

Running head: FORM AND MOTION IN EMOTION RECOGNITION

**Evidence for distinct contributions of form and motion information to the
recognition of emotions from body gestures**

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Abstract

The importance of kinematics in emotion perception from body movement has been widely demonstrated. Evidence also suggests that the perception of biological motion relies to some extent on information about spatial and spatiotemporal form, yet the contribution of such form-related cues to emotion perception remains unclear. This study reports, for the first time, the relative effects on emotion recognition of inverting and motion-reversing patch-light compared to fully illuminated displays of whole body emotion gestures. Inverting the gesture movies or playing them backwards significantly impaired emotion classification accuracy, but did so more for patch-light displays than for identical but fully illuminated movement sequences. This result suggests that inversion impairs the processing of form information related to the configuration of body parts, and reversal impairs the sequencing of form changes, more than these manipulations impair the processing of kinematic cues. This effect was strongest for inversion, suggesting an important role for configural information in emotion recognition. Nevertheless, even in combination these stimulus manipulations did not abolish above chance recognition of any of the emotions, suggesting that kinematics help distinguish emotions expressed by body gestures. Disproportionate impairments in recognition accuracy were observed for fear and disgust under inversion, and for fear under motion reversal, suggesting a greater role for form-related cues in the perception of these emotions.

Keywords: Emotion recognition, biological motion, body movement, body gestures, configural cues.

Evidence for distinct contributions of form and motion information to the recognition of emotions from body gestures

Recognition of another's emotional expression likely involves processes that link the perceptual properties of the stimulus to various knowledge structures, such as the specific emotion concept, the lexical label for that emotion, and the perception of the emotional response (or a central representation thereof) that the stimulus triggers in the observer (see Atkinson & Adolphs, 2005). Research on emotion recognition has been dominated by studies using photographs of facial expressions, yet movement of the body or its parts is also revealing of other people's emotions. Using standard recognition tasks, such as those requiring forced choices from a list of emotion labels or judgments of emotional intensity, several studies have demonstrated that, even in the absence of facial and vocal cues, humans are adept at identifying basic emotions¹ signaled by static body postures (e.g., Atkinson, Dittrich, Gemmell, & Young, 2004; Coulson, 2004), arm movement (Pollick, Paterson, Bruderlin, & Sanford, 2001), and whole body movement (e.g., Atkinson et al., 2004; de Meijer, 1989; Dittrich, Troscianko, Lea, & Morgan, 1996). On what visual information is this ability based?

Three main classes of information relevant to the perception of body gestures and actions are: structural or form information and its changes over time (including motion-mediated structural information), kinematics (e.g., velocity, acceleration, displacement) and dynamics (motion specified in terms of mass and force). Considerable attention has been given to the role of kinematics in specifying cues for action and person perception. Typically, these studies employ *point-light* or patch-light displays of human or other biological motion, in which static form information is minimal or absent but motion information (kinematics and dynamics) and motion-mediated structural information are preserved (Johansson, 1973). Point-light displays

of body movements provide a sufficient basis for observers to discriminate biological motion from other types of motion, and to make accurate judgments about the people making the movements, including sex from gait (e.g., Barclay, Cutting, & Kozlowski, 1978), identity from gait (Richardson & Johnston, 2005) or actions (Loula, Prasad, Harber, & Shiffrar, 2005), the weight of boxes from the lifting movement (Runeson & Frykholm, 1981), and complex individual or social actions (Dittrich, 1993). Some of this evidence shows equivalent or near equivalent performance with point-light compared to full-light (or solid-body) displays, in which the whole body or face is visible (e.g., Hill, Jinno, & Johnston, 2003; Runeson & Frykholm, 1981), which suggests that static form cues are rather less important than motion cues and may often be unnecessary for successful judgments about people and their actions based on their visible behavior. Evidence for the relative importance of kinematic cues comes from studies that measure the effects on recognition of changes in certain kinematic or structural dimensions of point-light stimuli. For example, accuracy in judging the sex of point-light walkers was influenced more by “body sway” than by the ratio of shoulder to hip width, in Mather and Murdoch’s (1994) study, and was greater when point-light walkers were normalized with respect to their size (thus providing only motion information) than when they were normalized with respect to their motion information (thus providing only size cues), in Troje’s (2002) study.

It has been argued that the ability to discriminate at least simple biological movements in point-light displays may be based on relatively low-level or mid-level visual processing that does not involve the reconstruction of the form of body parts or of the whole body, either from static form or motion-mediated structural cues (e.g., Casile & Giese, 2005; Mather, Radford, & West, 1992). Nevertheless, neuropsychological and neurophysiological evidence demonstrates that form

information can indeed subserve biological motion perception from point-light displays (e.g., Hirai & Hiraki, 2006; McLeod, Dittrich, Driver, Perrett, & Zihl, 1996; Peelen, Wiggett, & Downing, 2006; Vaina, Cowey, LeMay, Bienfang, & Kikinis, 2002). The processing of changes in the form of the body over time may be particularly important (e.g., Beintema & Lappe, 2002), especially in the context of more sophisticated tasks, such as recognizing emotional states or complex actions (Casile & Giese, 2005; Giese & Poggio, 2003).

There is compelling evidence that the kinematics of body and body-part movements are at least sufficient, and may often be important, in furnishing cues for the perception of emotional expressions. For example, using point-light knocking and drinking arm movements as stimuli, Pollick et al. (2001) found that judgments of anger and happiness were more likely when the movements were fast and jerky, and that judgments of sadness were more closely associated with slow and smooth movements. And Sawada, Suda, and Ishii (2003) reported that arm movements made with the intention of expressing joy, sadness, or anger varied in their velocity, acceleration, and displacement, and that differences in these factors predicted the ability of observers to distinguish between the three types of emotional expression. Nonetheless, there is also evidence that form-related cues in moving bodies and faces, in addition to kinematics, contribute to emotion perception. Bassili (1978) reported greater emotion classification accuracy for full-light compared to point-light facial movements, except for happy expressions. Dittrich (1991) found equivalent emotion recognition performance for point-light face stimuli in which the dots demarcated key facial structures (e.g., eyes, mouth) and those in which the dots were positioned randomly on the face. This result contrasts with Hill et al.'s (2003) finding that sex judgments from facial movements were more accurate with spatially normalized than

pseudo-random dot placement, and thus highlights the relationship between form and motion information in specifying cues for emotion perception. In previous work, we reported a reduction in emotion recognition performance with point-light (Dittrich et al., 1996) and patch-light (Atkinson et al., 2004) displays of body gestures compared to full-light gestures. An important methodological advance introduced in the latter study was that our full-light and patch-light displays were made from identical recordings, in contrast to previous studies, in which these two conditions were filmed separately (e.g., Dittrich et al., 1996). Therefore, an argument that differences in task performance between the two conditions could be due to differences between emotion portrayals in each filming session, rather than to differences in the amount of static form information in each stimulus type, can be ruled out. In the present study, we capitalize on this methodological improvement to assess the relative contribution of form-related cues to emotion recognition. To this end, we combined the full-light versus patch-light manipulation with two other stimulus transformations that would impair the processing of form-related cues whilst preserving the processing of kinematic cues, viz., stimulus inversion and reversal of the direction of motion.

The disproportionate disruption to the perception of faces compared to other objects engendered by stimulus inversion (reviewed in Peterson & Rhodes, 2003) is also evident in the perception of body postures (Reed, Stone, Bozova, & Tanaka, 2003; Reed, Stone, Grubb, & McGoldrick, 2006; Stekelenburg & de Gelder, 2004) and movement. The spontaneous identification of point-light motion displays as biological motion is impaired when they are shown upside down (Bertenthal & Pinto, 1994; Pavlova & Sokolov, 2000; Shipley, 2003; Troje, 2003), even given prior knowledge about display orientation (Pavlova & Sokolov, 2003). Moreover, neural activation characteristic of upright biological motion displays is attenuated or absent

when such displays are inverted (Grossman & Blake, 2001; Pavlova, Lutzenberger, Sokolov, & Birbaumer, 2004). Inversion of point-light displays also disrupts the ability to distinguish the identity of the actors from their actions (Loula et al., 2005), and sex judgments based on gait tend to be reversed (Barclay et al., 1978). Most relevantly, Dittrich et al. (1996) found a main effect of stimulus orientation on the identification of basic emotions in whole-body dance movements in point-light and full-light displays, although it was only a decrement in accuracy with full-light anger expressions that was driving this effect. This result does not fit with the expectation that inversion would more severely impair emotion recognition from point-light than full-light stimuli, on the reasoning that if the kinematics and dynamics are identical across these two types of display, then the differential effect of inversion must be a function of the form-related differences between them. Hence we sought to examine further the effects of display inversion on the identification of emotions in whole-body gestures, using stimuli that, unlike those used by Dittrich et al. (1996), consist of more stereotypical, less stylized movements, often with specific gestures or actions, and that contained identical movement sequences across the full-light and point-light conditions.

Reversing biological motion does not impede the ability of observers to perceive that motion as biological, but such stimulus transformations influence perception nevertheless. Verfaillie (2000) reported that observers were faster to identify the direction of movement of point-light walkers when they were primed by a point-light walker moving and facing in the same direction, as compared to a walker moving and/or facing in opposite direction. Pavlova, Krageloh-Mann, Birbaumer, and Sokolov (2002) found that the identification of a point-light walking dog *as biological motion* was unaffected by motion reversal, whereas judgments as to the particular

type of animal depended on the perceived direction of locomotion. Similarly, Sumi (1984) found that human movement was still perceived even when a movie clip of a point-light walker was reversed *and* inverted, although rather less often when the actor moved three-dimensionally as compared to two-dimensionally. Upside-down and reversed two-dimensional human motion tended to elicit interpretations of the stimulus as a person in an upright orientation moving forward but in a strange manner. Following Giese and Poggio's (2003) "snapshot" approach, we suggest that motion reversal primarily disrupts the integration of static form information over time, rather than the extraction of static form *per se*.

On the basis of the evidence reviewed here, and given that our patch-light and full-light displays contain identical motion information, differing only in the amount of form information they provide, we made the following predictions. If inversion impairs the processing of static form and form-from-motion cues (perhaps by changing the hierarchy of the body parts — Reed et al., 2006) more than it does the processing of kinematic and dynamic cues, then we should find that stimulus inversion more severely impairs emotion recognition accuracy from patch-light gestures than from full-light gestures. Similarly, if motion reversal impairs the processing of changes in form over time more than it does the processing of kinematic and dynamic cues, then we should find that reversing the direction of play more severely impairs emotion recognition accuracy from the patch-light than from the full-light stimuli.

This study also had two auxiliary aims. One was to test the prediction that stimulus inversion and motion reversal would impair the identification of certain emotions more than others, given the following assumption. If evolutionary pressures selected for fast-acting mechanisms for the detection of threat-related stimuli (e.g.,

LeDoux, 1998; Walk & Homan, 1984), then the visual system might be biased towards the detection of threatening emotion signals in static images, given that presumably a longer time must elapse for signals in expressive movements to be made explicit (Dittrich et al.'s, 1996, "modified alarm hypothesis"). Thus, insofar as inversion impairs processing of the spatial configuration of body parts, we expected inversion to have a greater effect on the recognition of threat-related emotions — putatively, fear, anger, and (more debatably) disgust — than on the other emotions. In addition, we expected fear recognition to be most impaired by motion reversal, given that cowering or retreating in fear was one of the most consistent characteristic movements for any of our emotion displays, which when reversed would appear as advancements (to the neutral stance). Our second auxiliary aim was to assess the validity of a newly created set of emotionally neutral body movements, comprising everyday actions and exercises. In the context of our experiment, the emotional neutrality of these new stimuli would be confirmed to the extent that they would very rarely be classified as one of the basic emotions provided in the forced-choice emotion-labeling task.

Methods

Participants

Thirty-two students from Durham University participated in this experiment for a small monetary reward. One group of 16 (13 females) viewed the full-light stimuli (aged 18 – 26 years; $M = 21.2$ years, $SD = 3.3$), and the other group of 16 (15 females) viewed the patch-light stimuli (aged 19 – 46 years; $M = 21.8$ years, $SD = 6.7$). All participants had normal or corrected-to-normal vision.

Stimuli

All stimuli were grey-scale digital movie clips of people expressing emotions or performing simple actions with whole-body movement. Expressions of anger, disgust, fear, happiness, and sadness were selected from a larger set developed by Atkinson et al. (2004), for which the actors were free to interpret and express the emotions as they saw fit, with only minimal guidance as to the sorts of situations in which people might experience those emotions. Ten versions of each of these expressions were selected for the present study on the basis that they were well recognized as the intended emotion. (The selection process was thus blind to the particular movements made by the actors, and an informal inspection of the selected set revealed a range of movements representative of the larger set, as described in Atkinson et al., 2004.) In addition, 10 emotionally neutral, common human movements (3 bending or crouching, 2 hopping, 2 digging, 1 knocking, 1 walking, 1 star-jumpingⁱⁱ) were selected from a newly developed set created using the same techniques as described in Atkinson et al. (2004). A two-stage procedure was employed to select these 10 neutral movements. First, the original 96 full-light and 96 matching patch-light stimuli (4 actors X 8 movements X 3 versions in each lighting condition) were whittled down to a set of 32 identical movements in each lighting condition, based on the free-responses of 20 undergraduates when asked of each stimulus what the person was (a) doing and (b) feeling (the instructions allowed ‘nothing in particular’ as a valid answer for b). Four examples of each of the 8 actions were selected on the condition that, across their full-light and patch-light versions, each stimulus received no more than 1 emotion-related descriptor. The resultant 32 full-light and 32 patch-light clips were then utilized in a forced-choice experiment along with all 300 body expressions of emotion from Atkinson et al. (2004) (30

versions X 5 emotions X 2 lighting conditions). Prior to this second preliminary experiment, all the clips were edited to exactly 3 seconds in length, such that the clip began when the actor began moving from a neutral stance and ended before the actor had returned to that stance. Participants classified either the patch-light or full-light stimuli in a 6-alternative forced-choice emotion-labeling task (angry, disgusted, fearful, happy, sad, neutral).

On the basis of the results of this second preliminary experiment, 10 well recognized versions of each of the neutral and 5 emotional movements (X 2 lighting conditions) were selected for the present experiment. The stimuli were presented in the center of a 17-inch monitor screen, with a frame size of 200mm in height and 250mm in width. The viewed height of the actors at their neutral starting points ranged from 100mm to 120mm (mean = 110mm, with a visual angle of 4.5° from a viewing distance of 700mm). Examples of the stimuli can be viewed online at <http://www.dur.ac.uk/a.p.atkinson/>.

Design and procedure

All participants were tested individually in a quiet room. Each group of participants viewed the same stimuli (either 60 patch-light or 60 full-light clips) repeated in 4 modes of presentation (blocks), as determined by a 2 (upright, inverted) X 2 (forward, reversed) factorial design. The block order was counterbalanced across participants and within each block the stimuli were presented pseudo-randomly. Upon giving their signed, informed consent, the participants classified the stimuli in a 6-alternative forced-choice emotion-labeling task (angry, disgusted, fearful, happy, sad, neutral), beginning with a practice block, which consisted of 24 body-movement stimuli (6 emotions X 4 modes of presentation) not used in the experimental blocks. Instructions appeared after each stimulus, reminding the participants of the 6 labels,

and remained on the screen until the participants responded by pressing one of 6 keys on the keyboard labeled with the relevant emotions, after which the subsequent stimulus appeared.

Results

Participants were able to identify all emotions reliably at above chance levels (16.67%) under all conditions, as determined by one-sample t-tests (all $t_s > 5.0$). A mixed design ANOVA on the percentage correct classification data revealed highly significant main effects of stimulus orientation [$F(1, 30) = 78.87, p < .001, \eta^2 = .724$], direction of motion [$F(1, 30) = 108.62, p < .001, \eta^2 = .784$], lighting [$F(1, 30) = 19.08, p < .001, \eta^2 = .389$], and emotion [$F(3.64, 109.28) = 14.1, p < .001, \eta^2 = .32$, Greenhouse-Geisser corrected]. These effects reflected reductions in emotion classification accuracy for patch-light compared to full-light, inverted compared to upright, and reversed-motion compared to forward-motion displays, and differences in classification accuracy between emotions. However, these main effects were modified by four two-way interactions. A significant interaction between orientation and lighting [$F(1, 30) = 10.13, p < .005, \eta^2 = .252$] indicated that stimulus inversion reduced emotion classification accuracy more for the patch-light stimuli than for the full-light stimuli (Figure 1a). A marginally significant interaction between direction and lighting [$F(1, 30) = 3.41, p < .08, \eta^2 = .102$] indicated that playing the movie clips backwards reduced emotion classification accuracy slightly more for the patch-light stimuli than for the full-light stimuli (Figure 1b).

----- Insert Figure 1 about here. -----

The interaction between orientation and emotion was significant [$F(5, 150) = 4.63, p < .005, \eta^2 = .134$], as was the interaction between direction and emotion [$F(5,$

150) = 9.95, $p < .001$, $\eta^2 = .249$]. Post-hoc tests ($\alpha = .05$) revealed that display inversion and motion reversal each significantly reduced recognition accuracy in all 6 emotions (all F s > 6.7), yet inversion impaired the classification of fear and disgust more than it did the other emotions (Figure 2a), and reversal impaired the classification of fearful and (to a lesser extent) neutral expressions more than it did the other emotions (Figure 2b). All other interactions were not significant. The lack of an interaction between orientation and direction reflects a summative effect of inversion and reversal: participants were less accurate when these stimulus manipulations were combined than when either was implemented singly. Although the classification task of this experiment did not require a speeded judgment, an analysis of response times nevertheless confirmed that the accuracy data did not reflect a speed-accuracy trade-off.

----- Insert Figure 2 about here. -----

We conducted a subsequent analysis to assess the possibility that the greater effects of stimulus inversion and motion reversal on emotion recognition from the patch-light compared to the full-light displays could be due simply to the patch-light displays being more difficult to classify in the upright, forward presentations and thereby more vulnerable to stimulus degradation. A subset of the stimuli was selected for this analysis on the basis of data from a previous (unpublished) forced-choice experiment with the upright, forward displays, according to two criteria. The overall emotion recognition accuracy for the selected patch-light movements ($M = 81.7\%$, $SEM = 2.1$) was equated with that for the corresponding full-light movements ($M = 84.2\%$, $SEM = 1.3$) [$t = -1.73$, $df = 29$, $p > .09$], while maintaining an equal number of examples (5) of each emotion. The original 4-way ANOVA was then rerun with the data for these selected stimuli from the present experiment. All 4 main effects were

again significant, and although overall, full-light expressions were identified more accurately than patch-light expressions, they were equally well recognized in the upright, forward presentations (patch-light: $M = 80.8\%$, $SEM = 2.4$; full-light: $M = 83.5\%$, $SEM = 2.4$). Importantly, the Lighting X Orientation interaction was significant [$F(1, 30) = 11.4$, $p < .005$, $\eta^2 = .275$], suggesting that this effect cannot be accounted for by a simple difference in task difficulty. There was no significant Lighting X Direction interaction, however [$F(1, 30) = 0.007$, n.s.], which does not allow us to rule out a task difficulty explanation for the observed marginal effect in the original analysis.

Finally, in order to reveal any changes in patterns of misclassifications across the different display types, and to confirm the emotional neutrality of the body movements in the neutral set, we carried out single-link cluster analyses of the response frequencies for every combination of displayed emotion and response label. The results revealed very similar patterns of misclassifications regardless of the stimulus manipulation for the full-light displays (Figure 3). However, for the patch-light displays there were more changes in the confusability of emotions with inversion and reversal (especially between fear, anger, and happiness; see Figure 4). In all but the inverted, reversed patch-light displays, neutral gestures were clustered separately from all the emotional gestures. Thus, not only were gestures intended as emotionally neutral the least likely of the 6 emotion categories to be misclassified, but also, on the rare occasions when they were misclassified, there was no single emotion or set of emotions with which they were consistently confused.

----- Insert Figures 3 & 4 about here. -----

Discussion

This study has demonstrated robust effects of stimulus inversion and motion reversal on the classification of basic emotions from patch-light and full-light movie clips of body gestures. Inverting the movies significantly impaired emotion recognition accuracy, but did so more in the patch-light than in the full-light displays, indicating that inversion disrupts the processing of form cues more than it does the processing of kinematic and dynamic cues. Playing the movies backwards also significantly impaired emotion recognition accuracy, but this effect was only marginally greater for the patch-light than for the full-light displays, providing qualified support for the importance of the sequencing of changes in form to judgments of emotions from body gestures. While we cannot be certain that our stimulus manipulations completely eliminated all cues other than kinematics, even when in combination, the substantial reduction in emotion classification performance, especially for the inverted, reversed patch-light displays, attests to the importance of form cues in emotion perception; conversely, the fact that emotion classification performance was still substantially above chance, even in the inverted, reversed patch-light displays, attests to the importance of kinematics in providing cues for emotion perception. While it is likely that inversion of biological motion disrupts the processing of dynamic cues related to movement within the earth's gravitational field (Barclay et al., 1978; Bertenthal, Proffitt, & Kramer, 1987; Bertenthal & Pinto, 1994; Pavlova & Sokolov, 2000; Shipley, 2003), if that were *all* that inversion impaired, then we should not have seen a greater effect of orientation for the patch-light compared to full-light stimuli.

Our results provide partial support for Dittrich et al.'s (1996) modified version of Walk and Homan's (1984) "alarm hypothesis", insofar as the identification of

fearful and disgusted gestures was disproportionately impaired by inversion, suggesting a more important role for static form cues in the recognition of these emotions compared to the other emotions. On this reasoning, however, one would also expect a similar effect for anger, the identification of which was not disproportionately impaired by inversion. Consistent with the idea that an important diagnostic feature of fearful body movements is that they often involve cowering or retreating, which when reversed would appear as advancements (to the neutral stance), fear recognition was also disproportionately impaired by motion reversal.

What specific form-related cues are utilized in emotion perception from body gestures? One suggestion is that the overall shape of particular body postures, such as their angularity or roundedness, informs emotion judgments (Aronoff, Woike, & Hyman, 1992). The inversion effects reported here highlight the importance of ‘relational’ or ‘configural’ cues, whereas the effects of motion reversal tentatively suggest a possible role for spatiotemporal cues (changes in form over time). Inversion of faces is widely thought to disrupt the processing of configural information. Evidence suggests that face inversion affects the coding of second-order relational information, which specifies the metric distances amongst features, more than it does the coding of isolated features or first-order configuration (the relative positions of features) (e.g., Diamond & Carey, 1986; Rhodes, Brake, & Atkinson, 1993). The results of a recent study (Reed et al., 2006) indicate that inverting static, non-emotional body postures particularly affects the processing of structural information, which is defined as first-order configuration plus information about the relative position of features with respect to the whole body (i.e., the structural hierarchy of body parts). There is some evidence to suggest that inversion of whole-body *movements* impairs the processing of configural information per se (Lu, Yuille, & Liu,

2005; Pinto & Shiffrar, 1999), and our results add weight to previous claims that such information plays an important role in subserving emotion perception from body expressions (Dittrich et al., 1996; Stekelenburg & de Gelder, 2004).

In conclusion, the kinematics of body gestures are sufficient for observers to distinguish at least the basic emotions, yet we have demonstrated that form-related, especially configural, information can also provide important cues for emotion recognition. Given the conventional and sometimes symbolic (Buck, 1984) nature of our actors' movements (see Atkinson et al. 2004, for details), we speculate that configurations of static form and their changes over time are more closely associated with representations of *what* people do with their bodies than with how they move them, the latter being specified mostly by kinematics (see also Giese & Poggio, 2003).

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Footnotes

ⁱ For theoretical and practical reasons, research on emotion perception and recognition has focussed predominantly on the ability of people to discriminate or identify “basic” emotions (e.g., Ekman, 1992), such as anger, fear, and disgust, which are distinguished from more complex social and moral emotions, such as jealousy, guilt, and embarrassment. One such reason is that basic emotions are in part defined by characteristic facial expressions. (In more recent writings, Ekman, e.g., 1999, considers that many of these ‘higher’ emotions may in fact be ‘basic’, even if they lack corresponding facial expressions.) Notwithstanding the focus on basic emotions of research with *bodily* expressions, it is less clear whether these basic emotions can be defined by characteristic bodily as well as facial expressions; this issue is ripe for further investigation.

ⁱⁱ Star-jumps are also known as jumping-jacks.

References

- Aronoff, J., Woike, B. A., & Hyman, L. M. (1992). Which are the stimuli in facial displays of anger and happiness? Configurational bases of emotion recognition. *Journal of Personality and Social Psychology, 62*, 1050-1066.
- Atkinson, A. P. & Adolphs, A. (2005). Visual emotion perception: Mechanisms and processes. In L. F. Barrett, P. M. Niedenthal, & P. Winkielman (Eds.), *Emotion and consciousness* (pp.150-182). New York: Guilford Press.
- Atkinson, A. P., Dittrich, W. H., Gemmell, A. J., & Young, A. W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception, 33*, 717-746.
- Barclay, C. D., Cutting, J. E., & Kozlowski, L. T. (1978). Temporal and spatial factors in gait perception that influence gender recognition. *Perception and Psychophysics, 23*, 145-152.
- Bassili, J. N. (1978). Facial motion in the perception of faces and of emotional expression. *Journal of Experimental Psychology: Human Perception and Performance, 4*, 373-379.
- Beintema, J. A., & Lappe, M. (2002). Perception of biological motion without local image motion. *Proceedings of the National Academy of Sciences, 99*, 5661-5663.
- Bertenthal, B. I., & Pinto, J. (1994). Global processing of biological motions. *Psychological Science, 5*, 221-225.
- Bertenthal, B. I., Proffitt, D. R., & Kramer, S. J. (1987). Perception of biomechanical motions by infants: implementation of various processing constraints. *Journal of Experimental Psychology: Human Perception and Performance, 13*, 577-585.

Buck, R. (1984). *The communication of emotion*. New York: Guilford Press.

Casile, A., & Giese, M. A. (2005). Critical features for the recognition of biological motion. *Journal of Vision*, 5, 348-360.

Coulson, M. (2004). Attributing emotion to static body postures: Recognition accuracy, confusions, and viewpoint dependence. *Journal of Nonverbal Behavior*, 28, 117-139.

de Meijer, M. (1989). The contribution of general features of body movement to the attribution of emotions. *Journal of Nonverbal Behavior*, 13, 247-268.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, 115, 107-117.

Dittrich, W. H. (1991). Facial motion and the recognition of emotions. *Psychologische Beitrage*, 33, 366-377.

Dittrich, W. H. (1993). Action categories and recognition of biological motion. *Perception*, 22, 15-22.

Dittrich, W. H., Troscianko, T., Lea, S., & Morgan, D. (1996). Perception of emotion from dynamic point-light displays represented in dance. *Perception*, 25, 727-738.

Ekman, P. (1992). An argument for basic emotions. *Cognition & Emotion*, 6, 169-200.

Ekman, P. (1999). Basic emotions. In T. Dalgleish & T. Power (Eds.), *The handbook of cognition and emotion* (pp.45-60). New York: Wiley.

Giese, M. A., & Poggio, T. (2003). Neural mechanisms for the recognition of biological movements. *Nature Reviews Neuroscience*, 4, 179-192.

Grossman, E. D., & Blake, R. (2001). Brain activity evoked by inverted and imagined biological motion. *Vision Research*, 41, 1475-1482.

Hill, H., Jinno, Y., & Johnston, A. (2003). Comparing solid-body with point-light animations. *Perception, 32*, 561-566.

Hirai, M., & Hiraki, K. (2006). The relative importance of spatial versus temporal structure in the perception of biological motion: An event-related potential study. *Cognition, 99*, B15-B29.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics, 14*, 201-211.

LeDoux, J. (1998). *The emotional brain: The mysterious underpinnings of emotional life*. New York: Simon & Schuster.

Loula, F., Prasad, S., Harber, K., & Shiffrar, M. (2005). Recognizing people from their movement. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 210-220.

Lu, H., Yuille, A., & Liu, Z. (2005). Configural processing in biological motion detection: Human versus ideal observers [Abstract.]. *Journal of Vision, 5*, 23-23.

Mather, G., & Murdoch, L. (1994). Gender discrimination in biological motion displays based on dynamic cues. *Proceedings of the Royal Society of London, Series B: Biological Sciences, 259*, 273-279.

Mather, G., Radford, K., & West, S. (1992). Low-level visual processing of biological motion. *Proceedings of the Royal Society of London, Series B: Biological Sciences, 249*, 149-155.

McLeod, P., Dittrich, W., Driver, J., Perrett, D., & Zihl, J. (1996). Preserved and impaired detection of structure from motion by a "motion-blind" patient. *Visual Cognition, 3*, 363-391.

- Pavlova, M., Krageloh-Mann, I., Birbaumer, N., & Sokolov, A. (2002). Biological motion shown backwards: the apparent-facing effect. *Perception*, *31*, 435-443.
- Pavlova, M., Lutzenberger, W., Sokolov, A., & Birbaumer, N. (2004). Dissociable cortical processing of recognizable and non-recognizable biological movement: Analysing gamma MEG activity. *Cerebral Cortex*, *14*, 181-188.
- Pavlova, M., & Sokolov, A. (2000). Orientation specificity in biological motion perception. *Perception and Psychophysics*, *62*, 889-899.
- Pavlova, M., & Sokolov, A. (2003). Prior knowledge about display inversion in biological motion perception. *Perception*, *32*, 937-946.
- Peelen, M. V., Wiggett, A. J., & Downing, P. E. (2006). Patterns of fMRI activity dissociate overlapping functional brain areas that respond to biological motion. *Neuron*, *49*, 815-822.
- Peterson, M. P., & Rhodes, G. (Eds.) (2003). *Perception of faces, objects and scenes: Analytic and holistic processing*. Cambridge, MA: Oxford University Press.
- Pinto, J., & Shiffrar, M. (1999). Subconfigurations of the human form in the perception of biological motion displays. *Acta Psychologica*, *102*, 293-318.
- Pollick, F. E., Paterson, H. M., Bruderlin, A., & Sanford, A. J., (2001). Perceiving affect from arm movement. *Cognition*, *82*, B51-B61.
- Reed, C. L., Stone, V. E., Bozova, S., & Tanaka, J. (2003). The body-inversion effect. *Psychological Science*, *14*, 302-308.
- Reed, C. L., Stone, V. E., Grubb, J. D., & McGoldrick, J. E. (2006). Turning configural processing upside down: Part and whole body postures. *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 73-87.

Rhodes, G., Brake, S., & Atkinson, A. P. (1993). What's lost in inverted faces? *Cognition*, *47*, 25-57.

Richardson, M. J., & Johnston, L. (2005). Person recognition from dynamic events: The kinematic specification of individual identity in walking style. *Journal of Nonverbal Behavior*, *29*, 25-44.

Runeson, S., & Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology: General*, *112*, 585-615.

Sawada, M., Suda, K., & Ishii, M. (2003). Expression of emotions in dance: relation between arm movement characteristics and emotion. *Perceptual and Motor Skills*, *97*, 697-708.

Shipley, T. F. (2003). The effect of object and event orientation on perception of biological motion. *Psychological Science*, *14*, 377-380.

Stekelenburg, J. J., & de Gelder, B. (2004). The neural correlates of perceiving human bodies: an ERP study on the body-inversion effect. *Neuroreport*, *15*, 777-780.

Sumi, S. (1984). Upside-down presentation of the Johansson moving light-spot pattern. *Perception*, *13*, 283-286.

Troje, N. F. (2002). Decomposing biological motion: a framework for analysis and synthesis of human gait patterns. *Journal of Vision*, *2*, 371-387.

Troje, N. F. (2003). Reference frames for orientation anisotropies in face recognition and biological-motion perception. *Perception*, *32*, 201-210.

Vaina, L. M., Cowey, A., LeMay, M., Bienfang, D. C., & Kikinis, R. (2002). Visual deficits in a patient with 'kaleidoscopic disintegration of the visual world'. *European Journal of Neurology*, *9*, 463-477.

Verfaillie, K. (2000). Perceiving human locomotion: Priming effects in direction discrimination. *Brain and Cognition, 44*, 192-213.

Walk, R. D., & Homan, C. P. (1984). Emotion and dance in dynamic light displays. *Bulletin of the Psychonomic Society, 22*, 437-440.

Figure Captions

Figure 1. Mean percentage correct forced-choice emotion classification for full-light and patch-light body gesture movie clips (a) in upright and inverted displays, and (b) played forward and in reverse. Error bars indicate standard errors of the means (SEMs).

Figure 2. Mean percentage correct forced-choice emotion classification for body gestures (full-light and patch-light combined), as a function of emotion and (a) display orientation, and (b) motion direction. Error bars indicate SEMs.

Figure 3. Dendrograms constructed from single-link cluster analyses on the basis of the Euclidean distance between response frequencies for the full-light stimuli, for each emotion under each of the orientation and motion direction manipulations.

Figure 4. Dendrograms constructed from single-link cluster analyses on the basis of the Euclidean distance between response frequencies for the patch-light stimuli, for each emotion under each of the orientation and motion direction manipulations.

Figure 1.

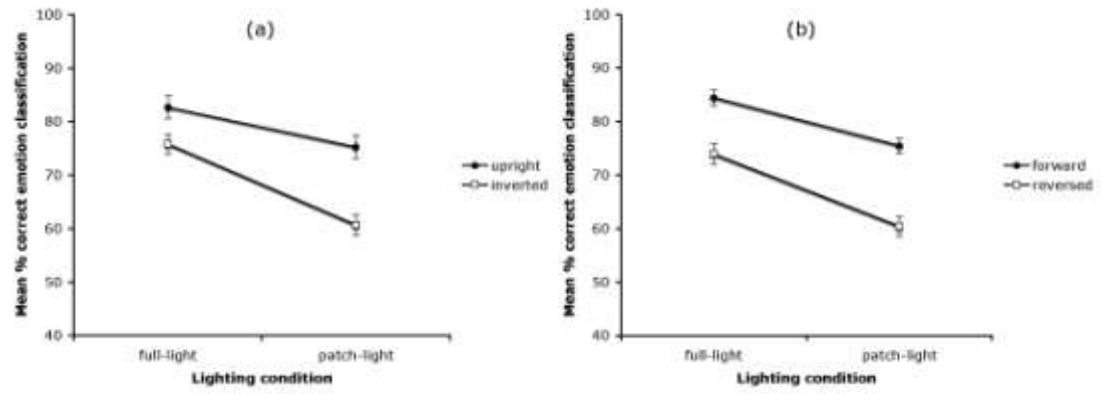


Figure 2.

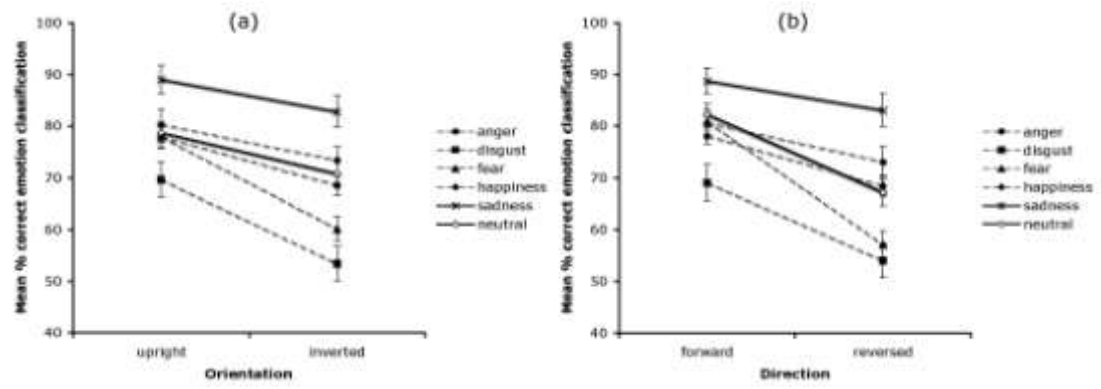


Figure 3.

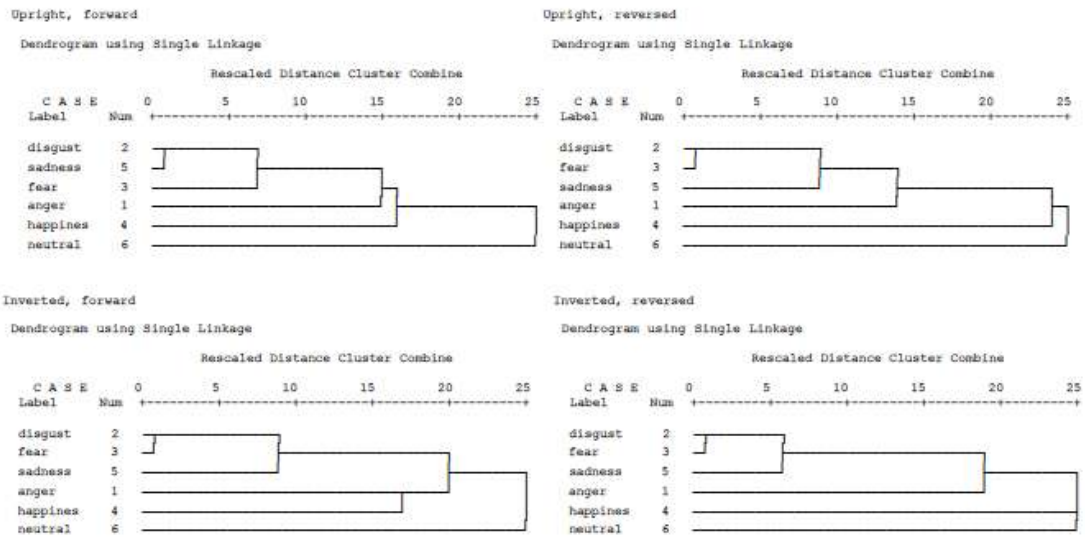


Figure 4.

