Proceedings of the 25th Anniversary Conference of the European Society for the Cognitive Sciences of Music, 31 July-4 August 2017, Ghent, Belgium
Van Dyck, E. (Editor)

Social eMotions: Exploring Emotional Expression and Contagion in Contemporary Dance

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ABSTRACT

We explored the social and dynamic aspects of emotions by combining movement science and contemporary dance. In artistic research, two dancers mapped physical correlates of social emotions (e.g. pride, shame, love), and created a neutral choreography that could then be performed in different emotional scenarios. We recorded motion capture data of performances of the duet, depicting different combinations of love and loathing, as well as versions where emotions change from one to the other. Kinematic analyses were conducted on the movement data to map the combinations of 372 kinematic features to different emotions. A perceptual study was conducted to explore how potential audience perceives the intended emotions. This project concluded as a performance combining dance, music, live projections, and audience input. Rehearsing for the performance, two cellists conducted artistic research. They emulated the choreographic process and mapped music performance characteristics used in modifying pre-composed loops to express a range of different emotions. Our research illuminates the correlates between bodily sensations, expressions, and perceptions of emotions. As our focus is in the interactive nature of emotions, this work helps performers understand emotional interactions, and scientists learn about the kinematic basis of emotional expression.

I. INTRODUCTION

Most research on emotions focuses on facial expressions, static emotional states, and individuals as both the stimuli and as participants. Only occasionally have the dynamic changes in emotional characteristics during musical performances been considered (Eerola & Vuoskoski, 2013). Perception of emotions from dynamic point-light displays was previously studied (Dittrich, Troscianko, Lea, & Morgan, 1996), but we report here a more complete study that spans from artistic research of the embodiment of social emotions to study of kinematic features of dance performances, to perceptual studies of real and modified animations of motion-captured performances, and finally to an artistic performance highlighting the findings of the study.

In this project, we wanted to study how emotions are expressed, communicated and perceived from body movements, and view emotions as social and constantly changing. This reflects better the central role emotions play in our social interactions (Frijda & Mesquita, 1994).

Earlier research has shown that emotions can be recognized from body movements, even when the movements are reduced to point-light displays, which removes all other cues we generally use for perceiving other people's emotions, such as facial expressions or voices (Johnson, McKay, & Pollick, 2011; Pollick, Paterson, Bruderlin, & Sanford, 2001; Wallbott, 1998). Expressive body movements are important in dance and music performances, but also in computer games and virtual characters. Knowledge about the body kinematics of emotions is applied in systems where virtual dancers respond to music (Taylor, Torres, & Boulanger, 2005), or teach dance moves to users (Huang, Uejo, Seki, Lee, & Kawagoe, 2012). These applications utilize movement synthesis and the synthesis of emotional motion styles, that allows a standard movement template to be adjusted depending on the required emotion (Förger, 2015; Förger & Takala, 2016).

Our study combines three points of view to bodily expression of emotions: the artistic point of view comes from the field of contemporary dance, where a wide range of different body movements is used, often with the intent to communicate emotional qualities of the character, or their relationship to other characters on stage, to the audience, or evoke certain emotional responses in the audience. The second point of view is that of social psychology and especially the study of the mechanisms of social interaction; the timing and coordination of expressive movements and gestures (Himberg, 2014; Himberg & Thompson, 2011). The third point of view comes from studies of computer graphics and virtual characters and how they can display different emotions in their behaviours, and react to the human users' actions in an emotionally congruent fashion (Förger, 2015).

The initial artistic, kinematic, and perceptual studies were carried out without music, but the performance at the end was for two dancers and two cellists. The cellists conducted artistic research in musical expression of emotions during its rehearsal period, and these results are briefly discussed in section III.a.

II. METHODS

A. Artistic Research

Two dancer-choreographers (authors 4 & 5) used Stanislavski's methods (Stanislavski, 2008) to explore the physical correlates of various social emotions. Evoking memories of having felt these emotions, they investigated the sensations they create in the body, how they influence movement, and their interactions with the other dancer. They studied the effects of different sources for these emotions (self/other/shared), as well as how long they can be maintained and how contagious they are. Based on the dancers' artistic research, the emotions of "loving" and "loathing" were selected for the kinematic and perceptual studies.

The results of the two-year project were summarised into a performance that combined dance, music, live motion capture –driven projections, and audience interaction (trailer in vimeo.com/175233100). The performance was a duet for two dancers and two cellists, and it explored the emotional interaction of two dancer-cellist pairs (A and B). During the performance, audience members periodically voted on their mobile phones, which emotions the interacting performers should aim for next; one emotion (out of two options) for pair A, another for pair B. The emotions came from a list of 21 emotions.

In the performance, emotions we in constant flux, in and through interaction with the other pair. Whereas in a typical music or dance performance the movement or musical material usually has primacy, and is pre-choreographed and pro-composed, here the choices of the audience guided the emotional drama, and this influenced which movement and musical material got used and how it was shaped.

The dancers and musicians were improvising based on pre-composed and choreographed loops, selecting loops and how to perform them (having considerable freedom to modify the material), depending on the emotions they wished to express, and how they responded to the other pair. Thus the objective of the artistic research that took place during the rehearsal period was to find the combinations of performance characteristics that conveyed the listed emotions, in the context of the piece and within the constraints of the material. An array with emotions and their performance characteristics was compiled to summarise these.

B. Motion Capture and Kinematic Analysis

We used a 20-camera optical motion capture to record performances of a neutral choreography, in different combinations of emotional states (see Figure 1). Each capture contained seven repetitions of a basic choreography. Different combinations of the two emotions (loving and loathing) and a neutral performance, and gradual changes from one to another were recorded.

From the 3D recordings, 372 kinematic features were extracted, following methods from an analysis of action verbs and adjectives describing different styles of walking (Förger, Honkela, & Takala, 2013). A principal component analysis (PCA) was then conducted to reduce the dimensionality of the feature space. In addition to providing us with a view of what kinematic features were associated with the expression of different emotions, and different intensities of those emotions, the PC's were later used in the correlation analysis of the perceptual data.

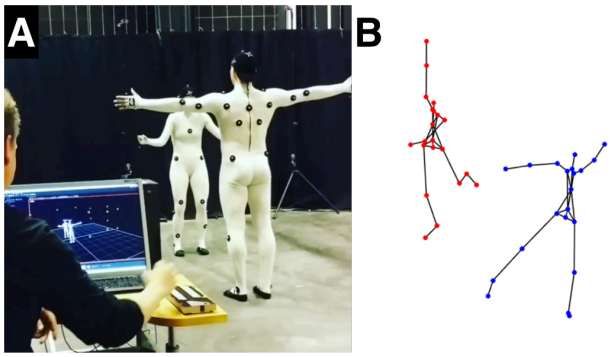

Figure 1. A) Performers being motion-captured; B) Stick-figure visualisation of motion data. Enhanced versions were used in the perceptual study: thicker bones, larger joints, and lighting effects for a better illustration of depth.

C. Perceptual Studies

The motion capture data was visualised as stick figure animations to be used in a perceptual study. In the study, viewers were rating one of the two figures (the blue one) on seven-step scales, judging the feeling that the dancer has towards the other character (very negative (–3) – very positive (+3)), how energetic the dancer appears (not at all (1) – very energetic (7)), and whether the blue dancer is leading or following the dance (following (–3) – leading (+3)).

Table 1. Extract from the array summarizing the results of the artistic research; emotions with characterisations of the performance features needed to produce them.

	DANCE				MUSIC			
Emotion	**Relationship**	**Distance (6x6 m)**	**Direction**	**Physicality**	**Phrasing**	**Phrase variation**	**Timbre**	**Synchrony**
loving	The other is the target	Aims to be close	Feels the other regardless of where they are	Heart throbs. Warmth spreads from heart to the whole body	Long lines	Searching for long lines, pick notes from here and there	Strong, warm, and free	In harmony with the other.
loathing	The other is the reason	Tries to escape	45 degrees away	Centre of gravity low. Slow. Nausea.	Shiver-inducing swells &glissandi	Dissonant intervals	Suffocated	Tries to break synchrony
interest	The other is the target	Tends towards the other	Towards the other	Positive, very focused	Playful	Rhythmisation (picks notes)	Playful and free	Listening eagerly
disappointment	Reason self or other, doesn't want to see or be seen	2–5m	Away	Looking down. Slouched. Heavy body.	A few notes and then pause	Repetition, individual notes or themes	Melancholic, distancing from the other	Somewhat negative connection

The stimulus material was generated from those recordings where the emotional instruction of the performers was kept constant, so that one video contained one repeating loop (out of seven) from the performance. From each performance, we picked three of the repetitions, and from each, animated two versions, with the colouring and position

of the dancers swapped. A total of 66 videos were created. In addition, a set of more controlled pairs of videos were created. In these videos, one of the characters was kept the same, but the partner swapped from a different performance, depicting a different emotion. This allowed us to see if ratings of the blue character changed when only the partner was changed.

The questionnaire was run on a crowdsourcing platform CrowdFlower. Each participant was able to rate up to 20 videos. Eventually, 275 people participated, and in total, every video was rated 30 times.

III. RESULTS

A. Artistic Research

The results of the dancers' artistic research were cross-referenced with the bodily maps of emotions (Nummenmaa, Glerean, Hari, & Hietanen, 2014) and a review of affect recognition in body expression (Kleinsmith & Bianchi-Berthouze, 2013). All three produced highly matching correlates of emotions and bodily and spatial features. For example, sadness lowers the dancer's overall energy level, which makes her movements heavier, and collapses her posture, and withers her limbs. Internally, sadness feels as increased pressure in the chest and head cavities. Similarly, respondents in the study by Nummenmaa et al., reported that sadness lowers the bodily activation in everywhere except in the chest and the head.

The results of the artistic results were later summarised into a tool for choreographers and performers. Table 1 shows four examples of emotions and their performance characteristics, both in dance as well as music.

B. Kinematic Analysis

Two PCA components were needed to map the movement features to the intentional variations in the performances. PC1 (51.6% of variance), loaded the velocity features, and mapped onto the overall amount of love or loathing in the performance, while PC2 (24.9%) represented the contrast in the two performer's dances (Fig 2.).

C. Perceptual Research

Ratings of arousal and valence were statistically significantly ($p<0.005$) correlated with both PC1 and PC2, whereas the ratings of dominance were only correlated with PC2 ($p<0.0001$) that represents differences between the two dancers. This suggests that PC2 was specific to the relationship between the characters, whereas the PC1 captured features of both.

Interestingly, even though the raters only evaluated one of the two stick-figures in the animation, the partnering figure influenced their evaluations of not only dominance, but also valence: for example, the character depicting loathing was rated neutrally, when it was seen with another character depicting loathing. As such, the loathsome movement was not enough to induce a negative interpretation of the character's emotions. However, when the loathsome character was seen next to a loving character, it was rated more negatively. This suggests that at least in this context, the ratings are influenced not only by the movement characteristics of the stick-figure in question, but also by its context, and how its movements compared with those of the other character.

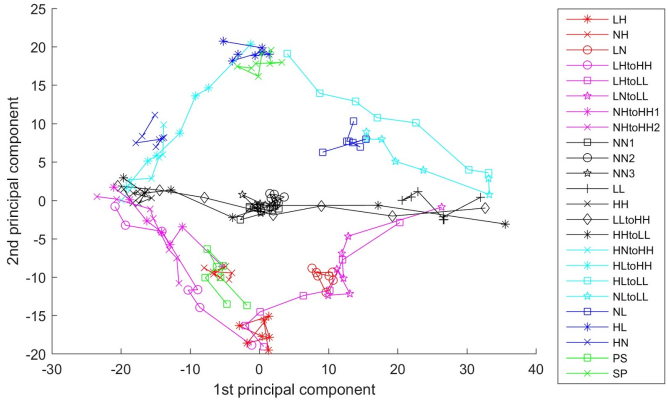

Figure 2. A PCA map of recorded motions colored to show differences between the dancers. Series are colored according to whether the 1st dancer shows: more love (L) = red, more or equal amount of love = magenta, equal instructions = black, more or equal amount of loathing or hate (H) = cyan, more hate = blue. Series with pride (P) and shame (S) are green. (N = neutral)

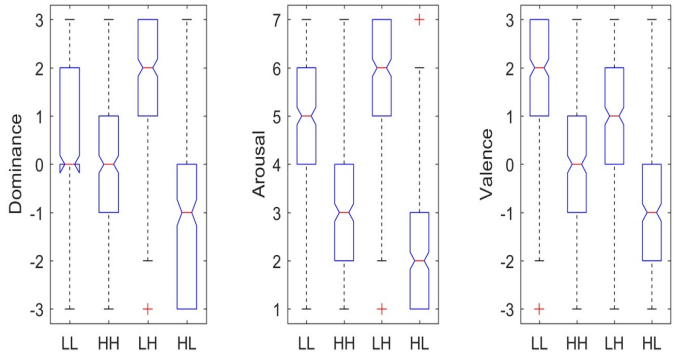

Figure 3. Box plots of ratings on the recombined dances, showing that changing the partner also induces changes in the evaluation of the emotions of the unchanged character.

IV. CONCLUSION

The correspondence between our artistic research and the different mappings of emotions was interesting, as each mapping was generated through a different methodology. Nummenmaa et al. (2014) had asked participants to draw on an outline of a body, where they felt more or less activation when experiencing each emotion. Kleinsmith et al. (2013) had surveyed people and collected together data from many sources, and in our study, the mappings were found through artistic exploration. After the initial artistic study using contemporary dance as the window to these emotions, two other matrices of emotions and their correlates were generated, one on musical expressions, by the two cellists performing in the dance piece that was produced, and another on computer graphics, by the visual artist who designed live projections for the show. The musical performance features are strongly context-dependent and were created with this specific performance in mind, and for the musical material that was composed for this performance. Yet, the findings could inspire research in music and emotions, as especially the

features relating to musical interaction are rarely considered in research.

The kinematic analysis highlights the importance of movement velocity in distinguishing the emotions of loving and loathing. They appear in opposite ends of the circumplex emotion space (Russell, 1980), loving in our case in the quadrant of positive valence and high arousal, and loathing in the negative valence, low arousal corner. As each cycle of the choreography was analysed as an independent unit (thus each performance, containing seven repetitions of this cycle, produced seven data points), it is possible to also evaluate how constant the performers were in increasing the amount of emotion over the seven cycles. This human performance could then be compared with motion style synthesis that gives parametric control over the kinematic features and thus the amount of given emotion in the movement. Having human raters (e.g. professional dancers) evaluate how natural the synthesised, linear progression is compared to the human version, could be further research direction.

The results of the perceptual study provide support to the prior research that has pointed out emotion perception is context-dependent (Pugliese & Lehtonen, 2011). Interestingly, the movements were judged either neutral or positive, even though the loathing/hate is a strongly negative emotion, and was very taxing to perform in the motion capture. Removing facial expressions and sounds seems to make differentiating the intended valence rather difficult, and the slower movement could be interpreted as peaceful or relaxed as well as sad, depressed, or consumed by loathing. While the posture of the dancer is a clear indicator of negative valence, it perhaps is more difficult to perceive from such complex movement that also contains changes in posture. However, when the loathing dance was presented in the context of the other dancer displaying an energetic and positive emotion, the average ratings of valence dropped to negative. Seeing the contrast seems to highlight the features that convey negative valence.

The collaboration between artists and scientists during this project was mutually enriching, and it produced insights to both "sides", understanding and knowledge that could not be achieved in a typical artistic or scientific project.

ACKNOWLEDGMENT

This work was funded by a grant from the Kone Foundation (2015–2016). We thank the Department of Computer Science in Aalto University for the use of their Motion Lab.

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