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RESEARCH ARTICLE

Perceiving bodies in motion: expression intensity, empathy, and experience

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Abstract This study investigated the perceptual identification of individuals' intended expression intensity in point-light displays depicting dance. Participants watched point-light displays of 200–1,000-ms duration, as well as static displays, of expressive and inexpressive dance performances. The task was to identify the intended expression intensity of the performer. The results indicate that expression intensity could be discerned reliably only from dynamic displays, even when they were as short as 200 ms, though the accuracy of judgments increased with exposure duration. Judgment accuracy for dynamic displays was positively correlated with self-report empathy indices and confidence in judgments. Accuracy for these displays also correlated with indices of informal music and dance experience. The findings are discussed in relation to sensorimotor and cognitive-emotional processes underlying action understanding and social cognition.

Keywords Action · Perception · Expression · Movement · Biological motion · Empathy

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Introduction

In many forms of social interaction, it is crucial to monitor the intentions of others' actions and their feelings. In certain human activities like music and dance, such capacities enable smooth interactions and creative outcomes, such as moving together as a group, or playing music jointly with others. Previous research has shown that in many activities—including music and dance—motor experience and expertise play a crucial role in social-cognitive processes involved in recognizing, predicting, and understanding the behavior, intentions, beliefs, and emotions of self and others (for reviews, see Knoblich 2008; Keller 2008; Sevdalis and Keller 2011b). Nevertheless, an interesting quality characterizes the perception of others' actions: each individual's movement kinematics are different from those of others—as evidenced by a range of experiments on self-other discrimination—both in individuals with domain-specific expertise and in non-experts (e.g., in tasks such as drawing, walking, playing piano, and dancing; see Knoblich 2008; Sevdalis and Keller 2011a). In these domains, even brief amounts of information related to one's own or others' actions are sufficient for social information—such as identity, intentions, and emotions—to be perceived accurately and reliably (Knoblich 2008; Sevdalis and Keller 2011b). Therefore, it seems that the brain is not only sensitive to differences between actions (i.e., individual differences in movement), but it is also sensitive to similarity in social-contextual cues and goals across individuals' differing actions (i.e., based on commonalities between movements). Which factors enable this flexible facility, and what is the nature of information that is required for these functions to operate effectively?

Accumulating evidence suggests that social cognition is underpinned by behavioral processes and neural mechanisms encompassing motor, emotional, and somatosensory components (Grafton 2009; Keysers and Gazzola 2009). Action resonance mechanisms (i.e., motor activation triggered by the observation of actions) related to the common coding of sensory and motor information have been proposed and tested empirically (Prinz 1990; Hommel et al. 2001) and have been found to share neural resources with 'mirror' and mentalizing networks (Van Overwalle 2009; Van Overwalle and Baetens 2009). These mechanisms operate rapidly and are triggered by a variety of information sources (e.g., facial, vocal, and motor). A heuristic framework incorporating the common coding principle, the mirror system, and social-cognitive brain networks has been of assistance in describing and discussing the various experimental approaches that have been employed to investigate the processes and neural substrates involved in cognitive, emotional, and social aspects of action understanding (Sevdalis and Keller 2011b). An issue of particular importance is to uncover the sources of information included in the common code underlying action and perception, and how they cause the sensory-motor system to resonate. In this study, we focus on dance movements, depicted as point-light displays.

Dance is an ancient form of non-verbal expressive communication. Sevdalis and Keller (2011b) reviewed research that used dance as a tool for uncovering perception–action links and suggested that one pervasive question concerns the factors that underlie action understanding. These may have to do predominantly with motor cues, since (biological) motion is an important source of information in understanding and predicting actions of others in social settings. Experimental manipulations of motion usually change the physical stimulus properties of an action (e.g., complexity of movement, contextual information; e.g., Broughton and Stevens 2009; Sevdalis and Keller 2010). This research indicates that even subtle motor cues are perceived accurately in a bottom-up fashion. Alongside physical stimulus properties and action parameters, top-down factors (and underlying brain networks) may also contribute to understanding others' actions (Grafton 2009; Sevdalis and Keller 2011b). Therefore, unraveling the factors that underpin action understanding and social cognition requires complementary assessment of spatiotemporal cues and cognitive-emotional factors (e.g., empathy and beliefs about one's performance).

Understanding the social connotations of other's actions has functional significance. The capacity to grasp the properties of an action and adjust one's response improves the smoothness of coordination between interacting individuals (Vesper et al. 2010): For example, varying the magnitude of one's actions may enable an observer or a co-acting partner to better predict upcoming actions and engage in successful coordinated activities. In our previous work (Sevdalis and Keller 2011a), we found that discerning between two levels of intended expression intensity in point-light depictions of dance—of one's own, one's co-acting partner, and unfamiliar 'stranger' performers'—was quite accurate with displays of 1-s duration, and that self-reported empathy and confidence ratings were positively correlated with accuracy in expression identification. The results of that study showed higher sensitivity for one's own movements, followed by those of a dance partner, and least for a stranger's movements. Thus, motor experience (observing one's own movements) was more important than visual experience (observing a partner's movements), and these two were better than having no motor or visual experience at all (observing a stranger's movements). We proposed that this sensitivity is based on an action simulation mechanism that depends on both spatial–temporal stimulus properties (i.e., movement amplitude and duration) and individual differences in cognitive-emotional indices (i.e., confidence and empathy).

Here, we examine whether the findings of this earlier experiment can be replicated and extended to even shorter stimulus durations. First, the rapid discrimination found in our previous research invited testing of whether the perceptual limit for accurate discrimination could be pushed to shorter than 1-s stimulus duration. Stimulus durations shorter than 1 s have been reported to be sufficient for other perceptual tasks based on point-light displays (e.g., perceiving a human form as such; Johansson 1976). Similarly, even briefer information displays could be sufficient to judge expression intensity. In addition, we introduced a control static condition in order to assess the potential contribution of non-motor physical stimulus properties (e.g., form and posture) to judgments (cf., Atkinson et al. 2004; Coulson 2004).

Further to the effects of the experimental manipulation of stimulus properties, we investigated individual differences in participants' identification performance. Thus, we reexamined the association of identification accuracy with cognitive-emotional indices, since the evidence found for associations of discrimination performance with cognitive-emotional indices spoke for a role of top-down modulation of performance. Replication in the context of shorter durations would confirm and extend this finding. Finally, in the realm of expert participants, it has been reported that motor expertise facilitates action perception (e.g., Calvo-Merino et al. 2010). Apart from long-term expertise and formal training, subjective (informal) experience associated with an individual's everyday music and dance activities could also provide some perceptual benefit. Thus, we assessed the relation of formal and informal musical and dance experience with the discrimination performance of our participants; even informal experience associated with an individual's everyday music and dance activities might provide some perceptual benefit in our task.

Methods

Participants

Twenty adults (10 females; aged 18–31 years; mean age: 24.75 years) participated in the study in return for financial compensation. They were university students who had no professional dance expertise or focused training in a particular dance style. Eleven out of 20 reported having received music education (mean = 4.73; range: 2–17 years), and 9 out of 20 reported having had dance education (mean = 1.3, range: 6 months-10 years) at some points in their lives. All participants reported to have normal or corrected to normal vision. None of them had previous experience with point-light displays, and they were not informed about the experimental hypotheses. The treatment of the participants complied with the guidelines of the Max Planck Institute for Human Cognitive and Brain Sciences, where the research was conducted. All participants signed a consent form before the experiment began.

Design

The experiment employed a within-subjects design. Motion capture recordings of solo and dyadic dancing, collected previously, were used as stimuli (see Sevdalis and Keller 2011a, for the details of the recording session). Participants rated point-light displays generated from these recordings in a single session. The independent variables of interest were physical stimulus parameters—specifically, expression intensity (expressive vs. inexpressive) and action display duration (1,000, 750, 500, 300, 200 ms, and a static control condition). Indices of self-reported empathy and informal musical/dance experience were included as additional variables. The dependent variables were accuracy and confidence in the task of expression intensity identification.

Materials

The point-light displays that were used as stimuli each depicted an individual dancer in profile views (left or right) using 13 markers located at the head and the main joints (see Fig. 1 & supplementary material). In our previous research (Sevdalis and Keller 2011a), a library of 960 such movies was created. For each of 10 dancers, 96 point-light movies contained all the possible combinations of 2 intensities (expressive and inexpressive), 2 observing conditions (visual and audiovisual, i.e., without or with the music that the dancers had danced to), 2 musical pieces (1st and 2nd piece), 2 tempi (100 and 120 bpm), 2 contexts (solo and dyad), and 3 different excerpts from each dancing performance (segments 20–25 s, 30–35 s, and 40–45 s from each entire movie) (for details of the data collection and stimulus creation, see Sevdalis and Keller 2011a). The frame rate for movie presentation was 24 frames per second.

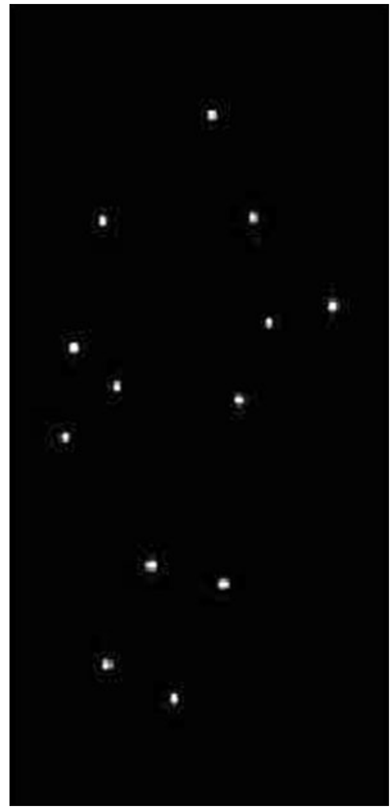

Fig. 1 Point-light depiction of a dancer with 13 markers attached at the head and the main joints of the body

For the current experiment, we selected 6 dancers from this library and used only the purely visual (i.e., silent) displays. This resulted in a total of 288 movies (48 movies per dancer). Thus, the point-light movies depicted the performances of 6 different individuals dancing with two different expression intensities (expressive vs. inexpressive).[1] In order to present the action duration conditions in a counterbalanced fashion, we used a Latin square design for the dancers and the selections. The first participant saw static displays from selection 1 (s1) of dancer 1, 1,000 ms from selection 2 (s2) of dancer 2, 750 ms from selection 3

[1] In the Sevdalis and Keller (2011a) study the participants were invited to execute the dancing action with two intentions for expression intensity (expressive versus inexpressive), in time with each of the two musical pieces. These pieces were composed of different drum loops and instrument samples, but were similar in terms of complexity and were designed to be movement inducing. In the ‘expressive’ condition, participants were instructed to dance to the pieces as they would naturally. In the ‘inexpressive’ condition, participants were instructed to dance with less expression than in the expressive condition. The inexpressive condition always followed the expressive one. The expressive and inexpressive conditions differed significantly in the amount of movement the dancers displayed (Sevdalis and Keller 2011a).

(s3) of dancer 3, 500 ms from s1 of dancer 4, 300 ms from s2 of dancer 5, and 200 ms from s3 of dancer 6. The second participant saw static displays from s1 of dancer 6, 1,000 ms from s2 of dancer 1, 750 ms from s3 of dancer 2, 500 ms from s1 of dancer 3, 300 ms from s2 of dancer 4, and 200 ms of s3 of dancer 5. This procedure was continued for each new participant and repeated from the beginning after every 6 participants. Thus, each individual received 288 trials: 2 intensities (expressive–inexpressive) × 48 point-light movies (according to selection/duration/dancer) × 3 blocks (repetitions). For the dynamic displays, the duration conditions were implemented by playing each movie from the start (first frame) of the 20, 30, and 40th second of the original movie, for 1,000, 750, 500, 300, and 200 ms. The static displays were selected from the start (first frame) of the 20th, 30th, and 40th second of the movies and were presented for a duration of 1,000 ms.

Equipment and procedure

Participants watched the movies on a computer monitor. The point-light figures were projected at a size extending over 11.42 degrees of visual angle; their height was ~10 cm, and the viewing distance was about 50 cm. The session started with the participants completing a block of 6 practice trials, depicting each of the 6 dancers in one of the 6 duration conditions. Examples of both expression intensity conditions were encountered in the practice trials. Before each trial onset, a white fixation cross appeared at the center of the monitor, lasting for 1 s. The participant pressed the space bar to initiate the trial. Stimulus presentation and response collection were controlled by Presentation software (Neurobehavioral Systems).

Participants were required (a) to indicate the dancer's expression intensity (expressive vs. inexpressive) and (b) to rate their confidence about their judgment on a 6-point scale (with anchors: not at all confident—very confident). Responses were registered by mouse click on correspondingly labeled squares on the computer monitor (e.g., for the first task, the left square was labeled 'Inexpressiv (Ausdruckschwach)', indicating 'inexpressive', and the right square was labeled 'Expressiv (Ausdruckstark)', indicating 'expressive'). No feedback about correctness was provided after responses.

At the end of the experiment, participants were administered a questionnaire on musical/dance experience[2] and the Interpersonal Reactivity Index (IRI) questionnaire[3] (Davis 1980) for the assessment of empathy dispositions. The musical/dance questionnaire was constructed with the aim of assessing background information on participants' tendencies to be involved with musical/dance activities. The experimental session lasted 60–70 min.

Results

Expression intensity identification was assessed by computing d′ (see Macmillan and Creelman 1991) as an index of the discriminability of expressive versus inexpressive displays. High d′ scores indicate accurate performance (i.e., high identification accuracy of expression intensity). Although our index of intensity identification accuracy (d′) is a bias-free measure, we also examined potential biases in participants' judgments by computing the criterion c (see Macmillan and Creelman 1991). Analyses of bias indicated that c differed significantly from chance level for static displays [$c = 0.26$, $t(19) = 2.4$, $p = 0.027$] and dynamic displays[($c = -0.15$, $t(19) = -2.82$, $p = 0.011$]. Thus, participants showed a tendency to judge dynamic displays to be expressive and static displays to be inexpressive. This is not surprising if it is assumed that expression in dance requires movement. When collapsed across static and dynamic displays, the criterion c was not significant [$t(19) = -1.71$, $p = 0.10$].

The results for the expressive versus inexpressive display identification analysis are shown in Fig. 2. Intensity identification accuracy was significantly better than chance (d′ = 0) for all duration conditions in the dynamic displays, even at 200 ms, $ts(19) > 9.76$, $p = 0.000$, but not in the static displays, $t(19) = -0.057$, $p = 0.96$. In raw scores, when collapsed across both expression intensity levels, correct identification performance (i.e., expressive as 'expressive' and inexpressive as 'inexpressive') ranged from 76.88 % (SE = 2.34) at 1,000 ms to 69.69 % (SE = 1.72) at 200 ms, and 51.77 % (SE = 1.39) for the static displays.

A repeated measures analysis of variance (ANOVA) on d′ for the 5 dynamic condition levels revealed a statistically significant main effect of duration, $F(4, 76) = 3.13$, $p = 0.020$. The duration effect across the dynamic conditions was characterized by a significant linear trend,

[2] Examples of these questions read: how many years of music education do you have?; how many years have you played a musical instrument?; how many hours per week do you play?; do you make music/play with other people? Two questions, additionally, assessed liking and perceived difficulty of the experiment. The answers were provided on a 5-point scale with anchors 'not at all-very much', apart from those that required response with a specific amount of hours/years.

[3] The IRI is a 28-item self-report measure that contains four subscales: Empathic Concern, the tendency to feel compassion toward others; Perspective Taking, the tendency to take the point of view of another person; Fantasy, the tendency to relate to fictional characters; and Personal Distress, the tendency to feel negative emotion in stressful situations. Each question is answered using a 5-point scale (anchors: does not describe me at all-describes me very well).

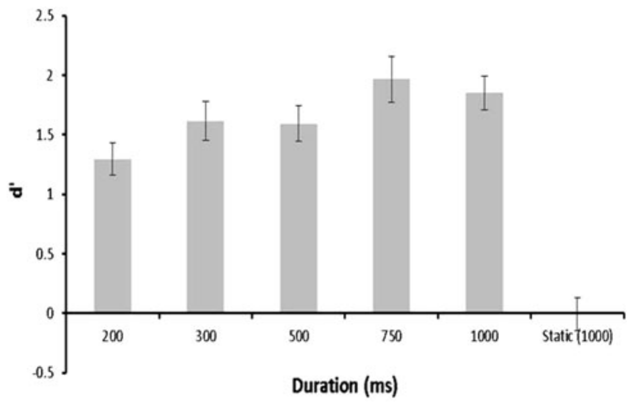

Fig. 2 Average d′ scores for expression intensity identification in the five duration conditions for dynamic stimuli and in the static display condition. *Error bars* indicate standard error

$F(1, 19) = 9.57$, $p = 0.006$. No higher-order trends were significant ($Fs < 3.81$, $ps > 0.07$).

Correlational analyses were conducted to address relationships between questionnaire data and identification performance. Spearman's rho was used in these analyses to minimize effects of possible deviations from normality in the data. Separate correlation analyses were conducted for dynamic and static displays, since we sought to assess the potential relationship between identification performance and kinematic versus form/postural cues. For the dynamic displays, there was a significant positive correlation between confidence scores and mean identification accuracy (as assessed by d′) across individual participants: $\rho = 0.55$, $p = 0.012$. That is, participants who were more accurate were also more confident in their judgments. There was no correlation between confidence and identification accuracy for static displays ($\rho = -0.036$, $p = 0.88$).

Furthermore, correlation analyses examined relations between empathy scores and the accuracy of expression intensity judgments across participants ($N = 18$).[4] This analysis revealed a significant positive correlation between average empathy score (i.e., the mean of the four subscales of the questionnaire) and identification accuracy for the dynamic displays: $\rho = 0.57$, $p = 0.014$. That is, performance accuracy was higher in individuals with higher empathy scores. Again, there was no correlation for static displays ($\rho = 0.005$, $p = 0.98$). Separate correlation analyses conducted with each of the four individual subscales did not reach significance. Therefore, from these results, it is not possible to identify whether a specific dimension of empathy is linked to expression intensity judgment (cf. Jabbi et al. 2007; Sevdalis and Keller 2011a).

A correlation analysis examining relations between empathy scores and confidence about expression intensity judgments revealed no significant correlation.

Finally, we examined the relationships between identification performance and questionnaire items assessing the informal music and dance experience of the participants (see Table 1). These data revealed that frequency of informal music listening and dancing, as well as the general liking of these activities, was positively associated with identification performance for dynamic displays. No correlation with formal music training reached significance (e.g., existence and years of music education, instrument playing, playing with others, and frequency of these activities). Performance in the static displays did not enter into any significant correlation with these indices. We also compared performance between groups of participants who reported having formal music education versus not, and those having formal dance education versus not. These comparisons did not yield any significant difference in performance. Overall, no correlation was observed between perceived difficulty and liking of the experiment and identification performance.

Discussion

The aim of this study was to investigate the role of spatial–temporal cues, cognitive-emotional indices, and music/dance experience in the identification of intended expression intensity in point-light displays depicting dance. Judgment accuracy of intended expression intensity in these displays improved with increasing display duration and was still reliably recognizable in dynamic displays of very short duration, that is, 200 ms. Furthermore, the tendency to discriminate intensities was positively correlated with scores on a self-report measure of empathy, suggesting that the tendency to empathize with other individuals is associated with good performance in the intensity identification task. Accuracy and confidence of judgments were positively correlated with one another, indicating a rather good calibration of performance, in the sense that objective and subjective performance covaried. Finally, accuracy of judgments was positively associated with dance experience and participation in dance activities, despite this experience being informal. All of the above correlations were only present for dynamic, not static, displays.

The current findings supplement our previous research on the links between action execution and action perception in tasks requiring self–other discrimination and intention recognition for point-light displays of dancers (Sevdalis and Keller 2009, 2010, 2011a). The results show that visual information about movement is sufficient for intended expression intensity identification, even under

[4] Two participants were excluded from these analyses because their scores were greater than 1.75 times the SD of the residuals (which were computed as the vertical distance of observed scores from the regression line).

Table 1 Correlations between responses to questionnaire items concerning informal music/dance experience and expression intensity identification performance with dynamic displays and with static displays

Questionnaire item	Correlation with identification performance (dynamic displays)	Correlation with identification performance (static displays)
How often do you listen to music?	$\rho = 0.55$, $p = 0.012$	$\rho = 0.18$, $p = 0.45$
How many hours per week do you listen to music?	$\rho = 0.67$, $p = 0.001$	$\rho = 0.19$, $p = 0.43$
How often do you dance to music?	$\rho = 0.50$, $p = 0.026$	$\rho = 0.35$, $p = 0.13$
How many hours per week do you dance?	$\rho = 0.50$, $p = 0.025$	$\rho = 0.28$, $p = 0.23$
Do you dance together with other people?	$\rho = 0.54$, $p = 0.015$	$\rho = -0.085$, $p = 0.72$

severely impoverished conditions (point-light displays of 200-ms duration). These results dovetail with previous evidence from psychophysical experiments suggesting that brief durations are sufficient for grasping physical stimulus properties in point-light displays (e.g., Chang and Troje 2008; Johansson 1976; Thurman et al. 2010). Our findings suggest that expression intensity identification—and, possibly, therefore, activation of structures within the action–observation network (cf., Cross et al. 2006)—is attainable within very brief time windows and depends on the stimulus duration that is available to the observer. According to our results, static displays (in which this dynamic information is absent) may have less potential to induce motor resonance and do not afford significant cues for action perception—at least in the context of the present experiment (cf., Atkinson et al. 2004; Coulson 2004; Kourtzi and Kanwisher 2000). Further research could potentially apply eye-tracking methodology to identify crucial body movement features and/or explore how specific kinematic parameters (e.g., velocity, acceleration) relate to perceptual performance.

A further noteworthy finding of the present study is that performance accuracy on the expression intensity identification task was related to cognitive-emotional factors and personal experience indices. This association was observed only for dynamic point-light displays, but not for static displays, underscoring further the role of spatial–temporal cues in action understanding and social cognition. It may be the case that purely spatial (form/postural) information in static displays does not support action simulation, at least not in the same way, or with the same degree of potency, as the spatial–temporal information (i.e., intensity and duration) in dynamic displays. Our findings also suggest a role for empathy in the perceptual task of discriminating between expression intensity levels in point-light displays (confirming the results of Sevdalis and Keller 2011a), thus underscoring further the link between motor and cognitive-emotional processes. Taken together, these findings corroborate recent discussions on the role of both bottom-up and top-down modulations of action understanding and social cognition (e.g., Grafton 2009), suggesting that empathy, confidence, and action simulation may be interconnected. However, the nature of potential causal links between these different parameters—which may be direct or mediated by another additional common factor—remains an open empirical question (cf. Sevdalis and Keller 2011a).

Finally, the correlations between informal dance experience and identification performance add a new dimension to the interplay of factors affecting action understanding. The findings suggest that, in addition to motor expertise—which may lead to higher resonance in one's motor system while observing actions related to dance, music, and other tasks (Knoblich 2008; Sevdalis and Keller 2011a; Keller et al. 2007; Repp and Keller 2010)—one's informal everyday experience with these activities may already provide a benefit in perceiving actions, thus enabling distinction between intended expression intensity levels. Thus, action understanding may be modulated by incidental variations in everyday experience and not only by deliberately cultivated expertise-related differences (e.g., Broughton and Stevens 2009; Calvo-Merino et al. 2010). Taken together, the results suggest that expression intensity identification may be mediated by a simulation process comprised of complementary motor and cognitive-emotional components (see also Grafton 2009; Keysers and Gazzola 2009; Sevdalis and Keller 2011b).

To conclude, the present findings suggest a mechanism for action understanding that underscores the importance of dynamic information for eliciting action simulation, but this may not be simply a motor process; it may be rather a process involving a balance of cognitive-emotional (top-down) social tendencies and experience-based (bottom-up) motor resonance. These findings highlight the importance of a pluralistic approach to action understanding and the need to examine different processes at multiple levels of analysis (see Sevdalis and Keller 2011b).

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