The Impact of Induced Emotions on Free Movement

Edith Van Dyck,*1 Pieter-Jan Maes,*2 Jonathan Hargreaves,#3 Micheline Lesaffre,*4 Marc Leman*3

*Department of Arts, Music and Theater Sciences, Ghent University, Belgium

#Department of Music, Trinity Laban Conservatoire of Music and Dance, UK

[1]Edith.VanDyck@UGent.be, [2]PieterJan.Maes@UGent.be, [3]JonHargreaves@me.com, [4]Micheline.Lesaffre@UGent.be, [4]Marc.Leman@UGent.be

ABSTRACT

The goal of this study was to examine the effect of two basic emotions, happiness and sadness, on free movement. A total of 32 adult participants took part in the study. Following an emotion induction procedure intended to induce emotional states of happiness or sadness by means of music and guided imagery, participants moved to an emotionally neutral piece of music that was composed for the experiment. Full body movement was captured using motion caption. In order to explore whether differences in corporeal articulations between the two conditions existed, several movement cues were examined. The criteria for selection of these cues was based on Effort-Shape. Results revealed that in the happy condition, participants showed faster and more accelerated body movement. Moreover, movements proved to be more expanded and more impulsive in the happy condition. These findings provide evidence of the effect of emotion induction as related to body movement.

I. INTRODUCTION

Emotions are essential to our social relationships, psychological well-being, cognitive functioning, moral sensitivity and other important developmental processes (Sroufe 1996). Moreover, as emotions serve as signals that convey information about the friendliness or dangerousness of our environment, the communication of emotions has proved to be crucial to our survival (Ekman 1992). In daily life, emotions are communicated through speech prosody (McCann and Peppé 2003) and voice quality (Gobl and Ní Chasaide 2003; Laukkanen et al. 1997). In addition, they can be communicated through nonverbal communication channels. Emotions can for instance be recognized from facial expressions (Ekman 1972), but also from movements of particular parts of the body such as the trunk (de Meijer 1989), the arms (de Meijer 1989; Wallbott 1998), and the hands (Gross et al. 2010). Moreover, both children and adults are believed to master the talent to decode emotions from full body movements (Boone and Cunningham 1998; Dittrich et al. 1996; Lagerlöf and Djerf 2002; Van Meel et al. 1993).

An interesting type of full body movement, and in particular with regard to emotion research, is dance, as a dancer is believed to express several different emotions in a non-verbal way (Levy 1988). Some studies have started to classify the types of dance movements prompted by emotions, and made attempts to explain how dance might be modified by emotions (Camurri et al. 2003; Brownlow et al. 1997; Dittrich et al. 1996; Walk and Homan 1984). Previous studies tend to work with actors and predefined movements. Camurri et al. (2003, 2004), for example, used 'acting' dancers in their study on modern dance movement, where they aimed at identifying the kinematic cues that are crucial for emotion recognition. In this study, dancers were instructed to repeatedly perform the same choreography, designed exclusively for the experiment, each time expressing a different basic emotion (i.e. anger, fear, happiness and sadness). However, several studies have shown that not all actors generate equally recognizable, emotionally expressive corporeal articulations (Gross et al. 2010; Montepare et al. 1987; Wallbott 1998). Instead of portraying emotions through acting, we believe that emotion induction techniques could be applied when studying emotions through body movement. A second concern is the restriction of dance movements. Most previous research regarding expressive dance movement has made use of choreography (e.g. Brownlow et al. 1997; Camurri et al. 2003, 2004; Montepare et al. 1999; Wallbott 1998). Yet, we believe that free movement is a better option in favor of participant's expression of emotions as this method could prove to be a more ecological strategy to study emotional dance movement cues.

The goal of this study was to examine the effect of basic emotions (i.e. happiness, sadness) on dance movement to 'neutral' music. The study used an emotion induction procedure that consisted of guided imagery and emotion-supporting music that was intended to induce emotional states either of happiness or of sadness. In order to explore whether differences in corporeal articulations between the two conditions existed, six movement cues were examined. The selection of these cues was based on Laban's Effort-Shape Theory (Laban 1950). It was hypothesized that the emotional state of the participants would influence their dance movements and would therefore result in dissimilarities in kinematic cues between the two conditions.

II. METHOD

A. Participants

A total of 32 adult participants (16 females, 16 males) took part in the study. As it is believed that the duration of negative emotional states decreases with age (Larcom and Isaacowitz 2009), only participants between 20 and 30 years of age were included in the experiment. The average age of the participants was 22.75 years (SD = 3.12).

B. Materials and Stimuli

1) Emotion Induction Procedure. The emotion induction procedure consisted of a combination of eight guided imagery vignettes and two musical pieces, both in the happy and in the sad condition. The vignettes were Dutch translations of the ones developed by Mayer et al. (1995). In advance, 20 judges had rated the eight vignettes, presented in randomized order. A five point Likert (ranging from '1 = not' to '5 = a lot' according to the emotions 'happiness' and 'sadness') was used. The validity of the translations was ensured as all happy emotion induction vignettes were rated near 5 (M = 4.77) for happiness and near 1 (M = 1.11) for sadness whereas all sad emotion induction vignettes were rated near 5 (M = 4.64) for sadness and near 1 (M = 1.28) for happiness. During the experiment, the vignettes were projected on a Sanyo PLC XU-105 projector screen.

The musical pieces that accompanied the vignettes were all non-vocal classical compositions drawn from prior designed emotion induction procedures (cf. Bower and Mayer 1989) (Table 1). Again, before the actual experiment, 20 judges had rated the musical pieces, presented in randomized order, on a five point Likert scale (ranging from '1 = not' to '5 = a lot' according to the emotions 'happiness' and 'sadness'). All happy emotion induction pieces were rated near 5 (M = 4.66) for happiness and near 1 (M = 1.24) for sadness whereas all sad emotion induction pieces were rated near 5 (M = 4.47) for sadness and near 1 (M = 1.34) for happiness. During the experiment, the musical pieces were played through four Altec 1218A speakers.

Table 1. Overview of the musical pieces used in the emotion induction procedure.

Happy emotion induction	Sad emotion induction
Delibes. Mazurka from *Coppelia*	John Williams. *Theme from Schindler's List*
(Alternate:) Bach. *Brandenburg Concerto No. 2*	(Alternate:) Chopin. Opus 28 No. 6 from *Preludes*

2) Emotion Rating Scale. Self-reported emotional experience was measured using a shortened version of the Differential Emotions Scale (cf. Lundqvist et al. 2009; Izard et al. 1974). Participants were asked to report 'to what extend each of the described feelings match the emotion they currently experience', using separate unipolar rating scales. Sadness was represented by Dutch translations of the words 'sad' (triest), 'blue' (droevig) and 'downhearted' (neerslachtig) while happiness was represented by Dutch translations of the words 'cheerful' (vrolijk), 'happy' (gelukkig) and 'joyful' (blij). Below each word was a five-point Likert scale with each number accompanied by a verbal description (1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Very, 5 = Extremely). To ensure that participants would not be aware of the true nature of the experiment, a total of 14 other feelings were added to the list (e.g. relaxed, sleepy and awake). Moreover, they were told that the questionnaire merely served as a control instrument. During the experiment, the questionnaires were filled out on a MacBook Air laptop.

3) Musical Stimulus. A professional composer designed the music that accompanied the dance movements of the participants with the intention of providing music that could be danced to intuitively. As far as possible, this music was composed to not arouse the participants to the extent that it led to heightened emotion, or to a marked change in the valence or potency of the emotion induction procedure. Another argument for composing the music exclusively for this study was to overcome that familiarity with the music would increase the intensity of emotional responses to music (Ali and Peynircioğlu 2010).

The neutrality of the music was justified by characteristics of the tempo, harmony, timbre and style. As music with a fast tempo and major mode is generally experienced as 'happy', whereas music with a slow tempo and minor mode is mainly understood as 'sad' (Hunter et al. 2010), the harmony alternated between major and minor chords and the tempo was mid-paced, set at 120 beats per minute (BPM). Moreover, according to a long-term study of dance music tempi by Moelants (2008), a tempo around 120 BPM represents the most common tempo in contemporary dance music and is believed to stimulate movement. The timbres were chosen in such a way that they would be heard as complementary, and importantly, not 'harsh-sounding' (Hailstone et al. 2009): Mellotron flute, Mellotron strings, Rhodes electric piano, a clavichord sound with a phaser effect, and a drum kit. No vocals were used, so that lyrics could not have any influence at all. In addition, the intention was to produce a stimulus that was ecologically valid: the stimulus had to sound like modern dance music, such as the participants might encounter in 'everyday life' situations, particularly those that might involve dancing. Thus, in composing the music, there was a clear balance to be struck between not arousing the participants too much on one hand, and not arousing them sufficiently on the other (thus, perhaps, leading to boredom). On that account, the style of the music was intended as 'middle of the road' rock/pop, with an emphasis on the drumbeat, so that participants could move intuitively to the rhythm, as they might do in a dance club.

Before the actual experiment, the neutrality of the music was validated by 20 judges who rated the musical stimulus on a five point Likert scale (ranging from '1 = not' to '5 = a lot' according to the emotions 'happiness' and 'sadness'). The musical piece was rated near 3 for both happiness (M = 3.15) and sadness (M = 3.08). During the experiment, the musical stimulus was played back from a Max/MSP patch, where the recording of the motion caption data was synchronized with the music.

C. Procedure

Participants were tested individually in a laboratory room with dimmed lighting. Black curtains surrounded the test area so that participants would be shielded from outside influences. The experiments took place in the early morning in order to control for possible shifts in emotional state due to time of the day (Hill and Hill 1991; Thayer 1994). The design of the experiment in combination with the emotion induction procedure required for each participant to perform the experiment on two occasions, sufficiently separated in time (i.e., different days). To avoid possible effects due to any specific order, half of the participants first performed the experiment in the sad condition while the other half started with the happy condition.

Upon arrival, the participant was informed about the procedure and was asked to sign a consent agreement declaring that he/she volunteered freely, had been informed about the tasks, had been given the opportunity to ask questions, understood that (depersonalized) recordings were going to be made and that the data would be used for scientific and educational purposes only. Afterwards, the participant was equipped with a suit required to facilitate motion capturing. Subsequently, all further instructions were given to enable the participant to continue the rest of the procedure by himself/herself without intervention of the experimenter.

The actual experiment consisted of four parts, namely the filling out of the emotion rating scale questionnaire, the emotion induction procedure, the performing of the dance task, and the filling out the emotion rating scale questionnaire for a second time.

Firstly, the participant was asked to sit down in the experimenting room and fill out an emotion rating scale questionnaire on a laptop.

Secondly, the emotion induction procedure started automatically when the questionnaire was filled out. At the very start of both the happy and sad emotion induction procedure, only music was presented. After 10 seconds, the guided imagery vignettes started to accompany the musical piece at 30-second intervals (cf. Mayer et al. 1995). When the first musical piece ended, the second (alternate) piece faded in. At the end of all eight vignettes, the music faded out. Both the happy and sad emotion induction procedures lasted 4 minutes and 30 seconds. The participant had been instructed to read the sentences that would appear on the projector screen, to listen to the music that would simultaneously play through the speakers and to try to imagine to be in the same situation as described in the sentences.

Thirdly, after the emotion induction procedure had ended, a final vignette appeared instructing the participants to stand up and to take place at the center of the motion capture space. Next, music started to play automatically and the participant executed the task he/she had received beforehand, namely to 'move in any way he/she wanted' to the music.

Finally, when the music had stopped, the participant had to sit down again, reopen the laptop and fill out the same emotion rating scale once more. Afterwards, the participant received a beverage and a snack and was thanked for taking part in the study. Participants in the sad condition had the opportunity to listen to cheerful music in order to improve their emotional state before departure.

III. MOVEMENT DATA ANALYSIS

As the primary aim of the experiment was to explore the effect of induced emotions on participants' dance movement responses to a musical stimulus, measures needed to be obtained (i.e., dependent variables) which allowed comparison between these movement responses. The methodology underlying our definition of these measures was based on the layered conceptual framework presented by Camurri et al. (2003, 2004). This framework starts with modeling human movement in terms of low-level physical measures, followed by the extraction of features, and finally a high level description and taxonomy linking these objective features with the aspects of expressivity and the subjective, emotional state of participants.

A. Data Acquisition.

Full body motion capturing was realized with an OptiTrack infrared optical system consisting of 12 synchronized cameras with related ARENA motion capture software (http://www.naturalpoint.com). Participants were equipped with a special suit consisting of a jacket, trousers and cap on which markers could be attached. A default human skeleton model provided in the ARENA software was constructed from 34 infrared reflecting markers that were attached to the suit in a predefined manner: four markers for hip, three markers for head, chest, upper arms, hands, and two markers for thighs, shins, and feet. Afterwards, the performances of all participants were exported into BioVision Hierarchy (BVH) files. Using the MATLAB motion capture toolbox (http://www.cs.man.ac.uk/~neill/mocap/) complemented with own algorithms, the three-dimensional position (and displacement) of 18 body parts (in the following referred to as 'joints') in reference to the body-centre (i.e., the pelvis) was calculated independent of the position or orientation of a participant in the motion capture space. The following 18 joints were considered: head, neck, chest, left shoulder, right shoulder, left elbow, right elbow, left wrist, right wrist, left hand, right hand, hips, left knee, right knee, left ankle, right ankle, left foot and right foot.

B. Feature Extraction

The selection of movement features that were extracted from this "raw" position data was grounded on concepts and theories of the Laban Movement Analysis (LMA) model (Laban 1950). The LMA model provides an integrated terminological system that facilitates to highlight expressive movement features based on four main categories: Body, Effort, Space and Shape (the so called BESS categories). In this study, six movement features (Directness Index, impulsiveness, smoothness, velocity, acceleration and expansion) were extracted that either relate to aspects of Effort (i.e., Effort category) or to the geometric, spatial aspects of trajectory Shapes in reference to the human body (i.e., Shape category).

C. Effort Category

As in the LMA model, the Effort category was further subdivided into four subcategories: space effort, time effort, flow effort, and weight effort. The expressive attributes associated with these subcategories in the LMA model are structured around two opposite polarities indicating subtle, qualitative aspects of a performed gesture. Space effort relates to the polarities direct-indirect, time effort to sudden-sustained, flow effort to bound-free, and weight effort to strong-light. In this study, space effort found its kinematic counterpart in the Directness Index, time effort in impulsiveness, flow effort in smoothness and weight effort in both velocity and acceleration. Because three of these features (i.e., Directness Index, impulsiveness and smoothness) are based on a segmentation process, we first describe the details of this process before providing more information concerning the features.

1) Segmentation Process. The extraction of the features Directness Index, impulsiveness and smoothness described below was based on a segmentation process that divides the complete (sampled) motion stream into discrete segments, called gestural units. The segmentation process resembles methods presented in previous research that take the velocity profile as basis for defining the boundaries of each segment

(Camurri et al. 2003, 2004; Leman et al. 2009). From a physical point of view, the velocity signal of a movement performed by a specific body part is characterized by a concatenation of bell-shaped curves (i.e., motion bells). The boundaries of a segment are determined by local minima in the velocity signal (i.e., points in time where the acceleration is zero). These indicate a transition from a decrease to an increase of movement velocity. As such, each segment is defined by an increase and subsequent decrease in movement velocity. For each performance of a participant, the segmentation process was executed for all joints.

2) Space – Directness Index. The Directness Index (DI) concerns a concept adopted from a large body of studies conducted by Camurri et al. (e.g., Camurri et al. 2003, 2004). It expresses, for each segment, the proportion between (1) the Euclidean distance of the straight trajectory between the position occupied by a joint at the beginning of a segment and at the end of that segments, and (2) the distance covered in reality (i.e., the sum of distances from sample to sample)

3) Time – Impulsiveness. Again in line with studies of Camurri et al. (2003, 2004), impulsiveness relates to the shape of the motion bells. Impulsiveness is a function of the duration and amplitude of the bell-shaped velocity curve. Sharp, distinct peaks imply a high impulsiveness while longer, more rounded bells imply a lower impulsiveness. As such, the measure for impulsiveness was expressed as the duration divided by the amplitude range of the motion bell.

4) Flow – Smoothness. Smooth movement trajectories are related with a minimum of acceleration transients, also called jerk (Hogan 1984; Lee et al. 1997; Todorov and Jordan 1998). Therefore, the description of the smoothness of motion segments was based on the constrained minimum-jerk model presented by Todorov and Jordan (1998). Based on the algorithms presented in this study, the minimum-jerk trajectory (i.e., the trajectory minimizing the integral of the squared derivative of acceleration) could be computed. Next, the difference between the minimal-jerk trajectory and the actual trajectory covered by a specific body part was calculated. For this, a Normalized Root-Mean-Square Error measure was used.

5) Weight – Velocity and Acceleration. In contrast with the previous features, both velocity and acceleration do not depend on the segmentation process. Velocity, as the first derivative of distance with respect to time, expresses the rate of displacement (i.e., change of position) of a joint. Acceleration, being the second derivative of distance, describes the rate of change in velocity. Although calculated differently, these measurements show resemblances with the Quantity of Motion (QoM) feature presented in the study of Camurri et al. (2003, 2004), which is considered as an overall measure of the amount of detected motion.

D. Shape Category

The Shape category describes the dynamic form outlined by the constellation of body parts in one's kinesphere (i.e., the peripersonal space immediately surrounding a person's body which can be reached by the limbs). While five different effort features were studied, only one shape feature was included.

1) Expansion. The most general elements of shape are opening (i.e., extending the limbs far in one's kinesphere) and closing (i.e., contracting the limbs close to the body-center) (cf. Billingham 2009). Movement size and openness can be related to emotional intensity (Camurri et al. 2004; Davidson 1994; Maes et al. 2010). *Expansion* is represented by the mean distance between the joints of the upper limbs (i.e., both elbows and hands) and the body-centre during the complete length of a movement performance. This measure shows resemblances with the Contraction Index (CI) measure used in the study of Camurri et al. (2004) and of Maes et al. (2010).

IV. RESULTS

To investigate the effect of the emotion induction procedure, scores on the emotion rating scales before and after the dance session were analyzed and six movement features were tested for dissimilarities between happy and sad conditions.

A. Emotion Rating Scale

Wilcoxon signed-rank tests revealed that at the start of the experiment, scores for happiness (Mdn = 3.67) were significantly higher than scores for sadness (Mdn = 1.33), $z = -6.92$, $p < .001$. Yet, after the happy emotion induction procedure (Mdn = 4.00), scores for happiness were significantly higher than at the start of the experiment (Mdn = 3.50), $z = -2.56$, $p < .05$. In addition, scores for sadness were significantly higher after the sad emotion induction procedure (Mdn = 1.83) than at the beginning of the experiment (Mdn = 1.33), $z = -2.92$, $p < .01$. Moreover, scores for happiness were significantly higher after the happy emotion induction procedure (Mdn = 4.00) than after the sad emotion induction procedure (Mdn = 3.33), $z = -2.85$, $p < .01$, whereas scores for sadness were significantly higher after the sad emotion induction procedure (Mdn = 1.83) than after the happy counterpart (Mdn = 1.00), $z = -3.45$, $p < .001$.

To summarize, analysis of the scores on the emotion rating scales showed that the intended effect of the emotion induction procedure was obtained.

B. Movement Features

All six movement features and 18 joints (i.e. body parts) were tested separately in order to search for differences between the happy and sad condition. First, the differences between scores were calculated and tested for normality by means of Kolmogorov-Smirnov tests. If the assumptions of homogeneity of variances and normality could be accepted, dependent t-tests, with the scores for the two conditions as variables, were performed. If the assumption of normality could not be accepted, Wilcoxon signed-rank tests were executed. Only significant results are reported in Table 2.

Table 1. *M* and *SE* of the movement feature as a function of emotion condition and joint are reported for the paired-samples t-test. *Mdn* of the movement feature as a function of emotion condition is reported for the Wilcoxon signed-rank test. Only significant effects are shown.

	Happy condition	Sad condition	*t*	*z*	*p*
Impulsiveness					
Chest	7.91	6.81		-2.00	<.05
L Shoulder	13.78	9.25		-1.98	<.05
L Elbow	20.00	14.01		-2.04	<.05
L Wrist	26.73 (1.91)	21.04 (2.18)	2.17		<.05
R Wrist	24.37 (1.71)	20.38 (1.90)	2.30		<.05
L Hand	34.80	28.61		-2.19	<.05
R Hand	33.56 (2.15)	28.72 (2.52)	2.06		<.05
Hips	2.18	1.79		-2.30	<.05
Velocity					
R Shoulder	29.63	27.57		-1.98	<.05
L Elbow	41.80 (3.40)	36.35 (3.57)	2.08		<.05
R Elbow	40.42	35.54		-2.13	<.05
L Wrist	67.24 (5.51)	56.59 (5.25)	2.81		<.05
L Hand	94.09 (7.64)	80.82 (7.41)	2.68		<.05
R Hand	93.76 (7.48)	82.61 (7.97)	2.37		<.05
Acceleration					
Head	1.82	1.59		-2.02	<.05
Neck	1.39	1.14		-2.13	<.05
L Wrist	3.11 (0.24)	2.68 (0.25)	2.03		<.05
L Hand	4.47	3.58		-2.32	<.05
Hips	0.19	0.16		-1.98	<.05
L Ankle	4.23	3.94		-2.34	<.05
R Ankle	4.18	3.84		-2.09	<.05
L Foot	4.62	4.49		-2.26	<.05
Expansion					
L Hand	37.12 (1.22)	35.01 (1.15)	2.53		<.05
R Hand	37.96 (1.11)	36.24 (1.07)	2.29		<.05

To summarize, significant effects of the condition were revealed for four features, namely impulsiveness, velocity, acceleration and expansion. The effects were particularly observable in hand, wrist and elbow movement. No effects were uncovered for Directness Index and smoothness.

V. DISCUSSION

The overall goal of this study was to investigate the effect of emotions on dance movement. Both hypotheses that the emotional state of the participants would affect their dance movement and would result in dissimilarities in kinematic cues between the happy and sad condition were supported.

First, the self-reported emotional state of the participants was examined. At the start of the experiment, participants reported to be in significantly stronger happy than sad emotional states. This could be linked with findings of several different emotion studies, which revealed that participants usually report to experience stronger positive than negative emotions before any emotion induction took place (e.g., Jallais and Gilet 2010; Mayer et al. 1990). This finding could either indicate that people feel rather happy in general, or it could merely refer to the impression participants would like to convey.

Concerning the emotion induction procedure, the combination of guided imagery and music significantly raised levels of the targeted emotion and suppressed the non-targeted emotion as scores for happiness increased and scores for sadness decreased after the happy emotion induction while scores for sadness increased and scores for happiness decreased after the sad emotion induction. These results indicate that the combination of guided imagery, which occupies foreground attention, and music, which contributes to a congruent background atmosphere, could indeed serve as a successful means of inducing emotions (Bower 1981; Clark 1983; Corson and Verrier, 2007; Jallet and Gilet 2010; Mayer et al. 1995) and could therefore be effectively applied to future studies regarding expressive movement.

With regard to corporeal articulations, the results provided evidence of the effect of emotion induction as related to movement. In the happy condition, participants displayed significantly faster and more accelerated body movement compared to the sad condition. These results are similar to findings of the study by Camurri et al. (2003) regarding dance choreography, where automatically obtained movement cues were extracted from dancers portraying emotions of anger, fear, grief and joy. Afterwards, these cues were compared between the four emotion categories. Results revealed a main effect of Quantity of Motion (QoM), as performances for joy received significant higher mean scores than performances for grief. As QoM is considered as an overall measure of the amount of detected motion, involving velocity and force, these findings are in accordance with the current results regarding velocity and acceleration.

Moreover, an effect of impulsiveness was exposed as movements proved to be more impulsive in the happy condition compared to the sad condition. Rather similar results have been reported in a study by Lagerlöf and Djerf (2000), in which participants judged videos of a dance choreography where dancers explicitly aimed at expressing anger, fear, grief or joy. Results unveiled a relationship between joy and frequent tempo changes, while only few tempo changes were identified in the grief condition.

In addition to velocity, acceleration and impulsiveness, an effect of expansion was unveiled as movements proved to be significantly more expanded in the happy condition compared to the sad condition. This finding is well in line with results by Camurri et al. (2003), indicating that dancers who portrayed grief displayed a higher level of contraction compared to dancers portraying joy. Similar findings were also reported by Lagerlöf and Djerf (2000), as they revealed a correlation between joy and the tendency for movements to reach out from the body centre.

A remarkable observation was that significant differences between the two conditions were particularly observable in hand, wrist and elbow movement. This is consistent with the belief of the hands having a privileged role in music-related gestures (Godøy 2010). It also accords with the more general cognitive phenomenon that hand movement is closely linked with the expression of emotions (Goldin-Meadow 2003). In fact, one of the first functions of spontaneous hand movement in early infancy is believed to be emotional (Trevarthen 1986). This predominance of the hands in expressive movement is facilitated by the many biomechanical degrees of freedom of the jointed lever system of arms and hands. In addition, the cerebral programming of the combinations of rotation about the many joints is, from birth, extremely refined and informed by many sensitive receptors. Hands can be projected from the body with high velocity to transmit large forces, moved with perfect temporal and spatial precision of guidance in an extensive reaching field, and accurately rotated in any direction (Trevarthen et al. 2009). Therefore, we believe that future studies should pay sufficient attention to hand and arm movement when analyzing expressive movements.

The use of free dance movement was deliberately chosen to explore the effect of emotion on kinematics. Our results confirm that this type of dance can serve as an adequate substitute for choreography when studying expressive movement. Applying free dance movement has the advantage that it enables participants without professional background to participate in dance experiments and therefore it facilitates researchers to address a broader group of possible participants. In addition, as participants are granted the freedom to move in the way they prefer, they will probably feel less inhibited and will move with less restrictions.

However, as participants were equipped with a motion caption suit and were 'instructed' to move to the music, the question could rise whether participants were truly able to move without boundaries. As this was not a real-life setting, but an experimental one in which accurate kinematic data needed to be obtained, some levels of freedom were indeed impossible to obtain. Yet, before the experiment started, we ensured that the motion caption suit was non-intrusive to the participants' mobility. In addition, the participants were instructed to move in any way they wanted to, which resulted in some participants moving very actively whereas some did almost not display any movement at all. Therefore, in our study, free movement should be understood as unprepared, unchoreographed movement with as little restrictions as possible but within predetermined boundaries of the motion caption mechanism.

Another deliberate choice in our experimental setup was the absence of a neutral control condition. As we learned from the self-reported emotional state that participants reported to be in overall happy emotional states before any induction took place, incorporating a neutral emotional state would perhaps have created a situation without any natural parallel and therefore a too artificial one. Yet, Jallais and Gilet (2010) stated that induced emotions are supposed to be equivalent to naturally occurring emotions.

A critical aspect of our study might be that the music participants moved to music that was composed for this particular study. This was done in order to ensure full control over every parameter in the music. Inevitably, it could be argued that the stimulus was in some way artificial. However, the ecological validity of the composition was ensured as an experienced composer created it. Moreover, assessments of the music in a pilot study justified its neutrality and besides, implementing existing music could have caused confounding effects due to familiarity.

VI. CONCLUSION

Although studies regarding the effect of emotions on dance movement are rather rare, the results of our study are consistent with reports by others but go beyond by showing that using combined emotion induction techniques consisting of guided imagery and music, is an adequate tool to study expressive movement. Moreover, this study shows that free dance movement is as an excellent means of studying the effect of emotion on kinematics. Apart from these findings, our data supports the notion that hand movement plays a prominent role in the expression of emotions.

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