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Does anxiety induced by social interaction influence the perception of bistable biological motion?

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A R T I C L E I N F O

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A B S T R A C T

When observing point light walkers orthographically projected onto a frontoparallel plane, the direction in which they are walking is ambiguous. Nevertheless, observers more often perceive them as facing towards than as facing away from them. This phenomenon is known as the "facing-the-viewer bias" (FTV). Two interpretations of the facing-the-viewer bias exist in the literature: a top-down and a bottom-up interpretation. Support for the top-down interpretation comes from evidence that social anxiety correlates with the FTV bias. However, the direction of the relationship between the FTV bias and social anxiety is inconsistent across studies and evidence for a correlation has mostly been obtained with relatively small samples. Therefore, the first aim of the current study was to provide a strong test of the hypothesized relationship between social anxiety and the facing-the-viewer bias in a large sample of 200 participants recruited online. In addition, a second aim was to further extend top-down accounts by investigating if the FTV bias is also related to autistic traits. Our results replicate the FTV bias, showing that people indeed tend to perceive orthographically projected point light walkers as facing towards them. However, no correlation between the FTV bias and social interaction anxiety ($tau = -0.01$, $p = .86$, $BF = 0.18$) or autistic traits ($tau = -0.0039$, $p = .45$, $BF = 0.18$) was found. As such, our data cannot confirm the top-down interpretation of the facing-the-viewer bias.

1. Introduction

The detection and interpretation of biological motion is a fundamental social perceptual process that is essential for inferring the goals and intentions of other people and animals (Troje, 2008a). Based on the seminal work by Johansson (1973, 1976), biological motion processing is often studied using point light walkers instead of real human body movement. Although these walkers consist only of dots representing the main joints of the human body, research suggests that they nevertheless contain a host of socially meaningful cues, allowing observers to infer the walker's age (Montepare & Zebrowitz-McArthur, 1988), gender (Cutting & Kozlowski, 1977; Pollick, Kay, Heim, & Stringer, 2005; Troje, 2002), intentions (Hohmann, Troje, Olmos, & Munzert, 2011), emotion (Atkinson, Dittrich, Gemmell, & Young, 2004; Clarke, Bradshaw, Field, Hampson, & Rose, 2005; Dittrich, Troscianko, Lea, & Morgan, 1996), and even personality (Troje, 2008b).

Importantly, because point-light figures are projected orthographically, they are depth-ambiguous. As a result, they support two different percepts, each of which has a different facing orientation (Vanrie, Dekeyser, & Verfaillie, 2004). However, even though the information contained in the image supports both percepts equally, naïve observers usually perceive ambiguous walkers as facing towards instead of away from them, a phenomenon that has been termed the "facing-the-viewer bias" (Vanrie et al., 2004; Weech, McAdam, Kenny, & Troje, 2014). There are two theoretical approaches explaining the facing-the-viewer bias: a bottom-up and a top-down approach. The bottom-up approach argues that kinematic and structural properties of the walker explain the bias (Schouten, Troje, & Verfaillie, 2011). Supporting this view, Schouten et al. (2011) manipulated the integrity of point-light walkers by only showing either the upper part or the lower part of the body. The results showed that only the lower part caused a facing-the-viewer bias, whereas the upper part elicited a facing away bias instead. This suggests that these biases are not driven by the walker itself but rather by local stimulus properties in specific parts of the walker.

In contrast, the top-down approach argues that the facing-the-viewer bias can be traced back to sociobiological processes (Brooks et al., 2008;

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Cicone & Ruble, 1978; Schouten, Troje, Brooks, van der Zwan, & Verfaillie, 2010). Specifically, it is argued that the percept of someone facing towards you is more threatening than that of someone facing away from you and that the facing-the-viewer bias is therefore an evolutionary adaptive bias. In other words, according to this view, the facing-the-viewer bias is caused by the fact that mistakenly identifying someone as walking away from you is more dangerous than mistakenly identifying someone as walking towards you. In line with this view, Brooks et al. (2008) found an influence of walker gender on the facing-the-viewer bias, suggesting that observers perceive males, who are often perceived as more threatening (Cicone & Ruble, 1978), as facing towards them more often than females. Further evidence for the sociobiological theory comes from research investigating the relationship between (social) anxiety and the facing-the-viewer bias. For example, Heenan and Troje (2014) measured the facing-the-viewer bias after reducing participants' anxiety by letting them to do physical exercise on a treadmill (standing, walking, or jogging) in one experiment and relaxation exercises in another experiment (Heenan & Troje, 2014; Salmon, 2001). If the facing-the-viewer bias is driven by threat, it should be weaker when anxiety is reduced (Brooks et al., 2008). In line with this view, both experiments found that anxiety reduction indeed reduced the facing-the-viewer bias. In addition, the facing-the-viewer bias in the first experiment was found to correlate positively with social anxiety. A similar correlation was also found two other studies, albeit in different directions (Heenan & Troje, 2015; Van de Cruys, Schouten, & Wagemans, 2013). That is, while Heenan and Troje (2015) found a positive correlation with social anxiety, van de Cruys et al. (2013) found a negative correlation instead. Importantly, both correlations can be explained within the framework of the sociobiological theory: if social anxiety leads to increased attention for threatening stimuli, a positive correlation is expected (Heenan & Troje, 2014, 2015). In contrast, if it leads to a self-serving bias favoring the perception of safe configurations, a negative correlation is expected (Van de Cruys et al., 2013).

Thus, there is preliminary evidence that social anxiety correlates with the facing-the-viewer bias. This evidence is preliminary for two reasons. First, it is unclear whether the correlation is positive or negative (Heenan & Troje, 2015; Van de Cruys et al., 2013). Second, the evidence has been obtained with relatively small samples (i.e., $37 \leq N \leq 55$). Given that correlations are known to be unstable and unreliable in such samples (Kelley & Maxwell, 2003; Maxwell, Kelley, & Rausch, 2008; Schönbrodt & Perugini, 2013), an open question is whether there is in fact a correlation and, if so, in which direction this correlation goes. Therefore, the primary aim of the current study was to provide a strong test of the sociobiological theory of the facing-the-viewer bias by investigating its relationship with social anxiety in a large sample of participants recruited online. In line with the sociobiological theory, we expected a significant correlation. However, given that previous research has obtained diverging results (Heenan & Troje, 2015; Van de Cruys et al., 2013), we did not have a strong hypothesis regarding the direction of this correlation.

Apart from social anxiety, a secondary aim of this study was to further extend the sociobiological theory by investigating the relationship between the facing-the-viewer bias and autistic traits. If the facing-the-viewer bias is indeed a social bias, atypical social processing should be accompanied by an atypical bias. Atypical social processing is a core feature of autism (Adolphs, Sears, & Piven, 2001). Hence, we hypothesized that the facing-the-viewer bias would correlate with autistic traits. On the one hand, this correlation might be positive, given that autism is related to social anxiety (Bellini, 2004; Maddox & White, 2015). In this case, the correlation between autistic traits and the facing-the-viewer bias should be mediated by social anxiety. On the other hand, the correlation might also be negative, given that biological motion processing is known to be impaired in autism (Todorova, Hatton, & Pollick, 2019; Van der Hallen, Manning, Evers, & Wagemans, 2019; Blake, Turner, Smoski, Pozdol, & Stone, 2003).

2. Materials & methods

2.1. Participants

200 participants recruited on Prolific (Palan & Schitter, 2018) were included in this study (70 women, 130 men). A sensitivity analysis indicated that this provided us with 80% power to detect even relatively small *r* values ($r = 0.20$). After exclusions, described in the Data analysis section, 173 participants remained (62 women, 111 men, $range_{age} = 18$ to 40, $M_{age} = 27.53$ years, $SD_{age} = 5.94$ years). All participants enrolled in this study were fluent in English. Every participant recruited from the platform received £2.5 for successful participation. All study procedures were performed in accordance with the general ethics protocol of the Faculty of Psychology and Educational Sciences at Ghent University.

2.2. Questionnaires

Social anxiety was measured using the Social Interaction Anxiety Scale (SIAS; Heimberg, Mueller, Holt, Hope, & Liebowitz, 1992; Mattick & Clarke, 1998), measuring the prevalence, severity, and treatment outcomes of social anxiety disorders. The SIAS consists of 20 items asking respondents to rate how they experience social situations often associated with social anxiety (e.g., "*I get nervous if I have to speak with someone in authority (teacher, boss, etc.)*"). Participants rate how characteristic each statement is for them on a 5-point scale ranging from 0 ("not at all") to 4 ("extremely"). Research has shown that the SIAS has high internal consistency ($\alpha = 0.94$) and test-retest reliability ($r = 0.92$) (Mattick & Clarke, 1998).

Autism traits were measured using the abridged version of Autism-Spectrum Quotient (AQ-Short) (Hoekstra et al., 2011). The AQ-Short consists of 28 items measuring the level of autistic traits on five phenotypes: social skills, routine, switching, imagination, and factors numbers & patterns (e.g., "*I prefer to do things with others rather than on my own*"). Statements are rated on a 4-point scale ranging from 1 ("definitely agree") to 4 ("definitely disagree"). Research has shown that the internal consistency of the AQ-Short is good ($0.77 < \alpha < 0.86$) (Hoekstra et al., 2011).

2.3. Stimuli and apparatus

The stimuli, task, and procedure were based on Heenan and Troje (2014, 2015). All stimuli were generated using the BMLkit (see https://www.biomotionlab.ca/). Stimuli consisted of stick figures or solid cubes rotating counterclockwise or clockwise around the vertical axis. The stick figures consisted of 15 interconnected dots, corresponding to the main joints of the human body (shoulders, elbows, wrists, hips, knees, ankles, etc.). The motion and the spatial configuration of these dots represents the average computed over a database of 100 individual people, half male and half female, that were motion captured while walking overground, biomechanically modelled, and then averaged. Translational movements were subtracted such the walker appears to walk on the spot (Troje, 2002a; Troje, 2002b; Troje, 2008a, 2008b).

On each trial, the initial phase of the walking movement and the initial camera azimuth (i.e., the starting position of the walker around the vertical axis) were set randomly to 1 of 12 different levels, distributed equally between 360° and 0° in increments of 30°. Note that a 0° azimuth combined with counterclockwise rotation results in exactly the same walker stimulus as a 180° azimuth combined with clockwise rotation. Thus, the walking direction of the walker (i.e., clockwise or counterclockwise) was completely ambiguous. The gender of the walker was set to neutral, because previous research suggests that there is an influence of walker gender on the perception of depth-ambiguous figures (Brooks et al., 2008; Schouten et al., 2010). Stick walkers were rendered using an orthographic camera with a horizontal optical axis and appeared in white on a black background (see Fig. 1A). Rotating cubes were used as catch trials. In contrast to the walkers, the rotation

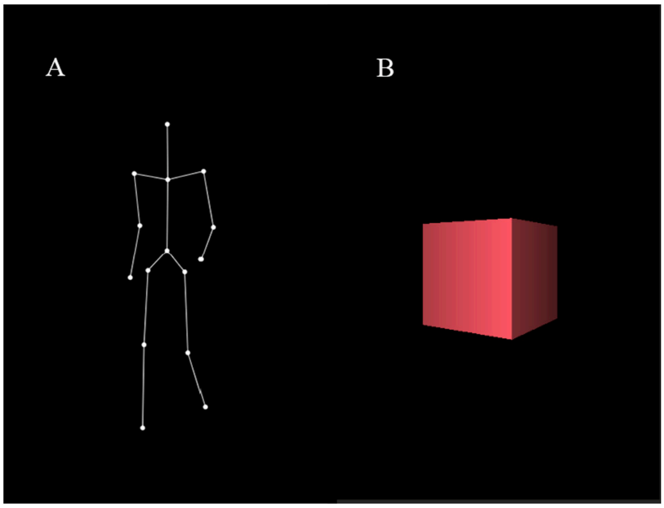

Fig. 1. Example stimuli. Panel A shows a stick point-light walker. Panel B shows a catch trial. See Supplementary material for example videos.

direction of these cubes is unambiguous and the cubes could hence be used to check whether participants understood and did the task (Heenan & Troje, 2014, 2015).

2.4. Procedure

The study could only be done on a computer and consisted of two parts: a biological motion perception task and a series of questionnaires (Fig. 2). First, participants were directed to an interface containing information about the study and providing them with a basic introduction of the two tasks. Next, they completed the biological motion task (~5 min). On each trial of this task, participants saw a walker or a cube walking/rotating clockwise or counterclockwise around the vertical axis. Stimuli were presented for 0.5 s with a walking/rotation speed of 45°/s and participants had to indicate whether the walker (or cube) was walking (or rotating) clockwise or counterclockwise. As explained below, this allowed us to measure the facing-the-viewer bias independent of potential response biases (Heenan & Troje, 2015). The response deadline was 4 s and the inter-trial interval 2 s. In total, each participant was presented with 72 walking stick figure trials and 12 solid cube trials (see Fig. 1B). Solid cubes were presented at random twice every 12 trials. After the biological motion task, participants completed a series of questionnaires on LimeSurvey 3.15. More specifically, participants first completed the AQ-Short and SIAS and after this were asked to also complete the Free Will Inventory (FWI) (Nadelhoffer, Shepard, Nahmias, Sripada, & Ross, 2014) and the abbreviated internal-external locus of control scale (Valecha & Ostrom, 1974). The last two scales were included for different purposes and the data associated with these scales will not be reported here.

2.5. Facing-the-viewer calculation

The facing-the-viewer bias was calculated as the proportion of trials in which participants saw the walker as coming towards them (Heenan & Troje, 2015; Weech et al., 2014). A score larger than 0.5 thus reflects a facing towards bias, while a score smaller than 0.5 reflects a facing away bias. Importantly, as stated above, participants were not asked directly whether they perceived the walker as coming towards them or as going away from them. Rather, they indicated whether they saw the walker as "rotating clockwise" or "rotating counterclockwise". Whether a clockwise or counterclockwise response reflected a facing towards or facing away percept depended on the camera azimuth (see Table 1). When the initial azimuth was 0°, 30°, 60°, 270°, 300°, and 330° ("type I azimuth"), a counterclockwise response meant that participants perceived the walker as coming towards them. In contrast, when the initial azimuth was 90°, 120°, 150°, 180°, 210°and 240° ("type II azimuth"), a counterclockwise response meant that participants perceived the walker as going away from them (Weech et al., 2014). Thus, to calculate the FTV bias, we compared the number of clockwise (CW) and counter-clockwise (CCW) responses using the formula: $FTV = \{[x1/(x1+y1)] + [y2/(x2+y2)]\}/2$ (Weech et al., 2014).

2.6. Data analysis

Because the walkers were depth-ambiguous, there was no correct answer on walker trials. Therefore, to exclude inattentive participants, we discarded 27 participants who made more than 1 mistake on the catch trials. Correlations were tested using Pearson correlations when the Shapiro–Wilk test indicated that the data was normally distributed and using Kendall's tau when it indicated it was not.

3. Results

3.1. Descriptive statistics

Descriptive statistics are reported in Table 2. Participants perceived a facing towards percept on 64% ($SD = 14\%$) of the trials. A one sample *t*-test comparing this score to chance level (50%) showed that it was significantly above chance, $t(139) = 19.09$, $p < .001$. The mean score on the SIAS was 34.84 ($SD = 15.7$, $\alpha = 0.93$) and the mean score on the AQ was 67.34 ($SD = 9.40$, $\alpha = 0.80$). In line with previous research, a Pearson correlation showed that there was a strong positive correlation between both questionnaires, $r = 0.68$, $p < .001$ (Bellini, 2004; Maddox

Table 1
Different types of azimuth (Type I/II) and responses (CW/CCW).

	Type I	Type II
CCW	x1	x2
CW	y1	y2

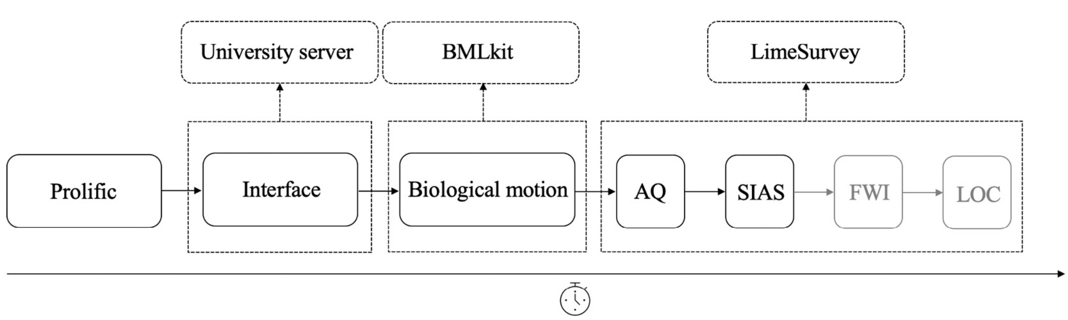

Fig. 2. Experimental procedure. Participants were directed from Prolific to an interface which then directed them first to the biological motion task and subsequently to the questionnaires.

Table 2
Descriptive statistics of dependent variables based on gender.

	Male (N = 111)	Female (N = 62)
Age	26.91 (5.94)	28.65 (5.82)
FTV	0.66 (0.14)	0.61 (0.13)
AQ	66.90 (8.89)	68.11 (10.27)
SIAS	33.92 (16.28)	36.50 (14.81)

Note. Each cell shows the mean and its standard deviation between parentheses.

& White, 2015).

3.2. Facing-the-viewer bias, social anxiety, and autism traits

A Shapiro–Wilk test indicated that FTV scores were not normally distributed (p = .001). Therefore, Kendall's tau was used. The result showed that FTV scores were correlated with neither SIAS scores (*tau* = −0.01, p = .86, Fig. 3A), nor with AQ scores (*tau* = −0.0039, p = .45, Fig. 3B). A subsequent Bayesian analysis using the "BayesFactor" package in R with default priors revealed moderate evidence in favor of the absence of a correlation between SIAS and FTV (*BF* = 0.18) as well as between AQ and FTV (*BF* = 0.18) (Jeffreys, 1961; Lee & Wagenmakers, 2013).

4. Exploratory analyses

As previous research suggests that participant characteristics may influence the facing-the-viewer bias (Schouten et al., 2010), we also performed an exploratory analysis investigating whether our effects were modulated by participant sex or age. To this end, we first fitted a multiple regression model with age and gender as predictors and the facing-the-viewer bias as dependent variable. This indicated a significant effect of gender on the facing-the-viewer bias, $F(2, 170) = 3.11$, $p < .05$, $R^2 = 0.35$, indicating that male observers perceive the walker more as coming towards them than female observers, but no effect of age (see Table 3). Next, to check whether age or gender modulated the

Table 3
Regression results using FTV as the dependent variable.

	Estimate	Std. error	*t* value	*Pr(>|t|)***
(Intercept)	0.567	0.054	10.43	<0.001***
Gender	0.054	0.022	2.45	0.015*
Age	0.001	0.002	0.810	0.420

* $p < .05$.
** $p < .01$.
*** $p < .001$.

relationship between social anxiety and the facing the viewer bias, we added social anxiety as a third predictor to the model. However, neither interactions (i.e., age x social anxiety or gender x social anxiety) were significant, both $p > .64$ suggesting that age and gender did not have an influence on the association between social anxiety and the facing-the-viewer bias.

5. Discussion

Ever since 1973, when Johansson (1973, 1976) found that human motion can be accurately represented by 10 to 12 point-lights, point-light walkers have become a popular and effective tool to investigate biological motion processing. Due to the depth-ambiguous attribute of orthographically projected point-light aminations, these stimuli equally allow two percepts, namely a facing away and facing towards percept. Nevertheless, naïve observers still perceive these walkers more often as facing towards them than as facing away and this phenomenon has been termed the facing-the-viewer bias (Vanrie et al., 2004; Weech et al., 2014). There are two theoretical approaches explaining the facing-the-viewer bias: a bottom-up and a top-down approach. The bottom-up approach suggests that the kinematic and structural properties of the stick walker explain the bias (Blake & Shiffrar, 2007; Schouten et al., 2011; Weech et al., 2014). In contrast, the top-down approach argues that the facing-the-viewer bias has a sociobiological basis: stimuli coming towards us are more dangerous and it is therefore safer to

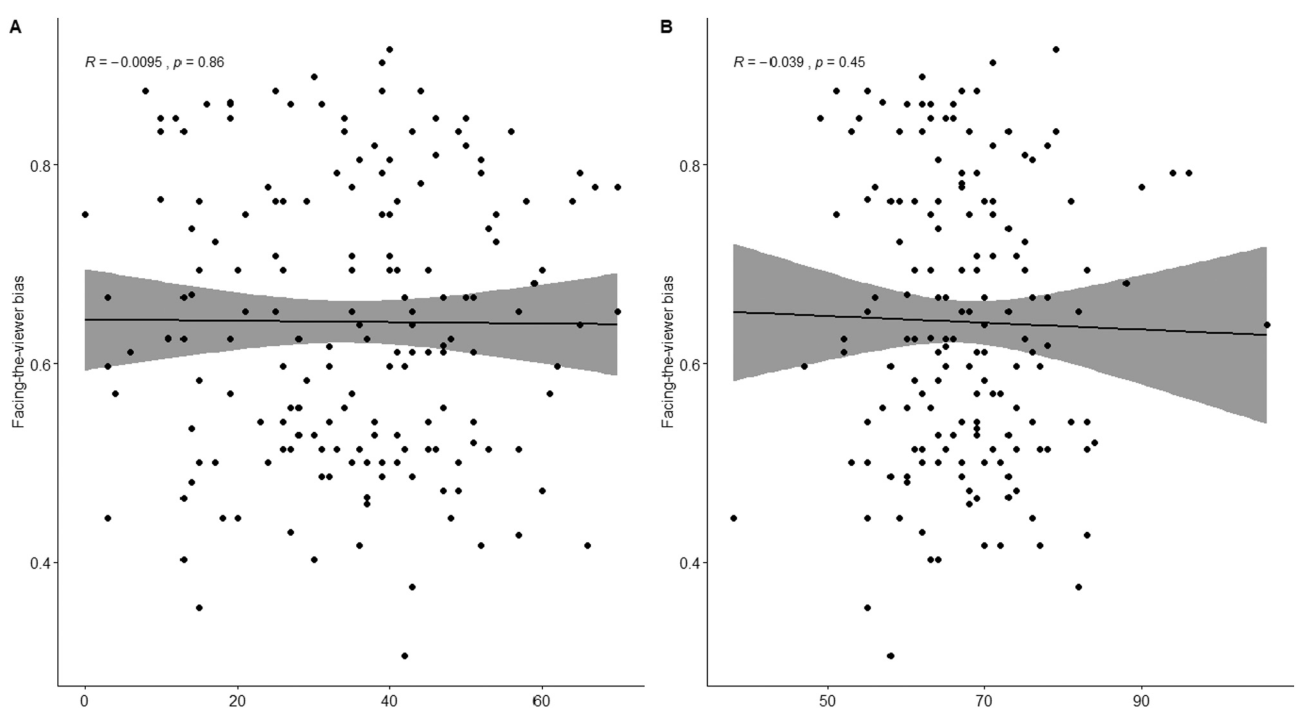

Fig. 3. Correlation between (A) SIAS & FTV and (B) AQ & FTV. For (A), the x-axis represents the social interaction anxiety score, and the y-axis represents the facing-the-viewer bias; for (B) the x-axis represents autistic traits and the y-axis represents the facing-the-viewer bias. The black line represents the regression trend. The shaded grey area represents the 95% confidence interval. Both figures indicate a non-significant correlation between the two variables.

identify ambiguous stimuli as coming towards us than as going away (Brooks et al., 2008; Cicone & Ruble, 1978; Schouten et al., 2010).

An important piece of evidence supporting the top-down theory is that the facing-the-viewer bias correlates with social anxiety. However, this evidence has been obtained with relatively small sample sizes and is inconsistent, with some research finding a positive (Heenan & Troje, 2014, 2015) and other research finding a negative (Van de Cruys et al., 2013) correlation. Given that correlations are known to be unstable and unreliable with small samples (Kelley & Maxwell, 2003; Maxwell et al., 2008; Schönbrodt & Perugini, 2013), it is currently unclear whether there is in fact a correlation and, if so, in which direction this correlation goes. Therefore, the primary goal of the current study was to investigate whether and how social anxiety correlates with the perception of ambiguous biological motion in a large sample. Furthermore, a secondary goal was to explore the correlation between the facing-the-viewer bias and autism traits.

However, in contrast to our hypotheses, and despite finding a robust facing-the-viewer bias, we found no evidence for a correlation with either social anxiety or autism traits. These results speak against social anxiety or autistic traits as top-down modulators of the facing-the-viewer bias. An additional exploratory analysis did, however, reveal evidence for an effect of participant gender, with male participants showing a larger facing-the-viewer bias than female participants. This goes in line with a previous study, finding an interaction between walker and participant gender (Schouten et al., 2010). More specifically, this study found that the facing-the-viewer bias was larger for male than female participants when the walker was a neutral or male walker but not when it was a female walker. Assuming that men are more likely to get into fights than women and might therefore be more likely to perceive threat in bivalent walkers, this gender effect could be interpreted as evidence for a top-down mechanism (Schouten et al., 2010). However, such an explanation is highly speculative, and the opposite argument could equally well be made, namely that women are on average less able to physically defend themselves to offenders and might therefore be more likely to perceive threat in ambiguous stimuli. Moreover, a participant gender effect could also have a bottom-up explanation, if male observers attend to different parts of the stimulus than female observers (Schouten et al., 2010). Hence, while the gender effect found here could be interpreted in terms of top-down mechanisms, this requires further evidence, especially considering that variables more directly related to the sociobiological theory, such as social anxiety, were not related with the facing-the-viewer bias.

In sum, while our results cannot completely rule out top-down processes, they do indicate that the evidence for such processes is weaker than previously thought. This, in turn, opens the door to an explanation in terms of bottom-up processes (Schouten et al., 2011; Weech et al., 2014). For example, Schouten et al. (2011) found that the influence of walker gender on bistable human motion perception is related to kinematic and structural differences between male and female walkers rather than to differences in threat (Brooks et al., 2008). In a first experiment, they manipulated the perceived gender of the walker by changing either its structural or kinematic properties. If the facing-the-viewer bias has a sociobiological basis, then all adjustments leading to changes in perceived gender should elicit corresponding changes in perceived threat and therefore in perceived orientation (Brooks et al., 2008). In contrast, the two adjustments led to opposite changes. This suggests that there is no causal relationship between perceived gender and perceived facing orientation. Instead, the facing-the-viewer bias might be driven by kinematical and structural properties of the walkers. This was further supported by two additional experiments in which the wholeness of the walker was manipulated by showing either only its lower or only its upper part (Schouten et al., 2011). In both experiments, the results showed that only the lower part contributed to the facing-the-viewer bias and that the upper part instead elicited a facing away bias. Overall, these results demonstrate that the perceived in-depth orientation of bistable point-light walkers heavily relies on the local structure of the walker stimulus because in all the three experiments, a causal relationship was found between local structure and perceived orientation, indicating a strong bottom-up component in the facing-the-viewer bias.

Further evidence for a bottom-up mechanism was obtained by Weech et al. (2014), who compared stick figures to human silhouettes and only found a facing-the-viewer bias with stick figures, regardless of the posture, gender, or walking motion of the silhouettes. In other words, even though silhouettes elicit the same social relevance signals as normal stick walkers, no significant facing-the-viewer bias was detected, thus speaking against a top-down sociobiological explanation. Instead, an additional experiment found that the facing-the-viewer bias was driven by a convexity bias causing people to perceive depth-ambiguous surfaces as convex as opposed to concave (Beardslee & Wertheimer, 1958; Kanizsa, 1976; Koffka, 2013). This convexity bias only applies when the local surface orientation is ambiguous, which is the case for the stick walkers but not the silhouettes. Therefore, even though both stimuli are depth-ambiguous, only the stick walkers elicit a convexity bias and hence a facing-the-viewer bias. Supporting this idea, adding convexity cues to the silhouettes did result in a facing-the-viewer-bias.

Based on this research, and on the fact that we found little evidence for top-down influences, a bottom-up explanation currently seems the most parsimonious explanation for the facing-the-viewer bias. However, it should be noted that our study was not a direct replication of previous research showing a correlation between the facing-the-viewer bias and social anxiety and that it is therefore possible that differences in the stimulus material or procedure can explain why we found no evidence for a top-down influence of social anxiety (Diener & Biswas-Diener, 2017). While we measured the facing-the-viewer bias and social anxiety in the same way as Heenan and Troje (2014, 2015), who found a positive correlation, our procedure differed substantially from the procedure used by Van de Cruys et al. (2013), who found a negative correlation. A first difference is that Van de Cruys et al. (2013) used the Liebowitz Social Anxiety Scale (Fresco et al., 2001) to measure social anxiety, whereas we used the SIAS (Heimberg et al., 1992; Mattick & Clarke, 1998). As a result, it is possible that the facing-the-viewer bias is sensitive to aspects of social anxiety only measured by the Liebowitz scale. This seems unlikely, however, as both questionnaires are known to be highly correlated (Heimberg et al., 1999). In addition, while Van de Cruys et al. (2013) instructed participants to indicate directly whether the walker was facing towards or facing away, we followed Heenan and Troje (2014, 2015) in using an indirect procedure that rules out potential response biases (i.e., indicating the spinning direction of the point-light animation). As such, a second hypothesis is that social anxiety is related not with a perceptual bias but with a response bias in facing away/towards judgements. Finally, a last difference is that in Van de Cruys et al. (2013), there was no time limit to respond, whereas in our study and in Heenan and Troje (2014, 2015) the time limit was 2 s. In this sense, a potential avenue for future research could be to test the contribution of these procedural differences to the facing-the-viewer bias (Diener & Biswas-Diener, 2017).

Another limitation is that this study only investigated two potential top-down factors. In addition to direct replications, future research could thus additionally explore other potential top-down factors. An interesting factor in this respect is people's motivation to affiliate, as previous research looking at social phenomena such as motor mimicry (Chartrand & Bargh, 1999; Lakin & Chartrand, 2003) has already shown that affiliation motivations can influence social behavior (Chartrand, Maddux, & Lakin, 2005; Lakin & Chartrand, 2003). In the same vein, people that are motivated to affiliate may also be more likely to perceive ambiguous stimuli as coming towards them. Similarly, it might be interesting to vary the emotion displayed by the point-light walker (Alaerts, Nackaerts, Meyns, Swinnen, Wenderoth, 2011; Atkinson et al., 2004) to see if a relationship with social anxiety could perhaps be observed if the walkers display aggression and are therefore more threatening. Finally, it is important to mention that we investigated the facing-the-viewer bias in an online experiment. Online experiments allow testing large numbers of participants and therefore provide an opportunity to carry out highly powered studies. Here we replicated the facing-the-viewer bias indicating that online experiments are suited to investigate biological motion.

6. Conclusion

Previous studies found inconsistent results as to whether and how top-down factors like social anxiety influence the perception of ambiguous point-light displays. A potential reason for this inconsistency is the relatively small samples used in those studies. Using a large sample, this study found no correlation between either social anxiety or autism traits and the facing-the-viewer bias. While future research is needed, these findings speak against top-down accounts of the facing-the-viewer bias.

CRediT authorship contribution statement

Wei Peng: Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing

Emiel Cracco: Conceptualization, Formal analysis, Investigation, Supervision, Writing - Review & Editing

Nikolaus F. Troje: Software, Resources, Writing - Review & Editing,

Marcel Brass: Conceptualization, Supervision, Project administration, Funding acquisition, Writing - Review & Editing

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://www.dropbox.com/s/kvivpqk2q7uugnx/FTV.mp4?dl=0.

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