DANCE

D1.4 – Demonstrate how sonification training modulates mental imagery

Version	Edited by	Changes
1.0	UM, UNIGE	

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Introduction

Dance (def. "the movement of one or multiple bodies in a choreographed or improvised manner with or without music" (Blasing et al., 2012)) is one type of full body movement, which is regularly used in research when assessing the affective properties of body movement. It has received substantial attention in cognitive and neuroscientific research (for review see: Blasing et al. (2012); Karpati, Giacosa, Foster, Penhune, and Hyde (2015)), and some attention in neuroaesthetic research (Cross, Kirsch, Ticini, & Schutz-Bosbach, 2011). This relatively new field in neuroscience is interested in the esthetic experience of an observer when e.g. listening to music or viewing art. Dance is specifically of interest since it can be seen as a universal form of human expression, which has for a long time and still is, performed in many cultures all over the world (Hanna, 1988).

Recently, Christensen, Pollick, Lambrechts, and Gomila (2016) pointed out that when viewing dance in video clips, some observers experience an affective response. They also found out that this was mostly based on imagery and personal memories of the observers.

Whereas previous research concerning affective and expressive research has focused on presenting dances in which the dancers express a certain emotion, e.g. happy, fear or sad (Van Dyck, Vansteenkiste, Lenoir, Lesaffre, & Leman, 2014), in this deliverable we present the studies, which aim at investigating how humans perceive expressive qualities (e.g., Lightness) from full-body movements Next we choose some of the evaluated stimuli and we use them in the second study which aims to investigate the role of the interactive sonification training in the perception of the expressive qualities.

The DANCE-Project and its Multi-layered Framework

The primary aim of the EU ICT 2020 DANCE project is the development of techniques and models for the analysis of the quality of human body movement. Within this aim, the particular focus lies on the affective expressiveness of human body movement and the perception of the expressive qualities of body movement by an external observer (Alborno et al., 2016). The ultimate goal is the translation of visual stimuli into auditory stimuli, in order to allow for visually impaired individuals to experience the expressive qualities of dance.

To make this translation, information about the processing of expressive qualities of body movement is needed. The Multi-Layered Computational Framework of Qualities in Movement (Camurri et al., 2016) is a model which was developed within the DANCE Project and tries to render certain features which are present within human body movement. This model consists of four layers (Fig. 1), which can be distinguished from each other by, among other things, a time scale. The first layer (physical signals) can be considered as the raw data of movement measured by sensors like motion sensors, accelerometers or EEG. Data received from this measuring equipment lays the basis for several parameters (e.g.

Trajectories, Acceleration, Physiological sensors data). Layer two (Low-Level features) extracts a group of features from this raw data which characterize the movement locally in time. Layer three (Mid-Level features) computes several features to describe structural aspects of one single movement. In comparison to layer two, layer three takes enough time to follow the evolution of a movement. The final layer, layer four (Body communication of expressive qualities), presents the expressive qualities of body movement that arise from all the previous layers combined. More about the model can be found in D2.2.

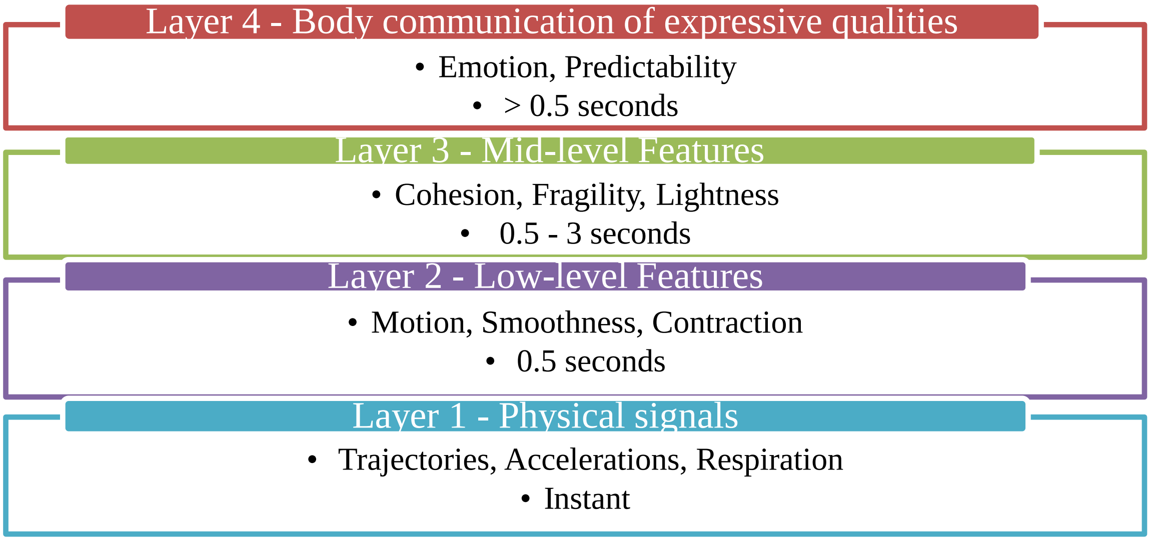

Figure 1: Overview of the Multi-Layered Computational Framework of Qualities in Movement (modified from (Camurri et al., 2016))

One step towards this translation is to understand how healthy individuals perceive specific qualities of body movements. To explore this, a neurofunctional approach was set up, focusing on the Mid-level Features Layer (Layer 3).

One of the research questions addressed by DANCE concerns whether the human brain distinguishes between, e.g., two mid-level features of this model (Layer 3) and, if so, how (see D1.3 for details). For this purpose, an fMRI (functional Magnetic Resonance Imaging) study is set up to investigate brain activation of participants who passively view dance choreography, which contain two mid-level features. Before using the stimuli for the fMRI study, they need to be validated on the perception level. This problem is addressed by the first study presented in this deliverable.. A second motivation is related to study the perception of the expressive qualities from their sonifications. To evaluate the role of the interactive sonification training, first, we need to check whether the stimuli to be sonified convey the expected expressive quality.

Aims and hypotheses

This deliverable presents two experiments.

The aim of the first study is to measure the subjective perception of two expressive qualities: Fragility and Lightness. Once these stimuli are validated they can be used in neuroscientific experiments (see, for example, D1.3). In the second study presented in this Deliverable we aim to evaluate the perception of the same two qualities from their sonifications, with and without a preliminary training. The other aim of the first study is to validate the multilayer structure of the Conceptual Framework discussed in the D2.2 (see the previous section for a short introduction). Three aspects were investigated in parallel that match three different levels of the Framework. The first question concerned whether participants were able to correctly identify two Mid-level dance qualities (i.e., Layer 3 of the Framework). The second question concerned what emotion participants associated with the dance qualities (i.e., at the Layer 4 of the Framework). The third question concerned how participants rated 7 specific low-level features (Layer 2 of the Framework) in the same clips.

For the second study, evaluating the role of the interactive training in the perception of the movement quality from sounds is important for the strategy chosen in the DANCE Project: we need to check whether the "translation of visual stimuli into auditory stimuli" in a dance context requires a training or not (e.g., in context of the future public dance performance where the sonifications will be applied to communicate the audience expressive content of the dance).

In this deliverable we focus on two mid-level dance quality features, which were defined as: ***Fragility*** *A sequence of non-rhythmical upper body cracks and leg releases. It emerges, for example, when moving at the boundary between balance and fall, resulting in short movements with continuous interruption of motor plans. The resulting movement is non-predictable, interrupted, and uncertain.* ***Lightness*** *A series of body movements that are smooth, fluid and elegant and therefore result in predictable, continuous and certain movement.*

First Experiment

Methods

The aim of this study was to measure the subjective perception of two expressive qualities: Fragility and Lightness by healthy individuals from the video stimuli.

Since both dance types are extracted by two different algorithms (see D2.2) and since these algorithms use different aspects of body movement (e.g. upper body cracks for Fragility and fluid movement for Lightness), it was hypothesized that participants will be able to distinguish between both dance qualities and that both qualities will be rated differently on 7 low-level features from the model previously described.

Further, since Layer 3 does not contain emotions, it would be ideal that the movements in this layer are not associated with an emotional content, so that the fMRI study is able to compare both dance types with each other and not one dance type with an associated emotion. Therefore, it was hypothesized that participants will rate both qualities as having no emotional content, i.e., being neutral.

Besides the main questions stated, it was decided to implement two possible effectors; gender of the participants and their dancing experience. Previous research has shown that dancing experience influences the perception of dance, not only regarding the movement being performed (Sevdalis & Keller, 2011), but also regarding the affective nature of the movement (Christensen, Gomila, Gaigg, Sivarajah, & Calvo-Merino, 2016). Therefore, it was decided to split the participants into two groups (experienced and not experienced) and compare those in their ratings. For this it was hypothesized that dancing experience will have an influence on the three main questions previously stated. As well as dancing experience, gender has shown to have an influence on the recognition of emotions in body movement (Sokolov, Kruger, Enck, Krageloh-Mann, & Pavlova, 2011). Therefore, it was decided to investigate if there would be a difference between males and females in their responses to the three main questions. Hypothesized was that females tend to have a better eye for neutral content, whereas males have a better eye for happy content (Sokolov et al., 2011).

In addition to investigating these questions, this study aims to validate the dance stimuli, so that these can also be used in the fMRI study mentioned before and possible future research.

Ethics statement

This study has received ethical approval (reference: ERCPN-170_02_08_2016) from the Ethical Review Committee of Psychology and Neuroscience at the Maastricht University. Additionally, all participants provided an informed consent which stated that they had the opportunity to ask questions about the study, that participation in this study was on a voluntary basis and that they have the right to withdraw their consent at any time, without having to justify their decision.

Participants

Forty-nine healthy participants (37 females and 12 males) were recruited for this online survey (age M= 23 years, range= 19-44 years). Previous research has shown that people who suffer from an eating disorder have deficits when it comes to emotional processing. Not only have they difficulty identifying and understanding their own emotions, but they also show impairment when judging the affective experience of others (Bydlowski et al., 2005). Therefore, one participant was excluded since she indicated that she was suffering from an eating disorder. None of the other participants noted any mental or neurocognitive disorders. Thirty-four participants were dance naïve and fourteen participants had at least three years of dancing experience in at least two dance styles. Three of the fourteen dance experienced participants are receiving formal dance training at the time of this survey. Participants were recruited via an online student recruitment tool of the Maastricht University (SONA), as well as advertisements, which were distributed over Maastricht University campus. Participants were compensated either by course credits or monetarily.

This study was conducted at the University of Maastricht (The Netherlands) between April and June 2017.

Stimuli

Stimuli featured twelve semi-professional Italian female dancers, who were instructed to perform two particular dance qualities; Fragility and Lightness. These qualities were chosen because of their distinct differences. Whereas Fragility contains interrupted, unpredictable and discontinuous movements, Lightness is characterized by uninterrupted, predictable and continuous movements. Dancers were asked to freely present both qualities for about ninety seconds.

Five wireless accelerometers were placed on wrists, ankles and coccyx of the dancers to track and capture body motion flow for both types of movement. The dance choreography video clips were recorded with high quality cameras with fifty frames per second. Additional parameters like breathing and floor feet pressure were recorded, however, they were not used in this study.

The stimuli were recorded at the Casa Paganini InfoMus laboratory with the use of the EyesWeb XMI software (Piana et al., 2016). This software was additionally used to analyze the multimodal data (in this case video, audio and motion capture sensors) and to validate the qualities performed. Validation was done using algorithms, specifically designed for each type (see D2.2).

From the captured footage of all twelve dancers, one hundred twenty different dance video stimuli (see Figure 2 for an example) were constructed, and edited to have an average length of approximately ten seconds each. All dance video clip stimuli were standardized with: faces of the dancers blurred to reduce the effect of face recognition in the human brain, and soundtracks deleted from all clips. Furthermore, there was a uniformity of clothing for the dancers and no additional visual or auditory distractions, to avoid any distraction from the movements.

Figure 2: Example of a video clip

Questionnaires

For practical reasons, and to reach a larger study population at a faster pace, it was decided to use an online questionnaire study. All questionnaires were constructed using Qualtrics (https://www.qualtrics.com/). Due to a high number of stimuli (n=120) and to prevent participant fatigue, stimuli were equally divided among five questionnaires (24 stimuli each). All sub-questionnaires were identical of nature, except for the stimuli included. More specifically, every sub-questionnaire contained one Fragility and one Lightness clip from every dancer. All stimuli were presented in a randomized order to limit the effect of an order and participants were limited to watch each video clip only once.

For the actual task, participants were asked to attentively watch each dance choreography video and after every clip to answer three questions (see Annex 1). Question one was simply to select the condition that the participants thought they recognized in the clip (Fragility vs. Lightness). Question two concerned the affective nature of the dance video clip and asked participants which of five emotions (happy, sad, fearful, angry or neutral) best described the dance choreography video they had watched. Choice randomization was used for every emotion question to limit the effect of habituation. Question three was a rating 5-point Likert scale question (1 = Very Low to 5 = Very High) to assess the dance choreography videos on several low-level features of the model described below (Table 1).

Table 1: Low-level features with the definitions

	How energetic is the movement
	The degree of movement displayed
	The degree of fluency displayed by the movement
	The degree of downward movement/direction displayed
	The degree of balance displayed by the movement
	The degree of clenching

	The degree of symmetry displayed by the body

Procedure

Participants were randomly provided with one of the five web-links of the questionnaires. Before starting with the actual task, participants were asked to provide some standard demographic data (age and gender) and some background information about their dancing experience. Specifically, it was asked whether or not participants had received formal dance training in the past, and if so, what type of dance they had performed and for how long they received this training. Furthermore, participants received information about what the task would look like and what questions would be asked after each stimulus. In addition, they were provided with the definitions of the two dance qualities described above, and with the low-level features with their definitions (Table 1) which they should watch attentively when viewing each clip. Completion time of one questionnaire was on average 25 minutes.

Statistical analysis

Data of all questionnaires were retrieved from Qualtrics. Conversion of each dataset into an appropriate format was done using a customized Matlab script (R2014a, 8.3.0.532) and data was inserted into IBM SPSS Statistics (v21) for statistical analysis.
A Chi Square Test was used to assess correct recognition of each of the dance qualities, affective rating and the stimuli validation. A Multi Analysis of Variance (MANOVA) was conducted to assess the low-level feature rating. Within this statistical testing, the effects of gender and dancing experience of the participants were examined.

Representational Dissimilarity Matrices

Representational Dissimilarity Matrices (RDM) are computational models which can be used to visualize behavioral data and look at correlations. They contain a cell for each pair of stimuli and represent the similarity between both stimuli in that cell. Therefore, the RDM represent the degree to which stimuli are alike or different from each other (Kriegeskorte, Mur, & Bandettini, 2008). This method was used in this study to visualize the data and compare correlations for dance quality and dancers. A customized Matlab script was used to produce the matrices shown in the results.

Results

Participant response was as follows: eight participants rated questionnaire 1, seven participants rated questionnaire 2, ten participants rated questionnaire 3, fourteen participants rated questionnaire 4 and nine participants rated questionnaire 5.

Precision of recognition

After viewing each stimulus, participants were asked to select the dance type they thought was performed in the dance choreography video. Accuracy for recognition was high (

Table 2). A Pearson chi square test (χ^2= 192.552, p <.001) showed that participants were accurate at recognizing both conditions from the dance choreography videos (

Table 2). Accuracy was similar for both dance types, indicating that accuracy was not dependent on the perceived quality.

Table 2: Recognition of each of the dance qualities

	Perceived Quality	Fragility	Lightness	Total	Accuracy
Actual Quality	Fragility	469	107	576	81%
	Lightness	112	464	576	80%
Total		581	571	1152	

There was no difference (χ^2= 442.565, p >.001) in recognition of Fragility and Lightness between males and females (Table 3), since accuracy did not differ substantially for both genders.

Table 3: Recognition of each of the dance qualities by gender

	Perceived Quality	Gender	Fragility	Lightness	Total	Accuracy
Actual Quality	Fragility	Male	115	29	144	80%
	Fragility	Female	354	78	432	82%
	Lightness	Male	27	117	144	81%
	Lightness	Female	85	347	432	80%
Total			581	571	1152	

There was no difference in recognition of Fragility and Lightness between participants with or without dancing experience (

Table 4), since accuracy for both was similar.

Table 4: Recognition of both dance qualities for participants with and without dancing experience

	Perceived Quality	Group	Fragility	Lightness	Total	Accuracy
Actual Quality	Fragility	DanceEXP	143	37	180	79%
	Fragility	NoDanceEXP	326	70	396	82%

	Lightness	DanceEXP	34	146	180	81%
	Lightness	NoDanceEXP	78	318	396	80%
Total			581	571	1152	

(DanceEXP=Dancing experience of the participant; NoDanceEXP=No dancing experience of the participant)

Affective rating

A Pearson Chi Square value of χ^2= 99.701 (p <.001) showed that perceived emotions were different for both dance qualities (Figure 3).

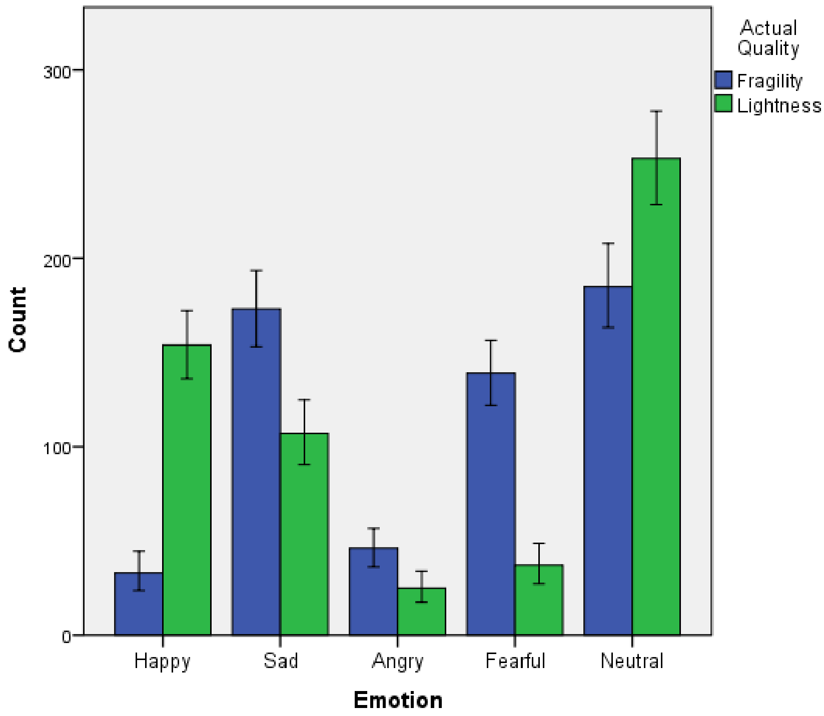

Figure 3: Selected emotion of participants compared for each dance quality (Error Bars CI=95%)

Each participant selected one emotion that best characterized the dance performances they viewed. The majority of participants selected ‘neutral’ as most appropriate for both dance types. For Fragility, however, the overall selection of negative emotions was high, with ‘sad’ and ‘fearful’ being selected with almost similar frequency as ‘neutral’. For Lightness, ‘happy’ was the second most selected emotion. In comparison, Fragility was associated more often with negative emotions than Lightness (Table 5: Affective ratings of each Table 5).

Table 5: Affective ratings of each dance quality

Emotion	Total Negative Emotions	Total

		Happy	Sad	Angry	Fearful	Neutral		
Actual Quality	Fragility	33	173	46	139	185	358	576
	Lightness	154	107	25	37	253	169	576
Total		187	280	71	176	438	527	1152

The effects of gender and dancing experience were explored. Males and females rated Fragility similarly, but Lightness differently. Overall, females selected more 'neutral' for Lightness than men. Men, however, selected more 'happy' than 'neutral' for Lightness (Table 6).

Table 6: Affective rating for each dance quality compared by gender

	Perceived Quality	Gender	Happy	Sad	Angry	Fearful	Neutral	Total
Actual Quality	Fragility	Male	13 (9%)	43 (30%)	8 (6%)	37 (26%)	43 (30%)	144
	Fragility	Female	20 (5%)	130 (30%)	38 (9%)	102 (24%)	142 (33%)	432
	Lightness	Male	49 (34%)	36 (25%)	6 (4%)	5 (4%)	48 (33%)	144
	Lightness	Female	105 (24%)	71 (16%)	19 (4%)	32 (7%)	205 (48%)	432
Total			187	280	71	176	438	1152

Dancing experience does not seem to have an effect on the previously described trends (Table 7).

Table 7: Affective rating for each dance quality compared for participants with and without dancing experience

	Perceived Quality	Group	Happy	Sad	Angry	Fearful	Neutral	Total
Actual Quality	Fragility	Dance EXP	14 (8%)	50 (28%)	12 (7%)	52 (29%)	52 (29%)	180
	Fragility	NoDance EXP	19 (5%)	123 (23%)	34 (6%)	87 (22%)	133 (34%)	396
	Lightness	Dance EXP	47 (26%)	38 (21%)	14 (8%)	7 (4%)	74 (41%)	180
	Lightness	NoDance EXP	107 (27%)	69 (17%)	11 (3%)	30 (8%)	179 (34%)	396
Total			187	280	71	176	438	1152

(DanceEXP=Dancing experience of the participant; NoDanceEXP=No dancing experience of the participant)

Low-level feature rating

Finally, participants had to rate the stimuli they watched on 7 previously described low-level features. A Multivariate Analysis of Variance (MANOVA) was performed to assess the scores of the low-level features rated by all participants on both dance qualities. Specifically, all aspects where rated higher by the participants for Lightness, except gravity and tension (Figure 4).

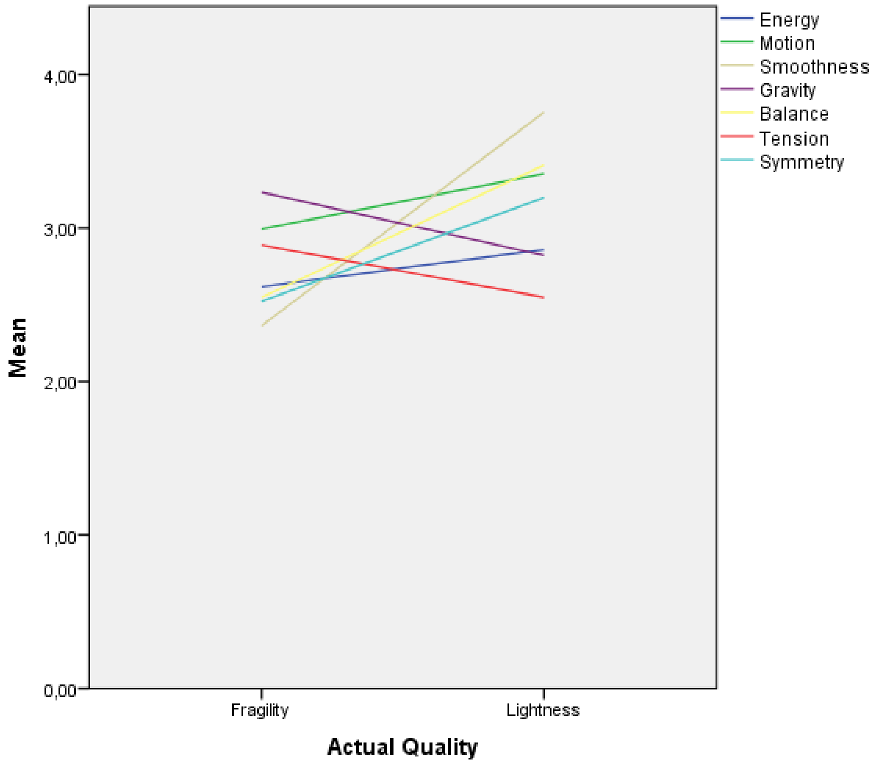

Figure 4: Low-level feature ratings compared for each dance quality

No overall qualitative differences between males and females for the low-level feature rating were found. Specifically, however, female participants rated 'energy' higher for Lightness as compared to Fragility, whereas males did not (Table 8).

Table 8: Low-level feature rating for each dance quality compared by gender

	Actual Quality	Male	Female
Energy	Fragility	2.65	2.61
	Lightness	2.74	2.90
	Total	2.70	2.76
Motion	Fragility	2.98	3.00
	Lightness	3.31	3.37
	Total	3.15	3.19
Smoothness	Fragility	2.34	2.37
	Lightness	3.70	3.77
	Total	3.02	3.07
Gravity	Fragility	3.34	3.20
	Lightness	2.92	2.79
	Total	3.13	3.00
Balance	Fragility	2.47	2.57
	Lightness	3.37	3.42
	Total	2.92	3.00
Tension	Fragility	2.92	2.88
	Lightness	2.44	2.59
	Total	2.68	2.74
Symmetry	Fragility	2.49	2.53
	Lightness	3.14	3.22
	Total	2.82	2.88

Overall, there was no difference between the low-level feature rating for participants with or without dancing experience. However, ‘smoothness’ tended to be higher rated by participants who had dancing experience as compared to those without dancing experience (Table 9).

Table 9: Low-level feature rating for each dance quality compared for participants with and without dancing experience

	Actual Quality	Dancing Experience	No Dancing Experience
Energy	Fragility	2.57	2.64
	Lightness	2.82	2.88
	Total	2.70	2.76
Motion	Fragility	2.97	3.01
	Lightness	3.38	3.34
	Total	3.18	3.18
Smoothness	Fragility	2.49	2.31
	Lightness	3.87	3.70
	Total	3.18	3.01
Gravity	Fragility	3.25	3.22
	Lightness	2.79	2.83
	Total	3.02	3.03
Balance	Fragility	2.69	2.48
	Lightness	3.44	3.40
	Total	3.07	2.94
Tension	Fragility	2.94	2.87
	Lightness	2.53	2.56
	Total	2.74	2,72
Symmetry	Fragility	2.58	2.50
	Lightness	3.24	3.18
	Total	2.91	2.84

Stimuli validation

In general, accuracy for both types was >75% for most of the dancers. Dancer 5 was one exception with accuracy levels for both dance types below the threshold of 66%. Three other dancers (3, 8 and 9) performed poor on only one dance type (

Table 10). For each specific dancer, the ability of the study participants to correctly assign each performance to the correct dance type was assessed by a Chi-square test. This was highly significant for all dancers except for Dancer 5 (Table 10).

Table 10: Recognition of each dance quality performed by each of the dancers

	Fragility			**Lightness**			**Overall**	**χ^2 and**
Dancer	Fragility	Lightness	Accuracy	Fragility	Lightness	Accuracy	**Accuracy**	**p-value**
1	41	7	85%	11	37	77%	81%	37.762, p <.001
2	45	3	94%	8	40	83%	89%	57.667, p <.001
3	46	2	96%	23	25	52%	74%	27.259, p <.001
4	40	8	83%	9	39	81%	82%	40.059, p <.001
5	23	25	48%	18	30	63%	56%	1.064, p =.302
6	40	8	83%	1	47	98%	91%	64.752, p <.001
8	38	10	79%	21	27	56%	68%	12.709, p <.001
9	28	20	58%	6	42	88%	73%	22.042, p <.001
10	37	11	77%	1	47	98%	88%	56.450, p <.001
11	40	8	83%	6	42	88%	86%	48.250, p <.001
12	47	1	98%	7	41	85%	92%	67.725, p<.001
13	44	4	92%	1	47	98%	95%	77.344, p<.001

No overall differences were found when comparing dancer with emotion selected by the participant (Table 11). The emotion ‘happy’ was presented with the largest range (2-32) as compared to the other emotions.

Table 11: Affective ratings for each of the dancers

	Emotion					
Dancer	Happy	Sad	Angry	Fearful	Neutral	Total
1	16	19	3	12	46	96
2	2	42	4	18	30	96
3	6	21	5	36	28	96
4	11	25	3	9	48	96
5	22	16	6	9	43	96
6	9	16	8	11	52	96
8	6	26	11	10	43	96
9	16	18	17	12	33	96
10	32	28	2	6	28	96
11	19	28	5	10	34	96
12	23	24	4	24	21	96
13	25	17	3	19	32	96
Total	187	280	71	176	438	1152

There were no notable findings when comparing dancers with low-level feature rating.

Representational Dissimilarity Matrices

Representational dissimilarity matrices were used to visualize the behavioral data, besides the already shown graphs. They specify that from a correlational point of view the dance qualities as well as the dancers differ from each other (Figure 5).

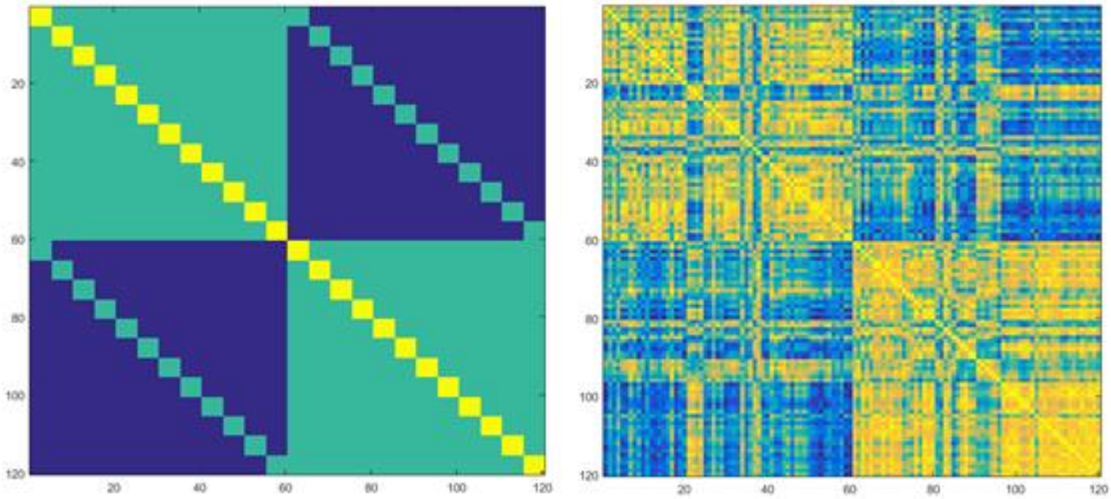

Figure 5: Representational dissimilarity matrices for the theoretical model (left) and the actual behavioral data model (right) (Color: yellow=high correlation for 2 clips based on rating, blue=low correlation)

Discussion

Several questions were tested in this study. First, it was tested whether participants can correctly identify two dance qualities. Second, it was tested whether participants will rate both qualities as neutral or with an emotional content and if both qualities differ in emotional content. Third and final, it was tested whether both qualities will be rated differently on 7 low-level features from the Multi-Layered Computational Framework of Qualities in Movement.

Similar recognition of Fragility and Lightness

The first hypothesis of this study was that participants can distinguish between both dance qualities. In line with this hypothesis, results revealed that participants were indeed able to correctly identify both dance qualities and they did so with an accuracy of around 80%. Both genders seemed equally accurate at identifying the dance qualities since both showed an accuracy of around 80%. Dance experience of the participant did also not affect the correct recognition of the dance qualities, since both, experienced and non-experienced participants, showed similar accuracies of around 80%.

In line with these findings, Brownlow, Dixon, Egbert, and Radcliffe (1997) found that, when students rated happy or sad dance video clips on movement measures (e.g. fluidity, energy) or on dancer characteristics, the gender or level of dancing experience of the participants globally speaking did not have an influence on their rating. Others, however, came to a different conclusion: one example is the study of Henley (2015) where the experimenter manipulated dance video clips in shape, time and space. He then compared recognition of this manipulation for novice and expert dancers and found that expert dancers were better at identifying the manipulations for time and space, as compared to novice dancers. Of note is that the differences to be recognized by the participants in the Henley study were more subtle than the difference between the dance qualities in the present experiment. It is thus well perceivable that for recognition of dance qualities in the present study, no dance experience is needed, since the differences are much more obvious. This is supported by the fact that in the present study the recognition accuracy was very high, irrespective of dance experience, while in the Henley experiment this was much lower, even for expert dancers. Whereas participants from the current study showed an accuracy of around 80% to correctly identify the dance qualities, the participants of Henley's study showed an average accuracy of less than 50%. Another example is the study of Calvo-Merino, Ehrenberg, Leung, and Haggard (2010) who found that expert dancers are more sensitive to recognizing subtle differences between two-point light display ballet dances, as compared to non-experts. They let twenty-four experts and twenty-four matched controls watch pairs of dances and then asked them whether they were the same or different. Experts showed to be better at this task when the clips were in their canonical orientation, but no difference was found when the clip was shown upside down.

Neutrality was most often associated with each of the dance qualities

The second hypothesis was that participants rate both dance qualities as having no emotional content (neutral). Results showed that participants, overall, indeed associate neutrality more often with both dance qualities than with any particular emotion. Taken together, however, the majority of participants associated any emotion with both dance qualities rather than neutrality. Notably, Fragility was associated with mostly negative emotions. Interestingly, there was no gender difference in the rating of Fragility, while Lightness was rated differently: Males rated Lightness as being 'happy' more often, whereas females rated Lightness as being 'neutral' more often. Similar results were found in Sokolov et al. (2011). In this study, body movement in general was the major point of interest. They had thirty-four students select either 'happy', 'neutral' or 'angry' for point-light displays which displayed knocking movements on a door. Study participant characteristics were similar for both this experiment and the current experiment; however, in the current study both experienced and non-experienced dancers were used whereas in the experiment by Sokolov et al. (2011) no information on dance experience of the participants was provided. From their experiment, Sokolov and colleagues concluded that men were presumably better tuned at recognizing happiness from actions whereas women are better at perceiving a lack of emotional content from body actions. Why this is the case is still unclear and further research is needed to investigate this phenomenon.

In the present study, no overall differences were found for the affective rating compared with dancing experience. This is in contrast with previously done research. Christensen, Gomila, et al. (2016) for example found that having dancing experience influences emotional processing. They let forty-four undergraduates and ballet experts rate forty-eight dance video clips on how 'happy' and 'sad' the movements performed in the clips made them feel. Additionally, they measured Galvanic Skin Reponses

(GSR) and found that ballet experts showed a higher level of GSR to happy movements, as compared to participants without dancing experience, who showed the same levels for happy and sad movements. Although the current study did not use ballet as the dance type to be investigated, the ballet experts used in the experiment by Christensen and colleagues had ballet as their main dance style, but many of them were also proficient in other styles such as jazz dance and commercial dance. This variety in background dance style is similar to the experiences of the participants in the present study, and even though the current study did not have experts but only experienced dancers, the effect described by Christensen could apply to the dancers in this study as well.

Low-level feature rating is different for each quality

The third and final hypothesis was that participants would rate both dance types differently on the 7 low-level features previously presented. Results revealed that participants certainly do rate both dance types differently. Specific differences were found in Lightness being rated higher on all aspects except tension and gravity, as compared to Fragility. When comparing gender differences, it was found that ‘energy’ was rated higher for Lightness by females. Surprisingly, dance experience of the participants does not seem to have an effect; however, smoothness was rated higher by participants with dancing experience. From the studies of Henley (2015) and Calvo-Merino et al. (2010), one would expect that dance experience helps in identifying subtle differences in dance features, however in this study this is not the case. A major difference between the present study and the one by Henley and Calvo-Merino and colleagues is the degree of dance experience: while Henley and Calvo-Merino and colleagues used expert dancers versus novices, in the present study a participant qualified as being dance experienced with three years of practicing dance any time in his/her life. Another study done by Henley (2013) showed that indeed dance experience only has a little influence on dance perception and the accuracy of the participants rating. He let twelve expert dancers with a variety of dance type background and twelve similar novices rate a 30s contemporary dance clip on four categories: Shape, Space, Time and Effort. His results only showed a statistical difference in accuracy when looking at Space rather than any of the other categories directly describing the movement. This finding is of interest for the present study, since movement characteristics were rated by participants and dance experience did not show any effects.

Correlations within the behavioral data

The RDM showed that there is a high correlation (yellow color) within each dance quality and a low correlation (blue color) between the dance qualities. In addition, the RDM shows that some of the dancers stand out, one example being dancer 5. This is represented by the blue/yellow “cross” in the model. This indicates that dancer 5 is not reliable in presenting both dance qualities in a manner from which the participants were able to correctly distinguish both qualities. Very promising to see, however, was that the matrix calculated from our behavioral data, overlaps relatively well with the theoretical matrix model.

Successful validation of stimuli

Finally, this study validated the stimuli to be used in the fMRI study described above. To validate the dancers, it was important that dancers scored more than 66% on accuracy for both dance types. Eight dancers met this criterion. Dancer 5 scored below 66% accuracy for both types and dancers 3, 8 and 9 had an accuracy of below 66% for one of the types. Those will be thus excluded from the fMRI study. Additionally, a Chi Square test showed that there were no statistical differences between both dance qualities for dancer 5 (Table 10). This meant that participants were not able to correctly differentiate between both dance qualities for this dancer. When comparing the emotion selected by the participants with the dancers, no overall differences were found, however, there was a large range for ‘happy’ (Table 11). Although, stimuli were most often rated emotionally neutral, there was a higher than expected association with positive or negative emotion that differed between the two dance qualities. Therefore, future research should keep this in mind and be careful with any findings using these stimuli. No notable findings were found when comparing dancer with low-level feature rating.

Potential limitations of the present study

Limitations in this study are present. The main ones will be described. First, since this was an online questionnaire, it was not possible to control the environment participants filled in the questionnaire. To have optimal circumstances, it would have been best to ask participants to come to a lab, and have the experiment conducted in a controlled setting. Second, since there were one hundred twenty dance choreography stimuli it was decided to use sub-questionnaires. This has as disadvantage that not all stimuli are rated by every participant. Finally, it would have been better and more accurate if participants rated the dance qualities on all the emotions presented and to not have them select only one. By doing so a better statistical analysis could be performed, providing more precise information. Future research should keep these restraints in mind when continuing research in this topic.

One step closer to sonification of visual stimuli

To conclude, it can be stated that participants were accurate in correctly identifying Fragility and Lightness. Furthermore, the association of ‘neutrality’ with both the dance qualities and the validation of most of the stimuli, makes these dance choreography videos useful for further research into this topic, however they should be used with caution.

The results found in this study will be taken into account when conducting data analysis for fMRI experiment. Both data of this experiment and data of the fMRI experiment are an important step towards understanding how the human brain perceives the two dance qualities mentioned. Additionally, due to validation of the stimuli used, these can now be applied in future studies with which the EU ICT 2020 DANCE Project is one step closer towards the sonification of visual stimuli. A successful translation of visual stimuli into auditory stimuli could have great implications for further improving the senses of blind and visually impaired people.

Second Experiment: is there a significant effect of the interactive sonification training on the perception of the expressive qualities?

In this experiment we evaluate the role of the interactive training in the perception of expressive qualities from the appropriately designed sonifications. We aim checking if playing an interactive sonification on herself will improve the understanding of the mapping between the movement quality and the sounds.

We selected two different groups of participants, to ask them to evaluate the degree of Fragility and Lightness in the corpus of sonifications obtained from the same stimuli stimuli used in the fMRI experiment:

- the first group (Condition A) did not performed any training, and only watched few videos showing Fragility and Lightness;
- the second group (Condition B) was trained by wearing the sensor systems developed in DANCE (the same IMU sensors were adopted for the public event demonstration of DANCE at Celebration of the Treaty of Rome EU Event with the choreographer Virgilio Sieni, consisting of IMUs on wrists, ankles, and coccix, see D2.2 for details on the movement quality recognition algorithms) to experience on their own body the sonification of the qualities.

That is, the second group performed a training in which the qualities were learned by embodiment and full-body physical experience by means of interactive sonification. The following video with Virgilio Sieni is an example of interactive sonification of movement qualities: https://www.youtube.com/watch?v=fUffjPnXXtE

Hypothesis

- **H1) There is a significant effect of the interactive sonification training on the perception of the expressive qualities.**

Setup and Protocool

Forty participants (36 females) participated in the experiment: 32 participants had some prior experience with dance (25 at amateur, and 7 at professional level). 19 out of 40 participants had some prior experience with music creation (13 at amateur level and 6 being professionists). The participants were divided into two groups: 20 out of 40 participants had an opportunity to test the sonifications (Condition B), the others only watched some short video-examples of the performances of professional dancers expressing both qualities, and they did not hear sonifications at all.

All participants listened 20 audio files. The audio segments are sonifications of the two qualities: they are automatically generated as the result of the application of the computational models of the sonification of the two qualities. For this purpose, 20 stimuli were chosen from the set used in the Study 1 (fMRI experiment).

For each audio segment, they were asked to rate the global level of Fragility and Lightness they perceived using two independent 5-point Likert scales (from "absent" to "very high").

Sonifications were played in the random order using Latin Square Design.

Results

Each participant listened 20 sonifications, and we collected 1600 answers. The overall results divided by the type of stimuli are presented in Figure 6 and Table 1.

Sonified Lightness		
	Perceived Lightness	*Perceived Fragility*
Condition A	2,75 (1.106)	0.96 (1.090)
Condition B	2,82 (0.971)	0.47 (0.814)
Sonified Fragility		
	Perceived Lightness	*Perceived Fragility*
Condition A	1.05 (0.991)	2.79 (1.078)
Condition B	0.86 (0.773)	3.01 (0.888)

Table 1. Average scores for Perceived Lightness and Fragility

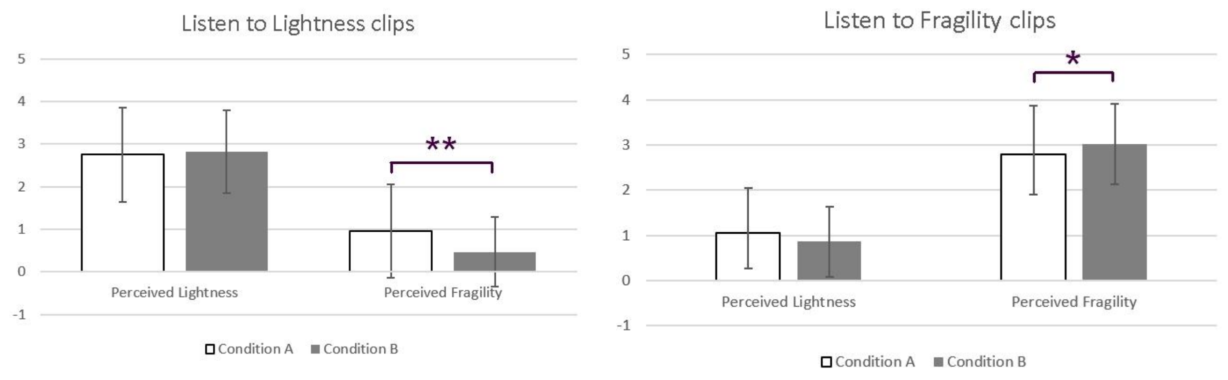

Figure 6: Summary of the results: significant differences according to M-W test signed with ** (p<.05), trends are signed with * (p<.1).

We checked the assumptions of ANOVA test. Verification of normal distribution *for* each experimental group separately using Shapiro-Wilks test as well as the verification of the normal distribution of the residuals were performed and the results showed *that the data* are not normally distributed (see also Figure 6). This result is not surprising because we ask our participants to rate the perceived Fragility and Lightness of the sonifications of the segments that contain strong Fragility or Lightness. The distributions are skewed because people tend to answer “very high” or “absent” (i.e., the two extremes of 5 point scale used in the experiment). Consequently, to test our hypothesis (H1) we opted for non-parametrical Mann–Whitney U (M-W) test and we applied it separately on each combination of two independent variables.

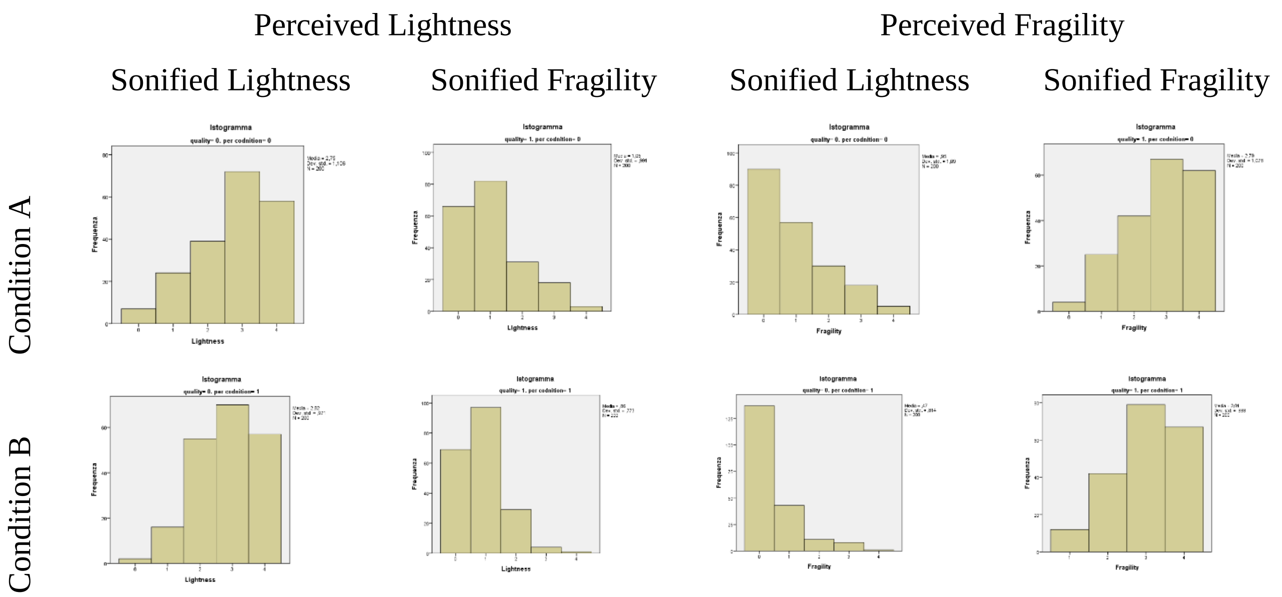

Figure 7: Distribution of the ratings *distribution* for *each experimental group*

For Lightness stimuli, a M-W test indicated that people who did not participate in the “embodied” interactive sonification training (Condition A) perceived a higher level of Fragility than people who participated in training (Condition B) ($U = 14728$, $p < .001$). At the same time, there was no significant difference in the perception of Lightness ($U = 19744$, $p = .818$).

For Fragility stimuli, a M-W test indicated the tendency for untrained participants (Condition A) to perceive a lower level of Fragility compared to the trained participants ($U = 1812.5$, $p = .088$). Again, there was no significant difference in the perception of Lightness ($U = 18348$, $p = .125$).

Conclusion

The effect of the embodied interactive sonification training was observed on the perception of one out of two qualities, namely Fragility. The results show that **participants who did the embodied interactive sonification training improved significantly their performance: they perceived less Fragility in *Lightness stimuli*, and they had tendency to perceive more Fragility in Fragility stimuli** (although the second result is on the margin of significance). It means that **the embodied training improved the association between the expressive quality and sonification**. As concerns Lightness, the embodied training did not influence the perception of Lightness. This might be also due to the complexity of Fragility with respect to Lightness: fragility implies a continuous interruption and re-planning of motor actions (Camurri et al 2017). Further studies should check whether the observed results depend on the expressive quality and/or on the sonification model. In particular, different sonification models might be used to sonify the same quality to evaluate whether the observed effect depends on this variable. It should be noted that the choice of the sonification models is the result of an evaluation of different alternatives, based on a serious games presenting alternative models to a population of participants (Kolykhalova et al 2016).

References

Alborno, P., Piana, S., Mancini, M., Niewiadomski, R., Volpe, G., & Camurri, A. (2016). Analysis of Intrapersonal Synchronization in Full-Body Movements Displaying Different Expressive Qualities. 136-143. doi: 10.1145/2909132.2909262

Kolykhalova, K., P.Alborno, A.Camurri, G.Volpe (2016). A serious games platform for validating sonification of human full-body movement qualities, Proc. MOCO 2016 Intl Workshop, Thessaloniki, DOI: http://dx.doi.org/10.1145/2948910.2948962

Blasing, B., Calvo-Merino, B., Cross, E. S., Jola, C., Honisch, J., & Stevens, C. J. (2012). Neurocognitive control in dance perception and performance. Acta Psychologica (Amst), 139(2), 300-308. doi: 10.1016/j.actpsy.2011.12.005

Brownlow, S., Dixon, A. R., Egbert, C. A., & Radcliffe, R. D. (1997). Perception of Movement and Dancer Characteristics from Point-Light Displays of Dance. The Psychological Record, 47(3), 411-421.

Bydlowski, S., Corcos, M., Jeammet, P., Paterniti, S., Berthoz, S., Laurier, C., . . . Consoli, S. M. (2005). Emotion-processing deficits in eating disorders. Int J Eat Disord, 37(4), 321-329. doi: 10.1002/eat.20132

Calvo-Merino, B., Ehrenberg, S., Leung, D., & Haggard, P. (2010). Experts see it all: configural effects in action observation. Psychol Res, 74(4), 400-406. doi: 10.1007/s00426-009-0262-y

Camurri, A., Volpe, G., Piana, S., Mancini, M., Niewiadomski, R., Ferrari, N., & Canepa, C. (2016). The Dancer in the Eye - Towards a Multi-Layered Computational Framework of Qualities in Movement. 3rd International Symposium on Movement and Computing, MOCO 2016, 5-6 July 2016, Thessaloniki, Greece., 1-7. doi: 10.1145/2948910.2948927

Christensen, J. F., Gomila, A., Gaigg, S. B., Sivarajah, N., & Calvo-Merino, B. (2016). Dance Expertise Modulates Behavioral and Psychological Responses to Affective Body Movement. Journal of Experimental Psychology: Human Perception and Performance, 42(8), 1139-1147. doi: http://dx.doi.org/10.1037/xhp0000176

Christensen, J. F., Pollick, F. E., Lambrechts, A., & Gomila, A. (2016). Affective responses to dance. Acta Psychologica (Amst), 168, 91-105. doi: 10.1016/j.actpsy.2016.03.008

Cross, E. S., Kirsch, L., Ticini, L. F., & Schutz-Bosbach, S. (2011). The impact of aesthetic evaluation and physical ability on dance perception. Front Hum Neurosci, 5, 102. doi: 10.3389/fnhum.2011.00102

Hanna, J. L. (1988). To dance is human: A theory of nonverbal communication. Chicago: University of Chicago Press.

Henley, M. K. (2013). Is perception of a dance phrase affected by physical movement training and experience? Research in Dance Education, 15(1), 71-82. doi: 10.1080/14647893.2013.835124

Henley, M. K. (2015). Comparison of Shape, Space, and Time Judgments in Expert Dancers and Novices: Evidence that Production Enhances Perception. Journal of Dance Medicine & Science, 19(3), 103-109. doi: 10.12678/1089-313X.19.3.103

Karpati, F. J., Giacosa, C., Foster, N. E., Penhune, V. B., & Hyde, K. L. (2015). Dance and the brain: a review. Annals of the New York Academy of Sciences, 1337, 140-146. doi: 10.1111/nyas.12632

Kriegeskorte, N., Mur, M., & Bandettini, P. (2008). Representational similarity analysis - connecting the branches of systems neuroscience. Front Syst Neurosci, 2, 4. doi: 10.3389/neuro.06.004.2008

Piana, S., Coletta, P., Ghisio, S., Niewiadomski, R., Mancini, M., Sagoleo, R., . . . Camurri, A. (2016). Towards a Multimodal Repository of Expressive Movement Qualities in Dance. 3rd International Symposium on Movement and Computing, MOCO 2016, 5-6 July 2016, Thessaloniki, Greece., 1-8. doi: 10.1145/2948910.2948931

Sevdalis, V., & Keller, P. E. (2011). Captured by motion: dance, action understanding, and social cognition. Brain Cogn, 77(2), 231-236. doi: 10.1016/j.bandc.2011.08.005

Sokolov, A. A., Kruger, S., Enck, P., Krageloh-Mann, I., & Pavlova, M. A. (2011). Gender affects body language reading. Front Psychol, 2, 16. doi: 10.3389/fpsyg.2011.00016

Van Dyck, E., Vansteenkiste, P., Lenoir, M., Lesaffre, M., & Leman, M. (2014). Recognizing induced emotions of happiness and sadness from dance movement. PLoS One, 9(2), e89773. doi: 10.1371/journal.pone.0089773