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Emotion perception from dynamic and static body expressions in point-light and full-light displays

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Abstract. Research on emotion recognition has been dominated by studies of photographs of facial expressions. A full understanding of emotion perception and its neural substrate will require investigations that employ dynamic displays and means of expression other than the face. Our aims were: (i) to develop a set of dynamic and static whole-body expressions of basic emotions for systematic investigations of clinical populations, and for use in functional-imaging studies; (ii) to assess forced-choice emotion-classification performance with these stimuli relative to the results of previous studies; and (iii) to test the hypotheses that more exaggerated whole-body movements would produce (a) more accurate emotion classification and (b) higher ratings of emotional intensity. Ten actors portrayed 5 emotions (anger, disgust, fear, happiness, and sadness) at 3 levels of exaggeration, with their faces covered. Two identical sets of 150 emotion portrayals (full-light and point-light) were created from the same digital footage, along with corresponding static images of the 'peak' of each emotion portrayal. Recognition tasks confirmed previous findings that basic emotions are readily identifiable from body movements, even when static form information is minimised by use of point-light displays, and that full-light and even point-light displays can convey identifiable emotions, though rather less efficiently than dynamic displays. Recognition success differed for individual emotions, corroborating earlier results about the importance of distinguishing differences in movement characteristics for different emotional expressions. The patterns of misclassifications were in keeping with earlier findings on emotional clustering. Exaggeration of body movement (a) enhanced recognition accuracy, especially for the dynamic point-light displays, but notably not for sadness, and (b) produced higher emotional-intensity ratings, regardless of lighting condition, for movies but to a lesser extent for stills, indicating that intensity judgments of body gestures rely more on movement (or form-from-movement) than static form information.

1 Introduction

Everyday life involves many social interactions in which nonverbal communication plays a significant part. In this way, emotions or other expressive statements can be shared and constitute a social setting for our actions. Movement of the body or its parts makes a substantial contribution to nonverbal communication. Therefore, it is necessary to understand our abilities to use this motion information to distinguish between basic emotional states and identify what is impaired when emotion recognition as a form of nonverbal communication breaks down.

Studies of people with circumscribed deficits in emotion perception and brain-imaging studies of neurologically intact participants indicate a degree of emotion-specific functional organisation of the neural substrate for perceiving fearful and disgusted static

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facial expressions (for a review, see Calder et al 2001). It is not yet known whether these findings extend to dynamic expressions. We therefore report the first stages in the development of a new set of dynamic and static whole-body expressions of basic emotions, in both point-light (PL) and full-light (FL) forms. Our aims were to examine whether these body-expression stimuli would yield patterns of recognition accuracy in neurologically normal adults similar to previous findings, and to examine how increasing the degree of exaggeration of body movements would influence recognition accuracy and judgments of emotional intensity.

1.1 *Neuropsychological background*

The perception and interpretation of other people's feelings is essential to effective social interaction. Witness, for example, the impaired social functioning manifest in certain neurodevelopmental and psychiatric conditions, such as autism and schizophrenia, that can be directly attributed (at least in part) to deficits in the ability to perceive and respond appropriately to the emotional displays of others (eg Archer et al 1992, 1994; Hobson et al 1988).

There is much to be gained by studying cases in which the normal processes involved in the breakdown of emotion perception, both for our understanding and eventual rehabilitation of people with disorders of emotion, and for our understanding of normal emotional functioning and its role in social interaction. Our study is set against the background of a body of research that suggests that the perception of certain basic emotions, as expressed in the face and perhaps also in the voice, is subserved by distinct neural substrates (Calder et al 2001). Emotion-specific recognition deficits revealed with the use of static stimuli provide evidence that distinct and nonoverlapping neural structures are involved in the perception of fear and disgust. Patients with bilateral amygdala damage have particular difficulty recognising fearful and sometimes angry facial expressions, but have relatively little difficulty recognising other emotions expressed in the face, such as disgust, happiness, and sadness (eg Adolphs et al 1994, 1999; Broks et al 1998; Calder et al 1996). In contrast, people with damage to the anterior insula and surrounding tissue have particular difficulty recognising facial expressions of disgust, but are not so impaired at recognising other facial expressions, including fear and anger (eg Calder et al 2000a; Sprengelmeyer et al 1996, 1997). This double dissociation is supported by functional brain-imaging evidence: the amygdala is particularly active when normal subjects view static expressions of fear, but when they view static expressions of disgust, the anterior insula is one of the most active regions (eg Morris et al 1996; Phillips et al 1997, 1998; Sprengelmeyer et al 1998).

1.2 *Why use dynamic emotional expressions?*

The study of emotion perception in both clinical and normal populations, including the above work, has relied primarily on visually presented static emotional expressions. By far the most common stimuli are photographs of faces. Static body-posture expressions are also occasionally used (eg Sprengelmeyer et al 1999). Responses to these static expressions of emotion are highly consistent. Both static facial displays (eg Ekman and Friesen 1978; Ekman et al 1972) and static body displays (eg James 1932; Sprengelmeyer et al 1999) are sufficient to specify recognisably distinct expressions of at least the basic emotions: happiness, sadness, fear, anger, disgust, and surprise (Ekman 1992). There is, however, a relative paucity of studies that have employed dynamic portrayals of emotion, despite the greater ecological validity of these stimuli.

There is a considerable adaptive advantage in members of highly social species being able to interpret their conspecifics' emotional displays (eg Darwin 1872/1998; Dawkins and Krebs 1978; Plutchik 1980; Schneider and Dittrich 1989), even if those displays are unconnected to the actor's emotional state (Fridlund 1994). Dynamic portrayals of emotional expressions have greater ecological validity than static portrayals because faces and bodies move a great deal in social interactions, especially when we are emotional, whereas emotions portrayed in static images actually correspond only to identifiable peaks or to intermediate stages of socially meaningful movements. It is thus a reasonable working hypothesis to suppose that mechanisms that process movement information might be important components of a neural network, shaped by evolution, for the functions of discriminating and interpreting emotional displays. Indeed, past research points in just that direction. There is considerable evidence for the existence of a neural system, critically involving the superior temporal sulcus (STS), dedicated to the perception of high-level motion stimuli, especially facial and body movements, which is further differentiated with respect to the processing of movements across and within faces and body parts (eg Allison et al 2000; Grossman et al 2000; Haxby et al 2000). There might also be processes within this system specialised for emotional expressions, from faces at least (Narumoto et al 2001). Also, there is a bifurcation in the processing of information conveyed by static form and form-from-movement (Braddick 1992; Oram and Perrett 1994), and the processing of facial expressions relies in part on the perception of form-from-movement, which can be selectively spared after brain damage (Humphreys et al 1993). Moreover, dynamic properties of emotional expressions, such as their time course and vigour, influence recognition performance and ratings of emotional intensity (Kamachi et al 2001; Paterson et al 2001; Pollick et al 2001b, 2003). Thus, studies with static stimuli will not provide a complete account of emotion perception and its neural basis.

Johansson (1973) devised a technique for studying the perception of biological motion that minimises or eliminates static form information from the stimulus but retains motion information. In these point-light (PL) or patch-light displays, the moving figure, such as a body or face, is represented by a small number of illuminated dots or patches, positioned so as to highlight the motion of the main body parts. Video clips are made in which the only visible elements are these bright points. When static, the display can give the impression of a relatively meaningless configuration of points, but when moving this meaningless configuration is transformed into a striking impression of a moving body or face. PL displays are sufficient for people to identify certain characteristics of actors, such as the sex of individuals from their gait (Kozlowski and Cutting 1977; Mather and Murdoch 1994), and the identity of familiar individuals from their gait (Cutting and Kozlowski 1977) or arm movement (Hill and Pollick 2000). PL displays also provide sufficient information for people to judge characteristics of actions or their consequences, such as whether two people are dancing, boxing, or greeting or threatening each other (Dittrich 1993). Of particular relevance to the present study is the fact that PL displays are sufficient for people to identify basic emotions portrayed by body movements (Brownlow et al 1997; Dittrich et al 1996; Walk and Homan 1984), as well as by facial movements (Bassili 1978, 1979; Dittrich 1991; Humphreys et al 1993; Pollick et al 2003).

It remains to be seen whether the emotion-specific recognition impairments introduced above are evident for dynamic as well as static expressions. An early report of a patient with bilateral amygdala damage indicated that she was no better at identifying basic emotions in dynamic than static FL facial expressions (Young et al 1996). Further studies with this and other amygdala lesion patients have shown that the recognition deficit is most evident for expressions of fear in static faces (eg Calder et al 1996), but the apparent lack of facilitation for facial movement has not been followed up. More recently, there has been a report of a patient with brain damage encompassing bilateral insula whose recognition performance significantly improved for dynamic over static facial expressions, except for expressions of disgust (Adolphs et al 2003). To date, there has been only one study of the effects of brain damage on emotion perception from dynamic body expressions: Heberlein et al (in press) found that impairments in judging emotions from PL walkers were associated with damage to several components of a network of neural structures, with the most reliable region of lesion overlap in right somatosensory cortices.

Only a few functional brain-imaging studies have examined the perception of dynamic facial expressions of emotion, and then in FL conditions only (Kilts et al 2003; LaBar et al 2003; Wicker et al 2003). There are currently no functional imaging studies that have used dynamic body expressions of emotion. Furthermore, brain-imaging studies of biological motion are not conclusive at present and further evidence from studies with different types of movement stimuli, such as emotional expressions, is needed to reveal the neurological basis of human-motion processing (eg Dittrich 1999).

1.3 *Why use body expressions?*

Characteristic body movements and postures indicate specific emotional states. This has long been recognised and exploited by actors, directors, and dramatists (eg Roth 1990; Stanislavski 1936). Psychologists have long regarded static body postures as providing information about the quality or specificity of emotions (Darwin 1872/1998; James 1932), but body movements were, until recently, commonly regarded as providing information about the quantity or intensity of emotions but not about their specificity (eg Ekman and Friesen 1974). The consensus is now that many emotions are indeed differentiated both by characteristic body movements and by static postures (Aronoff et al 1992; De Meijer 1989; Wallbott 1998), and that these are effective cues for judging the emotional states of other people in the absence of facial and vocal cues (eg Brownlow et al 1997; De Meijer 1989, 1991; Dittrich 1991; Dittrich et al 1996; Walk and Homan 1984). An interesting application of such regularities between movement patterns and emotions has recently been used in attempts to change the design and behaviour of robots (Breazeal 2002).

As indicated above, body posture and movement stimuli have rarely been used in investigations of emotion perception in clinical populations, and they have been used in only one functional-imaging study of emotion perception. Early indications are that bilateral amygdala damage can disrupt the ability to recognise fear expressed in FL static body postures (Sprengelmeyer et al 1999). However, there has not yet been a systematic study of patients with bilateral amygdala lesions that has used a single set of stimuli consisting of both dynamic and static body expressions in both PL and FL conditions. Nor are there any reports of people with disgust-recognition deficits for static faces being tested with either static or dynamic body expressions. Hadjikhani and de Gelder (2003) functional-imaging study found amygdala and fusiform cortex activation to static, FL fearful compared to neutral body expressions. Further studies are required that employ dynamic, FL and PL as well as static body stimuli, along with expressions of emotions in addition to fear.

1.4 *Why create a new set of stimuli?*

Our long-term aim is to explore and identify the functional organisation and neural substrate of emotion perception by building upon, but going beyond, the now substantial corpus of work with static facial expressions. This will involve examining emotion perception in neurologically intact participants and brain-damaged patients, and conducting brain-imaging studies, by using dynamic body-expression and facial-expression stimuli. Clearly it is important that such a research programme utilises a psychometrically sound, well-normed set of stimuli. The work reported here represents the first stage in the development of what is to our knowledge the first set of dynamic and static, FL and PL body-expression stimuli created expressly for use with patient populations and in functional brain-imaging experiments with neurologically normal volunteers.

Four specific developments to increase the ecological validity of the new set of stimuli over the stimuli employed in previous studies will be highlighted here. First, our PL and FL versions of each emotion portrayal were made from identical recordings (with digital-editing techniques inspired by the work of Thomas and Jordan 2001). This allows for a fairer comparison between the FL and PL conditions because it eliminates the possible confound between the effects of movement without static form information (the PL condition) and the actual emotion-specific differences among the various emotion portrayals.

Second, previous studies of emotion perception from body movements have tended to provide the actors with instructions as to the particular types of movement they are to make, according to some prespecified scheme (eg De Meijer 1989, 1991; Dittrich et al 1996), typically in the form of dance and mime portrayals (eg Brownlow et al 1997; Dittrich et al 1996; Heberlein et al, in press; Walk and Homan 1984). With the aim of achieving greater ecological validity, our actors were given more free reign in their choice how to express a given emotion. As a result, our actors used more conventional and typically well-experienced movements to express basic emotions (eg advancing forward and shaking fists in anger, retreating and cowering with hands raised in fear, jumping for joy) than those seen in previous studies.

Third, previous studies have tended to employ only a small number of actors (typically two or four), despite evidence that there can be considerable variation between actors in their ability to encode emotions (see Wallbott and Scherer 1986). Moreover, having only a small number of actors further restricts the range of movement styles as well as the total number of stimuli from which a suitable test set could be selected.

Fourth, by starting with a large number of stimuli (considerably more than used in previous studies of body expressions) and reporting the recognition scores obtained with all these stimuli prior to selecting the final test set, the data we collect in the future using that selected stimulus set can be assessed with respect to concerns over preselection (Russell 1994, pages 113 – 114). Russell's concern here was that while the facial expressions constituting the actual test sets of many studies had high recognition scores, the much larger stimulus pools from which those expressions were selected returned considerably lower, and sometimes not significantly above chance, emotion-recognition scores. If there is little difference between the recognition scores for our initial large stimulus sets (reported here) and those for the corresponding final test sets (to be presented in future research), then our work will not fall foul of the preselection criticism.

1.5 *Do exaggerated movements increase classification performance and perceived emotional intensity?*

A further feature of the present study that distinguishes it from previous work is its additional focus on the effects of increasing the vigour or exaggeration of the body movements of the actors. Recent research indicates that varying the speed or degree of body movements, or both, will influence recognition accuracy for, and rated intensity of, emotional expressions by participants, but no one has yet directly addressed these issues using both FL and PL whole-body stimuli. There are four main relevant studies here.

First, there is Pollick et al's (2001a) study showing that recognition of movement style was enhanced by spatial exaggeration of animated, FL whole-body tennis serves captured from video of real human movements. Second, Wallbott (1998) found that various emotions portrayed in FL video clips of whole-body movements can be differentiated from each other according to a combination of specific patterns of movements and the vigour or quality of those movements. The third relevant study is Pollick et al's (2001b), in which participants classified the emotions in PL knocking and drinking arm movements. Multidimensional scaling of the classification data revealed that the emotion categories clustered within a psychological space were defined by two dimensions: 'activation' and 'pleasantness'. The activation dimension correlated with the velocity, acceleration, and jerkiness of the arm movements, such that fast and jerky movements tended to be judged as emotions with high activation (eg anger, happiness), whereas slow and smooth movements were more likely to be judged as emotions with low activation (eg sadness). The pleasantness dimension, in contrast (which distinguishes between eg anger and happiness), was more closely correlated with the phase relations between the limb segments. Finally, Paterson et al (2001) found that the speed (and thus duration) of movement differentially affects both emotion classification and intensity ratings of anger and sadness in PL knocking and lifting arm movements. Given these four studies, it is reasonable to suppose that manipulating the vigour of whole-body movements will also affect how they are classified according to emotion and rated in terms of intensity.

Further motivation for examining the influence of exaggerated movements on classification accuracy and rated emotional intensity comes from the following research. First, there is the work with computer-caricatured photographic images of facial expressions: exaggerating the metric differences of facial expressions from a 'norm' or average expression for a particular emotion enhances recognition of those expressions and ratings of their emotional intensity (Benson et al 1999; Calder et al 1997, 2000b). Second, Hill and Pollick (2000) reported that observers recognised individual arm movements that they had learned to discriminate better when shown positively exaggerated versions of these arm movements. It was not absolute duration but exaggerated temporal differences between the individual components of the arm movements that improved discrimination performance. Third, Kamachi et al (2001) found that adjusting the speed and thus duration of FL sequences of dynamic facial expressions created from morphed photographs influenced emotion classification and intensity ratings in different ways, depending on the emotion. Finally, Pollick et al (2003) found that emotional-intensity ratings were enhanced by spatial exaggeration of PL facial movements, while temporal exaggeration had a small effect, insofar as there was a trend for expressions of shorter durations to be rated as less intense.

On the basis of this previous work, we expected that exaggerating body movement would significantly enhance recognition accuracy and judged emotional intensity for the dynamic presentations, in both FL and PL conditions. However, we expected that exaggerating body movement would have relatively little effect on recognition accuracy and judged emotional intensity for the static presentations. For there is evidence to suggest that the spatiotemporal properties of the body and its parts (eg speed and jerkiness) are more important than simply the spatial relations between body parts in conveying differences between emotions and changes in emotional intensity (eg Boone and Cunningham 1998; De Meijer 1991; Wallbott 1998), and, of course, only the spatial relations between body parts are directly perceivable in static displays, not their spatio-temporal properties.

2 Stimulus preparation

2.1 *Apparatus*

The filming took place in front of a black curtain, on a black floor, in a venue where all ambient light was shut out. A Sony DCR-VX2000E digital video camera was used, mounted stationary on a tripod. Two redhead halogen spotlights mounted on tripods were placed either side of the camera, directed at the actor with a wide beam setting. Two stationary, 60 cm ultraviolet strip lights were also directed at the actor.

2.2 *Actors*

Ten actors (five male and five female), aged between 18 and 22 years, were recruited from final year undergraduate classes in Drama or Performing Arts at King Alfred's College, Winchester. Each actor was instructed on his/her performance, on the day of filming, and no actor saw any others' performances—thus helping to ensure a wide range of interpretations and patterns of movement which were spontaneous rather than over-rehearsed. The instructions were minimal (see below), and were devised with the help of a professional actor who carried out a pilot filming session.

2.3 *Recording of body expressions*

The actors wore uniform dark-grey, tight-fitting clothes and headwear, so that all parts of their anatomy were covered. One large and one small suit were created, to ensure a reasonable fit for all actors. The headwear consisted of several layers of tights, which allowed the actor's head orientation and movement to be seen, but not the features or expressions on his or her face. Thirteen 2-cm-wide strips of white reflective tape were placed on the actor: one wrapped around each ankle, knee, elbow, and hand; one on each hip and shoulder; and one on the forehead. Each ankle, knee, elbow, and hand strip completely encircled the limb. The hip strips were positioned horizontally and facing forward from the midpoint of the side of the hip. The shoulder strips were positioned diagonally across the shoulder from front to back. Strips of tape were chosen over smaller patches or single points of light because strips are visible from many more angles, allowing the actor freedom of movement without the strips disappearing too easily in the PL condition. [This is presumably the reason for Johansson's, 1973, comment that "ribbons" of tape placed around the actor's joints are to be preferred "in studies where the actor is moving in curvilinear (as opposed to rectilinear) tracks", page 202.] In contrast to previous studies, strips were placed on the hands rather than the wrists because the results of Wallbott's (1998) examination of body expressions indicated that hand postures and movements were one of the most significant characteristics for distinguishing between emotions.

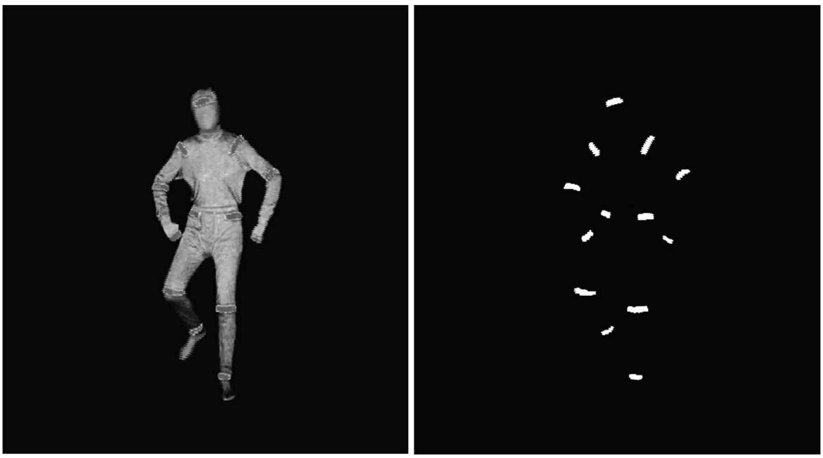
The actors had a workspace encompassing an area of approximately 2 large paces in any direction from their central starting point, within which they were free to move where they liked. The instructions also required the actors to start and finish in a neutral stance (arms by the side, feet shoulder-width apart, facing the camera), and to complete each portrayal within approximately 6 s. This time period was counted aloud for the actors during the filming to ensure the clips were similar in length.

The actors were instructed to portray each of the five emotions (happiness, sadness, fear, anger, and disgust) in turn at 'typical', 'exaggerated', and 'very exaggerated' levels of movement. They 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. (For example, to avoid interpretations of disgust as contempt or moral disgust, it was suggested to the actors that they might want to think about experiencing foul smells or tastes, or seeing something repulsive.) To obtain increasing levels of movement exaggeration, the actors were encouraged to produce their first portrayal of a given emotion with a moderate degree of movement and to make their expressions progressively bigger and more animated for the remaining two portrayals of that emotion.

Expressions of anger portrayed by the actors typically involved expansive movement towards the camera (in 24/30 stimuli), often including shaking of the fists or stamping of the feet, or both, whereas expressions of fear almost without exception involved movement away from the camera (29/30), typically involving contracting or cowering movements, and often including raised hands (22/30), especially in front of the face. Happy expressions, as with angry ones, very often included raising the arms, almost always accompanied by shaking of the fists, either above the head or in front of the body (28/30). Other movements used to portray happiness included jumping up and down and skipping. Expressions of sadness were especially characterised by three types of movement: dropping the head (27/30), bringing the hands to the face or head (20/30), and bringing and often crossing the arms in front of the body (22/30).

In all instances in which the hands were brought to the face or head, the arms were also brought in front of the body. Common movements in expressions of disgust included: bringing a hand (occasionally two hands) to the face, especially in the region of the mouth and nose (21/30), turning the face away from the camera (15/30), dropping the head (13/30), and swiping a hand in front of the face, often repeatedly, as if dispersing a bad smell (10/30).

A total of 150 body-expression movie clips (10 actors $\times$ 3 portrayals $\times$ 5 emotions) were obtained, which were then digitally edited to produce the final 150 FL and corresponding 150 PL clips. Following Thomas and Jordan (2001), our aim was to produce PL and FL video clips from identical recordings. This was achieved with Apple Computer's Final Cut Pro 2.0 and Pinnacle Systems' Commotion Pro 4.0 DV editing software packages. (For an alternative technique, see Hill et al 2003.) In the PL movies the white strips only were visible, whereas with the FL clips the white of the strips was turned grey to match the grey of the clothing as close as possible, leaving the shape of the strips still visible (see figure 1). All movie clips were converted to QuickTime movie files. The clips ranged in length from 4.2 to 8 s (mean = 5.8 s).



(a) (b)

Figure 1. Example stills comprising the identical frame from movies of (a) full-light (FL) expressions and (b) matching point-light (PL) expressions of anger, at the judged peak of the expression.

For the PL-stills condition, single still frames were taken from the PL movies. The stills depicted the peak (or as close to the peak as possible) of each emotional expression. Frames with the least amount of blurring were chosen, to minimise the chances of the participants using this aspect of movement information to inform their responses. The exact same frames were selected from the FL movies to create the FL-stills stimuli. The presentation time for these PL and FL stills was set to 6 s each. Examples of the dynamic and static stimuli can be viewed on the *Perception* website, at http://www.perceptionweb.com/misc/p5096/.

3 Experiment 1: Emotion classification

The first experiment was conducted to assess forced-choice emotion-classification performance with the four sets of body-expression stimuli (FL movies, PL movies, FL stills, and PL stills) in neurologically healthy adults relative to the results of previous studies, and to test the hypothesis that more exaggerated whole-body movements would produce more accurate emotion classification. On the basis of previous research with body and facial expressions, we expected: (a) the emotions displayed in FL movies to be more accurately classified than their PL counterparts, but that both types of display would produce above-chance performance; (b) the emotions displayed in FL stills to be more accurately classified than their PL counterparts; (c) the emotions displayed in movies to be more accurately classified than their static counterparts; (d) classification accuracy to vary between emotions within each of the four conditions; and (e) more exaggerated movements to produce more accurate emotion classification.

3.1 *Method*

3.1.1 *Participants.* A total of thirty-six students from King Alfred's College, Winchester took part, with six different males and six different females undertaking each of three separate experiments. The participants in experiment 1a ranged in age from 18 to 33 years, with a mean age of 22.8 years. Those who took part in experiment 1b ranged in age from 19 to 34 years, with a mean age of 22.5 years. The participants in experiment 1c were aged from 19 to 24 years, with a mean age of 20.4 years. All participants had normal or corrected-to-normal vision and were paid to take part.

3.1.2 *Materials and apparatus.* All stimuli were presented on a 17-inch PC colour monitor run from an Apple G3 iBook laptop computer with PsyScope experimental software (Cohen et al 1993). In order that the two monitor screens were not both visible, a piece of card was placed over the screen of the laptop. Printed on the card were the five emotion labels and the numbers corresponding to the response keys on the keyboard. All stimuli were presented in the centre of the monitor screen, with a frame size of 20 cm in height and 25 cm in width. The viewed height of the actors at their neutral starting points ranged from 10 cm to 12 cm (mean = 11 cm, with a visual angle of 4.5 deg from a viewing distance of 70 cm).

3.1.3 *Design.* The PL-movie and FL-movie conditions were run together in a repeated-measures design (experiment 1a), with their order counterbalanced across participants. The conditions were run in separate sessions to reduce the effects of boredom and fatigue (each session took up to 45 min to complete). There was a seven-day gap between the two conditions for each participant, making it less likely that they would be able to remember any of the 150 expressions or recognise that the same footage was used in both conditions (particularly important for the participants who saw the FL movie clips first, given the greater amount of information available in those clips). All participants were asked not to discuss the experiment with any other participants until all participants had completed both conditions. The PL-stills and the FL-stills conditions were run as two separate repeated-measures experiments (experiments 1b and 1c), with different groups of participants. Within each of the four lighting conditions the stimuli were presented in a pseudorandom order.

3.1.4 *Procedure.* The participants were seated directly in front of and approximately 70 cm away from the monitor screen. Their task was to choose, after the presentation of each stimulus, which one of the five stated emotions was best represented in the movie (or picture), by pressing one of the labelled keys on the laptop keyboard. Standardised instructions prior to the start of the experiment informed the participants that they were going to see a series of short movie clips, or, in the case of the PL-stills and FL-stills experiments, a series of pictures. The participants in the PL-stills experiment were also informed that: (i) each picture was of an actor portraying an emotion; (ii) each actor had worn a dark suit on which were placed uniformly sized and positioned strips of white tape (but they were not told the number or position of the strips); and (iii) the actors were filmed against a black background so only the white strips would be visible. These participants were then shown an example still and informed that the actor in the picture was standing in the neutral position, facing the camera. The aim of this additional descriptive and visual information was to make the PL-stills condition as comparable as possible with the PL-movie condition, strengthening the possibility that any differences in emotion-classification performance between the two conditions could be reliably attributed to the addition of movement information, rather than to a difference in the ease with which the pattern on the screen could be interpreted as a human body.

3.2 *Results*
The overall mean correct forced-choice responses for the three experiments (movies and stills) are shown in figure 2. A series of one-sample t-tests revealed that all emotions in all conditions were correctly categorised above chance level (20%), with the exception of disgust in the PL-stills condition, $t_{11} = 0.53$, ns.

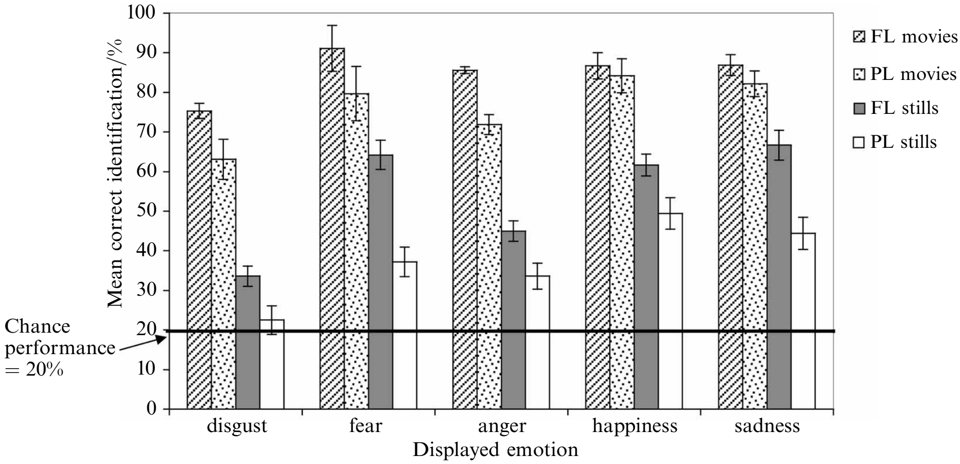


Figure 2. Mean correct forced-choice identification for experiments 1a–1c, by condition and emotion. [Experiment 1a: full-light (FL) and point-light (PL) movies, $n = 12$; experiment 1b: full-light (FL) stills, $n = 12$; experiment 1c: point-light (PL) stills, $n = 12$.]

3.2.1 *Categorisation performance with FL movies compared to PL movies.* The mean correct-categorisation scores for the FL and PL movies were analysed in a repeated-measures ANOVA, with lighting (FL, PL), emotion (anger, disgust, fear, happiness, sadness), and quality of movement (typical, exaggerated, very exaggerated) as the within-subjects factors. There were main effects of lighting ($F_{1,11} = 12.06$, $p < 0.01$, $\eta^2 = 0.523$), emotion ($F_{1.85,\,20.32} = 5.35$, $p < 0.05$, $\eta^2 = 0.327$; sphericity assumption violated, Greenhouse–Geisser reported) and quality of movement ($F_{2,22} = 28.65$, $p < 0.001$, $\eta^2 = 0.723$). These main effects were modified by two two-way interactions.

A significant lighting × emotion interaction ($F_{4,44} = 2.86$, $p < 0.05$, $\eta^2 = 0.206$) indicated that classification performance was better in the FL than in the PL conditions for some emotions but not others (see figure 3). This was confirmed by conducting simple main-effect analyses of the effect of lighting condition for each emotion, separately. Expressions of disgust were correctly classified significantly more often in FL (mean = 75.28%, SEM = 5.81%) than in PL (mean = 63.06%, SEM = 6.81%) displays ($F_{1,11} = 7.37$, $p < 0.05$, $\eta^2 = 0.401$), as were expressions of anger [(FL: mean = 85.56%, SEM = 1.9%; PL: mean = 71.94%, SEM = 5.05%), $F_{1,11} = 10.64$, $p < 0.005$, $\eta^2 = 0.492$] and expressions of fear [(FL: mean = 91.11%, SEM = 0.85%; PL: mean = 79.72%, SEM = 2.51%), $F_{1,11} = 19.04$, $p < 0.005$, $\eta^2 = 0.634$]. In contrast, there was no significant difference in classification performance between FL and PL displays for either expressions of happiness [(FL: mean = 86.67%, SEM = 3.33%; PL: mean = 84.17%, SEM = 4.29%), $F_{1,11} = 1.09$, $p > 0.05$, ns] or sadness [(FL: mean = 86.94%, SEM = 2.61%; PL: mean = 82.22%, SEM = 3.24%), $F_{1,11} = 1.33$, $p > 0.05$, ns].

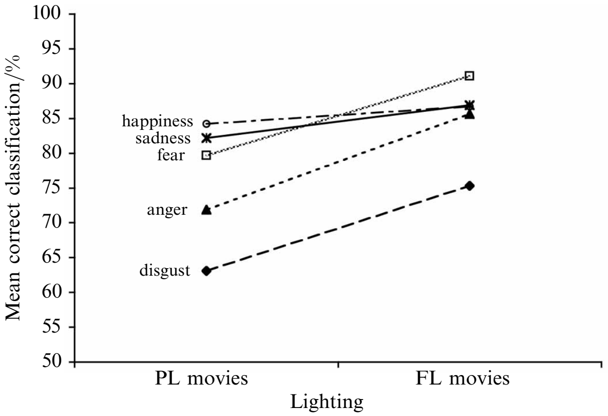


Figure 3. Mean correct forced-choice identification of emotions for full-light (FL) movies versus point-light (PL) movies.

A significant emotion × quality-of-movement interaction ($F_{8,88} = 9.51$, $p < 0.001$, $\eta^2 = 0.464$) indicated that while participants were generally more accurate at classifying emotions as the portrayals increased in exaggeration, this was notably not the case with expressions of sadness, which showed the opposite trend (see figure 4). This was confirmed by conducting simple main-effect analyses. Quality of movement had a significant effect on classification performance for all the individual emotion categories: anger ($F_{2,22} = 12.44$, $p < 0.001$, $\eta^2 = 0.531$), disgust ($F_{2,22} = 8.16$, $p < 0.005$, $\eta^2 = 0.426$), fear ($F_{2,22} = 31.05$, $p < 0.001$, $\eta^2 = 0.738$), happiness ($F_{2,22} = 5.08$, $p < 0.05$, $\eta^2 = 0.316$), and sadness ($F_{2,22} = 4.66$, $p < 0.05$, $\eta^2 = 0.297$). Yet as is clearly shown in figure 4, classification performance for expressions of sadness declined rather than increased as the level of movement increased. Pairwise comparisons ($\alpha = 0.05$, Bonferonni corrected) were conducted to follow-up these significant simple main effects. For expressions of anger and fear, classification performance was significantly better for portrayals that were 'very exaggerated' (anger: mean = 87.92%, SEM = 3.34%; fear: mean = 89.58%, SEM = 1.89%) and 'exaggerated' (anger: mean = 82.08%, SEM = 4.5%; fear: mean = 93.75%, SEM = 1.39%) compared with 'typical' (anger: mean = 66.25%, SEM = 4.4%; fear: mean = 72.92%, SEM = 2.78%), but did not differ between 'very exaggerated' and 'exaggerated' portrayals. For expressions of disgust, classification performance was significantly better for portrayals that were 'very exaggerated' (mean = 75.83%, SEM = 7.07%) compared with 'exaggerated' (mean = 64.58%, SEM = 5.76%) and 'typical' (mean = 67.08%, SEM = 5.52%), but did not differ between 'exaggerated' and 'typical' portrayals. For expressions of happiness, none of the simple pairwise comparisons was significant, although there were trends for 'very exaggerated' (mean = 90.0%, SEM = 3.2%) portrayals to be correctly classified more often than 'exaggerated' (mean = 83.33%, SEM = 4.5%) and 'typical' (mean = 82.92%,

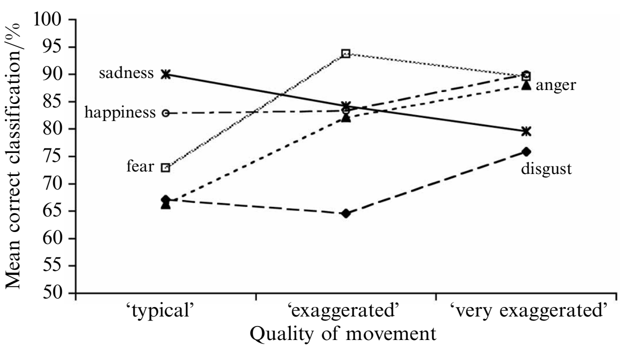


Figure 4. Mean correct forced-choice identification of emotions in dynamic displays for 'typical', 'exaggerated', and 'very exaggerated' portrayals, collapsed across full-light and point-light conditions.

SEM = 3.96%) portrayals (ps = 0.055 and 0.082, respectively). For expressions of sadness, classification performance was significantly less accurate for 'very exaggerated' (mean = 79.58%, SEM = 3.67%) compared with 'typical' (mean = 90.0%, SEM = 1.63%) portrayals, but did not differ between either 'very exaggerated' and 'exaggerated' (mean = 84.17%, SEM = 3.01%) or 'exaggerated' and 'typical' portrayals.

3.2.2 *Categorisation performance with PL movies compared with PL stills.* To compare categorisation performance for the PL movies and PL stills, a 2 (movement) × 5 (emotion) × 3 (quality of movement) mixed-design ANOVA was conducted, with movement as the between-subjects factor, and emotion and quality of movement as the within-subjects factors. There were significant main effects of emotion ($F_{4,88} = 16.82$, $p < 0.001$, $\eta^2 = 0.433$), movement ($F_{1,22} = 81.02$, $p < 0.001$, $\eta^2 = 0.786$), and quality of movement ($F_{2,44} = 16.36$, $p < 0.001$, $\eta^2 = 0.426$). Of particular interest are the latter two main effects. The main effect of movement reflects the fact that participants who classified the emotional expressions in the dynamic PL displays were considerably more accurate (mean = 76.2%, SEM = 2.96%) than the participants who classified the emotional expressions in the static PL displays (mean = 38.6%, SEM = 2.96%). The main effect of quality of movement reflects the fact that 'very exaggerated' (mean = 61.42%, SEM = 2.45%) and 'exaggerated' (mean = 58.58%, SEM = 2.18%) movements yielded reliably more accurate emotion-classification performance than did movements at the 'typical' level (mean = 52.25%, SEM = 2.24%), but did not differ between 'very exaggerated' and 'exaggerated' portrayals.

These main effects were modified by a significant emotion × quality of movement interaction ($F_{8,176} = 3.68$, $p < 0.005$, $\eta^2 = 0.143$) and a significant emotion × quality of movement × movement interaction ($F_{8,176} = 4.34$, $p < 0.001$, $\eta^2 = 0.165$). The three-way interaction, illustrated in figure 5, indicates that, while for PL movies increasing movement exaggeration enhanced recognition of most emotions except sadness, for which it reduced recognition accuracy, the same interaction was not evident for PL stills. This was confirmed by conducting separate emotion × quality-of-movement analyses for the two movement conditions: PL movies ($F_{8,88} = 8.54$, $p < 0.001$, $\eta^2 = 0.437$); PL stills ($F_{8,88} = 1.37$, $p > 0.05$, $\eta^2 = 0.111$, ns). Simple main-effects analyses revealed that variation in quality of movement significantly affected classification of the dynamic PL displays of all emotions except happiness, for which a nonsignificant trend was nevertheless evident ($F_{2,22} = 3.33$, $p = 0.055$, $\eta^2 = 0.232$); anger ($F_{2,22} = 8.44$, $p < 0.005$, $\eta^2 = 0.434$), disgust ($F_{2,22} = 11.92$, $p < 0.001$, $\eta^2 = 0.52$), fear ($F_{2,22} = 21.6$, $p < 0.001$, $\eta^2 = 0.663$), sadness ($F_{2,22} = 5.6$, $p < 0.05$, $\eta^2 = 0.337$). Pairwise comparisons ($\alpha = 0.05$, Bonferroni corrected) were conducted to follow up

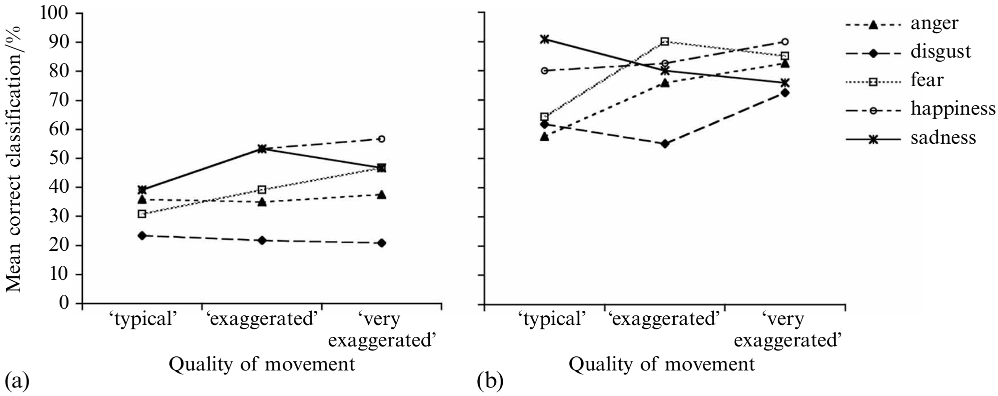


Figure 5. Mean correct forced-choice identification of emotions in the (a) point-light stills and (b) point-light movies conditions for 'typical', 'exaggerated', and 'very exaggerated' portrayals.

these significant simple main effects. Participants were reliably more accurate at classifying dynamic expressions of anger in 'very exaggerated' (mean = 82.5%, SEM = 5.79%) compared with 'typical' (mean = 57.5%, SEM = 6.17%) portrayals, but their performance did not differ between 'exaggerated' (mean = 75.83%, SEM = 6.68%) and 'typical' or between 'very exaggerated' and 'exaggerated' portrayals. A similar pattern obtained for dynamic expressions of sadness, except in the opposite direction: classification performance was worse for 'very exaggerated' (mean = 75.83%, SEM = 3.98%) compared with 'typical' (mean = 90.83%, SEM = 3.36%) portrayals. For dynamic expressions of fear, classification performance was significantly better for 'very exaggerated' (mean = 85.0%, SEM = 3.14%) and 'exaggerated' (mean = 90.0%, SEM = 2.13%) compared with 'typical' (mean = 64.17%, SEM = 4.68%) portrayals, but did not differ between 'very exaggerated' and 'exaggerated' portrayals. For dynamic expressions of disgust, classification performance was significantly better for 'very exaggerated' (mean = 72.5%, SEM = 8.27%) compared with 'exaggerated' (mean = 55.0%, SEM = 6.46%) and 'typical' (mean = 61.67%, SEM = 6.49%) portrayals, but did not differ between 'exaggerated' and 'typical' portrayals. A separate analysis of the effect of quality of movement on emotion classification for the static PL displays revealed a significant main effect ($F_{2,22} = 4.94$, $p < 0.05$, $\eta^2 = 0.31$), reflecting the fact that, collapsed across emotions, 'exaggerated' (mean = 39.67%, SEM = 2.87%) movements yielded reliably more accurate classification performance than 'typical' (mean = 33.33%, SEM = 2.57%) movements, whereas the other pairwise comparisons were not significant ($\alpha = 0.05$, Bonferonni corrected).

3.2.3 *Categorisation performance with FL movies compared with FL stills.* To compare categorisation performance for the FL movies and FL stills, a 2 (movement) × 5 (emotion) × 3 (quality of movement) mixed-design ANOVA was conducted, with movement as the between-subjects factor, and emotion and quality of movement as the within-subjects factors. There were main effects of motion ($F_{2.57,56.46} = 19.95$, $p < 0.001$, $\eta^2 = 0.476$; sphericity assumption violated, Greenhouse – Geisser reported), movement ($F_{1,22} = 174.13$, $p < 0.001$, $\eta^2 = 0.888$), and quality of movement ($F_{2,44} = 3.67$, $p < 0.05$, $\eta^2 = 0.143$). Of particular interest are the latter two main effects. The main effect of movement reflected the fact that participants who classified the emotional expressions in the dynamic FL displays were considerably more accurate (mean = 85.1%, SEM = 1.66%) than the participants who classified the emotional expressions in the static FL displays (mean = 54.2%, SEM = 1.66%). The main effect of quality of movement reflected the fact that, overall, emotion classification was reliably more accurate for 'very exaggerated' portrayals (mean = 71.33%, SEM = 1.33%) compared with those that were 'exaggerated' (mean = 69.5%, SEM = 1.35%) or 'typical' (mean = 68.17%, SEM = 1.38%), but did not differ between 'exaggerated' and 'typical' portrayals (Bonferroni corrected pairwise comparisons, $\alpha = 0.05$).

All three two-way interactions were significant: emotion × movement ($F_{4,88} = 4.82$, $p < 0.005$, $\eta^2 = 0.13$), quality of movement × movement ($F_{2,44} = 8.44$, $p < 0.005$, $\eta^2 = 0.277$), and emotion × quality of movement ($F_{8,176} = 2.37$, $p < 0.05$, $\eta^2 = 0.097$). These two-way interactions were modified by a significant emotion × quality-of-movement × movement interaction ($F_{8,176} = 3.43$, $p < 0.005$, $\eta^2 = 0.135$), illustrated in figure 6. This three-way interaction indicates that the emotion × quality-of-movement interaction differed across the dynamic and static stimuli. This was confirmed by conducting separate emotion × quality-of-movement analyses for the FL-movies and FL-stills conditions, followed by simple main-effects analyses. The emotion × quality-of-movement interaction was evident for both the dynamic FL displays ($F_{8,88} = 3.34$, $p < 0.005$, $\eta^2 = 0.233$) and the static FL displays ($F_{8,88} = 2.65$, $p < 0.05$, $\eta^2 = 0.194$). Yet quality of movement had an effect on only one emotion category in the stills condition,

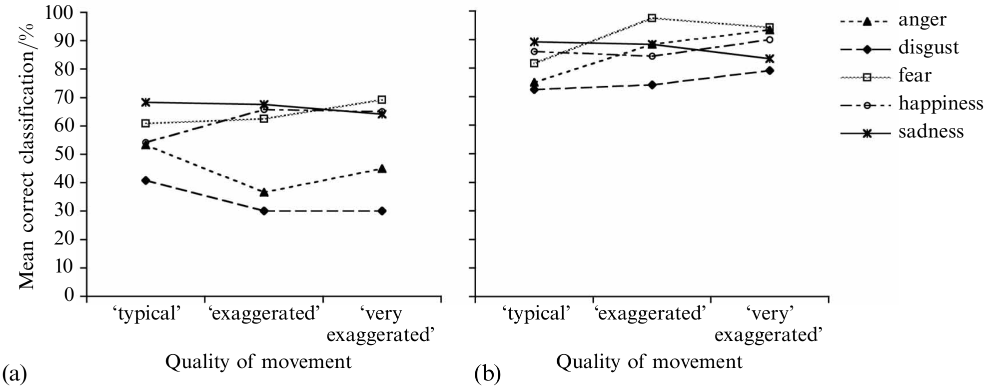


Figure 6. Mean correct forced-choice identification of emotions in the (a) full-light stills and (b) full-light movies conditions for 'typical', 'exaggerated', and 'very exaggerated' portrayals.

namely anger ($F_{2,22} = 9.17$, $p < 0.005$, $\eta^2 = 0.455$), but on both anger ($F_{2,22} = 8.15$, $p < 0.005$, $\eta^2 = 0.425$) and fear ($F_{2,22} = 15.4$, $p < 0.001$, $\eta^2 = 0.583$) in the movies condition. Pairwise comparisons ($\alpha = 0.05$, Bonferroni corrected) were conducted to follow-up these significant main effects. For static FL expressions of anger, 'exaggerated' portrayals (mean = 36.67%, SEM = 4.32%) were correctly classified reliably *less* often than 'typical' portrayals (mean = 53.33%, SEM = 3.55%), while the other pairwise comparisons were not significant. For dynamic FL expressions of anger, 'very exaggerated' portrayals (mean = 93.33%, SEM = 1.88%) reliably enhanced classification performance compared with 'typical' portrayals (mean = 75.0%, SEM = 4.17%), while the other pairwise comparisons were not significant. For dynamic FL expressions of fear, 'very exaggerated' (mean = 94.17%, SEM = 1.93%) and 'exaggerated' (mean = 97.5%, SEM = 1.31%) portrayals were correctly classified reliably more often than 'typical' portrayals (mean = 81.67%, SEM = 2.41%), but there was no difference between 'very exaggerated' and 'exaggerated' portrayals.

3.2.4 *Categorisation-performance error analysis.* Table 1 reports the complete stimulus–response matrix of mean percentage classification scores under each condition. The diagonal entries are scores for the correct response category (where participants' response = actors' intended emotion), which are without exception higher than the rest, reflecting the fact that all emotions were recognised above chance under all conditions (with the exception of PL still images of disgust).

To represent the error data graphically, and with a similar method to that described in Dittrich et al (1996), the confusability of the stimulus and response emotions was taken to be the frequency of each of the 5 emotion labels for each of the emotions presented. A single-link cluster analysis on the basis of the Euclidean distance between response frequencies was employed to generate a dissimilarity matrix and dendrograms, as shown in figure 7. Under dynamic FL conditions (a) expressions of disgust and sadness tend to be confused with each other. There seems to be a tendency to mix up fear with these two emotions as well, in contrast to anger and happiness. The latter tend to be seen as separated from the other emotions and from each other. Under dynamic PL conditions (b) a different pattern seems to emerge. Now, disgust and anger are most likely to be confused. Again, these two emotions seem to be mixed up with fear, in contrast this time to sadness and happiness. If an emotion is mixed up with sadness, it is most likely to be one of disgust, anger, or fear, and not happiness. Sadness and happiness seem highly separated and less likely to be confused. Under static FL conditions (c), anger and happiness group very closely together, and otherwise there is a similar pattern as found under dynamic PL conditions: anger and disgust are grouped,

Table 1. Mean percentage classification scores for each emotion-response category when each emotion stimulus was presented, under four conditions. Figures in bold are for correct responses.

Stimulus	Response				
	anger	disgust	fear	happiness	sadness
Full-light movies					
anger	**85.55**	1.39	1.11	7.78	1.39
disgust	6.67	**75.28**	6.39	2.78	6.11
fear	2.50	11.39	**91.11**	1.11	5.28
happiness	3.33	3.33	0.00	**86.67**	0.28
sadness	1.95	8.61	1.39	1.67	**86.94**
Point-light movies					
anger	**71.94**	6.11	3.05	8.61	2.78
disgust	9.44	**63.06**	9.72	3.89	7.22
fear	5.28	14.44	**79.72**	5.28	6.67
happiness	8.33	4.72	2.50	**84.17**	1.11
sadness	5.00	11.67	5.00	1.11	**82.22**
Full-light stills					
anger	**46.95**	5.83	12.78	23.89	5.28
disgust	10.56	**34.17**	10.00	5.56	7.50
fear	9.44	28.89	**64.17**	5.56	19.44
happiness	29.17	8.33	3.06	**61.67**	1.11
sadness	3.89	22.78	10.00	3.33	**66.67**
Point-light stills					
anger	**36.94**	11.67	12.22	21.67	10.28
disgust	18.61	**23.06**	16.39	7.78	15.56
fear	11.94	27.22	**38.89**	12.50	21.94
happiness	22.22	9.72	8.61	**49.72**	5.83
sadness	10.28	28.33	23.89	8.33	**46.39**

distinguished clearly from fear and even more clearly from sadness. Under static PL conditions (d), we found the same basic pattern of linkage as under dynamic FL conditions although, in general, showing far less distance or higher similarity between emotions.

3.3 *Discussion*

Observers were able to recognise emotions from body expressions alone (without accompanying facial expressions), indicating that (i) emotions in short dynamic scenes are readily recognisable and (ii) that this ability is not restricted to FL conditions but remains intact for PL presentations and to a lesser degree for static images. On the basis of confusion matrices there were two clusters of confusable emotions, 'positive' (happiness) and 'negative' (fear, sadness, disgust), but it was not clear in which cluster anger belonged.

Our results confirm findings (eg Dittrich 1991; Dittrich et al 1996; Wallbott 1998) that human-movement information can convey information about emotional body expressions. Furthermore, the overall result that recognition success clearly differed for individual emotions corroborates these earlier results about the importance of distinguishing differences in movement characteristics for different emotional expressions. The error confusion dendrogram for FL conditions is in keeping with earlier findings on emotional clustering (eg Dittrich et al 1996; Scherer et al 1986). As Dittrich (1999) argued, however, one should not rule out additional cognitive factors such as feature selection, familiarity, or typicality that could also play a role in biological-motion recognition.

Our findings, overall, are consistent with the notion that the brain makes specific use of dynamic information in processing expressions of individual emotions (Dittrich et al 1996).

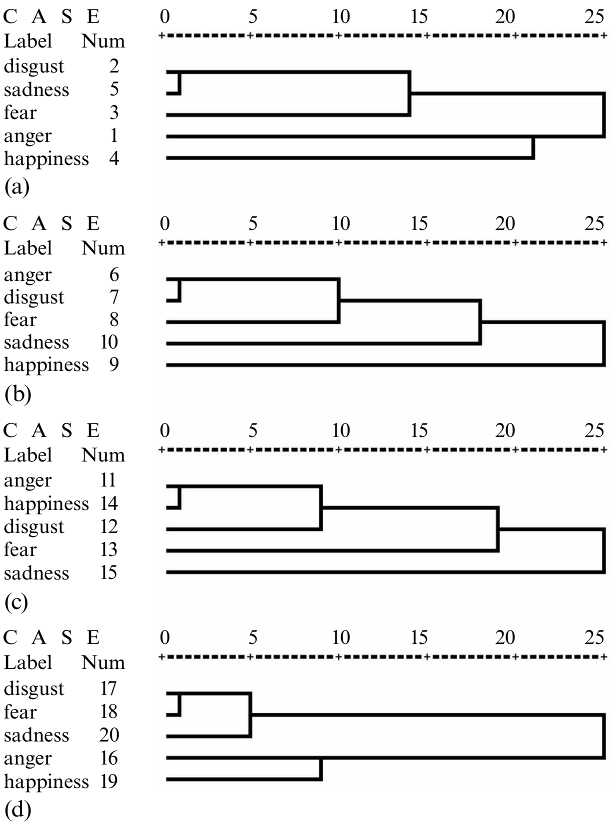


Figure 7. Four dendrograms of the recognition rates for each emotion in each condition: (a) dynamic full light, (b) dynamic point light, (c) static full light, (d) static point light.

However, we did not confirm Walk's (1984) 'alarm hypothesis', according to which expressions of anger and fear are easier and more readily recognised than other emotions. We found that under biological-motion conditions anger was relatively poorly recognised compared with the other emotions (except disgust).

Our main result over and above these corroborations of previous findings was that the more the actors exaggerated their emotion portrayals (ie increased the degree and speed of movement), the more accurate people tended to be at identifying the emotion. This effect was most evident in the dynamic PL displays, with the notable exception of sadness expressions, which showed the opposite trend. Increased movement exaggeration enhanced classification accuracy for two of the five emotions (fear and anger) in dynamic FL displays, and was also evident for the static PL displays, although less markedly than for the dynamic displays. There was no such trend for the static FL displays (indeed, one emotion—anger—showed the opposite trend). There was no significant decrement (or increase) in classification accuracy with increasingly exaggerated portrayals of sadness for the dynamic FL displays, nor for the PL or FL static displays.

4 Experiment 2

What these findings do not yet tell us directly is whether people perceive exaggerated body movements as more emotionally intense portrayals than the less exaggerated body movements. Experiment 2 was conducted to answer this question. On the basis of previous research with body and facial movements (eg Paterson et al 2001; Pollick et al 2003), we expected that ratings of emotional intensity would increase with increasing exaggeration of movement.

4.1 *Method*

4.1.1 *Participants.* Twelve university students (six females and six males) took part in this experiment. They were aged 18 to 23 years, with a mean age of 19.8 years, and all had normal or corrected-to-normal vision. They were paid to take part.

4.1.2 *Materials and apparatus.* All 150 FL and 150 PL movie stimuli used in experiment 1 were employed in this experiment. An additional 30 example body-expression movie clips were also employed, consisting of 3 FL and 3 corresponding PL versions of each of the 5 emotions. These additional stimuli were selected from 'out-takes' of the filming sessions with the ten actors.

The stimuli were presented to the participants with the same computer hardware and software as in experiment 1, and were presented in the centre of the larger monitor screen, with exactly the same dimensions and visual angles as before. The piece of card placed over the laptop's screen this time reminded the participants of the 9-point rating scale and the appropriate numbers corresponding to the 9 response keys on the keyboard.

4.1.3 *Design.* The basic design was the same as for experiment 1: the PL and FL movie stimuli were presented as separate conditions in a repeated-measures design, with the conditions run in separate sessions and their order counterbalanced across participants. (This time the gap between experimental sessions was between 24 and 48 h.) However, instead of all the stimuli being blocked together in each condition, for this experiment the stimuli were blocked within each condition according to emotion. Thus there were five blocks of trials within each condition: anger, disgust, fear, happiness, and sadness. A different random ordering of these blocks was chosen for each participant in each experimental session. Within each block the stimuli were presented in a pseudorandom order. Prior to the start of each block, the 3 example body expressions of that particular emotion (in the appropriate lighting condition) were presented to the participants in order of the level of exaggeration, from lowest to highest.

4.1.4 *Procedure.* The basic procedural details were the same as for experiment 1. This time, however, the instructions informed the participants that they were going to see a series of short movie clips, with each clip showing a moving figure expressing a single emotion, and that the clips were grouped by emotion into 5 sets ie expressions of fear, anger, disgust, happiness, and sadness. At the beginning of each block the participants were informed by an instruction screen which emotion they were about to see expressions of in the subsequent clips. After this instruction screen the 3 example stimuli appeared, to which the participants were not required to respond. In each block, these example stimuli were followed by the 30 test stimuli, which the participants were asked to rate according to perceived emotional intensity using a 9-point scale, where 1 = very low intensity and 9 = very high intensity. After each stimulus they were presented with this scale and asked to make their response by pressing the appropriate number key on the keyboard.

4.2 *Results*

Figure 8 shows the mean emotional-intensity ratings for each level of movement exaggeration under FL and PL conditions. This figure shows a progressive increase in mean intensity ratings as movement exaggeration increased, but that lighting had no effect on these ratings. This was confirmed by conducting a 3 (quality of movement) $\times$ 5 (emotion) $\times$ 2 (lighting) within-subjects ANOVA. There were significant main effects of quality of movement ($F_{1.17, 12.88} = 463.43$, $p < 0.001$, $\eta^2 = 0.977$; sphericity assumption violated, Greenhouse–Geisser reported), and emotion ($F_{4,44} = 7.39$, $p < 0.001$, $\eta^2 = 0.402$) but no effect of lighting ($F_{1,11} = 0.52$, ns). The main effects were modified by a significant quality-of-movement $\times$ emotion interaction ($F_{8,88} = 7.91$, $p < 0.001$,

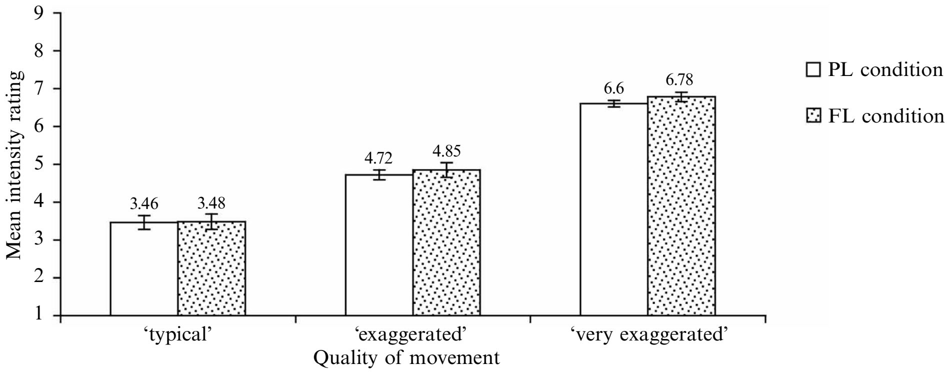


Figure 8. Mean emotional-intensity ratings for 'typical', 'exaggerated', and 'very exaggerated' dynamic portrayals under point-light (PL) and full-light (FL) conditions.

$\eta^2 = 0.418$). Simple main-effects analyses showed that variations in quality of movement influenced intensity ratings for all emotion categories: anger ($F_{2,22} = 187.28$, $p < 0.001$, $\eta^2 = 0.945$), disgust ($F_{2,22} = 241.79$, $p < 0.001$, $\eta^2 = 0.956$), fear ($F_{1.15,12.64} = 184.78$, $p < 0.001$, $\eta^2 = 0.944$; sphericity assumption violated, Greenhouse–Geisser reported), happiness ($F_{2,22} = 188.59$, $p < 0.001$, $\eta^2 = 0.945$), and sadness ($F_{1.12,12.3} = 203.54$, $p < 0.001$, $\eta^2 = 0.95$; sphericity assumption violated, Greenhouse–Geisser reported). All pairwise comparisons ($\alpha = 0.05$, Bonferroni corrected) for these simple main effects were significant for all five emotions (all ps < 0.001). Moreover, as figure 9 clearly illustrates, emotional intensity ratings increased for all emotion categories as movement exaggeration increased from 'typical' (anger: mean = 3.25, SEM = 0.19%; disgust: mean = 3.63, SEM = 0.21%; fear: mean = 3.66, SEM = 0.17%; happiness: mean = 3.86, SEM = 0.22%; sadness: mean = 2.94, SEM = 0.24%) to 'exaggerated' (anger: mean = 4.81, SEM = 0.17%; disgust: mean = 4.49, SEM = 0.22%; fear: mean = 4.88, SEM = 0.11%; happiness: mean = 5.08, SEM = 0.19%; sadness: mean = 4.66, SEM = 0.16%) to 'very exaggerated' (anger: mean = 6.2, SEM = 0.14%; disgust: mean = 6.53, SEM = 0.12%; fear: mean = 6.58, SEM = 0.14%; happiness: mean = 7.19, SEM = 0.13%; sadness: mean = 6.94, SEM = 0.13%). Figure 9 also suggests that expressions of disgust did not show as steep an increase in rated intensity between the 'typical'

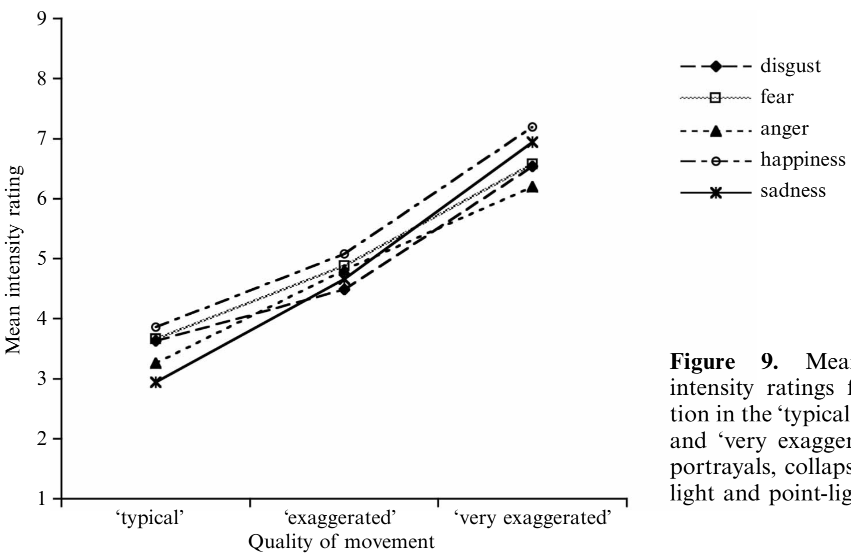


Figure 9. Mean emotional-intensity ratings for each emotion in the 'typical', 'exaggerated', and 'very exaggerated' dynamic portrayals, collapsed across full-light and point-light conditions.

and 'exaggerated' levels of movement, as did the other emotions. Similarly, expressions of anger appeared not to show as steep an increase as the other emotions in rated intensity between the 'exaggerated' and 'very exaggerated' levels of movement.

4.3 *Discussion*

The more exaggerated the body movements the more emotionally intense they were perceived to be. The finding that intensity ratings for the dynamic emotional expressions did not differ across lighting conditions, combined with the assumption that the PL technique eliminates, or at least substantially reduces, static form information, suggests that emotional-intensity judgments rely more on movement (or form-from-movement) than static form information.

5 Experiment 3

We set out to assess the idea that static body form is less efficient in conveying emotional-intensity information than body movements directly, by obtaining emotional-intensity ratings for the static body-posture stimuli. A greater contribution of movement than static form information to emotional-intensity judgments would be indicated by (a) the absence of the clear, stepwise increase in emotional-intensity ratings with increasing levels of movement exaggeration that was obtained with the dynamic stimuli, and (b) little difference between intensity judgments for FL compared with PL static expressions. Furthermore, any differences in intensity ratings between the three levels of exaggeration for the static body postures would indicate that static body-form information can nevertheless contribute to intensity judgments, whereas no difference in intensity ratings across the three classes of static body postures would be consistent with static body-form information having no role in intensity judgments.

5.1 *Method*

5.1.1 *Participants.* Twelve university students (six females, six males) took part in this experiment. They were aged 19 to 54 years, with a mean age of 23.9 years, and all had normal or corrected-to-normal vision. They were paid to take part.

5.1.2 *Materials and apparatus.* This experiment employed all the 150 FL and 150 PL still images of body expressions of emotion.

5.1.3 *Design and procedure.* The design and procedure of this experiment were identical to those of experiment 2, except that the participants were asked to rate the emotional intensity of still images of body postures (rather than moving images).

5.2 *Results*

Figure 10 shows the mean emotional-intensity ratings for the static body-posture expressions in the FL and PL conditions as a function of the quality of movement in the dynamic portrayals from which those still images were extracted. Inspection of this figure shows that, as with the dynamic expressions in experiment 2, there was very little difference in emotional-intensity ratings across lighting conditions for the static expressions. However, unlike experiment 2, mean intensity ratings did not increase with each increasing level of movement exaggeration. Nevertheless, the static expressions taken from the movies with very exaggerated movements were rated as more emotionally intense than the static expressions taken from the movies with the other two (less exaggerated) levels of movement. These impressions were confirmed by a 3 (quality of movement) × 5 (emotion) × 2 (lighting) within-subjects ANOVA, which revealed significant main effects of quality of movement ($F_{1.17,\,12.93} = 77.96$, $p < 0.001$, $\eta^2 = 0.876$; sphericity assumption violated, Greenhouse–Geisser reported), and emotion ($F_{4,\,44} = 7.14$, $p < 0.001$, $\eta^2 = 0.394$), but no effect of lighting ($F_{1,\,11} = 0.12$, ns).

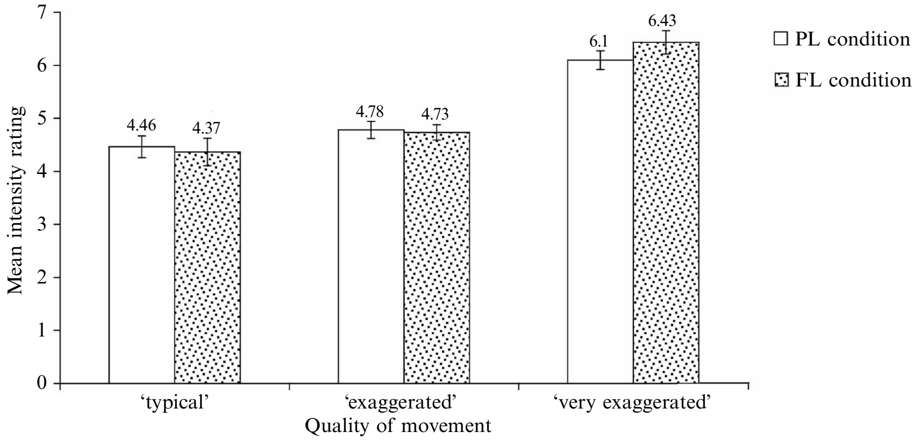


Figure 10. Mean emotional-intensity ratings for the static portrayals taken from movies with 'typical', 'exaggerated', and 'very exaggerated' movement, under point-light (PL) and full-light (FL) conditions.

The main effects were modified by a significant quality-of-movement × emotion interaction ($F_{8,88} = 12.55$, $p < 0.001$, $\eta^2 = 0.533$), depicted in figure 11. Simple main-effects analyses showed that variations in quality of movement influenced intensity ratings for all emotion categories: anger ($F_{2,22} = 21.51$, $p < 0.001$, $\eta^2 = 0.662$), disgust ($F_{1.21,13.28} = 23.92$, $p < 0.001$, $\eta^2 = 0.685$; sphericity assumption violated, Greenhouse–Geisser reported), fear ($F_{2,22} = 43.31$, $p < 0.001$, $\eta^2 = 0.797$), happiness ($F_{2,22} = 76.36$, $p < 0.001$, $\eta^2 = 0.874$), and sadness ($F_{1.11,12.17} = 56.15$, $p < 0.001$, $\eta^2 = 0.836$; sphericity assumption violated, Greenhouse–Geisser reported). Pairwise comparisons ($\alpha = 0.05$, Bonferonni corrected) were conducted to follow-up these simple main effects. For expressions of anger, disgust, and happiness, 'very exaggerated' portrayals (anger: mean = 5.55, SEM = 0.23; disgust: mean = 5.73, SEM = 0.21; happiness: mean = 6.79, SEM = 0.16) were rated as significantly more intense that 'exaggerated' (anger: mean = 4.72, SEM = 0.17; disgust: mean = 4.45, SEM = 0.28; happiness: mean = 5.05, SEM = 0.13), and 'typical' (anger: mean = 4.52, SEM = 0.16; disgust: mean = 4.51,

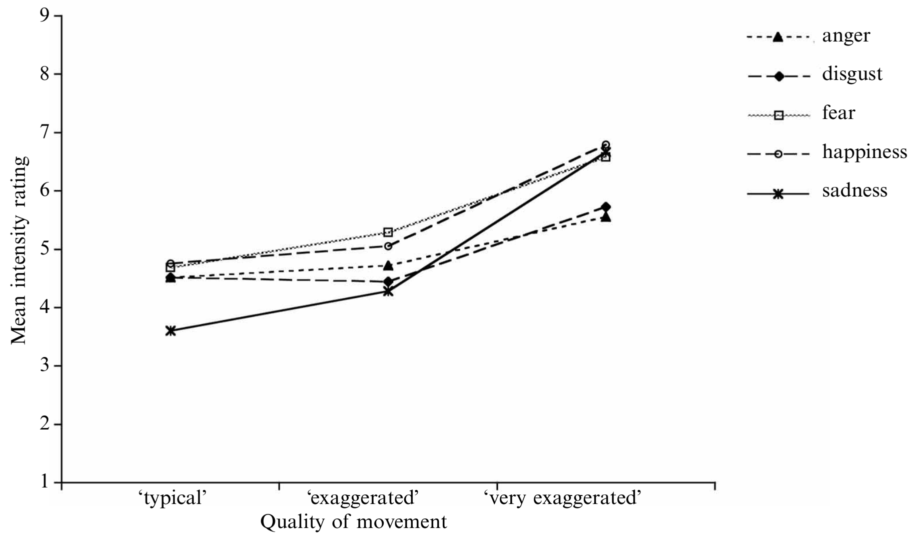


Figure 11. Mean emotional-intensity ratings for each emotion in the static images taken from movies with 'typical', 'exaggerated', and 'very exaggerated' movement, collapsed across full-light and point-light conditions.

SEM = 0.29; happiness: mean = 4.75, SEM = 0.22) portrayals, but there was no difference in ratings between 'exaggerated' and 'typical' portrayals. For expressions of fear and sadness, all pairwise comparisons were significant: 'very exaggerated' portrayals (fear: mean = 6.58, SEM = 0.21; sadness: mean = 6.67, SEM = 0.17) were rated as significantly more intense than 'exaggerated' portrayals (fear: mean = 5.28, SEM = 0.14; sadness: mean = 4.28, SEM = 0.27) which were in turn rated as significantly more intense than 'typical' portrayals (fear: mean = 4.68, SEM = 0.22; sadness: mean = 3.6, SEM = 0.32).

5.3 *Discussion*
The results of experiment 2 suggested that emotional-intensity judgments rely more on movement (perhaps including structure-from-movement) than static form information. The results of the present experiment partially support this suggestion in two respects. First, while the degree of movement exaggeration did influence intensity ratings for the static expressions, this effect was not as consistent across the five emotion categories as it was for the dynamic expressions. Second, participants were generally no better at judging emotional intensity from the FL static expressions than they were from PL static expressions. Nevertheless, the results of this experiment indicate that successful emotional-intensity discriminations can sometimes be made from static body postures. That this result held for PL static postures as well as for FL ones suggests that the static form information required to make these successful intensity discriminations is rather minimal, or that our PL stills contain more static form information than is usually assumed of such stimuli (which coheres with our finding of above-chance recognition accuracy for PL stills for all emotions except disgust), or both.

6 General discussion
The results of the forced-choice recognition tasks reported here corroborate the findings of previous studies that basic emotions are readily identifiable from body movements, even when static form is minimised by use of PL displays. Unlike previous studies, these results were obtained with stimuli in which the body movements portrayed in the FL and PL displays were identical, as they were created from the same footage, eliminating the possible confound of differences in movement between these conditions. Moreover, our study employed a considerably larger and more varied set of stimuli. Recognition accuracy was reliably greater for FL than PL and for moving than static displays, and, except for disgust, was above chance even for PL stills. A more detailed comparison of our classification results with those of earlier studies is set out below.

The present study goes beyond earlier research on body expressions of emotion in its examination of how exaggeration of body movement affects forced-choice classification accuracy and judged emotional intensity. More exaggerated body movements enhanced recognition accuracy, especially for the dynamic PL displays (although dynamic PL expressions of sadness showed the opposite trend). This effect was also evident for dynamic FL displays, although only for expressions of fear and anger, and the general trend was even evident in the static PL but not FL displays. More exaggerated body movements also produced higher ratings of emotional intensity for all emotions in both FL and PL dynamic displays. Intensity ratings for movies did not differ across lighting conditions, indicating that emotional-intensity judgments rely more on movement (or form-from-movement) than static form information. This was partially supported by the intensity ratings for the static stimuli, to the extent that intensity ratings were not enhanced for each level of movement exaggeration for all emotions, as they were for the dynamic displays (even if there was an overall effect of exaggeration on intensity ratings), and that there was little difference in the intensity ratings across lighting conditions for the static expressions.

6.1 *Comparisons of emotion-classification performance across studies*
The results of our forced-choice emotion-classification experiments are similar to the results obtained in previous studies of emotion classification from whole-body expressions (see Appendix). The findings that basic emotions are readily identifiable from whole-body movements, in both FL and PL displays, but that dynamic FL displays are more accurately classified than dynamic PL displays, replicates the results of Dittrich et al's (1996) study, which is the only other one to compare directly classification performance for FL and PL movies. However, one clear difference is that classification scores for PL movies were somewhat higher in the present study than in Dittrich et al's study for all 5 emotions (mean difference = 11.2%). One possible explanation for this could be that the strips of tape used in the present study revealed more body-form information than did the small lamps used in the Dittrich et al study. However, that is unlikely to be the sole reason, for Walk and Homan (1984) obtained marginally higher classification accuracy scores for PL movies than we did, yet their actors had small white cotton balls attached to their dark clothing, which would have revealed less form information than did strips of tape.

Another notable difference between our study and Dittrich et al's (1996) is that the identical overall classification performance for FL movies was not reflected in identical performance for all emotions. In particular, while expressions of anger received very similar classification scores across the two studies (a difference of 3%), our participants were rather more accurate than Dittrich et al's participants for expressions of fear (91.1% to 78.4%, a difference of 12.7%). Indeed, expressions of fear presented the largest difference in classification accuracy of any of the 5 emotions between the two studies in the PL-movies condition as well, our participants again being considerably more accurate (79.7% to 60.4%, a difference of 19.3%). Possible reasons for this consistent difference across the two studies for expressions of fear, and for other differences between the studies discussed here, include: the more conventional or stereotypical emotion portrayals of the present study, compared with the dance and mime portrayals of the other studies; the greater variety of emotion portrayals in the present study; and the fact that, unlike in previous studies, the movement sequence in each emotion portrayal was identical across the FL and PL displays. Despite these differences, a common finding in both studies is that disgust consistently shows the lowest recognition rates.

With respect to the PL-stills conditions, it is clear that classification accuracy was higher in the present study than in Walters and Walk's (1988) study for all 5 emotions (mean difference = 12.9%), with expressions of sadness showing the greatest difference (19.6%), closely followed by expressions of fear and happiness (with differences of 16.7% and 14.3%, respectively). Nevertheless, the relative performance across emotions for the PL stills in these two studies was similar, with disgust expressions being the most poorly recognised (below chance) and happiness being the best recognised. The overall better performance of our participants for PL stills is likely to be attributable, at least in part, to the different nature of the PL stills in the two studies. Walters and Walk's PL-stills stimuli consisted of photographic slides of PL video images displayed on a black-and-white monitor, taken with a long exposure, thus revealing the paths tracked by the white patches as the actor moved. Our own PL stills, in contrast, were freeze-frame images from the judged peak of each expression that contained minimal blurring and minimal information about movement trajectories.

The finding in two separate studies that emotional expressions can be correctly categorised significantly above chance from static PL displays is interesting, given that people typically cannot recognise still PL displays as human figures (Johansson 1973). The findings of Walters and Walk (1988) and the present study suggest that when participants are told that the PL displays depict human-body postures, it is possible for them to classify these postures according to expressed emotions more accurately than would be achieved simply by guessing. Thus it seems that more can be inferred from static PL displays, which contain an apparently "meaningless, random array of light points" (Thomas and Jordan 2001, page 59), than is commonly assumed. We shall return to this issue in the next section.

6.2 *Comparisons of misclassification performance across studies*

Wallbott's (1998) coding scheme for patterns and quality of body movements forms a useful reference point for examining the patterns of emotion misclassification in our study, on the assumption that the more characteristics two types of expression have in common the more likely they are to be confused in classification tasks. The most consistently common confusion in our data was between expressions of disgust and sadness: disgusted expressions tended to be misclassified as sad and sadness expressions tended to be misclassified as disgusted, in both the FL and PL conditions. A very similar pattern of results was found by Dittrich et al (1996), evident in the highly similar error-confusion dendrograms: expressions of disgust and grief in their study were one of the most commonly confused pairs, in both FL and PL displays. According to Wallbott's scheme, body expressions of both disgust and sadness involve passive, low-activity movements with low energy or power. More specific movements that Wallbott found were common in expressing these two emotions were moving the shoulders forward, and moving the head downward, both of which were frequent occurrences in our actors' portrayals. Yet Wallbott's actors often crossed their arms in front of their body when expressing disgust but not sadness, whereas our actors tended to do the converse.

Our results showed that expressions of disgust were also often confused with expressions of anger and fear, more so in the PL than in the FL displays. Dittrich et al (1996) also found that disgust and fear were quite highly confusable, but disgust and anger rather less so. In Wallbott's (1998) coding scheme, expressions of disgust, fear, and cold anger are typically characterised by moderate movement activity. In contrast, hot anger and terror—the latter which we can suppose would be equivalent to the more exaggerated displays of fear in our stimuli—involve high-movement activity, yet our results showed that expressions of fear and anger themselves were not highly confused. This is likely to be due to the rather different style and components of movement adopted by our actors when expressing these two emotions, with fearful expressions characterised by cowering movement away from the camera, and angry expressions characterised by expansive, aggressive movement towards the camera. A common type of movement that expressions of disgust and fear share in Wallbott's scheme is moving the shoulders forward, which is also evident in our stimuli, manifest in hunched over retching movements for disgust and cowering for fear. Expressions of disgust and fear by our actors also had in common the bringing of a hand (occasionally two hands) towards the face, although in the case of fear, more than disgust, such a movement involved holding the hands out in front of the face rather than actually touching the face. It is not clear what specific types of movement might have contributed to the confusability of disgust and anger, as portrayals of these emotions did not appear to have much in common. Instead these results might reflect more of a conceptual rather than perceptual confusability, with disgust sometimes being interpreted in a more moral sense by the participants in the classification experiments than in the intended 'core disgust' sense (Rozin and Fallon 1987; Rozin et al 1993); the former interpretation being closely related to contempt and moral anger (Rozin et al 1999).

There was also a moderate degree of confusion between expressions of anger and happiness. In the FL condition, angry expressions were sometimes misclassified as happy, but not vice versa, whereas in the PL condition, angry–happy confusions were evident in both directions. Dittrich et al (1996) also found that angry and happy expressions tended to be confused in both directions in their PL condition, but not so often in either direction in their FL condition. Expressions of elated joy and hot anger have a lot in common in Wallbott's (1998) coding scheme, being characterised by highly expansive and energetic body movements, as was evident in our stimuli. Moreover, both angry and happy portrayals by our actors frequently included raising the arms and shaking the fists.

6.3 *Effects of movement exaggeration*

The present study went beyond previously published studies of emotion perception from whole-body expressions by examining the effect of increasing the vigour of body movement on classification accuracy and on perceived emotional intensity. First, we found that the more exaggerated the expression, the more easily it was identified. This effect was most consistent across emotions for dynamic PL stimuli, except for expressions of sadness, for which increased movement reduced classification accuracy. For the dynamic FL stimuli, increased movement enhanced classification accuracy for 2 of the 5 emotions, namely, fear and anger. That recognition accuracy for expressions of sadness decreased rather than improved with more exaggerated body movements is consistent with the idea that expressions of sadness are associated with a lack of movement, relative to many other emotions. When one is experiencing sadness or grief, as Darwin (1872/1998) observed, one tends to "remain motionless and passive, or may occasionally rock ... to and fro" (pages 176 – 177). More recently, Frijda (1989) characterised sadness expressed by the body as involving "generally passive posture, and reduced movement and scope" (page 210), and Wallbott's (1998) study found that expressions of sadness were characterised by, inter alia, low movement activity and low movement dynamics. In portraying more exaggerated emotional expressions, our actors tended to make bigger and faster movements, even in the case of sadness. This appears to have decreased the accuracy of our participants in classifying PL dynamic expressions of sadness as movement exaggeration increased. If that is the case, however, it is not clear why the same result did not obtain for the FL dynamic displays. One avenue for future research would be to examine the effect on emotion classification of movement exaggeration in the opposite direction: the effect of decreasing the size and speed of movements relative to the same 'typical' or baseline level of movement.

Second, we also found a clear, direct relationship between the level of movement exaggeration and ratings of emotional intensity: the more exaggerated the body movements, the more intense people judged those expressions to be. This held for all emotions, including sadness, which is perhaps surprising, given that expressions of sadness are not so easily identifiable in their more exaggerated forms. Recall, however, that in the intensity-rating experiments all expressions of a given emotion were grouped together into the same block of trials and for each block participants were told of which emotion they would be judging the intensity.

What exactly is it about increasing the exaggeration of movement that enhances perceived emotional intensity and classification accuracy? Two obvious candidates are the speed or vigour and degree or size of movement. While it is not possible to assess the individual contributions of these variables in our stimuli, for we did not systematically manipulate them, we can nevertheless address this issue from two angles. First, that there was a general trend for enhanced classification accuracy even though the static PL displays might suggest that, insofar as a degree of static form information can be inferred from these stimuli, any variation in the size of body movement reflected in static displays could act as a cue for emotion judgments. Such an argument is, however, weakened by our finding that movement exaggeration did not enhance classification accuracy of static FL expressions. Indeed, given our result of enhanced classification accuracy for the more exaggerated PL but not FL static displays, it is more likely that participants were using traces of speed rather than size of movement cues in the static displays, such as blurring, despite our efforts to minimise these when selecting the movie frames depicting the emotional 'peaks'—cues that informal inspection of our stimuli suggest were more evident in the PL than FL stills.

Second, other studies indicate that the speed or vigour of movement plays a large role in allowing us to both differentiate between emotions and judge their emotional intensity, more so in body than facial expressions. Pollick et al (2001b) found that the velocity, acceleration, and jerkiness of PL arm movements correlated with an emotion's characteristic level of activation or arousal, and thus differentiated amongst those emotions associated with high activation (eg anger, happiness) and those associated with low activation (eg sadness). Variations in the speed and thus duration of PL knocking and lifting arm movements differentially affected classification accuracy for, and rated intensity of, angry and sad expressions in Paterson et al's (2001) study. Angry movements tended to have high velocities, while sad movements had low velocities. When the speed of angry movements was artificially adjusted, participants still tended to classify them as angry and rated the faster ones as more intense and the slower ones as less intense. In contrast, when the speed of sad movements was artificially adjusted, slower sequences were rated as more intense sad movements while faster sequences tended to be categorised as angry. Using fully illuminated movement sequences of morphed still images of facial expressions, Kamachi et al (2001) found that happiness and to some extent surprise were more accurately classified from faster sequences, whereas sadness was more accurately classified from slower sequences, and anger from sequences of medium pace. Longer and thus slower displays of sadness were rated as significantly more intense than shorter sadness displays. While the effect of speed on rated emotional intensity was not statistically significant for the other emotions, there were nevertheless the following trends, which were consistent with the accuracy data: faster happy and surprised expressions tended to be rated as more intense than slower ones, and anger expressions of medium pace tended to be rated as more intense than either faster or slower ones.

Thus, emotion-classification performance and judged emotional intensity can be substantially affected by speed of body movement, and somewhat less so by speed of facial movement. Moreover, there is the suggestion from Hill and Pollick's (2000) study of identity judgments from PL arm movements that it is the temporal differences between individual components of the movements, rather than the overall duration of the movement sequence, that improves discrimination performance. Whether this result will also apply to whole-body expressions of emotion is an open question.

Future work with our stimuli could include manipulations of the speed of movement by, for example, varying the frame rate of the movies. Systematically manipulating the degree or size of movement would be much more difficult with the present stimuli, but could possibly be achieved by first having people rate or code all the stimuli with respect to degree (rather than speed) of movement.

6.4 *Implications for the PL technique*

It is generally regarded that the PL technique for the study of biological motion eliminates or at least substantially reduces static form information (Johansson 1973). If so, then subtracting movement from these stimuli as well, by capturing a still image from each dynamic portrayal, should make perceptual judgments regarding the social meaning of such stimuli very difficult indeed. On this reasoning, in the present case it should be very difficult to judge successfully the emotion category or emotional intensity of still images extracted from dynamic PL portrayals of emotion at the peak of the expression. However, some of the results reported here are surprising in this regard. First, while forced-choice recognition accuracy for the PL static body expressions was significantly lower than for the FL static and PL and FL dynamic expressions, it was nevertheless still above chance level for all emotions except disgust. Second, participants successfully discriminated variation in emotional intensity in dynamic, and, to a lesser extent, in static body expressions, and they did this equally well with PL and FL stimuli. Given these results, we can conclude that our PL expressions contain more cues to form information than is commonly assumed of PL stimuli. While the perceptual complexity of our dynamic PL body expressions is clearly reduced relative to their FL counterparts, the movement (and form-from-movement) information contained in these displays is sufficient for successful discrimination of basic emotion categories and variations in emotional intensity. The perceptual complexity of our static PL body expressions is even more reduced, yet emotion categorisation and emotional-intensity judgments can still be made on the basis of these impoverished stimuli, albeit rather less successfully than for the more complex stimuli.

It is possible that our use of strips of tape wrapped around the actors' limbs and across parts of their bodies has added more static form information to our PL stimuli than the use of smaller patches or dots would have. Nevertheless, we chose to use these strips because we wanted our actors to be free to move around as they wished and small patches or dots would have frequently disappeared from view when an actor's limbs or body were not directly facing the camera. In this initial stage of developing a standardised set of body-expression stimuli, we believe that having slightly less control over the extent to which the PL stimuli might contain static form information was a price worth paying for having as few restrictions as possible on the actors' movements and emotion portrayals, and thus for obtaining a wide variety of common or stereotypical emotional expressions. However, to the extent that one might be able to use these stimuli in future research to assess the contribution of movement information to emotion perception, it might be prudent for the selection criteria for a final test to include a control for the possibility that people are able to extract static form information from the dynamic PL stimuli. One way of achieving this would be to omit from the final test set all those individual PL movies for which the corresponding PL still image (or preferably, a selection of such emotional peaks) was correctly classified above chance.

6.5 *Conclusion*

We have confirmed previous findings that basic emotions are readily recognised from human-body movements, even when static form information is minimised by the use of PL displays, and from static body postures (though to a lesser extent). Our results extend these previous findings to body movements that were identical across the FL and PL displays, and which were more varied and conventional than the dance and mime movements employed in those earlier studies. Furthermore, we have shown, for the first time, that exaggerating whole-body movements increases both the recognisability of the expressed emotions and their rated emotional intensity. This work has allowed us to generate a new, standardised set of body-expression stimuli that avoid some of the shortcomings of existing stimulus sets. Future work with these stimuli will involve the selection of a smaller test set, which will then be used with brain-lesion and psychiatric patients who demonstrate emotion recognition difficulties with facial expressions, and in functional brain-imaging studies with neurologically intact participants. For this future work, we have also developed and are currently testing a set of control stimuli, consisting of FL and corresponding PL emotionally neutral whole-body movements, using the same techniques as described here. We have also shortened these and the emotional-body-movement displays such that they have identical duration, which is important for functional-imaging work, as it avoids the difficulty of accounting for different stimulus lengths in the analysis. Further behavioural baseline data will also be collected for these shortened stimuli.

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APPENDIX

A comparison of mean percentage correct categorisation scores for four studies with whole-body expressions, for each of the five basic emotions they had in common, across three lighting × movement conditions.

	Walk and Homan (1984)	Walters and Walk (1988)[a]	Dittrich et al (1996)[b]	Present study
PL stills				
anger	–	29.3	–	36.9
disgust	–	16.7	–	23.1
fear*	–	22.2	–	38.9
happiness*	–	35.4	–	49.7
sadness*	–	26.8	–	46.4
mean*	**–**	**26.1**	**–**	**39.0**
PL movies				
anger*	88	–	61.2	71.9
disgust	71	–	55.4	63.1
fear*	71	–	60.4	79.7
happiness*	96	–	73.8	84.2
sadness*	75	–	74.4	82.2
mean*	**80.2**	**–**	**65.0**	**76.2**
FL movies				
anger	–	–	88.6	85.6
disgust	–	–	70.0	75.3
fear*	–	–	78.4	91.1
happiness	–	–	95.8	86.7
sadness	–	–	93.0	86.9
mean	**–**	**–**	**85.2**	**85.1**

Note: Point-light stills = PL stills, point-light movies = PL movies, full-light movies = FL movies. (The FL-stills condition is not included in this table, as this condition was not included in any of the comparison studies.)

Emotions marked with an * indicate that there was a notable difference in categorisation scores for these emotions between studies, which is discussed in the text.

[a] Walters and Walk's (1988) PL-stills stimuli consisted in photographic slides of point-light video images displayed on a black-and-white monitor, taken with a long exposure, thus revealing the paths tracked by the white patches as the actor moved.

[b] Dittrich et al's (1996) study did not use classification scores in terms of percentage correct. The percentage figures quoted here have been converted from a table of mean scores in which a score of 5 represents 100% correct identification (see page 733), ie by multiplying the relevant figures in the table by 20.

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