Movement in a contemporary dance work and its relation to continuous emotional response

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ABSTRACT
In this paper, we describe a comparison between parameters drawn from 3-dimensional measurement of a dance performance, and continuous emotional response data recorded from an audience present during this performance. A continuous time series representing the mean movement as the dance unfolds is extracted from the 3-dimensional data. The audiences' continuous emotional response data are also represented as a time series, and the series are compared. We concluded that movement in the dance performance directly influences the emotional arousal response of the audience.

Keywords
Dance, Emotion, Motion Capture, Continuous Response.

1. INTRODUCTION
The last decade has seen a growing interest in investigating the art of dance in a scientific and systematic manner – the endeavour has been supported by the development of sophisticated motion capture devices, essential tools for many of the pertinent research questions. One of the reasons for the growth of this field of research is because it allows a new medium to investigate temporal cognition, non-verbal communication as well as the mental processes involved in dance creation, performance and perception [1, 2].

Simultaneously there has been an increasing interest in the continuous emotional response of subjects to a stimulus [3]. One example is for a student's musical or dance performance to be compared with an expert's performance and to assess the degree to which the student models the expert along the time dimension. A dance could also be compared in two conditions providing insights into cognition about how the dancer changes or adapts in the test condition relative to the other condition [4].

The aesthetic and affective responses to the arts are important parts of the experience and interaction that take place in those forms. For example, music has a strong tradition of being experienced and appreciated through emotional responses [5-7]. And recent studies have acknowledged the importance of collecting emotional response data continuously, particularly in music [8]. But little investigation of continuous emotional response to music has been conducted on continuous unfolding of emotional response to dance works [3], and none have examined a possible causal connection between dance movement and emotional response. The study we conducted provides a first attempt to address this relationship.

Specifically, we investigate whether emotional-arousal response of observers is associated with the movement of a dancer. An experiment was devised to investigate the continuous emotional response of an audience to a contemporary dance work.

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2. METHOD
We recorded a dance performance using a motion capture system and a video camera, and recorded an audience responding to this dance performance using the portable Audience Response Facility (pARF) [3]. The data we report here are a subset of a larger dataset, which include responses to dance performances where the accompanying musical stimulus was removed, as well as performances where the dance stimulus was removed and only the musical stimulus was presented.

2.1 Dance Measurements
The motion data were captured using a motion capture system, consisting of 10 Vicon cameras: 4 x MX40 cameras positioned 15 feet above the performance area and 6 x MX3 cameras positioned on 8 foot high tripods around the work performed live to an audience of 40 people. This Vicon system had a temporal resolution of 100 Hz. Using a digital video camera (Sony HandyCam HCR-30E) a video of each performance was made from the front right of the audience area. One of the three dancers (who was also a choreographer of the piece) wore a black lycra suit onto which 24 reflective markers were sewn. The positions of the left and right markers chosen were the ear (2), the top and bottom of the shoulder blade (4), the top of the shoulder (2), the top of the femur (2), the elbow joint (2), the wrist joint (2), the hip joint (2), the knee joint (2), the ankle joint (2), and the foot (2); the collar bone and base of the sternum served as two reference points. The position of each of the markers was recorded in 3 dimensions and the video recording was synchronised with the motion capture recording, by placing a timecode display in the view of the camera.

A dance trio performed *Reactional Movement*, choreographed by Emma Batchelor and James Batchelor, which had the duration 4 minutes and 40 seconds. The accompanying musical piece was *Mysta-Lilli Pilli Drive* by Fourplay (from the album *Digital Manipulation*). The dance was performed in front of an audience. The choreographer/dancer whose movements were recorded was 16 years old and started

dancing at 5 years. In the past three years he had performed in professional dance film and live productions.

2.2 Emotional Response

Self-reported emotional response can be derived from a 2-dimensional display. The two dimensions record the arousal (sleepy/excited) and valence (happy/sad) component of the emotions. To measure the emotional response of the audience during the dance performance we used an interactive response interface designed for recording continuous data – the portable Audience Response Facility (pARF) [3]. This system consists of a set of 21 PDAs that provides a user interface for respondents to record 2-dimensional emotional response with a stylus placed on the screen. The pARF system uses a 2 Hz sampling rate and is synchronized over a WiFi network to avoid any sampling drift error.

The pARF was configured to measure emotional valence and emotional arousal as described in [3] and as commonly used in two-dimensional configurations [8-10]. Twenty members of the audience volunteered to use the portable Audience Response Facility (pARF) to record their emotional response to the live dance work (12 females, 8 males, mean age = 32.3 years, SD=15.9 years). All participants attended dance performances on a regular basis (mean of 9.95 dance events attended per annum) and 12 participants reported having more than five years formal training in dance (mean=13.25 years, SD=7.50 years); the remaining eight participants had less than three years formal training in dance (mean=0.88, SD=1.13). Thus the sample comprised participants who were moderately- to highly-experienced observers of dance.

The median continuous emotional response was calculated, obtained by taking the median value amongst subjects at each time point for both the arousal and valence axes. We then applied a 3-sample moving average on the resulting series to smooth out rapid changes in values that were indicative of unwanted noise in the responses. Given the multiple subjective responses we follow Schubert's method for assessing the agreement in the subjective emotional response variables [11]. A low standard deviation (SD) indicates that subjective responses are in relatively greater agreement, and so the group's subjective response is more reliable. However, as an appropriate standard deviation score threshold is not known in advance, the second order deviation scores are calculated. This means that the standard deviation reading at each sample is collected and has its standard deviation calculated, 'SD2'. We then assert that when the SD falls below 0.5*SD2 above the mean SD, the mean response at that point in time is assumed to be reliable, i.e., observers agree. Pane 1 of Figure 1 shows the relevant data.

2.3 Time-series Dance Parameterisation

To summarise the time-varying change in the dancer motion measurements we have used some simple summaries of the multiple marker 3-dimensional dataset. These summaries produce single numbers which change with respect to time.

The time-series summary parameter we applied was based on the total movement recorded from the dancer by finding the mean absolute change in position between neighbouring time samples across the set of markers. Each marker's change in position per sampling period is reported as the Euclidean distance, and then the mean absolute change is calculated from the change in all the markers in this sampling period. Thus, a new series is created (which is one sample shorter than the original series) representing the mean movement over time (in m/s). This is a simple summary – it represents the amount of visible movement without being specific about what type of movement it is. Movements may involve large changes in position, changes in orientation, opposing or agreeing movements of various limbs, leaping or other movements – they will all be summarised according to the amount of movement in the markers. Movements that involve the dancer's position on stage remaining stationary, but the rapid movement of a small number of parts of the body, will be represented as having similar amounts of mean movement as movements where the whole body is moving slowly over the same period of time.

Finally, this series was smoothed with a 1 second long moving average filter to decrease the noise in the signal.

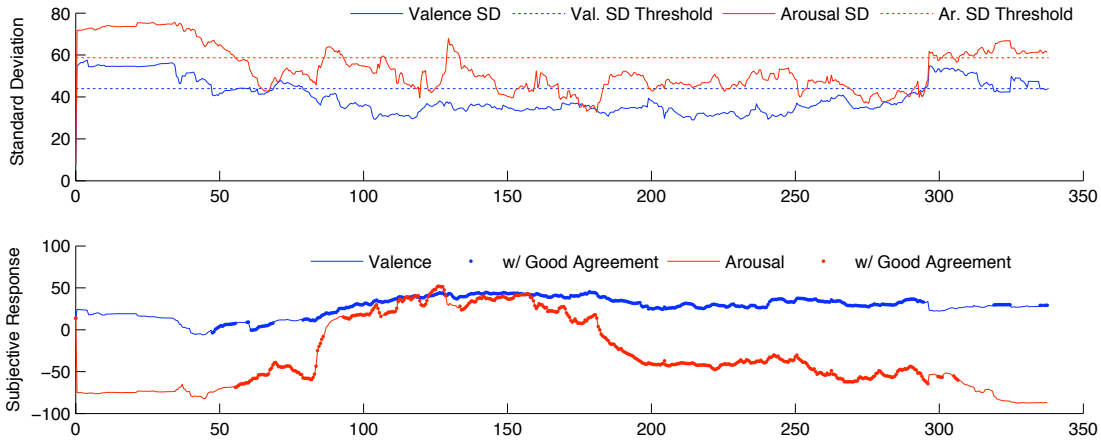

***Figure 1**: Standard Deviation Thresholding of self-reported Valence and Arousal dimensions calculated from 21 participants. For the second pane the reliable points – where the SD falls below the threshold displayed in pane 1 – are marked with dots.*

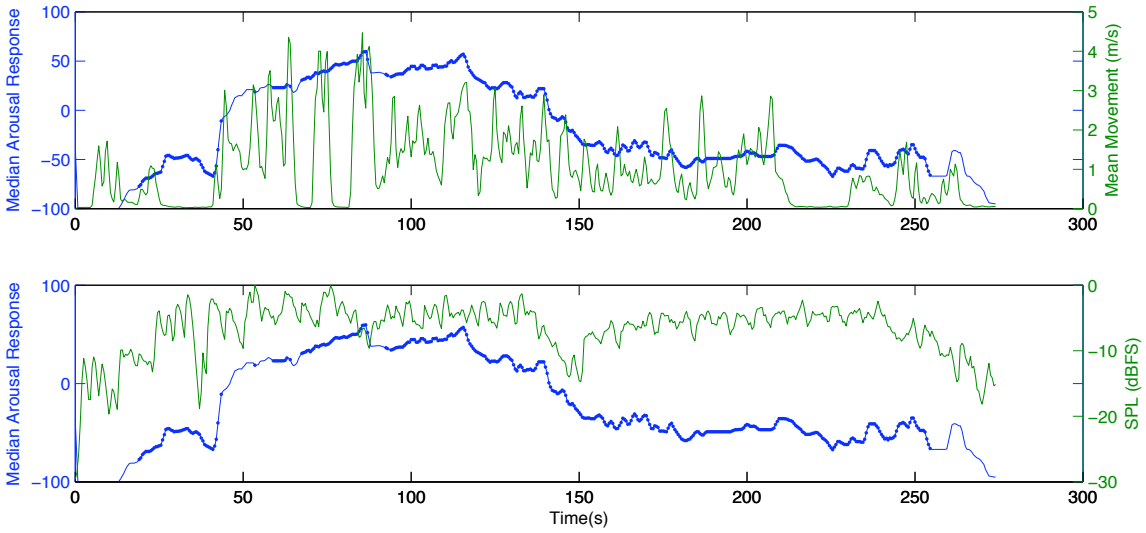

Figure 2 - *Median Arousal compared with Mean Movement (upper) and SPL (lower). The colours of the lines relate to the colours of the left and right axes which employ different scales. The points on the arousal response that are reliable are darker.*

2.4 Sound Intensity

The audience was simultaneously listening to the musical sound track during the dance performance, which may have also contributed to an emotional response. We examined sound intensity, a parameter that is likely to affect the emotional arousal response [9]. We extracted the sound intensity from the audio recording. This was calculated using a digital analysis performed using an integrating sound level meter [12]. An A-weighted frequency weighting was used, and the integration time was set to 1 second, so that the resulting trace was relatively smooth.

3. RESULTS

3.1 Emotional Response

Emotional response values are visualized in Figure 1. The two panes show the time-series standard deviation for each series, and the threshold below wherein standard deviation is considered to be satisfactory agreement for each series (see section 2.2). The pane below gives the actual mean values for the series, as well as showing where they are considered to be in good agreement.

It can be seen that the series are in good agreement for most of the performance. A commonly seen aspect of emotional response data is also clear [9] – the arousal data vary a lot more than the valence data, which stay close to zero, and change only gradually. The arousal data reflect a much greater use of the scale as well as rapid changes during the performance. Due to this finding, we are only examining arousal response in this paper.

3.2 Mean Movement and Arousal

The data for mean movement of the dancer, compared to the mean arousal data are displayed in Figure 2. Through visual inspection, we can see that the fit is quite close in terms of the overall shape of the data, but the statistical fit is not as close. The undulations in the movement time-series reflect periods of activity and inactivity of the dancer wearing the reflecting markers. The inactive sections, particularly around the 70th to 200th second of the work (see Figure 1) consists of fugues and periods where one or two dancers are active while the other is not. Indeed, a qualitative analysis of the video, compared with the numeric data suggest that the arousal responses are better reflected by overall changes in movement in all the dancers than the quantified data of the single dancer shown in Figure 1.

3.3 Sound Pressure Level and Arousal

In pane 2 of Figure 2, sound pressure level is presented alongside arousal. While there is a slight reflection in shape between the two – the two main plateaus appear to be in the same place – they do not match in general terms. Sound Pressure Level appears to reflect cyclical, rhythm-based musical attributes, rather than the phrase-based arc that is seen with the median arousal response.

4. DISCUSSION

Our investigation of the relationship between dancer motion and emotional response reveals two main findings. First, motion seems to be related to emotional-arousal, and second, valence response is little affected by motion, in this performance. We acknowledge the limitation of the present study in that only a single dancer's movements were tracked among the ensemble of three, however, it was possible to verify the visual inspection of the time series data with the video, where motion-arousal connection was present. We also acknowledge, in line with previous research, that music can have a powerful effect upon arousal response [9]. In the present dance, music was played, and there may well be an additive effect of music and motion, or perhaps some kind of interaction. Our analysis of the sound pressure level of the performance does not show a strong relationship between a primary musical attribute, overall level, and the arousal response. Other musical attributes may give different responses. Comparing the emotional effects of a dance work performed with and without music will be the next step in our

research, and a logical extension of another study we have performed using the same ensemble and piece [4].

5. CONCLUSION

Emotional responses to dance collected as the work unfolds is a new, promising area or research that will help to better understand the emotion and cognition that mediate audience response and intention-reception in dance. The present study provided initial evidence that there is a relationship between motion and emotion. Greater changes in dancer motion are connected with stronger audience arousal-emotion responses. Further analysis is planned in which more quantitative approaches will be applied, such as those described by Schubert and Dunsmuir [13].

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