Dance Expertise modulates behavioural and psychophysiological responses to affective body movement

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Abstract

The present study shows how motor expertise increases sensitivity to affective body movement at the behavioural and physiological level. Nineteen affective movement experts (professional ballet dancers) and twenty-four controls watched 96 video clips of emotionally expressive body movements while they performed an affect rating task (subjective response) and their galvanic skin response was recorded (psychophysiological response). The movements in the clips were either sad or happy, and in half of the trials movements were played in the order in which they are learned (forward presentation), and in the other half, backwards (control condition). Results showed that motor expertise in affective body movement specifically modulated both behavioural and physiological sensitivity to others' affective body movement, and that this sensitivity is particularly strong when movements are shown in the way they are learnt (forward presentation). The evidence is discussed within current theories of proprioceptive arousal feedback and motor simulation accounts.

Keywords: affect; emotion; expertise; neuroaesthetics; galvanic response; motor simulation; empathy, dance.

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1. Introduction

Cognitive neuroscience has begun to explore how expertise in the arts modulates behavioural, perceptual, and neurocognitive processes. *Musicians* process musical and auditory sounds more accurately than controls (Oechslin, Van De Ville, Lazeyras, Hauert, & James, 2013), they are more sensitive to musical dissonance (Dellacherie, Roy, Hugueville, Peretz, & Samson, 2010), and musical training results in changes in brain macro and microstructure, especially in regions implied in auditory processing and motor control, such as the temporal and frontal lobes (Bangert et al., 2006; Bengtsson et al., 2005; Gaser & Schlaug, 2003; Habib & Besson, 2009; Haslinger et al., 2005; Pantev et al., 1998; Schlaug, 2006). *Dance* expertise enhances perceptual sensitivity to familiar movements (Calvo-Merino, Ehrenberg, Leung, & Haggard, 2010), and modulates neural responses to familiar actions in the Action Observation Network (bilateral premotor and parietal cortices) (Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005; Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006; Cross, Hamilton, & Grafton, 2006; Fink, Graif, & Neubauer, 2009; Jang & Pollick, 2011; Orgs, Dombrowski, Heil, & Jansen-Osmann, 2008). Long-term dance training results in changes in brain structure, in particular, in premotor and sensorimotor regions (Hänggi, Koeneke, Bezzola, & Jäncke, 2010).

In contrast to the wealth of evidence describing expertise effects in the domains of action perception (see Bläsing et al., 2012 for a review of dance expertise effects in neurocognition), very little is known about how movement expertise modulates the processing of affective information in movement. Recent studies have shown that expert artists (an example of experts in emotional expression) have enhanced affective responses as compared to controls. For example, *actors* are more empathic than non-actors (Goldstein, 2009; Goldstein & Bloom, 2011; Goldstein & Winner, 2012), *musicians* are better at recognizing vocal expressions of emotions than non-musicians (Lima & Castro, 2011), ballet *dance* ability is associated with trait emotional intelligence (Petrides, Niven, & Mouskounti, 2006), and participants with dance experience show a modulation of their aesthetic response to familiar movements (Kirsch, Drommelschmidt, Cross, 2013; Kirsch, Dawson, Cross, 2015; see Christensen and Calvo-Merino, 2013 for a review on dance expertise and aesthetic perception). This suggests that expertise in the arts facilitates the processing of emotional information. To what extent this influence operates at the level of perceptual processes (indexed by an ability to discriminate between expressions of emotion), or is deeper rooted in 'hot affective' processes (evidenced by changes in psychophysiological arousal), however, remains unclear.

Exactly what constitutes an emotion and what the role is of physiological arousal in the perception of emotions in others and the subjective experience of emotions in oneself has been the focus of debate for more than a century. James (1894) famously contended that the conscious experience of *feeling* an emotion is a consequence of physiological arousal responses such as changes in heart rate, breathing rate, muscle tension and galvanic skin responses. Although this view initially attracted criticism (Cannon, 1927), accumulating evidence lends support to James' view and many contemporary theories of emotion continue to ascribe a central role to arousal in the elicitation of emotional experiences (Damasio, 1999; Lang, Bradley & Cuthbert, 1999; Scherer, 2009a,b; see also Laird & Lacasse, 2014). A robust finding in this context is that subjectively reported feelings are associated with particular changes in heart-rate, skin conductance and other physiological parameters (e.g., Lang et al., 1999). Interestingly, this association is often only moderate in general population (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), but increased in expert dancers (Sze, Gyurak, Yuan, & Levenson, 2010). This suggests that expertise in the bodily expression of emotion can augment the extent to which arousal influences the subjective experience of feelings and there are reasons to believe that this could enhance sensitivity to the emotion expressed in the movements of others. Specifically, theories of empathy suggest that emotional expressions directed toward us induce a form of embodied mimicry whereby our physiology instantiates the arousal and brain states that are suggested by the emotional expression of the other (e.g., Decety & Jackson, 2006). These states in turn give rise to subjective feelings in ourselves that serve as cues to allow us to perceive the emotion expressed by the other. Daily training in expressing affect through movement should enhance this embodied mimicry because of the repeated coupling between proprioceptive feedback from the dancers' own body and the exteroceptive sensory feedback due to self-observation and observation of colleagues in a dance studio mirror. Therefore, we expect dance expertise to enhance sensitivity to emotional body movements because of an enhanced embodiment of congruent arousal on the one hand, and greater influence of this arousal on *subjective* feelings on the other.

Based on the above arguments, the current study tested the hypothesis that expert dancers compared to non-dancers would be more accurate at discriminating the emotions expressed in dance at the level of subjective valence ratings, and that they will also be more responsive at the psychophysiological level to the emotions on display. Moreover, to establish whether these predicted effects are mediated by general expertise in affective body movement or more specific expertise with particular forms of movement, the responses in the two groups will be compared on displays of movements as they have been learnt (forward presentation), *vs.* movement displays that are less familiar (backwards presentation). Importantly, kinematic properties of the movements in these forward and backward presentation conditions (e.g., speed, degree of displacement, etc.) are matched. Therefore any difference in emotional responsiveness to forward as opposed to backward displays, particularly if observed only in expert dancers, would support the view that expertise with the specific type of movements the dancers have learned, rather than movement more generally, modulates affective processing. Finally, we explore whether expertise modulates the coupling between perceptual and psychophysiological emotional responses by examining correlations between subjective ratings and physiological arousal. Based on the observations of Sze and colleagues (2010) noted above, the prediction here is that the subjective ratings of expert dancers will more closely reflect their physiological arousal than is the case for non-experts.

2. Method

2.1. Participants

Twenty-four female undergraduate students with no formal dance experience (age Controls: *M* = 20.86; *SD* = 2.77; range: 18-32 years) participated in exchange for course credits. Twenty female ballet dancers (in professional training or working professionally with Ballet as their main dance style) (age Dancers: *M* = 24.85; *SD* = 4.22; range: 20-36 years) participated in exchange for a small time reimbursement (£8/h). Further details about the dancers are provided in Table 1. One participant in the dance group felt very uncomfortable during the experimental task and was not included in the data analysis. Thus, 19 Ballet dancers were included in the analyses presented below.

Table 1

Participant characteristics. Shown are mean and (*SD*). "Other dance styles" include Step Dance, Jazz Dance, Jazz Ballet, Burlesque, Lyrical and Commercial Dance

			DANCE STYLE					
			Ballet		**Contemporary**		**Other Dance Styles**	
GROUP	*Age*	*Age range*	*Years of experience*	*Hours training/ week*	*Years of experience*	*Hours training/ week*	*Years of experience*	*Hours training/ week*
Dancers	24.85 *(4.22)*	20-36	17.90 *(5.59)*	20.50 *(12.93)*	9.46 *(4.05)*	6.54 *(6.41)*	3 *(10.75)*	3.67 *(4.04)*
Controls	20.86 (2.77)	18-32	0	0	0	0	0	0

2.2. Materials

Forty-eight ballet dance video clips were selected from an affective body movement library of ballet movements (Christensen, Nadal, Cela-Conde, & Gomila, 2014a). These movement stimuli are 5-6 seconds long, and show an extract of a *solo* dancer in a genuine live performance, in black and white, without soundtrack and with the dancer's face blurred. In the 48 videos selected for the current study there were a mean of 4.35 (SD =0.36) full academic ballet movements as established by the respective ballet syllabi (Vaganova method and Royal Academy of Dance). These ballet syllabi have a limited number of movements and the 48 clips contained a unique combination of these. See the supplementary material for sample video clips. Sample clip S1 is from *Sleeping Beauty* and sample clip S2 from *Swan Lake*. Table S1 contains information regarding the stimuli selection.

For this study we required stimuli with strong emotional expression. However, ballet dancers do not always execute their movements in emotionally expressive manners, for example for training purposes or for abstract ballets without narrative or emotional content. Therefore, importantly, in the stimulus library from which the stimuli were selected, each video had been coded in terms of its valence and arousal. We used these scores to select 24 movements depicting happiness and 24 movements depicting sadness, while ensuring that each category of clips (happy *vs.* sad) had, respectively, 12 of high arousal and 12 of low arousal. Paired t-tests confirmed a significant difference between happy and sad videos in valence ratings (Happy: M = 4.75; SD = .84; Sad: M = 4.08; SD = .74; $t(23) = -2.397$; p = .025) but no significant difference between the two video categories in arousal ratings (Happy: M = 4.54; SD = 1.45; Sad: M = 3.75; SD = 1.31; $t(23) = 1.588$; p = .126). Since the expression of happiness or sadness in a ballet movement is primarily dependant on the quality of the movement (i.e., *how* it is performed) rather than on any particular step, it was also possible to ensure that the happy and sad clips did not differ with respect to the number of *pirouettes* ($t(23) = 1.56$; p = .127), *releves* ($t(23) = 0.00$; p = 1.00), large movements ($t(23)$ = .57; p = .57) and high frequency movements ($t(23) = 1.17$; p = .25) comprising them.

To ensure that possible differences in the affective responses between happy and sad movements were not due to other differences in the stimuli, such as speed or amount of movement, we created a set of control stimuli. For this condition, the same 48 stimuli were played backwards (transformation was done by means of *Adobe Premiere Elements* 7.5), thereby ensuring that the speed and amount of movement were identical for both forward and backward stimuli. This resulted in a total of 96 stimuli (48 forwards, and 48 backwards with half of the stimuli being Happy movements and half Sad movements in each condition).

2.3. Procedure

Stimuli were randomly presented using the stimulus presentation programme *E-prime* (version *E-Studio*, v. 2.0.8.90; www.pstnet.com). Stimuli were displayed on a black background with each dancer occupying approximately 5.5 cm on the screen (head to heel). Viewing distance was ~40cm. A fixation cross was presented before (1500ms) and after (1000ms) each video clip, which lasted for 5-6 seconds (*M* = 5.02; *SD* = .41) and was faded in and out to minimize surprise. Participants performed a subjective affect rating task (self-paced) after each video clip in which they were asked to rate how sad or happy the movements *made them feel.* This procedure follows that used in the norming study from which the stimuli were selected (Christensen et al., 2014a) and also the procedures commonly used in studies that assess emotional responses at the level of subjective experience and psychophysiological arousal (e.g., Lang, et al., 1999).

Responses were collected using a continuous visual analogical scale (VAS) presented at the bottom of the screen ranging from 0 (very sad) to 100 (very happy); 50 was neutral. The labels "*Sad*" (left) and "*Happy*" (right) displayed on either side of the VAS, while the indication "*Emotion?*" was displayed in the centre of the screen. The cursor of the mouse appeared always in the centre of the screen to avoid response tendencies. After the mouse click within the scale, the next trial was launched. Participants had a break after half the trials. Average experiment duration was 45 minutes. See figure 1 for the trial structure.

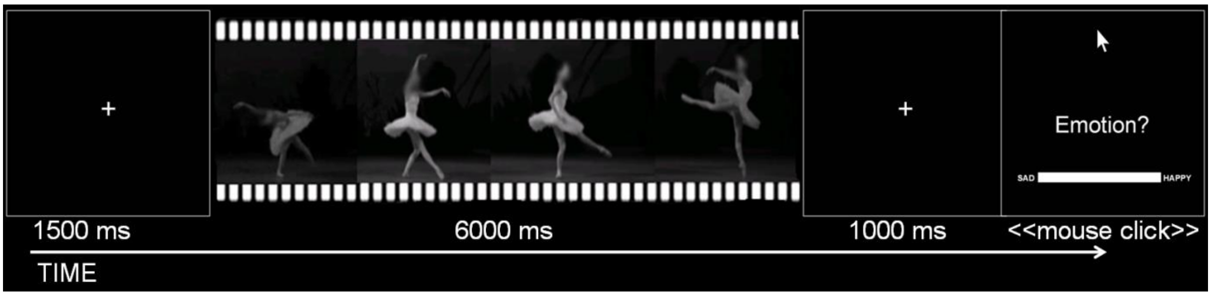

Figure 1. Trial structure. After a fixation cross (1500ms), the dance video was faded in (~6 seconds), faded out, and followed by a fixation cross (1000ms). Then the Visual Analogical Scale (ranging from Sad, 0; to Happy, 100) appeared below the word "Emotion?" written in the centre. The cursor of the mouse appeared always in the top centre of the screen rather than anywhere on the VAS scale to avoid the curser position biasing the participants' responses toward any of the extremes. Reproduced with permission (Christensen et al., 2014b).

Throughout the experiment, skin conductance was recorded at a frequency of 1kHz with an *ADInstruments PowerLab System* (ML845) including a GSR (ML 116) and Bioelectrical signal amplifier (ML408 with MLA2540 and MLA2505 5-lead shielded Bio Amp cables). Stainless steel bipolar GSR electrodes (MLT116F) were attached to the medial phalanges of the index and ring fingers of the participant's non-dominant hand using fitted velcro tapes. A second computer running *LabChart* 7 (v.7.3.1. 1994-2004; www.adiinstruments.com) was connected with a parallel-to-serial port interface to the computer running the stimulus presentation programme. A trigger was sent from *E-prime* to the trace of the GSR online recording in *LabChart* marking each stimulus event.

2.4. Analyses

Repeated measures (RM) Analysis of variance (ANOVA) were conducted on both participants' VAS ratings and GSR data in order to examine the effects of Stimulus Presentation (Forward vs. Backward) and Dance Emotion (Happy vs. Sad). Given our specific predictions, any interactions indicated by the ANOVAs were followed up using planned comparisons (t-tests), without applying additional corrections for multiple comparisons (Rothman, 1990; Saville, 1990; McDonald, 2009). As effect sizes we report partial eta (η_p^2), where .01 is considered a small effect size, .06 a medium effect and .14 a large effect (Cohen, 1988).

Following standard procedures (e.g., Bradley, Codispoti, Cuthbert & Lang, 2001), the GSR data were quantified by first subtracting the *maximum value* within the six seconds of the video stimulus duration from the GSR *value at the onset* of the stimulus and then applying a *log transformation* (log[GSR+1]) to normalize the distribution of the data (Bradley, Codispoti, Cuthbert, & Lang, 2001). Furthermore, all participants with 1.5 SD above or below the mean of their respective group were discarded. This left 18 Controls and 17 Dancers for the analyses of GSR data.

The final analysis was correlational and served to examine the extent to which subjective affective ratings reflected objectively measured arousal responses. For this purpose the VAS ratings and GSR responses were averaged for each stimulus across the participants in the two groups. These averages were then correlated with one another separately for forward and backward stimuli to quantify the association between the VAS ratings and GSR responses in the two groups (please refer to figure 4 for further details).

3. Results

3.1 Analysis of subjective affective ratings (VAS)

The analysis of participant's subjective VAS ratings confirmed that happy videos were rated as happier than sad videos and that forwards presentation resulted in more positive ratings than backwards ratings. The data also confirmed the prediction that dancers would be better able to differentiate happy and sad dance movements, particularly in the canonical forward presentation of the video clips. These conclusions were supported by a 2 x 2 x 2 RM ANOVA of the VAS ratings with the within group factors of Stimulus Presentation (Forwards, Backwards) and Dance Emotion (Happy, Sad), and the between group factor of Group (Controls, Dancers). This demonstrated a significant main effect of Dance Emotion (Happy: M = 60.539; SE = 1.159; Sad: M = 39.679; SE = 1.159; $F(1,41) = 175.794$, $p < .001$, $\eta_p^2 = .811$), confirming that videos in the Happy category received higher affective ratings than those in the Sad category. A significant main effect of Stimulus Presentation (Backwards: m = 48.66; SE = .862; Forwards: m = 51.556; SE = .930; $F(1,41) = 8.279$, p = .006, $\eta_p^2 = .168$), further showed that movements presented in their familiar forward direction were rated overall as of more positive valence than when played backwards. Although the main effect of group was not significant ($F(1,41) = .511$, $p = .479$, $\eta_p^2 = .012$), we observed an interaction between Group and Dance Emotion ($F(1,41) = 34.428$, $p < .001$, $\eta_p^2 =.456$), which is explained by a more pronounced differentiation in VAS ratings between the two displayed emotions (Happy, Sad) in the group of expert dancers (Happy: M = 64.624; SE = 1.490; Sad: M = 34.533; SE = 1.732) than in the control group (Happy: M = 56.453; SE = 1.326; Sad: M = 44.825; SE = 1.541), as set out in figure 2. The interaction between Group and Stimulus Presentation was also significant ($F(1,41) = 4.442$, $p = .042$, $\eta_p^2 = .098$) reflecting more pronounced differences in VAS ratings between forwards and backwards stimuli in the group of Dancers (Backwards: M = 47.071; SE = 1.288 *vs.* Forwards: M = 52.086; SE = 1.389) than in the Control group (Backwards: M = 50.252; SE = 1.146; Forwards: M = 51.026; SE = 1.236). Of most interest, however, is the fact that these 2-way interactions were further characterised by a marginally significant three-way interaction between Stimulus, Dance Emotion and Group ($F(1,41) = 4.047$, $p = .051$, $\eta_p^2 = .090$).

To understand the source of the three-way interaction we performed two separate 2x2 ANOVAs (Stimulus Presentation x Dance Emotion); one for the Dancer group and one for the Control group. The ANOVA in the Dancer group showed a significant main effect of Stimulus Presentation ($F(1,18) = 6.05$, $p = .024$, $\eta_p^2 = .251$); Backward stimuli received lower ratings ($M = 47.07$, $SE = 1.48$) than the Forward stimuli ($M = 52.09$, $SE = 1.61$). There was also a main effect of Dance Emotion ($F(1,18) = 98.58$; $p < .001$, $\eta_p^2 = .846$); Happy stimuli were rated as more happy ($M = 64.62$; $SE = 1.60$) than Sad stimuli ($M = 24.53$; $SE = 2.22$). Importantly, there was an interaction of Stimulus Presentation and Dance Emotion ($F(1,18) = 7.87$; $p = .021$, $\eta_p^2 = .304$). We followed up this interaction with paired t-tests. For Happy movements, we found significant differences between the Forward ($M = 68.98$; $SE = 1.32$) and Backwards ($M = 60.27$; $SE = 2.08$) conditions ($t(18) = -5.471$; $p < .001$). No such difference was significant for Sad movements (Forward: $M = 35.19$; $SE = 3.22$; Backwards: $M = 33.87$; $SE = 2.02$), ($t(18) = -.424$; $p = .609$). The same ANOVA in the Control group only showed a significant main effect of Emotion, with Happy movements rated as more happy ($M = 56.45$; $SE = 1.28$) than Sad movements ($M = 44.83$; $SE = 1.09$; $F(1,23) = 64.15$; $p < .001$, $\eta_p^2 = .736$). Neither the main effect of Stimulus Presentation ($F(1,23) = 0.98$; $p = .332$, $\eta_p^2 = .041$) nor the interaction between Dance Emotion and Stimulus Presentation ($F(1,23) = 0.38$; $p =.544$, $\eta_p^2 = .016$) were significant in this group. These results suggest that Experts' subjective affect ratings are sensitive to the Stimulus Presentation (Forward or Backwards) when the movements express happiness, while no such effect of affective sensitivity was observed in the Control group; see figure 2.

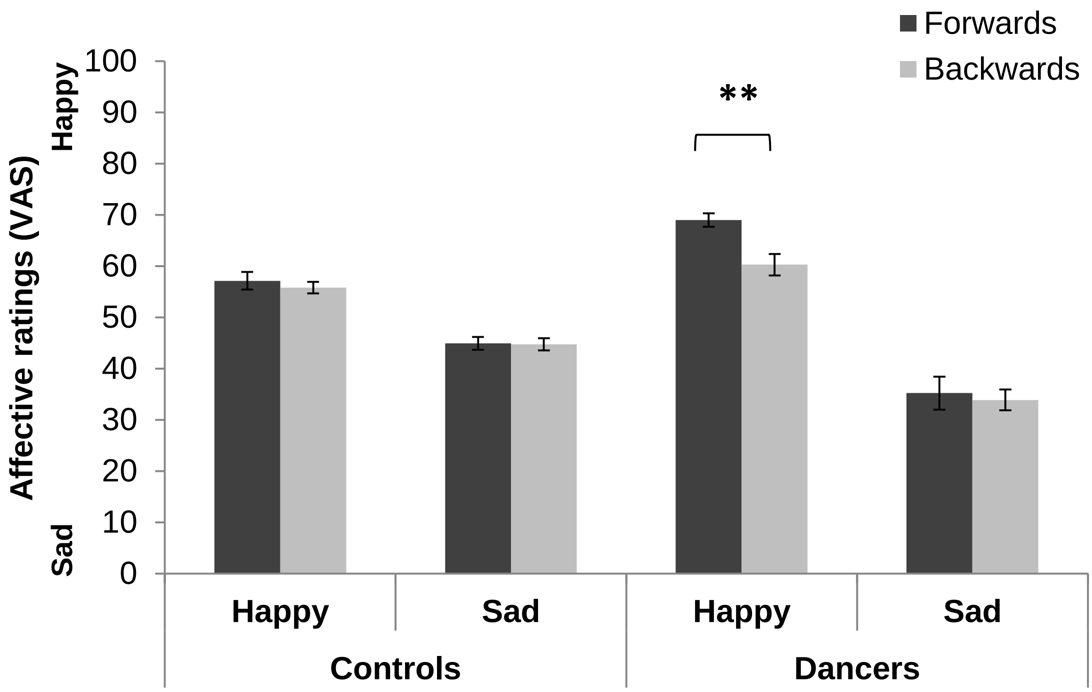

Figure 2. Subjective affect ratings means in the 2x2x2 design. Bars reflect the different conditions: Stimulus Presentation (Forward, Backwards), Dance Emotion (Happy, Sad) and Group (Dancers, Controls). (** $p < .001$). Error bars reflect S.E.M. (VAS = Visual Analogical Scale for the affective ratings).

3.2. Analysis of physiological data (GSR)

To analyse participants' physiological responses two approaches were taken. First the data were analysed according to the same '*normative*' (for ease of reference) principles as the VAS rating data above, comparing responses to happy and sad dance movements as defined by the norming study from which these stimuli were selected. In addition, however, it is also possible to examine physiological data on a '*subjective'* (for ease of reference) subject-by-subject basis whereby each stimulus is classified as happy or sad according to each participant's own subjective rating (e.g., Cela-Conde et al., 2004; Salimpoor et al., 2009). The stimuli are sorted according to each participant's VAS ratings from lowest to highest (0 to 100) and the top half are classified as subjectively 'Happy' stimuli with the bottom half considered to be the ‘Sad’ stimuli . This second procedure is particularly useful for examining physiological responses in relation to personally experienced feelings that may deviate from group averaged responses that make up normed stimulus libraries such as the one from which the materials for the current study were selected. Together, the analyses of normative and subjective GSR responses demonstrated overall higher GSR in Controls than Dancers but Dancers had a more differentiated response to happy and sad videos, which was particularly evident in an analysis of *subjective* GSR data that revealed significant differences between happy and sad videos only for Dancers and only when videos were played in their forward direction. These observations parallel the results of the subjective VAS data and were supported by the following analyses.

For the first analysis of normative GSR responses a 2 (Stimulus Presentation; Forward vs. Backwards) x 2 (Normative Dance Emotion; Happy vs. Sad) x 2 (Group; Controls vs. Dancers) mixed ANOVA was carried out, equivalent to the VAS analysis above. This revealed a main effect of Group (F(1,33) = 19.90, p < .001, η_p^2 = .376) with overall higher GSR responses in Controls (m = .144, SE = .010) than Dancers (m = .08, SE = .010) as well as a significant interaction between Dance Emotion and Group (F(1,33) = 8.065, p = .008, η_p^2 = .196). Follow-up comparisons showed that only for Dancers GSR responses differed significantly between the normatively Happy (m = .086, SE = .009) and Sad movements (m = .077, SE = .008; F(1,16) = 5.251, p = .036, η_p^2 = .247) whereas for controls this effect was weaker and fell short of conventional significance (Happy: m = .151, SE = .012; Sad: m = .136, SE = .012; F(1,17) = 4.170, p = .057, η_p^2 = .197). In this first analysis no other main effects or interactions were significant (η_p^2 < .035).

The second analysis of subjective GSR responses followed the same 2 (Stimulus Presentation; Forward vs. Backwards) x 2 (Subjective Dance Emotion; Happy vs. Sad) x 2 (Group; Controls vs. Dancers) as above and revealed a main effect of Emotion with more pronounced GSR for Happy movements (M = .116, SE = .007) than for Sad movements (M =

.108; *SE* = .007, $F(1,33) = 4.754$, $p = .036$, $\eta_p^2 = .126$). The main effect of Group was again also significant as in the first analysis above with Controls showing increased GSR (*M* = .143; *SE* = .010) compared to Dancers (*M* = .081, *SE* = .010; $F(1,33) = 19.680$, $p < .001$, $\eta_p^2 = .374$). No other main effects were significant but instead of the two-way interaction revealed by the normative analysis above, the current subjective analysis yielded a marginally significant three-way interaction between Stimulus Presentation, Dance Emotion and Group ($F(1,33) = 3.910$, $p = .056$, $\eta_p^2 = .106$) that parallels the 3-way interaction in the VAS analysis. Given this trend, our a priori hypothesis regarding group differences, and the significant between-group factor, we performed two additional RM ANOVAs separately for each group. A 2x2 RM ANOVA for the Dancer group showed a significant interaction between Stimulus Presentation and Subjective Dance Emotion ($F(1,33) = 5.634$, $p = .030$, $\eta_p^2 = .260$). Breaking down this interaction further with paired t-tests showed a significant difference in GSR in the two Dance Emotion categories as a function of Stimulus Presentation. Dancers' GSR was higher for Happy movements (*M* = .0873, *SE* = .009) than for Sad movements (*M* = .0724, *SE* = .008, $t(17) = -2.728$, $p = .015$) only in the Forward Condition. Conversely, there was no difference between the two Subjective Emotions for Backwards movements ($t(16) = .025$, $p = .980$). These data in the expert group show that physiological responses are sensitive to affective movement *only* when the movement is displayed in its familiar presentation (forward). By contrast a similar RM ANOVA for the Control group did not show any main effects (Dance Emotion: $F(1,17) = 2.204$; $p = .156$, $\eta_p^2 = .115$; Stimulus Presentation $F(1,17) = 0.015$; $p = .905$, $\eta_p^2 = .001$) or interaction between Dance Emotion and Stimulus Presentation ($F(1,17) = .716$; $p = .409$, $\eta_p^2 = .040$); their GSR during observation of self-rated Happy and Sad movements was similar, irrespective of Stimulus Presentation (figure 3).

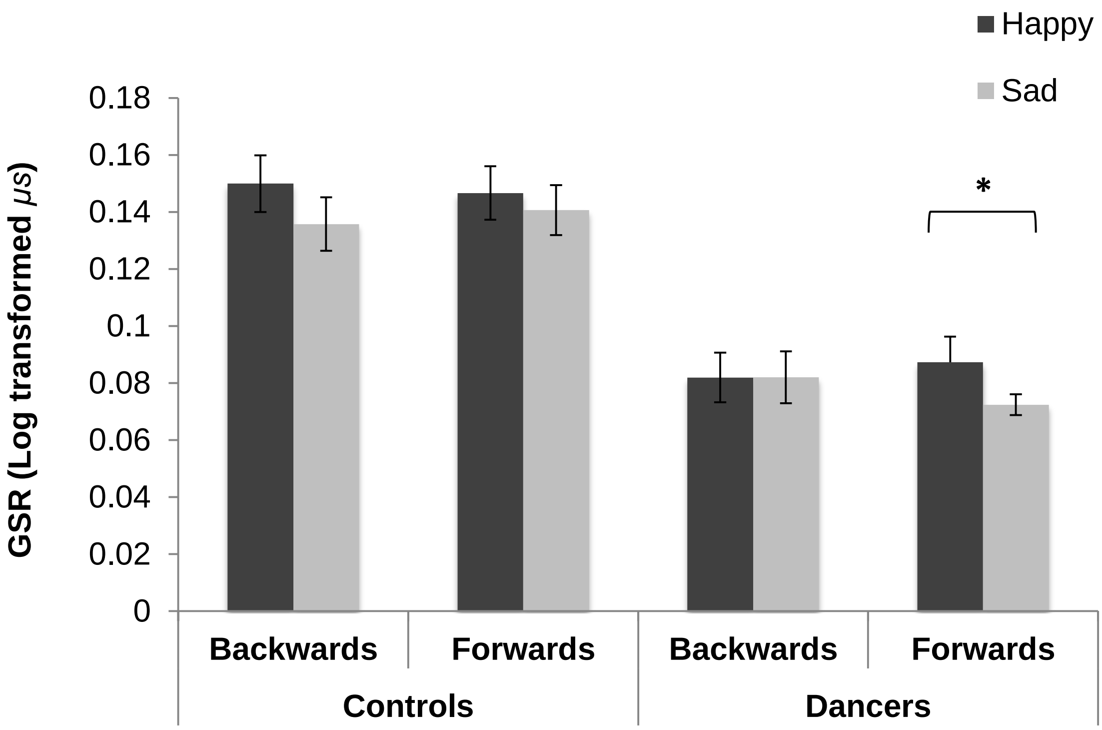

Figure 3. Physiological responses measured through Galvanic Skin Response (GSR, Log transformed *μs*) of Dancers and Controls during observation of dance videos rated as Happy and Sad. Data are presented for the two stimuli presentations conditions (Forward, Backwards). (* $p < .05$). Error bars reflect S.E.M.

3.3. Correlations between subjective affective experience and physiological responses

The above analyses show that expertise in ballet dance does not only enhance the ability to discriminate the valence expressed in dance movements but it also sensitises a person's emotional responsiveness to emotional dance at the physiological level. The fact that this is observed only in relation to familiar forward presentations of relevant movements lends support to the idea that relevant expertise rather than spurious stimulus characteristics are mediating these effects. In a final analysis we examined whether dance expertise may also modulate the extent to which subjective experiential and psychophysiological facets of emotional responsiveness are coupled, which is thought to provide another indicator of affective sensitivity (Sze, et al., 2010). Thus, as explained in the analysis section, the correlation between average VAS ratings and GSR responses were examined within each group for the forward and backward stimuli separately. The relevant scatter plots are illustrated in figure 4 and suggest that expert dancers were more sensitive affectively; their affective ratings correlated significantly with their physiological response (p = .003. r = .419) during observation of stimuli in their familiar presentation (forwards), while no such correlation was found when dancers observed the stimuli backwards (p = .832, r = .031). We did not find any significant correlation in the control group for neither the forward (p = .229, r = -.177) nor the backwards condition (p = .554, r = .088). These results suggest that when there is a strong degree of familiarity between the observer and the movement, (i.e. dancers observing forward dance movements) people reliably report their affective response in accordance with their bodily arousal.

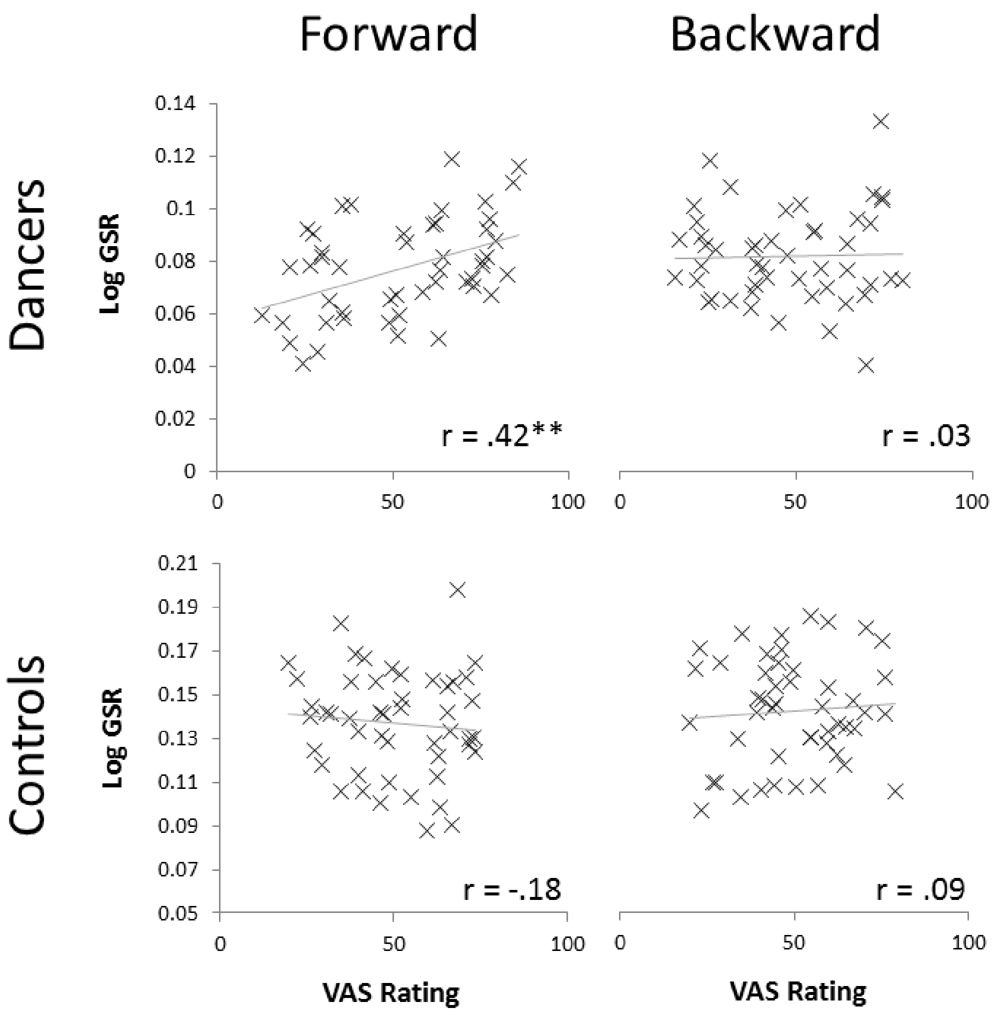

Figure 4: Scatter plots illustrating the association between subjective VAS ratings and GSR responses for the Forward and Backward dance stimuli as a function of group (Dancers vs. Controls). Only the association for the forward stimuli in Dancers is significant. ** $p = .003$. Note that the data points represent the average values for the stimuli in the respective condition (forward vs. backward) across the participants in the respective groups (Dancers vs. Controls).

4. Discussion

Movement expertise modulates perceptual processes involved in the observation and appreciation of movements (Calvo-Merino et al., 2010, Kirsch, Drommelschmidt, & Cross, 2013), and an increased coupling between subjectively reported emotion and psychophysiological aspects of the emotional experience in expert dancers has been reported (Sze et al., 2010). The present study is the first to examine how movement expertise in the expression of affect through movement modulates sensitivity to such bodily expressed emotion at the level of subjective experiences and objective measures of physiological arousal. Expertise in this context was operationalised in two ways; by comparing expert dancers to control participants with no dance experience and by comparing responses to movements in their normal forward presentation (i.e., as they would be learned by experts) and in an unfamiliar backward presentation.

The principal finding was that expertise in affective body movements indeed augmented sensitivity to observed affective body movements. With their subjective ratings expert dancers discriminated more strongly between happy and sad dance clips played in the usual, forward direction than control participants did. Furthermore, controls had the same level of GSR to happy and sad movements, irrespective of movement presentation, while expert dancers had increased GSR to happy as compared to sad movements, specifically only for movements presented in their forward presentation. Moreover a correlation analysis showed that only in the expert group subjective behavioural responses correlated with psychophysiological responses, and again this was specific when rating movements in their forward presentation. The observation that GSR responses were overall higher in controls rather than dancers. This is congruent with previous reported differences between experts and laypersons in other art domains (painting), where novel stimuli typically elicit greater physiological arousal responses than familiar responses (Pihko et al., 2011). This observation does, however, raise interesting questions for future studies in terms of how the effects of novelty/familiarity of stimuli interact with the sensitivity of the observer to affective dimensions.

Together, the findings suggest that dance training modulates *intra*personal as well as *inter*personal emotional processes. Further research is needed into the involved mechanisms by examining the emotional sensitivity of dancers longitudinally as they become experts, and by looking at correlations between indices of emotional sensitivity (e.g., the correlation between subjective emotion ratings and physiological arousal) and years of dance experience. Additional individual difference variables such as trait emotional intelligence or Alexithymia (difficulty to identify and describe one's own emotion) are important to consider in future studies as possible mediators/moderators of the effects of expertise on emotional processes.

Beyond the role of expertise in the processing of emotion in movement, the present data raise questions about what precisely constitutes *emotional* movement. Dance naïve participants can identify with the emotion expressed in ballet dance (Christensen et al., 2014a; Christensen, Gaigg, Gomila, Oke & Calvo-Merino, 2014b), at least as far as their subjectively reported feelings are concerned. Given that the happy and sad dance clips selected for the present study did not differ in terms of the particular steps that comprised the dance sequences, the emotional salience of movements must be transmitted through the quality with which the movements are performed. This is not necessarily surprising. What is less expected is that some of the quality that renders movements emotionally expressive appears to be preserved when the same movements are presented backwards. That is, both groups of participants reported differential happy and sad feelings in response to the dance clips irrespective of whether the clips were played in the normal forward or their unusual backward presentation. Dance expertise augmented the difference in the forward presentation but it did not diminish it in the backwards presentation. This finding could indicate that the emotional quality of movements is temporally relatively symmetrical such that temporal reversals do not result in a loss of emotional information. Or it could be that certain aspects of the temporal dynamics of movement are not critical for transmitting emotional information. It is worth noting, however, that dancers' GSR responses did not differentiate between happy and sad dance movements in the backward conditions, which suggests that the temporal dynamics of emotional movements impact differently on subjective and psychophysiological aspects of emotional responses. These issues warrant further investigation and future studies could seek to identify which properties of movement (e.g., angular velocity, jerk, etc.) predict subjective and/or psychophysiological responses. Such studies could lead to fruitful discoveries that may ultimately feed back into educational practices in ballet schools.

It will be important for the current observations to be replicated and extended to other expert groups such as actors, mimes and other performance artists who are experts in the bodily expression of emotion, and to use other types of stimuli materials; both artistic and everyday-type expressions of affect. The current study used a moderate sample size, given that some participants needed to be excluded from the analysis of GSR responses. Participant exclusions are unfortunately unavoidable in psychophysiological research and the recruitment of a specialist population (expert dancers) places certain constraints on achievable sample sizes.

In relation to the wider emotion literature, our results support the original conjecture made by James (1894) and reiterated in contemporary views (Laird & Lacasse, 2014; Niedenthal, 2007) that propioceptive arousal feedback informs the conscious experience of emotions. The data also speak to complementary motor simulation and *embodiment* accounts of social cognition (Keysers & Gazzola, 2006), which argue that a form of embodied simulation or mimicry of the behaviours and experiences of others is not only important for the understanding of others' actions (Jacob & Jeannerod, 2005; Jeannerod, 2001), but also for understanding and identifying with their affective experiences (Blackemore & Decety, 2001; Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Chatrand & Bargh, 1999; Critchley, 2005; Dapretto et al., 2006; Di Dio & Gallese, 2009; Gallese, 2003; Goldman & Sripada, 2005; Molnar-Szakacs & Overy, 2006). This idea is intuitive when considering that all affective expression –be it facial or bodily– normally involves movement of our muscles. After all, *e*motion is also motion. Importantly, in the context of this wider literature, the current observations suggest that training in the bodily expression of emotions enhances an individual's sensitivity to the emotions expressed by others, with potentially important implications for the possible utility of dance and movement therapies for the management of disorders such as Autism Spectrum Disorders (ASD) that are characterised by impairments in social-emotional and wider social-cognitive processes (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Gaigg, 2012; see particularly Scharoun, Reinders, Bryden & Fletcher, 2014).

5. Author contributions

J.F.Christensen, Dr. B. Calvo-Merino, Dr. S.B. Gaigg and Dr. A. Gomila developed the study concept. J.F.Christensen, Dr. B. Calvo-Merino and S.B. Gaigg contributed to the study design. Testing and data collection were performed by J.F. Christensen and N. Sivarajah. J.F.Christensen, and Dr. B. Calvo-Merino performed the data analysis and interpretation under the supervision of Dr. S.B. Gaigg and A. Gomila. J.F. Christensen drafted the manuscript, and Dr. B. Calvo-Merino, Dr. S.B. Gaigg and Dr. A. Gomila provided critical revisions. All authors approved the final version of the manuscript for submission.

Table and Figure legends:

Table 1: Participant characteristics. Shown are mean and (*SD*). “Other dance styles” include Step Dance, Jazz Dance, Jazz Ballet, Burlesque, Lyrical and Commercial Dance

Figure 1. Trial structure. After a fixation cross (1500ms), the dance video was faded in (~6 seconds), faded out, and followed by a fixation cross (1000ms). Then the Visual Analogical Scale (ranging from Sad, 0; to Happy, 100) appeared below the word “Emotion?” written in the centre. The cursor of the mouse appeared always in the top centre of the screen rather than anywhere on the VAS scale to avoid the curser position biasing the participants’ responses toward any of the extremes. Reproduced with permission (Christensen et al., 2014b).

Figure 2. *Subjective* affect ratings means in the 2x2x2 design. Bars reflect the different conditions: Stimulus Presentation (Forward, Backwards), Dance Emotion (Happy, Sad) and Group (Dancers, Controls). (** = $p < .001$). Error bars reflect S.E.M. (VAS = Visual Analogical Scale for the affective ratings).

Figure 3. Physiological responses measured through Galvanic Skin Response (GSR, Log transformed µs) of Dancers and Controls during observation of dance videos rated as Happy and Sad. Data are presented for the two stimuli presentations conditions (Forward, Backwards). (* = $p < .05$). Error bars reflect S.E.M.

Figure 4: Scatter plots illustrating the association between subjective VAS ratings and GSR responses for the Forward and Backward dance stimuli as a function of group (Dancers vs. Controls). Only the association for the forward stimuli in Dancers is significant. ** $p = .003$.

Note that the data points represent the average values for the stimuli in the respective condition (forward vs. backward) across the participants in the respective groups (Dancers vs. Controls).

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