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OBSERVATION

Our Own Action Kinematics Predict the Perceived Affective States of Others

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Our movement kinematics provide useful cues about our affective states. Given that our experiences furnish models that help us to interpret our environment, and that a rich source of action experience comes from our own movements, in the present study, we examined whether we use models of our own action kinematics to make judgments about the affective states of others. For example, relative to one's typical kinematics, anger is associated with fast movements. Therefore, the extent to which we perceive anger in others may be determined by the degree to which their movements are faster than our own typical movements. We related participants' walking kinematics in a neutral context to their judgments of the affective states conveyed by observed point-light walkers (PLWs). As predicted, we found a linear relationship between one's own walking kinematics and affective state judgments, such that faster participants rated slower emotions more intensely relative to their ratings for faster emotions. This relationship was absent when observing PLWs where differences in velocity between affective states were removed. These findings suggest that perception of affective states in others is predicted by one's own movement kinematics, with important implications for perception of, and interaction with, those who move differently.

Public Significance Statement

The way that we move provides useful cues about our emotions. For example, we move more quickly than our average speed when we are feeling angry and more slowly when we are feeling sad. The present study shows that we make judgments about others' emotional expressions relative to how we move ourselves. To give an example, rather than everyone interpreting movements of a certain speed as angry, individuals may only think that others feel angry if these movements are faster than their own typical movement speed. Therefore, we are better placed to understand the emotions of others who tend to move more similarly to us. These findings have important implications for our understanding of and interactions with clinical and cultural groups whose movements are dramatically different from our own.

Keywords: action perception, emotion, affective states, point-light walkers, expertise

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Behavioral expressions of affective states are often automatic and exhibit many similarities across individuals (Frijda, 2010). These similarities allow recognition of affective states in others from a range of cultures (e.g., Sauter, Eisner, Ekman, & Scott, 2010; Correction for Sauter et al., 2015). Various cues provide information about our affective states, such as facial expressions (Bassili, 1979; Ekman & Friesen, 1975), vocalizations (Scherer, 1995), and importantly, the way we move (Dael, Mortillaro, & Scherer, 2012). For example, anger is associated with fast movement (Sawada, Suda, & Ishii, 2003; Montepare, Goldstein, & Clausen, 1987; Roether, Omlor, Christensen, & Giese, 2009a) and sadness with low velocity (Michalak et al., 2009; Pollick, Paterson, Bruderlin, & Sanford, 2001). Some (e.g., Sawada et al., 2003), but not all (e.g., Barliya, Omlor, Giese, Berthoz, & Flash, 2013) studies have also found that happiness is associated with high velocity. Therefore, in the same way that perception of a smile prompts the attribution of happiness, perception of fast movements can prompt the attribution of anger (Atkinson, Tunstall, & Dittrich, 2007; Roether et al., 2009a; Roether, Omlor, & Giese, 2009b). The association of specific movement cues with specific affective states can provide a rapid route for the attribution of affective states to others, enabling fast and appropriate responses to others' behavior (Brown & Brüne, 2012; Klin, Jones, Schultz,

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& Volkmar, 2003; Sartori, Cavallo, Bucchioni, & Castiello, 2012).

It is likely that we are able to make these affective state inferences through models built on the basis of experience of our own movements. Our experiences with the world tune our perceptual systems (Blakemore & Cooper, 1970; Sangrigoli, Pallier, Argenti, Ventureyra, & De Schonen, 2005) and we have extensive experience with our own actions as we learn to control them (Rochat, 1998; Van der Meer, Van der Weel, & Lee, 1995). This experience, both through direct visual tuning from self-observation and motor contributions to perception (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006; Gerson, Bekkering, & Hunnius, 2015; Hunnius & Bekkering, 2014), may tune our perceptual models of action according to how we move. For example, it has been proposed that mirror mechanisms—mechanisms that generate activation of corresponding motor codes when action is passively observed—may influence action perception (Witt, South, & Sugovic, 2014). This framework could explain findings that one's own actions determine perception of related stimuli (Jordan & Hunsinger, 2008).

The present study tests for the first time whether participants' models of their own movements influence their interpretation of the emotions of others. This hypothesis predicts differences in affective state perception between participants who move with distinct kinematics. For example, we may all increase our velocity when we feel angry, and reduce our velocity when we feel sad. However, people who typically move faster than the average person (i.e., "fast movers") will move particularly fast quickly when they are angry, but when they feel sad, their speed might be more comparable to that of an average person not experiencing any strong emotional state (see Figure 1A). If this fast mover is using a model of his or her own kinematics to interpret others' affective states, another's fast movements, conveying anger, are unlikely to be perceived as intensely angry (see Figure 1Aii) because they are comparable to the fast mover's own typical movements. However, this fast mover will perceive sad (slow) movements as intensely sad, because these movements are very different from how they typically move. Conversely, someone who moves more slowly than average would perceive fast (angry) movements as more intensely emotional relative to slow (sad) movements (See Figure 1Ai).

Variability in participants' own typical kinematics was assessed by recording velocity while walking in a neutral context. In addition, participants viewed emotional (i.e., angry, happy, or sad) point-light walker stimuli (PLWs, see Figure 1B). The kinematics of these stimuli were either affect-specific (e.g., high velocity for angry walkers), or manipulated to converge to neutral kinematics (see Figure 1C). Participants were asked to rate the extent to which the PLW appeared happy, angry, and sad. We predicted that we would find a linear relationship between one's own walking kinematics and affective state judgments of others, such that the faster participants would rate the slower emotions more intensely, relative to the faster emotions. We predicted attenuation of this relationship as the differences in kinematics between affective states were removed. Findings of this nature would indicate that our perception of others' affective cues is determined by our own action models.

Method

Participants

This study was first conducted with 41 participants (17 men, aged 20–43 years, $M = 27.37$, $SEM = 1.04$) recruited from the local university database and the effects reported below were present in this initial group (see supplementary materials). It was subsequently deemed prudent to increase the sample to 87 (40 men, aged 18–62, $M = 29.48$, $SEM = 1.00$) to ensure that effects were not due to sampling error, and the effects were replicated in the 46 new participants (see supplementary materials). Given that the precision of effect-size estimation depends primarily on sample size (Asendorpf et al., 2013; Maxwell, Kelley, & Rausch, 2008), we pooled the participants for optimal sensitivity, and determined the robustness of the effect with bootstrapping analyses (see supplementary materials). There were no multivariate outliers. All participants gave informed consent, and procedures received local ethical approval.

Stimuli

The stimuli were PLWs (see Figure 1B) adapted from those developed by Nackaerts et al. (2012). The original PLWs depicted a male or female actor expressing happy, sad, angry, or neutral affective states at two different viewpoints (i.e., coronal [0°] and intermediate to coronal and sagittal [45°]).

To confirm that kinematic information is used to make affective-state judgments, and examine how this use varies according to one's own kinematics, we also generated three velocity-adapted animations corresponding to each original emotional animation (original animations are referred to hereafter as 100% emotion stimuli). The 0% animations exhibited a mean velocity equal to the mean velocity of the corresponding neutral animation, and 33% and 67% animations exhibited velocities between the neutral and 100% emotional stimuli (see Figure 1C). These manipulations resulted in 48 emotion stimuli.

Two random frames from each neutral-walker frame set were also selected, resulting in eight static control images that contained no affective information—postures were neutral and there was no kinematic information.

Procedure

All participants first completed emotion-perception tasks with the original PLWs, then the velocity-adapted PLWs, and finally, the static control images. Participants subsequently performed the walking task and completed the questionnaire measures.[1]

Emotion-perception tasks. On each trial, the participants were presented with a PLW and asked to rate the extent to which the walker was expressing one of the three target emotions: happy, angry, or sad. The rating scale ranged from "not at all (happy,

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[1] A fixed order was selected to enable comparability between the testing conditions for all participants and allow the study of individual differences. It was deemed that the walking task should always be performed after the emotion-perception tasks to minimize the risk that participants were primed to make explicit reference to their own walking pace during the perception tasks.

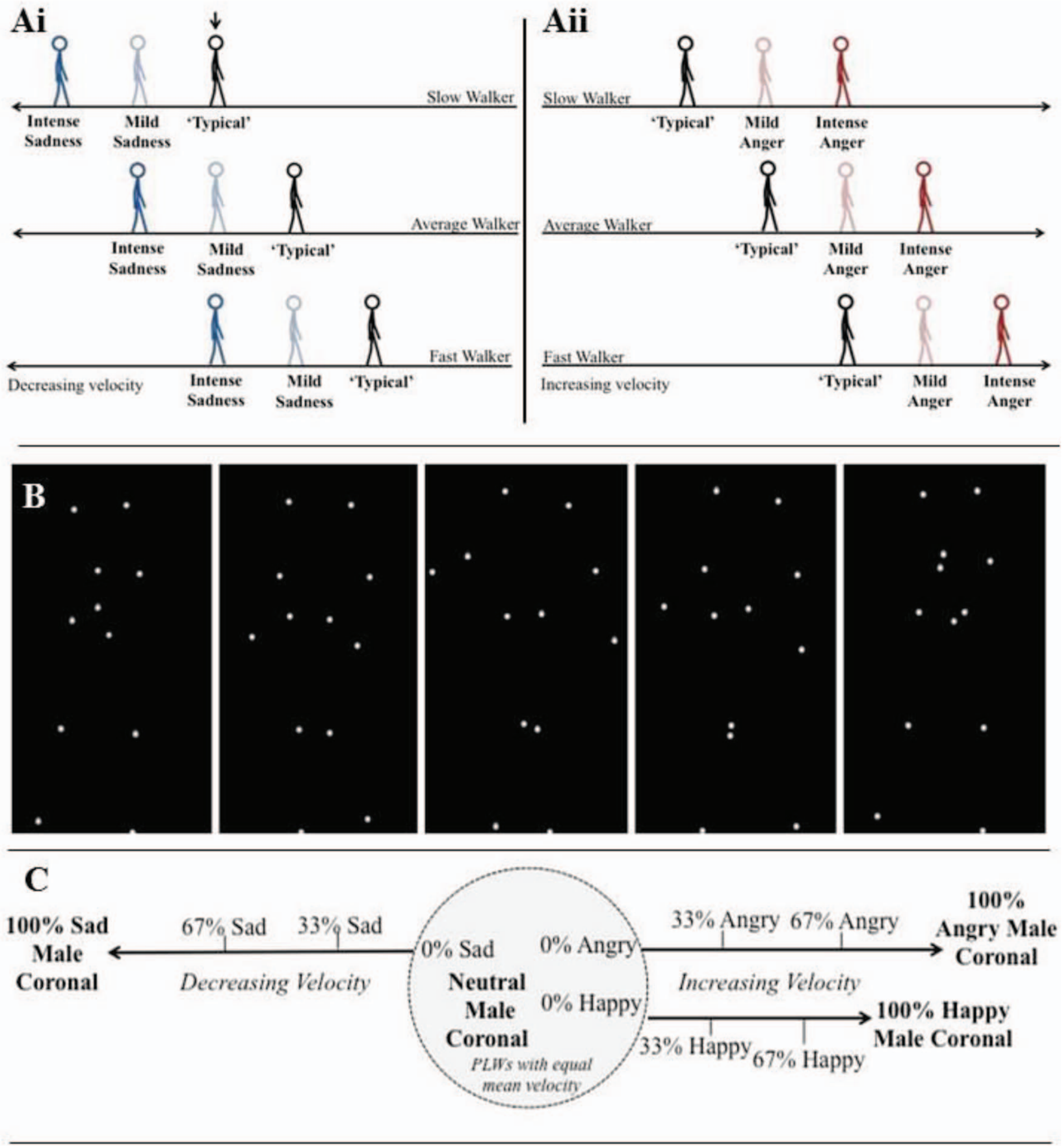

Figure 1. (A) Schematic diagram of the experimental hypothesis. The left panel (Ai) depicts the kinematics of sad, fast, average, and slow walkers. The right panel (Aii) depicts the kinematics of angry, fast, average, and slow walkers. Note that at the velocity highlighted by the arrow in the left panel, a slow walker is feeling no particular emotion, but a fast walker is feeling intensely sad. (B) Example frames taken from the happy intermediate (45°) male PLW. In these PLWs, 12 points reflect the motion at important joints in the body (see supplementary videos for examples). (C) The velocity of the original (100%) animations was altered to assess the extent to which kinematic information is used to make affective-state judgments. Stimuli at 0% exhibited velocities equal to the neutral stimuli (e.g., the 0% happy male coronal velocity was equal to that in the neutral male coronal animation), and 33% and 67% animations exhibited velocities between the neutral and 100% emotion stimuli. See the online article for the color version of this figure.

angry, sad)" to "very (happy, angry, sad)." Participants clicked on a visual analogue scale, and responses were recorded on a 0–10 scale (to two decimal places; value not shown to participants). The initial position of the cursor was randomized for each trial. Participants were able to change their responses until they pressed a key to continue. The affective-state judgment to be made was blocked, resulting in three separate blocks (happy, angry, and sad judgments). All stimuli were presented once in each block, and the order of the blocks was counterbalanced across participants. In addition, the order of presentation of the stimuli was randomized for each participant within each block. Before beginning the study, the participants had three practice trials. In each practice trial, participants were asked to rate one of the three emotions and were shown a randomly selected, 100% emotional, sagittal PLW.

The procedure was the same when viewing the static control images. On each trial within each of the three blocks, one of eight images was presented for 2.04 seconds (mean duration of the animations). These stimuli were used to measure response bias (see supplementary materials).

In the test phase, participants were therefore asked to make a total of 48 ratings of the original PLWs, then 108 ratings of the velocity-adapted emotional PLWs, and 24 ratings of the static control images.

Walking task and questionnaires. Participants were instructed to walk continuously between two cones (10 m apart) at their own typical walking pace and that they would be told when to stop (after 120 s). An iPhone 5c was attached to the medial side of the participants' right ankle, and the internal accelerometer was used to track the precise time taken and distance traveled for each participant, via the Sensor Kinetics Pro application. For preprocessing of the walking task data, see supplementary materials.

To assess any response biases associated with mood (Fiedler, Nickel, Muehlfriedel, & Unkelbach, 2000; Forgas, 1995), all participants rated their current mood (happy, angry, and sad) using the same scale as the one used in the emotion tasks, from *not at all* [*happy, angry, sad*] to *very* [*happy, angry, sad*]. Sixty-six of the participants also completed the *Positive and Negative Affect Schedule–Expanded Form* (*PANAS-X*; Watson & Clark, 1994) to assess general positive and general negative affect traits.

Results

Emotion-Perception Measures

We calculated emotional intensity scores (EIS) for each emotion and velocity level (3 emotions × 4 levels). These measures were calculated as the mean rating on the modeled emotion scale (e.g., angry for the 0%, 33%, 67%, and 100% angry stimuli) minus the mean of the two ratings on the nonmodeled emotion scales (happy and sad in this case; the subtraction was performed to isolate participants' ratings of the modeled emotion from the nonmodeled emotions). High EIS scores indicate that participants judged the PLW as intensely expressing the modeled emotion, while low (or negative) scores indicate that the PLW is judged as weakly expressing the modeled emotion or expressing a nonmodeled emotion. Group-level analyses of performance across different stimulus types are presented within the supplementary materials.

We then calculated composite emotional intensity beta scores (EIBS). The EIBS represent the linear relationship in intensity scores from the slowest (sad) to the fastest (angry) emotions (via happy). This score was calculated by modeling the regression slope, β, between animation kinematics and EIS, such that the predictor values were the mean velocity of each PLW's right ankle for each of the three modeled emotions in the 100% emotion stimuli (see Figure 2A), and the dependent values were the corresponding EIS. A positive EIBS denotes higher intensity ratings for the faster, relative to the slower, emotions, and a negative score represents higher intensity ratings for the slower emotions.

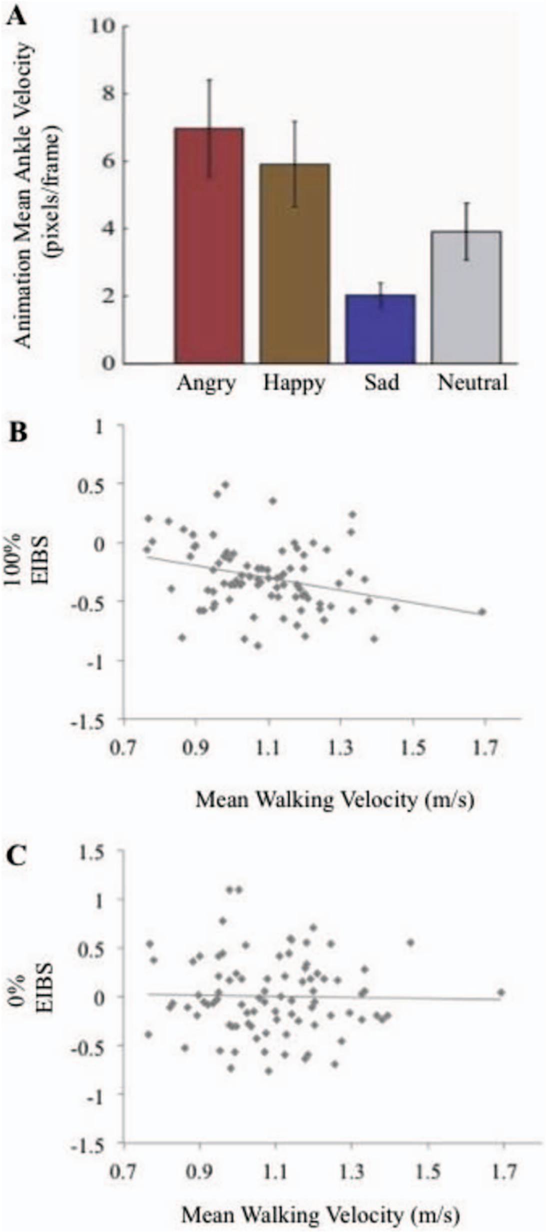

Figure 2. (A) Mean ankle velocity for animations in each affective category. Error bars represent *SEM* in both panels. (B) Scatter plot of the negative correlation between the 100% EIBS and the participants' own walking velocity. A high 100% EIBS represents participants rating the faster emotions (anger) as more intense relative to the slower emotions (sadness). (C) Scatter plot demonstrating no relationship between the 0% EIBS and participants' own walking velocity. See the online article for the color version of this figure.

Relationship Between Walking Kinematics and Emotion Perception

To test our primary hypothesis, we performed a Pearson product–moment correlation to examine whether individual differences in walking velocity were related to emotion perception, measured by our 100% EIBS. In line with our hypotheses, we found a negative relationship ($r = -.310$, $N = 87$, $p = .003$, 95% CI [$-.489$, $-.106$]; see Figure 2B), such that participants whose walking kinematics were faster rated the slower emotions more intensely than the faster emotions.

To test whether the kinematic cues in the PLWs mediated this effect, we examined whether a similar correlation was present between the 0% EIBS (i.e., animations with emotional postural information, but no emotion-specific kinematic cues) and walking velocity. There was no relationship between these variables ($r = -.025$, $N = 87$, $p = .820$, 95% CI [$-.234$, $.187$]; Steiger test comparing 0% and 100% EIBS correlation coefficients, $z = -2.38$, $p = .017$; see Figure 2C), indicating that the emotion-specific velocity cues are important for the observed relationship between walking velocity and emotion perception.

Finally, to ensure that mood did not mediate the observed relationships between walking kinematics and emotional perception, we performed partial correlations, controlling for variability relating to mood. The analysis controlling for participant's state mood ratings (happy, sad, and angry) showed the same negative correlations as reported above (100% EIBS, $r = -.305$, $N = 87$, $p = .005$, 95% CI [$-.485$, $-.101$], as did the analysis controlling for general negativity and positivity on the *PANAS-X*, in the subsample for whom we had these scores ($r = -.337$, $N = 66$, $p = .006$, 95% CI [$-.535$, $-.103$]).

Discussion

In this study, we examined whether an individual's own movement kinematics would predict the perception of others' affective states. In line with our predictions, we found that participants who walked with greater speed rated high-velocity (angry) emotions as less intense relative to low-velocity (sad) emotions. This association was abolished when the kinematic information relating to affective state was removed, and could not be explained by variance related to participants' state or trait mood.

Such findings provide novel evidence that attributions about others' covert affective states are calibrated to one's own action experiences. Passive action observation has been found to generate activation of corresponding motor codes, which may contribute to perception (e.g., Witt et al., 2014). Observation of walking may therefore be assumed to activate codes for walking at that velocity oneself, and attribution of an affective state to the observed other may be determined by the speed of these codes, relative to one's own typical pace. The precise nature of the general mechanism that links action and perception is a matter of debate, and a variety of versions of an "own action calibration" mechanism could generate our effects. For example, the effects may be a product of visual tuning of perceptual models during production of our own actions (Peelen & Dowling, 2007), or they may rely upon motor contributions to perception that are not exclusive to observation of actions, per se (Press & Cook, 2015).

The present findings have important implications for our understanding of affect perception between different populations. The current study predicts that social interactions should be most successful between interaction partners who move similarly, as greater understanding of others' internal states is likely to result in more successful social interactions. For example, differences in the production of actions may impact cross-cultural affect perception (Hareli, Kafetsios, & Hess, 2015; Matsumoto, Seung Hee Yoo, & Fontaine, 2008; Quiros-Ramirez & Onisawa, 2015). Consistent with this speculation, individuals with autism spectrum disorder, who have a range of social and communicative impairments, have been shown to move with atypical action kinematics compared with typical individuals, and individuals with the most atypical kinematics are also those with the most severe social difficulties (Cook, 2016; Cook, Blakemore, & Press, 2013; see also Edey et al., 2016). The speculation that social interaction may be impaired between interactants who move dissimilarly, might in part explain a range of social interaction difficulties across various clinical groups associated with motor atypicalities (e.g., attention-deficit hyperactivity disorder; Tervo, Azuma, Forgas, & Fiechtner, 2007, and cerebella ataxia; D'Agata et al., 2011).

In conclusion, the present findings suggest that we use models of our own movement kinematics to make affective judgments about others. This finding may have important implications for perception of, and interaction with, those who move differently.

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