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An anxiety-induced bias in the perception of a bistable point-light walker

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ABSTRACT

Human sensitivity for social cues is exquisite, as illustrated by the ease with which simplified point-light movements invoke social and emotional responses. Compared to faces, these biological motion stimuli only recently started to be used to explore questions regarding social cognition and anxiety. We presented human point-light walkers that could be perceived as facing towards or facing away from the observer, and tested whether participants with high social anxiety would perceive these bistable stimuli differently, because this type of stimuli has particular relevance for them. The results showed that observers with high social anxiety tended to see walkers as facing away more frequently than those with low social anxiety. This may mean that high socially anxious observers are biased towards the more positive perceptual alternative because they are motivated to protect themselves against threatening social experiences, but we also explore alternative explanations. The findings are in line with the evidence for a positivity bias in perception, also called wishful seeing, but in contrast with the attentional negativity bias often found in social anxiety. We discuss reasons for this divergence and possible limitations of the current study.

1. Introduction

The French–Cuban writer Anaïs Nin wrote "we do not see things as they are but as we are." For scientists, the question of whether this could literally be true is a fascinating, albeit a thorny one. Surely perception unchecked by external reality (i.e. hallucination) would serve us poorly. But when allowed only a glimpse, a perception biased by our own fears or hopes might enable faster or more appropriate responses. Theoretically, a role of emotion in perception has become more plausible since it has become clear that seeing relies heavily on top-down information flows, which include affective context (Barrett & Bar, 2009). Empirically, two opposing patterns of results have emerged. On the one hand, several studies find a negativity bias: a bias towards negative or threatening emotional stimuli, including the large body of work on attentional bias for negative facial expressions (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van IJzendoorn, 2007) and on better detection of negative stimuli (e.g. Dijksterhuis & Aarts, 2003). Reports by Stefanucci, Proffitt, Clore, and Parekh (2008) that acrophobic volunteers estimated vertical distances to be greater also fit within this negativity bias. Finally, negative emotional faces seem to break through more easily in continuous flash suppression (Yang, Zald, & Blake, 2007) and in binocular rivalry (Alpers & Gerdes, 2007), although for the latter a general emotional enhancement, irrespective of valence, is also reported.

By contrast, a second line of studies reports a positivity bias, also called wishful seeing. This line dates back to the 1940s, when it was found that observers tended to perceive the interpretation of an ambiguous figure that was previously rewarded (e.g., Schafer & Murphy, 1943). This tradition has received renewed attention recently with two studies confirming a role for motivation in perception. One used distance estimation and a throwing task to find that desired objects are seen to be closer (Balcetis & Dunning, 2010), while another showed that the first percept we experience for a bistable figure (e.g. 13 vs. B) can be influenced by what we currently prefer to see (Dunning & Balcetis, 2013). Finally, Voss, Rothermund, and Brandtstädter (2008) rewarded or punished ambiguous color patches differently and found that positive or non-negative stimuli required less information to be classified *and* were processed faster. Hence, the enhanced perception of positive perceptual alternatives seems to be more than just a post-perceptual decision bias.

Apparently, it can be hard to predict what type of bias (positive or negative), if any, will emerge in a particular perceptual situation involving emotional stimuli. Indeed, task context and even personality traits may play a crucial role. For example, trait emotion could be an important modulating factor, but most studies only looked at stimulus-emotion or short-term induced emotion. Gray, Adams, and Garner (2009) did look at trait anxiety in relation to binocular rivalry with faces and found that highly anxious individuals tend to perceive angry and fearful faces as more dominant, consistent with a negativity bias. Additionally, methodological concerns hamper the evaluation of the available evidence. The studies using distance estimation are prone to post-perceptual decision

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biases, while in the binocular rivalry studies there is the additional problem of low-level differences between neutral and emotional stimuli (e.g. faces) which could cause the observed differences in perception. We used a different bistable stimulus, an ambiguous point-light walker, to accommodate for these shortcomings.

Vision scientists have embraced biological motion stimuli, constructed from a handful of moving dots placed on the joints of a moving actor, because of the balance they strike between fine manipulability and immediate social and ecological relevance. Viewers easily recognize the gender, emotions and intentions of these figures based on gait dynamics (for a review, see Blake & Shiffrar, 2007). Fewer studies explored their potential bistability, first noticed by Vanrie, Dekeyser, and Verfaillie (2004). When projected without perspective information (orthographic projection), a walking figure facing the viewer can just as well be seen as facing away from the viewer, a categorically different percept (Fig. 1). Both interpretations are anatomically plausible and in principle equally likely. Importantly, low-level input characteristics remain exactly the same for both percepts. It turns out, however, that people perceive the walker in about 80% of the cases as facing them (Vanrie et al., 2004). The social or biological relevance of a person facing you is considered to be at least partly responsible for this so-called facing bias (Brooks et al., 2008; Vanrie et al., 2004). Indeed, the cost of not detecting an approaching person is potentially much higher than that of a false alarm.

Although social anxiety disorder (social phobia) only appeared in the Diagnostic and Statistical Manual of Mental Disorders (DSM-III) in 1980, it is today one of the most common psychiatric disorders. The 12 month prevalence in the general population is 15.6%, but signs of social anxiety as a personality trait (shyness, fear of public speaking, social avoidance) are widespread in healthy populations (Furmark et al., 1999). Assuming that for people with high social anxiety the difference in relevance of the two percepts of the biological walker is even more pronounced, we conjectured that this would be reflected in how these people perceive the walkers. In the real world, a person walking up to you implies an imminent social interaction with this agent. Note, however, that the body is reduced to a few dots in these stimuli, and the face is completely absent (one dot). Hence, these walkers are objectively neutral and any bias will be in the eye of the beholder. Since no fear-inducing cues (e.g. a facing face) are present, they can be considered to be the cleanest test for a fear of approach as such.

Based on the studies finding a stronger attentional and interpretational bias in phobics towards objects of their fears (Bar-Haim et al., 2007), and one report of increased dominance of negative faces in binocular rivalry for anxious people (Gray et al., 2009), we deemed it likely that a similar tendency would hold for our bistable stimuli. Namely, that people with high social anxiety would perceive the walker in its more threatening, approaching configuration and thus would report more facing towards viewer percepts, compared to non-anxious subjects. Still, we acknowledged from the outset that our stimuli were in several ways quite different from those previously used, most importantly that there was no explicit emotional manipulation within them. We were also aware of the studies finding a positivity bias, which led to the formulation an alternative hypothesis that predicts what one could call a self-serving bias in perception: a tendency to perceive the safer configuration of a person walking away from you. The latter bias could come about by an active enhancement of the more positive percept signaling no social interaction, or by an active avoidance of the more negative percept signaling a future social interaction, consistent with what is found for social stimuli in daily life in social anxiety.

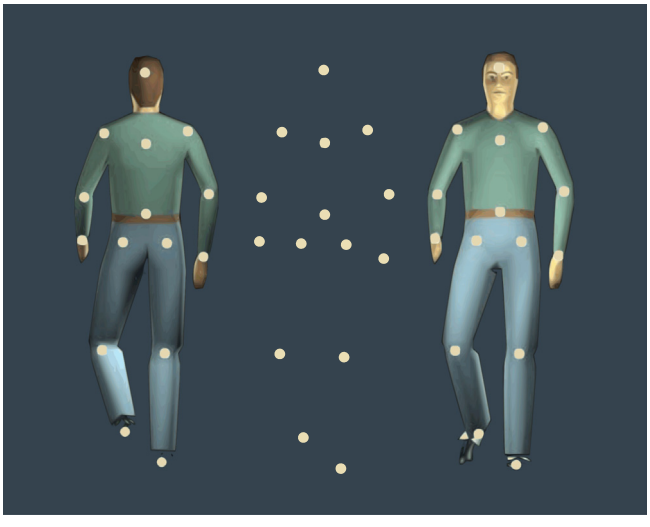

Fig. 1. Point-light stimulus (middle) flanked by overlays illustrating the two possible interpretations.

2. Method

2.1. Participants

On the basis of a validated, reliable questionnaire for social anxiety (Liebowitz Social Anxiety Scale; Fresco, Coles, & Heimberg, 2001; Liebowitz, 1987) we selected high and low socially anxious participants from a pool of 450 first bachelor psychology students. People with low anxiety had a total score lower than 25 (percentile .25, $n = 19$, $M = 15.3$, $SD = 4.53$, all females), while those with high social anxiety had a score higher than 65 (percentile .88, $n = 18$, $M = 76.8$, $SD = 8.02$, all females). The cutoffs were chosen to closely match the normative study of Fresco et al. (2001), in which non-anxious controls had a mean score of 14.5, while the patients diagnosed with social anxiety disorder had a mean score of 74.5 on the questionnaire. To avoid artifacts and to exclude clinical anxiety, people with very low (<5) and very high (>85) scores were excluded. A brief questionnaire after the actual experiment confirmed that none of the participants were diagnosed with a clinical mental disorder. They received course credit for their participation. All the participants had normal or corrected-to-normal vision. The study was approved by the Ethical Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven. Written informed consent was obtained from all participants.

2.2. Stimuli and procedure

Following a procedure developed by Schouten and Verfaillie (2010), we parametrically varied the amount of perspective information in the point-light walkers to systematically measure the bias for each participant. In practice, this boils down to disambiguating the walker by adding small amounts of perspective information of a walker that either approaches or walks away. In perspective projection a change in the distance between the collection of dots and the projection plane (or equivalently the field of view angle) causes a change in the relative locations of the 2-D projections of the dots on the display (for more details, see Schouten & Verfaillie, 2010). A period of two to four months separated the screening from the actual experiment, which made the link less obvious. Participants were not informed about their social anxiety score, and the experimenter was blind to the social anxiety group the participants belonged to. In a dimly lit, soundproof room the participants were randomly presented with a point-light walker (15 dots placed on coordinates from Troje (2002); 8° of visual angle) of one out of 13 different levels of perspective information, for a total of 520 trials (40 repetitions per level). Observers had to respond with the up and down arrows of the keyboard to indicate whether they saw the walker as facing towards or away from them (2-alternative forced choice). The walker remained (moving) on screen till the subject responded (no time limit). We instructed participants to focus on the center of the stimulus throughout the presentation and to respond according to their first impression.

3. Results

As already mentioned, people generally have a strong facing bias, with some individuals showing no variation at all in their experience even when presented with walkers with different amounts of perspective information. Participants that reported seeing the walker in more than 90% of the cases as coming towards them for all levels of perspective information were excluded from the dataset (5 in total, 3 of the high social anxiety group). However, analysis of the full set did not influence the main conclusions. We applied a two-way ANOVA on the probit transformed proportions of facing towards viewer responses with anxiety group (between-subjects) and perspective information (within-subjects) as factors. As expected, the amount of perspective information greatly influenced perceived orientation ($F(1,414) = 451.4$, $p < .001$), confirming the effectiveness of the parametrical perspective manipulation. The main effect of group was also significant ($F(1,414) = 11.4$, $p < .001$), with high social anxiety observers systematically showing lower proportions of facing towards viewer responses compared to low social anxiety observers (Fig. 2). Though it was not of prime interest, we also performed a repeated measures ANOVA on the reaction times (Fig. 3). Here the influence of perspective information was significant too ($F(1,30) = 21.8$, $p < .001$), indicating that less perspective information creates longer reaction times. This may be related to increased processing necessary to settle on a stable percept for more ambiguous figures. No main effect of group ($F(1,30) = 0.6$, $p = 0.45$) was present, but there was a significant interaction of group and perspective information ($F(1,30) = 7.8$, $p < 0.005$), apparently due to higher reaction times of the low social anxiety group on the first three levels of perspective information. This overlaps but does not coincide with the clearest discrepancies between groups on the facing responses.

4. Discussion

Our findings confirm that trait anxiety has an effect on the perceived in-depth orientation of point-light figures. Contrary to our original hypothesis, we found that higher social anxiety is associated with higher proportions of facing away percepts. We did not observe a greater dominance of the more negative (threatening) interpretation, but rather a suppression of the negatively valenced percept, an enhancement of the more positive configuration, or a combination of both. However, as discussed in the introduction, such a positivity bias has been reported earlier in studies of motivational effects on perception (Dunning & Balcetis, 2013; Voss et al., 2008), but not yet for socially anxious participants. Similarly to Voss et al. (2008), our highly anxious participants may have processed the non-negative 'facing away' interpretation more quickly, giving it the necessary edge over the competing facing-towards representation in the race for awareness. Alternatively, an active avoidance of the more negative percept signaling social interaction could lead to a similar outcome. Avoidance of threatening stimuli is frequently reported in the behavioral literature on social anxiety (Bögels & Mansell, 2004). Even attention studies often report an avoidance of emotional stimuli immediately following the increased capture of attention, prompting researchers to propose the vigilance–avoidance model of attention in social anxiety (Bar-Haim et al., 2007). In daily life, avoidance of social interaction is a major impairing factor for people with social anxiety and in the screening questionnaire we used, half of the questions concerns avoidance of social situations. In our experiment there was always a possible interpretation avoiding the approaching figure, and this may have been implicitly prioritized by people with social anxiety.

Both explanations imply that top-down information in the form of trait can bias perceptual organization. This is consistent with earlier findings that the meaning of a perceptual organization can influence the formation of this organization in a top-down manner (e.g. Peterson, 1994). Additionally, our study suggests that the facing-towards-viewer-bias in the general (non-anxious) population (Vanrie et al., 2004) is not due to anxiety elicited by the facing interpretation of these stimuli. Indeed, if this would be the case, selecting people with higher anxiety would produce an even stronger facing bias (the inverse of our findings). Assuming that the biological relevance of the facing percept causes the facing bias, this effect is probably not mediated by anxiety (i.e. the threat value of an approaching percept).

Nonetheless, some caution is needed when interpreting the current findings, since most previous studies in clinically anxious groups found a negativity bias, both in attention for threat-relevant stimuli and in the interpretation of ambiguous stimuli. Why did we not observe such a negativity bias? First, it is important to realize that our task is not strictly speaking an attentional one. There was no right or wrong in our task, so little or no performance context, which may influence people with high

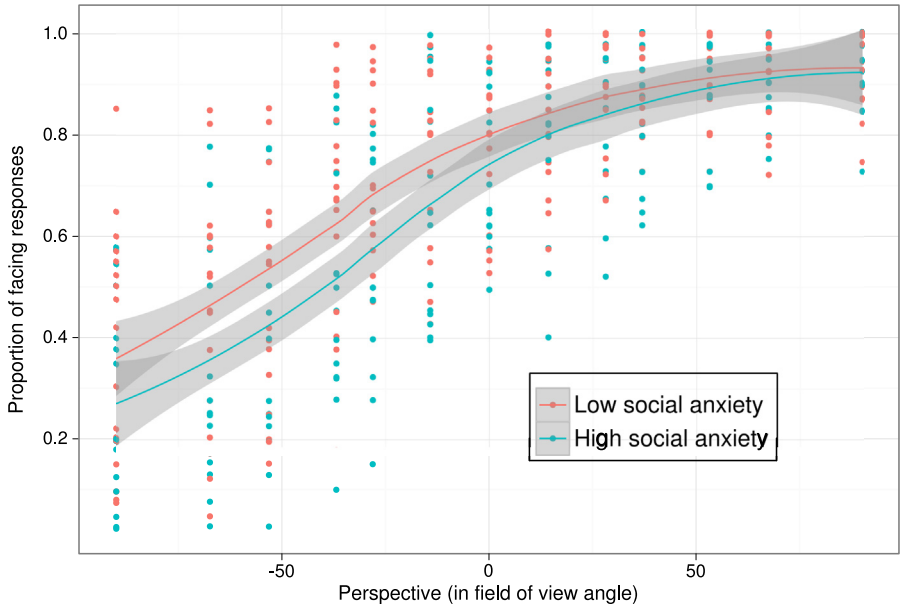

Fig. 2. Mean proportion of facing towards viewer responses by amount of perspective information for the high social anxiety group (blue-green) and low social anxiety group (red). Curves represent local regression fits (LOESS). Shaded area is standard error of mean. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

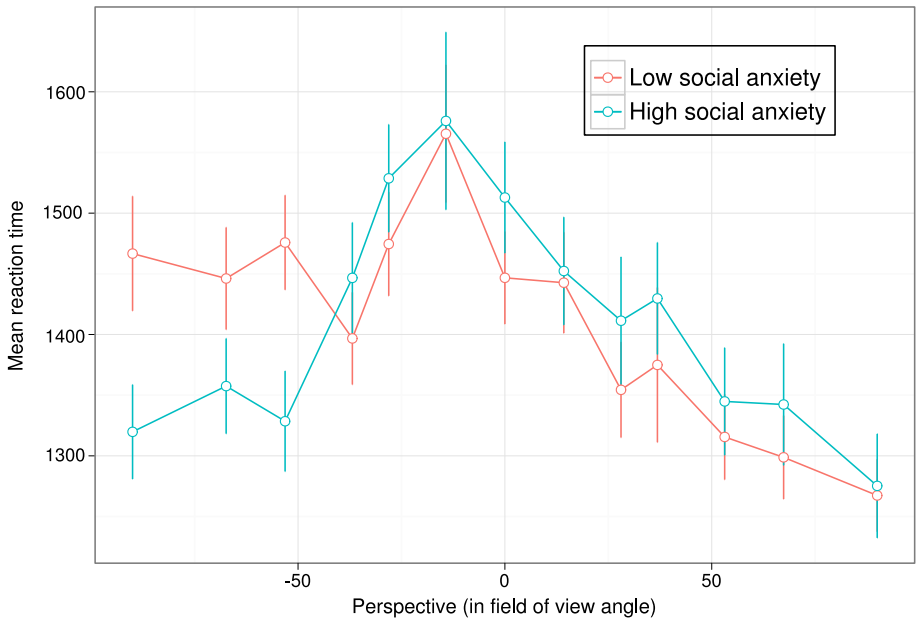

Fig. 3. Mean reaction times for the high social anxiety group (blue-green) and low social anxiety group (red). Error bars represent standard error of mean. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and low anxiety differently. Also, most reports of an attentional bias towards negative, fear-relevant stimuli used clinically anxious groups (Bar-Haim et al., 2007) while we only had nonclinical highly anxious participants. The perceptual and attentional strategies of clinical groups could be special in their focus on negative stimuli. Additionally, most research reporting a bias towards social threat in high social anxiety uses faces, the competing alternative being another, neutral face. According to some studies, these neutral faces are experienced as negative in high social anxiety (e.g., Cooney, Atlas, Joormann, Eugène, & Gotlib, 2006). Hence there is no real 'safe' alternative. This is different in our dynamic full-body stimuli: a person walking away can be considered an unmistakably safe situation.

Of course, more differences exist between biological motion stimuli and faces, hence the processes of social cognition involved in interpreting those two stimulus classes may not be comparable. Still, some neural regions seem to be engaged by both, most notably the superior temporal sulcus (Allison, Puce, & McCarthy, 2000). Incidentally, this region has also been found to be more active in social phobic patients than in healthy controls when viewing neutral and emotional faces (Gentili et al., 2008).

Another difference between faces and biological motion stimuli as we used them lies in their potential to induce distinct emotion. Evidently, any emotional relevance attributed to either of the biological motion percepts would be much more subtle than in the explicitly emotional faces used most frequently to investigate this kind of questions. In that context, a recent study that used continuous flash suppression to render faces invisibly may provide more clues (Stewart et al., 2012). These authors measured the time it took for faces that subtly varied in dominance and trustworthiness to emerge into awareness and found that dominant and untrustworthy faces took significantly longer to break through from suppression than neutral faces. Stewart et al. (2012) recognized that their results were counter to the negativity bias (or vigilance theory), but argued that they may reflect a suppression of a threat-related stimulus, flowing from a passive (avoidant) fear response (analogous to freezing). Interestingly, in a second experiment they asked people to rate their trait submissiveness and propensity to trust using two surveys. Individual personality differences correlated nicely with breaking times in continuous flash suppression. Specifically, for people high in trait submissiveness the breaking times for dominant faces (compared to neutral) was even longer, suggesting more avoidance. People with a high propensity to trust, on the other hand, showed less avoidance of untrustworthy faces (shorter breaking times), compared to neutral faces. Apart from highlighting the importance of individual differences in personality traits for these perceptual biases, these results nicely align with stronger suppression of an approaching percept for people with high anxiety in the current study.

Though Voss et al. (2008) already demonstrated that effects of emotion on perception cannot solely be attributed to response bias, we have a few other reasons to argue that post-perceptual decision bias is unlikely to explain our findings. First, the time gap between screening and the (blind) experimental tests obscured the link between anxiety and the visual task. Debriefings indicated that participants were not aware of the research question, let alone the expected direction of the effect. Second, we had to exclude a similar number of participants from both groups for a lack of variability in responses, suggesting that in both groups participants responded according to their percepts and did not feel obliged to vary their response criterion if their percepts did not change. We cannot completely rule out that other non-specific factors such as general intelligence played a role, but no evidence is available to substantiate such a role. Despite these arguments, future studies should investigate bias in a similar stimulus but lacking the social relevance of our point-light walkers, in order to completely rule out decision bias.

Altered perceptual abilities have been documented before in socially anxious viewers (e.g. better exogenous attention for neutral stimuli, Moriya & Tanno, 2009). This may be at least partially due to their lack of habituation, even to neutral stimuli, as measured by the amygdala and hippocampus activities (Blackford, Allen, Cowan, & Avery, 2012). Further experiments have to clarify to what extent these more bottom-up processing differences have contributed to our finding. The shorter reaction times in the high social anxiety group for certain levels of perspective information may support this explanation. For example, the strong facing bias in the general population implies that quite a lot of perspective information of a walker facing away from the viewer has to be added for people to actually perceive it so. Highly anxious people seem to pick up these physical perspective cues earlier, perhaps because they are more tuned to these personally relevant situations. In the light of recent evidence that oxytocin administration can improve the detection of biological motion (but not mechanical motion) in noise (Kéri & Benedek, 2009), it is tempting to speculate on a role for this neuromodulator here. It is thought that oxytocin exerts its influence on social behavior through its role in increasing salience of social cues (Bartz,

Zaki, Bolger, & Ochsner, 2011). Because levels of endogenous oxytocin increase with symptom severity in social phobia (Hoge, Pollack, Kaufman, Zak, & Simon, 2008), higher oxytocin in our high anxiety group may help them to better process the perspective cues.

A few studies found that looming stimuli (in the visual or the auditory domain) lead to shorter reaction times in (non-anxious) monkeys and humans (e.g., Maier, Neuhoff, Logothetis, & Ghazanfar, 2004; Schiff, Caviness, & Gibson, 1962; Wuerger, Crocker-Buque, & Meyer, 2012), presumably because they are ecologically important signals (analogous to our facing percept). We, on the other hand, found that high anxiety is associated with more receding percepts *and* shorter reaction times, though only for the lower perspective values (see Fig. 3). Note however, that earlier looming studies mostly used simple expanding disks (or increasing intensity of sounds in the auditory case). In our task, the size of the dots and the full size of the walker remained constant irrespective of perspective level. Whether the stimulus was "looming" or "receding" had to be decided based on the more subtle structural dynamics of dot relations. When comparing reaction times for the two different percepts, we found no clear differences, suggesting that *both* percepts (looming and receding) were formed faster in the high social anxiety group. If, as we proposed earlier, people with high social anxiety are more attuned to the cues in the walkers that distinguish in-depth orientation then that may have caused faster processing and responding. This would mean that the low social anxiety group literally needed more time to settle on an unambiguous percept. Unfortunately, we cannot exclude the possibility that this group did not comply with the instruction (to report initial percept) as well as the high anxious group and hence did not report their actual first percept, explaining the longer reaction times. However, since we did not explicitly instruct our participants to respond as fast as possible, we do not want to read too much into the reaction time data.

In recent years biological motion stimuli have been fruitfully used to better characterize information processing in people with altered configural or social cognition, such as autism (Nackaerts et al., 2012; Pavlova, 2011). Up till now the conventional task in these experiments is detection of point-light figures in noise. We have shown that processing differences can also be demonstrated in a task probing bistable walking direction. Future research may take advantage of this task and stimuli in two complementary ways. Instead of our emotionally neutral walkers, explicitly threatening body language can be used to elucidate the role of top-down semantic relevance (van Boxtel & Lu, 2012). Structural and kinematic features that are known to influence in-depth orientation can be manipulated to limit the availability of certain bottom-up information (Schouten, Troje, & Verfaillie, 2011).

We explored the role of social anxiety on the perception of a bistable, threat-relevant stimulus and have shown the usefulness of this paradigm for studies investigating differences in social anxiety and more generally influences of (trait) emotion on social perception. Our results indicate that trait social anxiety can bias perception in a way that counters this anxiety. This self-protective bias might be specific to our bistable task with the point-light stimuli, because it opposes the attentional bias towards threat usually found in anxious groups. Future studies will have to incorporate a broader range of social anxiety scores to see if this explanation holds ground and to accommodate the discussed limitations of these findings. The decreased amount of threatening conscious percepts in highly anxious people suggests that trait emotion of the observer and emotional relevance of stimulus material interact in ways unexplainable with traditional models of the perceptual system as disjointed from emotional processes. Our results extend the literature on the influence of emotion on perception, showing that not only emotional states but also traits can bias perception, though not necessarily in a detrimental way.

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