The relationship between social anxiety and the perception of depth-ambiguous biological motion stimuli is mediated by inhibitory ability

Adam Heenan [a,*], Nikolaus F. Troje [a,b,c]

[a] Queen's University, Department of Psychology, Kingston, ON K7L3N6, Canada
[b] Queen's University, School of Computing, Kingston, ON K7L3N6, Canada
[c] Queen's University, Department of Biology, Kingston, ON K7L3N6, Canada

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ABSTRACT

Orthographically projected biological motion stimuli are depth-ambiguous. Consequently, their projection when oriented towards the viewer is the same as when oriented away. Despite this, observers tend to interpret such stimuli as facing the viewer more often. Some have speculated that this facing-the-viewer bias may exist for sociobiological reasons: Mistaking another human as retreating when they are actually approaching could have more severe consequences than the opposite error. An implication of this theory is that the facing-towards percept may be perceived as more threatening than the facing-away percept. Given this, as well as the finding that anxious individuals have been found to display an attentional bias towards threatening stimuli, we reasoned that more anxious individuals might have stronger facing-the-viewer biases. Furthermore, since anxious individuals have been found to perform poorer on inhibition tasks, we hypothesized that inhibitory ability would mediate the relationship between anxiety and the facing-the-viewer bias (i.e., difficulty inhibiting the threatening percept). Exploring individual differences, we asked participants to complete anxiety questionnaires, to perform a Go/No-Go task, and then to complete a perceptual task that allowed us to assess their facing-the-viewer biases. As hypothesized, we found that both greater anxiety and weaker inhibitory ability were associated with greater facing-the-viewer biases. In addition, we found that inhibitory ability significantly mediated the relationship between anxiety and facing-the-viewer biases. Our results provide further support that the facing-the-viewer bias is sensitive to the sociobiological relevance of biological motion stimuli, and that the threat bias for ambiguous visual stimuli is mediated by inhibitory ability.

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1. Introduction

The human visual system is remarkably adept at deriving information from the movement of other living things (Johansson, 1973). This ability, referred to as biological motion perception, is often studied using point-light stimuli. These stimuli are comprised of relatively few dots representing the main joints of the body, yet naïve observers can accurately identify their gender (Pollick, Kay, Heim, & Stringer, 2005; Troje, 2002) and even make accurate estimates of a figure's mood or level of anxiety (Michalak et al., 2009). Another interesting property of point-light stimuli and related biological motion stimuli (e.g., silhouettes or stick figures) is their depth-ambiguity. Because such figures are depth-ambiguous when projected orthographically, they can elicit two equally plausible percepts with different facing orientations (see Fig. 1). Although the available visual information supports both percepts equally, naïve observers perceive these stimuli as facing towards them more often than facing away, a phenomenon that has been termed the facing-the-viewer bias (Brooks et al., 2008; Schouten, Troje, Brooks, Van Der Zwan, & Verfaillie, 2010; Schouten, Troje, & Verfaillie, 2011; Schouten & Verfaillie, 2010; Vanrie, Dekeyser, & Verfaillie, 2004; Vanrie & Verfaillie, 2006).

Some have argued that the facing-the-viewer bias may exist for sociobiological reasons (Brooks et al., 2008; Schouten et al., 2010; Vanrie et al., 2004). That is, mistaking an approaching person as retreating could potentially have more severe consequences than the opposite error. Implicit in this hypothesis is that the facing-towards percept of a biological motion stimulus is potentially more threatening than the facing-away percept, and in fact, there is some evidence that people perceive it as such. For instance, observers tend to perceive point-light displays depicting male walkers as facing towards them more often than female stimuli (Brooks et al., 2008; Schouten et al., 2010) and men are typically viewed as more threatening than women (see Cicone & Ruble, 1978). However, later studies (e.g., Schouten et al., 2011;

* Corresponding author at: Queen's University, Department of Psychology, 62 Arch Street, Humphrey Hall, Room 232, Kingston, ON K7L3N6, Canada. Tel.: +1 613 929 4862.
E-mail addresses: adam.heenan@queensu.ca (A. Heenan), troje@queensu.ca (N.F. Troje).
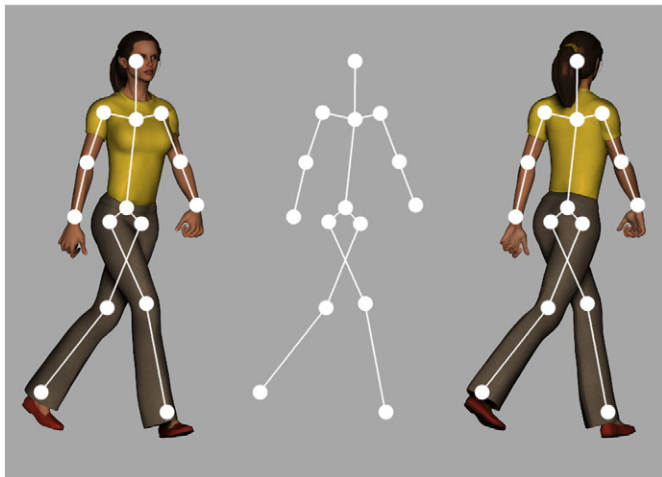
Fig. 1. An example of a static multistable stick figure walker (center), with both the front-facing (left) and rear-facing (right) orientations shown superimposed on the same stick figure walker in order to show the two possible perceptual interpretations of these stimuli. This figure is reprinted with permission from Weech et al. (2014).

Weech, McAdam, Kenny, & Troje, 2014) suggest that this gender effect might occur for reasons other than gender, and so further research on the relationship between the figure gender and the facing-the-viewer bias is needed.

Given this link between the facing-the-viewer bias and the perception of threat, one way to test the sociobiological theory would be to examine how this perceptual bias is affected by observers' level of anxiety. There is a wealth of evidence that both highly anxious nonclinical populations and those with diagnosed anxiety disorders display an attentional bias towards visual stimuli that are potentially threatening (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Gray, Adams, & Garner, 2009; Mogg & Bradley, 2005; Mogg, Bradley, de Bono, & Painter, 1997; Singer, Eapen, Grillon, Ungerleider, & Hendler, 2012). This predisposition towards threat has been found to occur at both the perceptual (unconscious) and attentional (conscious) levels (see Bar-Haim et al., 2007), though the distinction between these two is still unclear in the literature (for our purposes, we will refer to perceptual and attentional biases interchangeably). For example, MacLeod, Mathews, and Tata (1986) had people watch while two words (either threat words or innocuous ones) were displayed simultaneously on a computer screen. They found that more anxious individuals diverted more attention to processing the threatening words as evidenced by longer latencies to visual probes located near those words. The threat bias has also been confirmed with ambiguous visual stimuli, as more anxious individuals have been found to display a bias towards perceiving the more threatening percept of ambiguous figures (Fox, Russo, & Dutton, 2002; Gray et al., 2009; Singer et al., 2012). For instance, during binocular rivalry tasks (in which perceptual alternations are elicited by displaying different stimuli to each retina), researchers have found that more anxious individuals are more likely to perceive threatening images than neutral ones at stimulus onset (e.g., angry or fearful facial expressions; Gray et al., 2009; Singer et al., 2012). This threat bias does appear to be specific to anxiety itself, as it is not related to symptoms of depression (MacLeod et al., 1986) and has been found to diminish after successful treatment of anxiety (El Khoury-Malhame Myriam et al., 2011). In fact, some argue that this threat bias may contribute to and maintain some anxiety disorders by causing anxious individuals to attend to threatening stimuli or events in their environment that then evoke further anxiety in a self-perpetuating feed-forward loop (Heeren, Peschard, & Philippot, 2011; MacLeod et al., 1986).

Given the support for the threat bias and that the facing-the-viewer bias appears to be greater for more threatening stimuli, one would hypothesize that more anxious individuals would have greater facing-

the-viewer biases. Indeed, there is evidence that this is the case, as Heenan and Troje (2014) found that participants who exercised on a treadmill or those who performed a progressive muscle relaxation task had significantly lower facing-the-viewer biases than controls. Since both these tasks are known to cause reductions in anxiety, Heenan and Troje argued that anxiety and the facing-the-viewer bias are related. In support of this, these authors found that social interaction anxiety and facing-the-viewer biases were positively correlated and, in an earlier study, Heenan, Refling, MacDonald, and Troje (2012) reported a similar positive correlation between facing-the-viewer biases and attachment anxiety. Furthermore, Heenan et al. (2014) found that participants had greater facing-the-viewer biases immediately after conversing with an individual who was portraying symptoms of schizophrenia, which they argued supports the use of this bias as an implicit measure of perceived threat. On the other hand, Van de Cruys, Schouten, and Wagemans (2013) found that individuals with high social anxiety had significantly *weaker* facing-the-viewer biases than individuals with low social anxiety, as indicated by the total scores from the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987).

While more research on the facing-the-viewer bias is required, a consistent finding regarding anxiety and ambiguous visual stimuli is that reversal rates (i.e., the rate at which one experiences reversals between percepts) increase as a function of anxiety. For example, there is evidence that more anxious participants have significantly faster perceptual reversal rates during binocular rivalry tasks than those who are less anxious (Anderson et al., 2013; Meredith, 1967; Nagamine et al., 2007) and also while viewing static ambiguous figures such as the Schroeder staircase (Li et al., 2000). Furthermore, individuals with clinically significant anxiety have been found to have faster reversal rates than healthy controls before receiving treatment but not afterwards (Meldman, 1965).

One reason why anxious individuals perceive more frequent reversals might be that they are less able to inhibit percepts. Some people with anxiety disorders have difficulty inhibiting distracting thoughts, such as individuals with post-traumatic stress disorder (Swick, Honzel, Larsen, Ashley, & Justus, 2012) or obsessive–compulsive disorder (Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005; Enright & Beech, 1993). According to attentional control theory (Eysenck & Derakshan, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007), anxiety disrupts the interaction between top-down, goal-directed attention (e.g., focusing on a task) and bottom-up, sensory-driven attention (e.g., noticing a potential threat). Highly anxious people, according to this theory, are less able to inhibit threatening, task-irrelevant information (e.g., distracting memories of trauma), because they are less able to exert top-down attentional control to prevent bottom-up attentional resources from being used to detect potential threats (i.e., threat bias). These theorists also argue that anxiety diminishes the efficiency of executive functioning *in general*, meaning that greater anxiety is correlated with poorer inhibitory performance for neutral, non-emotional stimuli. Of note here, inhibition can be described either as an attentional (i.e., conscious, deliberate) process or as an executive function that is more unconscious and automatic in nature. While differentiating between these two types of inhibition is beyond the scope of the current paper, researchers have demonstrated that bistable reversals can be both unconsciously and consciously controlled (e.g., reversal rates can increase with voluntary effort; for a review, see Leopold & Logothetis, 1999). For the purposes of this paper, we will not differentiate between conscious or unconscious inhibition.

Attentional control theory might be useful for interpreting the link between anxiety and the perception of ambiguous visual stimuli. That is, it is possible that anxiety affects perceptual biases by making it more difficult to inhibit, or 'suppress' percepts generally. For completely non-threatening visual stimuli, this hypothesis would also explain why more anxious individuals have faster perceptual reversal rates: They have difficulty inhibiting percepts in general and thus experience more rapid perceptual alternations. Conversely, for ambiguous visual