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The Role of Velocity in Affect Discrimination

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Abstract

Two experiments are described that examine the role of speed in the categorisation of affective biological motion displays. For the first experiment movements were recorded for 10 affects and the point-light animations of them were shown to participants in a recognition task. The resultant confusion matrices were analysed using the ALSCAL multi-dimensional scaling procedure and produced a 2-dimensional psychological space. The psychological space for discrimination was similar to that from recent models of experienced affect in that the first dimension corresponded to the activation dimension from these models. A strong correlation between the movement speed and the activation dimension confirmed the finding. From these results it would appear that the mapping between stimulus properties and representation of activation in affect is a fairly direct one. For the second experiment more sad, angry and neutral movements were collected. New movements of different duration, but identical spatial displacement were made using an interpolation algorithm. Observers viewed the movements as point light displays and heir task was to rate intensity of affect. Results from this experiment indicate speed plays a major role in modulating the intensity of activation in perceived affect.

Introduction

Humans can easily tell each other apart and interpret subtle differences in behaviour that communicates intentions, identity and emotions easily. Cues from facial features are used for much of this recognition, however, highly impoverished stimuli - such as point-light displays - convey sufficient information for the recognition of such person properties (Barclay, Cutting & Kozlowski, 1978, Cutting & Kozlowski, 1977; Dittrich, Troscianko, Lea & Morgan, 1986; Hill & Pollick, 2000; Kozlowski & Cutting, 1978; Mather & Murdoch, 1994; Runeson & Frykholm, 1981; Runeson & Frykholm, 1983; Walk & Homan, 1984). The cues that convey this information in biological motion are of primary interest to us and using point light displays of human arm movements, we have concentrated on the recognition of emotion from biological motion.

In exploring the way in which humans recognise affect, it is possible not only to look at the accuracy with which an affect is recognised, but also at the structure of the representation of affect. A number of models for the structure of experienced affect have been suggested that resemble each other in a number of factors (Russell, 1980; Watson and Tellegen, 1985; Thayer, 1989, Larsen and Diener; 1992; Feldman, Barrett and Russell, 1999). The similarities between these models are that the structure of affect is a two-dimensional and continuous structure. This structure is referred to as a circumplex model (Feldman, Barrett and Russell, 1999). The two dimensions of the circumplex models are bipolar and independent. One dimension represents valence (for instance hedonic tone, pleasant – unpleasant) and the other, arousal or activation (arousal – sleep/ activated – deactivated). The models are also continuous, with affects falling on a circle, centred on the origin of the psychological space defined by the two dimensions.

Although these models were established as representing one's own experience of affect, there is recent evident to suggest that experience and perception interact when observing another person's actions (Decety and Grezes, 1999; Rizzolatti, Fadiga, Gallese and Foggassi, 1996). Additionally biological motion relies on both specialised bottom-up processes of motion detection (Mather, Radford and West, 1992; Neri, Morrone and Burr, 1998) and interactions between these and top-down processes (Shiffrar and Freyd, 1990, 1993; Thornton, Pinto and Shiffrar, 1998). In the case of affect perception such a top-down process may well originate from the influence of an internal structure of affect.

It seems reasonable, therefore, to further explore the possible relationship between perception and structure of affect. There is also, currently, little research that concentrates specifically at the recognition of emotion from biological motion. The special case of interpreting stylised dance movements from point-light displays, has received some attention (Dittrich, Troscianko, Lea & Morgan, 1986, Walk & Homan, 1984). Dittrich et al found good evidence that these movements can be expressive, however, they did not address more typical movements.

Two experiments are reported that highlight the relationship between the structure of experienced affect and perception of other's affect from simple arm movements. We also report the importance of the role that the speed of such movements, play in affect discrimination.

Experiments

General Methods

Movement Collection Arm movement data was obtained using a three-dimensional position measurement system (Optotrak, Northern Digital). Actors read the emotional scene setting story and then performed drinking and knocking actions. While they made the movements, the position of their head, right shoulder, elbow, wrist, and the first and fourth metacarpal joints were recorded using infra red emitting diodes.

Each movement record was processed to obtain the start and end of the movement as well as other kinematic properties such as tangential velocity, acceleration and jerk of the wrist. The start of the movement was defined as the point 116 msec before the tangential velocity of the wrist rose above a criterion value, and the end by the point 116 msec after the velocity passed below the criterion. This start/end velocity criterion was defined as 5% of the peak tangential velocity of the wrist. To measure kinematics, instantaneous measures of the wrist kinematics (velocity, acceleration and jerk) were taken and kinematic markers of duration, average velocity, peak velocity, peak acceleration, peak deceleration and jerk index were identified. Jerk index was defined as the magnitude of the jerk averaged over the entire movement and relates to the smoothness of a movement (Flash & Hogan, 1985).

Stimuli In all experiments each recorded point of the arm movement was presented as a point light on a graphics computer (Octane, SGI) from a sagittal view.

Experiment 1

We presented knocking and drinking movements with 10 different affects and measured the ability of participants to categorise affect. We examined the perception of affect within the framework of a psychological space and related aspects of this psychological space to physical properties of the movements.

Methods

Movement Collection Knocking and drinking movements were recorded with affect. Two actors read a brief story that set the emotional scene for each movement. Measurements of the 10 affects (afraid, angry, excited, happy, neutral, relaxed, sad, strong, tired and weak) were obtained. This yielded a total of 120 movements (10 affects X 2 actors X 2 actions X 3 repetitions), however, due to recording difficulties data was lost for 2 movements of one actor.

Stimuli and Participants All 118 movements were displayed as above to fourteen Glasgow University student volunteers. Participants were naïve to the purpose of the study and were paid for their participation.

Design and Procedure Displays were blocked by the possible combinations of actor and action (2 actors x 2 actions). There were 4 trial blocks and a practice session of four trials. The order of blocks was randomised and participants were told that they would see a knocking or drinking arm movement. For each trial, participants viewed a computer display of the movement and were then presented with a dialog box that contained the names of the ten possible affects. Their task was to identify the affect by selecting one of the 10 choices.

Results

Over all the trials participants answered correctly 30% of the time; ranging from 15% (strong) to 50% (afraid) correct, this was significantly better than the chance value of 10% [$t(13) = 20.3$, $p < .005$, two-tailed]. Although the overall recognition rate was not high this

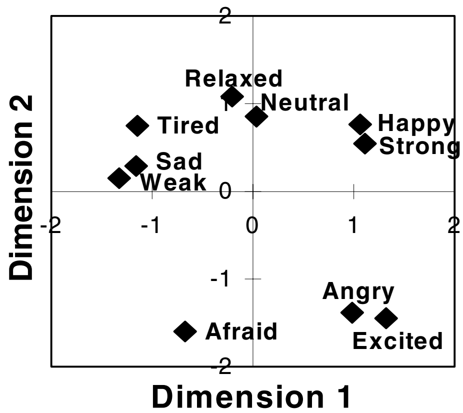


Figure 1. The psychological space obtained for Experiment 1

could be partially accounted for by some consistent misidentifications. For example, weak movements were identified as weak, sad or tired with equal frequency.

To better understand the structure of the results, a psychological space of the affects was constructed using the INDSCAL multidimensional scaling procedure (Kruskal and Wish, 1978). The 10x10 confusion matrix for each of the 4 block conditions was converted to measures of dissimilarity and input to the INDSCAL algorithm. The resultant solution was a unique 2-dimensional psychological space (see Figure 1) with $r^2 = .87$ and stress = .15. The first dimension accounted for approximately 70% of the variance and the second dimension for 17% of the variance. The two-dimensional structure of the psychological space is similar to that which would be predicted from a circumplex model of affect (see introduction) with the first dimension representing activation and the second dimension representing pleasantness.

Comparison of Psychological Space to Movement Kinematics.

We examined the movement kinematics to see whether any physical properties of the movement were related to either of the two dimensions defining the psychological space.

One of the striking things in the movement data is that the kinematic markers we measured consistently and smoothly differed between affects. For instance, sad movements were always slower than neutral movements and both these were slower than angry movement. This seems to correspond to the activation dimension from the models of affect. To test this, the kinematic markers were correlated to Dimension 1 and Dimension 2 co-ordinates of the 10 affects in the psychological space. Results of all these correlations are presented in Table 1, and Figure 2 shows an example of this relationship.

From Table 1 we can see the Dimension 1 (activation) co-ordinate of an affect correlated with the kinematic markers in such a way that energetic movements were positively correlated with shorter duration and greater magnitudes of average velocity, peak velocity, acceleration, deceleration and jerk. For Dimension 2 we found that, to a lesser extent there was a tendency of longer duration and smaller magnitude of the other kinematic markers to be correlated with positive affect. We examined this further by rotating the psychological space to find the orientation that maximised the r-squared values of the correlation with the six kinematic markers. It was found that a 27° counter-clockwise rotation resulted in the highest correlation with the kinematic markers with a r^2 value of 0.88 for Dimension 1 and 0.03 for Dimension 2. From these results it can be seen that while the original psychological space is roughly oriented so that energy in Dimension 1 is correlated with the speed of the movement, rotation of the space can improve the correlation.

Experiment 2

The aim of this experiment was to further investigate the role of speed in the recognition of affect from human movements. New sad, neutral and angry lifting and knocking movements were recorded from 3 women and 3 men. Through time warping (Bruderlin and Williams, 1995) the duration of movements were manipulated to change their speed. The original and morphed movements were displayed as point light stimuli to 10 participants who judged the intensity of affect.

Methods

Movement Collection Movements from 6 actors were recorded as they performed lifting and knocking actions with the three affects - angry, neutral and sad. As before, there were differences between kinematic markers for the movements. Angry movements had the

Table 1. Correlation of Movement Kinematics with Dimension 1 & 2 of psychological space. All values are Pearson's r and are significan at p<.oo5

Kinematic Properties	Dimension 1	Dimension 2
Duration	-0.85	0.65
Average Velocity	0.92	-0.49
Peak Velocity	0.91	-0.53
Peak Acceleration	0.83	-0.68
Peak Deceleration	-0.79	0.57
Jerk Index	0.83	-0.59

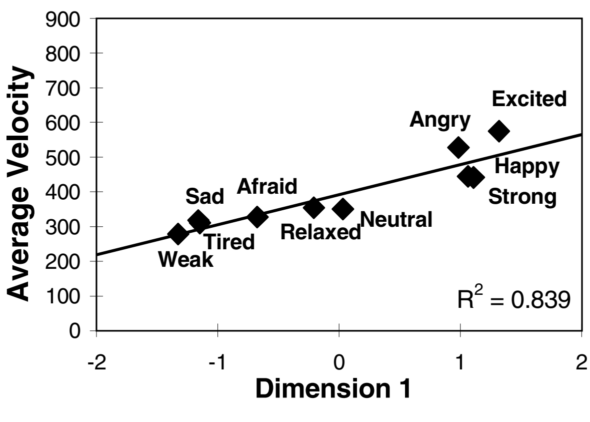


Figure 2. Plot of the average velocity of an affective movement versus the Dimension 1 coordinate obtained in the psychological space. Similar results are obtained for plots of the other kinematic markers versus Dimension 1.

shortest duration and highest velocities and sad the longest duration and lowest velocities.

For each movement the start and end points were defined using their velocity profile. Movement duration was defined as:

Duration = End point - Start point

For each actor a temporal step-size was calculated:

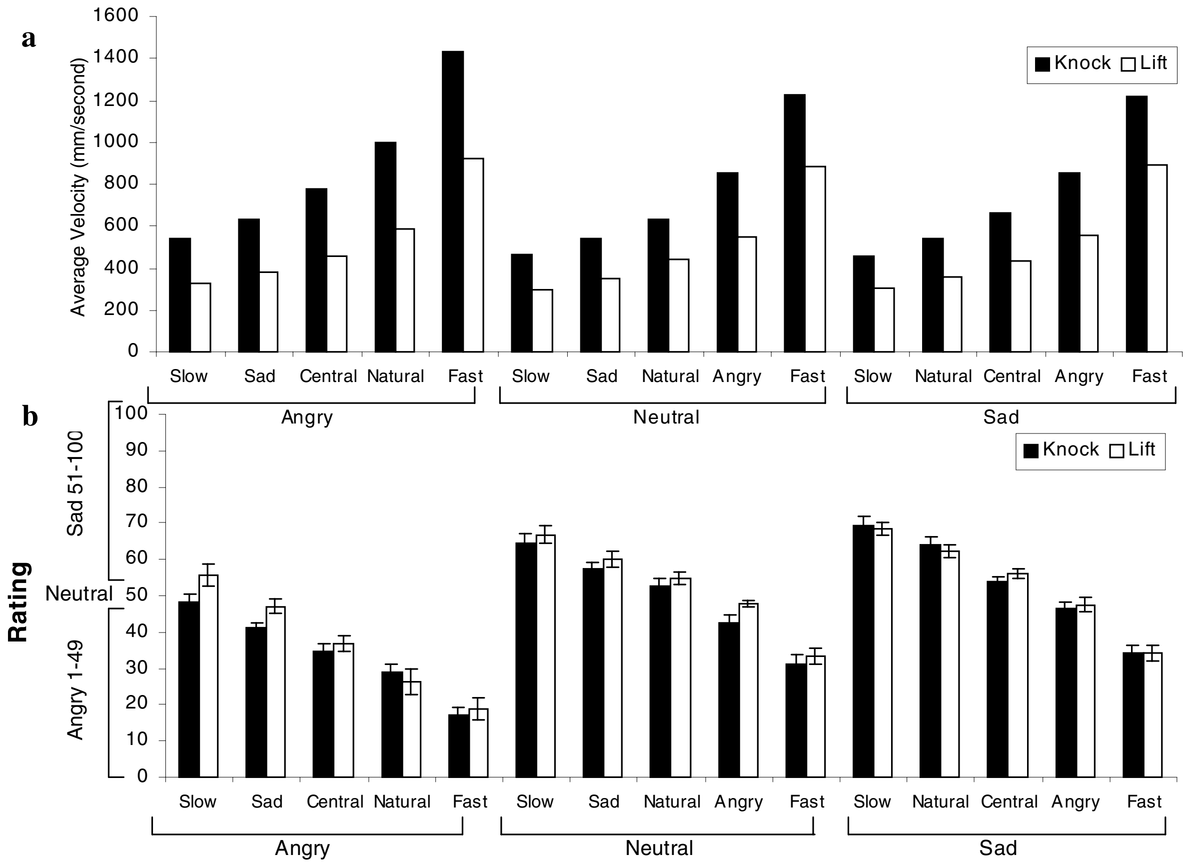
Step-size = (Sad Duration - Angry Duration)/2

The natural movements and the step-size calculation, were used in an interpolation algorithm (Hill and Pollick, 2000) to obtain 5 movements of differing duration for each affect. This yielded 15 movements for each actor, 3 of which were the natural movements. The interpolation preserved spatial properties of the movements such as the distance travelled by points between frames, but caused changes in spatio-tempotal properties, such as the average and peak velocities (see figure 3 and 4a). Movements had the following duration. A slow duration that was slower than the natural sad duration by one step-size; a natural sad duration; a central duration between angry and sad, this was very similar to the natural neutral movement duration; a natural angry duration; a fast duration, faster than the angry duration by 1 step-size. The central duration for neutral movements was the natural duration.

Participants Ten Glasgow University paid student volunteers participated in the experiment. All were naïve to the purpose of the study.

Design and Procedure Displays were blocked by action (2 actions). There were two blocks of trials, randomly ordered between participants. Participants were told that they would see human knocking and lifting movements. For each trial, participants viewed a computer display of the movement and were then presented with a dialog box that contained a 100-point scale for them to manipulate. First participants had to categorise the movement, then to rate its intensity.

A score between 1 and 49 indicates that the movement was perceived as angry, 1 being intense anger and 49, mild anger. A score of 51-100 indicates that the movement was perceived as sad, 51 being mildly sad and 100, intense sadness. A score of 50 indicates that the movement was neutral.



Frigure 3 a) The velocity of movements averaged across 6 actors and b) the rating participants gave to each movement, averaged across 6 actors and 10 participants. The x-axes illustrate the affect and duration used in the interpolation procedure. In b the rating scale is illustrated on the y-axis.

Results

For each affect there was a clear change in the classification and intensity ratings of affect as movement duration increased (figure 4b). This was the case for all three emotions, however, angry movements were seldom categorised as sad or neutral. These results are better illustrated when the rating data is correlated with kinematic markers, table 2 summarises these results.

Table 2. Correlation of kinematic markers with rating data, all values are Pearson's r and are significant at p< .001

Affect	Duration	Peak Velocity	Average Velocity
Angry	0.81	-0.67	-0.62
Neutral	0.91	-0.79	-0.79
Sad	0.96	-0.79	-0.82

Discussion

In this experiment the speeds of affective human arm movements were manipulated by changing movement duration. When new and original angry movements were viewed, they generally retained their identity as angry affect, but the intensity of perceived affect was modulated by velocity changes. Sad and neutral movements were similarly affected by changes in velocity, but faster movements were categorised as angry. These results further emphasise the role of velocity in affect, however, it is clear that there are other properties of the movements that were not controlled by velocity, but that play a role in the discrimination of affect. Currently it is only possible to speculate about what these properties are, but they may include spatial relationships, such as posture, between points of the displays; phase relations between the points or more dynamic properties, such as perceived force. It is clear, however, that velocity plays a major role in the recognition of affect from biological motion displays, particularly in modulating the intensity of perceived affect.

General Discussion

The results of Experiment 1 showed that the perceived affect of arm movements conformed well to models of experienced affect (Russell, 1980; Watson and Tellegen, 1985; Thayer, 1989, Larsen and Diener; 1992; Feldman Barrett and Russell, 1999). Moreover, the activation axis of these models was correlated to physical characteristics of the movement in a consistent manner such that greater activation was related to greater magnitudes of velocity, acceleration and jerk of the movement.

The finding of a circumplex structure for perceived affect is consistent both with duality between the perception and production of movement as well as a role for high-level information in the interpretation of motion derived from human movement. In addition, the continuous structure of the circumplex model parallels the smoothly varying range of speeds with which a movement can be performed. Thus, it would appear that the mapping between stimulus properties and representation of affect is a fairly direct one for the activation axis. However, such a direct connection between stimulus and representation has proven elusive for the second dimension of pleasantness. Other research has suggested that subtle phase relations between the joints (Amaya, Bruderlin and Calvert, 1996) might possibly carry information about affect.

The results from Experiment 2 further showed the way in which speed modulates interpretation of affective movements. However, factors controlling dimension 2 of the psychological space, could not be entirely discounted. For sad and neutral movements it was possible to change the percept to be angry, but angry movements remained discriminable as angry at most speeds. This suggests that angry movements are distinct form the other movements in some other way and that humans are sensitive to this difference. Indeed, angry, afraid and excited movements fell at a different location on the second dimension in Experiment 1, than the other movements. So perhaps whatever properties in the movements control this dimension also act as "danger indicators". From an evolutionary point of view such indicators makes good sense and it could be argued that this would enhance the models of experienced affect, since pleasantness may be just another way of discriminating emotions that a person seek out, from those they avoid.

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