved in viewing angry hands or faces. *Cerebral Cortex*, *16*(8), 1087–1096.

Hadjikhani, N., Joseph, R. M., Manoach, D. S., Naik, P., Snyder, J., Dominick, K., & de Gelder, B. (2009). Body expressions of emotion do not trigger fear contagion in autism spectrum disorder. *Social Cognitive and Affective Neuroscience*, *4*(1), 70–78.

Hietanen, J. K., & Leppänen, J. M. (2008). Judgment of other people's facial expressions of emotions is influenced by their concurrent affective hand movements. *Scandinavian Journal of Psychology*, *49*, 221–230.

Hietanen, J. K., Leppänen, J. M., & Lehtonen, U. (2004). Perception of emotions in the hand movement quality of finnish sign language. *Journal of Nonverbal Behavior*, *28*(1), 53–64.

Hietanen, J. K., Leppanen, J. M., Peltola, M. J., Linna-Aho, K., & Ruuhiala, H. J. (2008). Seeing direct and averted gaze activates the approach-avoidance motivational brain systems. *Neuropsychologia*, *46*(9), 2423–2430.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2003). Social phobics do not see eye to eye: a visual scanpath study of emotional expression processing. *Journal of Anxiety Disorders*, *17*(1), 33–44.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2004). Face to face: visual scanpath evidence for abnormal processing of facial expressions in social phobia. *Psychiatry Research*, *127*(1–2), 43–53.

Kennedy, D. P., & Adolphs, R. (2010). Impaired fixation to eyes following amygdala damage arises from abnormal bottom-up attention. *Neuropsychologia*, *48*(12), 3392–3398.

Kessler, R. C., Demler, O., Frank, R. G., Olfson, M., Pincus, H. A., Walters, E. E., & Zaslavsky, A. M. (2005). Prevalence and treatment of mental disorders, 1990 to 2003. *New England Journal of Medicine*, *352*(24), 2515–2523.

Kobayashi, H., & Kohshima, S. (1997). Unique morphology of the human eye. *Nature*, *387*(6635), 767–768.

Kret, M. E., & de Gelder, B. (2010). Social context influences recognition of bodily expressions. *Experimental Brain Research*, *203*(1), 169–180.

Kret, M. E., & de Gelder, B. (2013). When a smile becomes a fist: the perception of facial and bodily expressions of emotion in violent offenders. *Experimental Brain Research*, *228*(4), 399–410.

Kret, M. E., Denollet, J., Grèzes, J., & de Gelder, B. (2011). The role of negative affectivity and social inhibition in perceiving social threat: an fMRI study. *Neuropsychologia*, *49*(5), 1187–1193.

Kret, M. E., Fischer, A. H., & de Dreu, C. K. W. (2015). Pupil mimicry correlates with trust in in-group partners with dilating pupils. *Psychological Science*, *26*(9), 1401–1410.

Kret, M. E., Pichon, S., Grezes, J., & de Gelder, B. (2011). Similarities and differences in perceiving threat from dynamic faces and bodies. An fMRI study. *Neuroimage*, *54*(2), 1755–1762.

Kret, M. E., Pichon, S., Grèzes, J., & de Gelder, B. (2011). Men fear other men most: gender specific brain activations in perceiving threat from dynamic faces and bodies—an fMRI study. *Frontiers in Psychology*, *2*(3).

Kret, M. E., & Ploeger, A. (2015). Emotion processing deficits: a liability spectrum providing insights into comorbidity of mental disorders. *Neuroscience and Biobehavioral Reviews*, *52*, 153–171.

Kret, M. E., Roelofs, K., Stekelenburg, J. J., & de Gelder, B. (2013). Emotional signals from faces, bodies and scenes influence observers' face expressions, fixations and pupil-size. *Frontiers in Human Neuroscience*, *7*(810).

Kret, M. E., Stekelenburg, J. J., Roelofs, K., & de Gelder, B. (2013). Perception of face and body expressions using electromyography, pupillometry and gaze measures. *Frontiers in Psychology*, *4*(28).

Kret, M. E., Tomonaga, M., & Matsuzawa, T. (2014). Chimpanzees and humans mimic pupil-size of conspecifics. *Public Library Of Science*, *9*(8), e104886.

Meeren, H. K., van Heijnsbergen, C. C., & de Gelder, B. (2005). Rapid perceptual integration of facial expression and emotional body language. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(45), 16518–16523.

Mellings, T. M., & Alden, L. E. (2000). Cognitive processes in social anxiety: the effects of self-focus, rumination and anticipatory processing. *Behaviour Research and Therapy*, *38*(3), 243–257.

Mondloch, C. J., Nelson, N. L., & Horner, M. (2013). Asymmetries of influence: differential effects of body postures on perceptions of emotional facial expressions. *Public Library Of Science*, *8*(9), e73605.

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*(2), 147–151.

Pichon, S., de Gelder, B., & Grèzes, J. (2008). Emotional modulation of visual and motor areas by dynamic body expressions of anger. *Society for Neuroscience*, *3*(3–4), 199–212.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741–756.

Robson, K. S. (1967). The role of eye-to-eye contact in maternal–infant attachment. *Journal of Child Psychology and Psychiatry*, *8*(1), 13–25.

Scherer, S. E. (1974). Influence of proximity and eye contact on impression formation. *Perceptual and Motor Skills*, *38*(2), 538. http://dx.doi.org/10.2466/pms.1974.38.2.538

Terburg, D., Aarts, H., & van Honk, J. (2012). Memory and attention for social threat: anxious hypercoding-avoidance and submissive gaze aversion. *Emotion*, *12*(4), 666–672.

Tomasello, M., Hare, B., Lehmann, H., & Call, J. (2007). Reliance on head versus eyes in the gaze following of great apes and human infants: the cooperative eye hypothesis. *Journal of Human Evolution*, *52*(3), 314–320.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249.

Van den Stock, J., & de Gelder, B. (2006). Body language influences perception of facial expression and voice prosody. *Journal of Vision*, *6*(6), 1064.

Van den Stock, J., Righart, R., & de Gelder, B. (2007). Body expressions influence recognition of emotions in the face and voice. *Emotion*, *7*(3), 487–494.

Wallbott, H. G., & Scherer, K. R. (1986). Cues and channels in emotion recognition. *Journal of Personality and Social Psychology*, *51*, 690–699.

Weeks, J. W., Howell, A. N., & Goldin, P. R. (2013). Gaze-avoidance in social anxiety disorder. *Depression and Anxiety*, *30*(8), 749–756.