

Exploring Audience Behaviour During Contemporary Dance Performances

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ABSTRACT

How can performers detect and potentially respond to the reactions of a live audience? Audience members' physical movements provide one possible source of information about their engagement with a performance. Using a case study of the dance performance "Frames" that took place in Theatre Royal in Glasgow during March 2015, we examine patterns of audience movement during contemporary dance performances and explore how they relate to the dancer's movements. Video recordings of performers and audience were analysed using computer vision and data analysis techniques extracting facial expression, hand gestural and body movement data. We found that during the performance audiences move very little and have predominantly expressionless faces while hand gestures seem to play a significant role in the way audiences respond. This suggests that stillness i.e. the absence of motion may be an indicator of engagement.

Author Keywords

Audience dynamics; Audience engagement; Contemporary dance performance; optical flow; hand gestures; facial expressions; aggregated motion.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; I.4.8 Image Processing and Computer vision: Scene Analysis; J.4 Social and Behavioral Sciences; J.5 Arts and Humanities: Performing Arts.

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INTRODUCTION

In many genres, live audiences are separated from performers; sitting behind an imaginary line in the dark, silently observing. Nonetheless, the detailed dynamics of audience responses seem to be an important part of the experience of live performance [4], [6] [7]. The importance of audience responses is neatly illustrated by attempts to manipulate them. During classical times, organized bodies of professional applauders or "claquers" were very often used in French theatre and opera houses to influence the audience to applause during specific parts of the performance [1]. Although the idea of "claquers" mostly died out in Europe and America during the 20th century.

Understanding and sensing audience responses can act as an evaluation tool to help performance directors understand how their work is received and how their audience feels and reacts while the performance unfolds. Audience research is very complicated by its nature. It involves the examination of the way people find meaning, pleasure and satisfaction in response to different processes such as narratives, visual and aural effects or symbols. Performance unfolds in time, making the collection of data more problematic for researchers [9]. Recent advances in sensing technology helps researchers make some progress beyond this limitation. For example, in music perception there have been concerted efforts to measure continuous responses as a piece of music unfolds [9].

In dance research there are a growing number of studies that examine dancer positions in time as a dance work unfolds using motion capture hardware and software [3]. However very little research has focussed specifically on audiences (although see [4], [6], [7]). Continuous data provide new potential for quantitative analysis of the responses of large groups, offering new ways of analysing dance structure and audience responses to it. The most obvious way that one can measure satisfaction in audiences is through the final audience applause and cheering.

Researchers [8] used a mathematical model (Bayesian methodology) to quantify the role of social contagion in the starting and stopping of applause during an oral presentation. One of their findings was that both the onset and the pause of applause follow a sigmoidal curve similar to the ones that are very typically seen in the spread of diseases. The rate at which new individuals start clapping, after the first clap is made, is proportional to how many people are already clapping. However, this is a measure of response after the end of a performance or section of a performance rather than concurrent response.

Apart from recording applause, other methods have been used to measure the engagement of the audience, such as post performance tools, questionnaires, focus groups, audience interviews and other concurrent methods. Vincs et al [13], explored audience responses to dance performances by developing self-report based assessment tools. In both of their works they used the portable Audience Response Facility (pARF), a PDA that is able to record participants own estimates of their engagement during a dance work. The pARF tool consists of an interface that is able to measure 'engagement' with a scale ranged from 0 - 10, where 0 was completely unengaged, and 10 was very engaged. In their first work they sample the responses of up to 20 observers and plot the average engagement time series. They observed several responses to dance in which average engagement increases fairly suddenly. They found that periods of high self-reported engagement often follow choreographic surprises, and that periods of low engagement tend to be associated with more predictable dance structures [13], [12]. In another study, Vincs et al [13] compared responses recorded from two groups of dance observers - dance experts and dance novices. Both groups were asked to record their engagement level using the pARF tool. Their findings show that dance experts responded with more rises in average engagement than did the students.

Less interruptive methods of sensing the audience have been developed by Stevens et al, [11] who sense the audience without tethering them to any hand-held device or survey. Their method uses computer vision techniques to firstly track the eye movements of novice and expert observers as they watch the performance in a laboratory. They argue that there are differences in patterns of eye movement between novice and expert. Using typical field-linked tasks, their results showed that the fixation durations of experts were significantly shorter than those of novices [11]. They also found a tendency for novices to fixate the background while experts spend more time fixating the head and torso regions of the dancers. Questions relevant to audience engagement and to the live feedback occurring between a performer and their audience were addressed by Healey et al [6]. Using motion capture techniques, they explored the naturalistic patterns of head movement generated by performers and multiple audience members

during an academic seminar. The results of their study indicate that head movements of the performer reliably trigger the head movements of audience members.

A different approach relevant to audience dynamics in street performance was proposed by Gardair et al [4]. In their ethnographic of street performers in Covent Garden, they explore how passers-by notice when a street performance is happening, by first becoming casual observers and then transforming into audience members. Using video recordings of the street shows in Covent Garden, they analyse the performance space that is created by active collaboration between performers and their audiences. They argue that people's body orientations show the spaces that people most often interact with and also that people use their body torque to express their level of engagement with the performance. Schegloff and Kendon claim that the lower part of the body is generally oriented towards the main activity while the upper part of the body can be orientated towards lower priority activities [4]. As a result, the way pedestrians orient to each other and in respect to the performance can signal the special social status of a location. Another important point from Gardair's et al [4] research is the way passers-by become part of an existing audience by positioning themselves according to the people that are already part of the audience as well as to the performer. This finding is of prime importance since it shows the importance of audience interactions in actively configuring performance spaces.

Few of the above studies manage to record audience responses using both a naturalistic method and a satisfactory sample size. As a result, many basic questions about audience engagement, the dynamics of collective and individual responses during a live event and the ways in which these responses are captured and transmitted remain unanswered.

CASE STUDY: "FRAMES" - A CONTEMPORARY DANCE PERFORMANCE

The study presented in this paper took place at the Theatre Royal in Glasgow where the contemporary performance "Frames" made its world premiere. "Frames" was one of the three dance performances that Rambert Company presented in Glasgow for 3 days, on the 5th, 6th and 7th of March, 2015. As part of our first exploratory study of audience reactions, we filmed the audiences during the 3 days of the performances. In this paper, we will focus on the data collected during the first performance, on the 5th of March, 2015.

"Frames" is a contemporary dance performance that presents Rambert's dancers, directed by choreographer Alexander Whitley in collaboration with the artists Revital Cohen and Tuur Van Balen and with music made by the composer Daniel Bjarnason. It is 37 minutes in duration and has a cast of 12 dancers.

The piece incorporates movement, visual setting elements (lighting, set-design etc.) and aural elements (live music). The concept of the piece is broadly related with the notion of production, focusing on the manufacturing of objects as well as the manufacturing of experiences in the context of the theatre and how people, in that case dancers, can organise such processes [14].



Figure 1. “Frames” - a contemporary dance performance directed by Alexander Whitley

On stage, dancers construct different shapes using metal structures (frames) and portable light objects. As the choreography and the metal structures emerge, different images come to life that create a stage within a stage. The performance begins with a short section in which one of the dancers organizes the stage by placing the metal structures and the light objects in various locations to be ready for the dancers to pick them up during the performance. During this section the house lights are not still on and it is not clear if this is part of the performance or not. For the sake of the data analysis we will call this section “pre-performance”. Following this, the music starts with the dancer performing a first solo. At the end of the solo, the rest 11 dancers come on stage and with choreographed movements start to arrange the metallic frames around the stage. During the performance the dancers use the frames to build up different shapes and control them with their bodies and in collaboration with the other dancers. The performance terminates with the frames hanging from the ceiling and the dancers performing a final choreography.

METHODOLOGY

The main aim of the case study was to investigate the behavioural, overt responses of a live audience during a contemporary dance performance and use the findings as a baseline for our next study. We visited the Theatre Royal for 3 days while the performances were taking place to film the audiences and collect the appropriate data. For the filming of the audiences, we used a Basler ace camera (1280x1024px resolution) and the related Basler Pylon software operated on a Windows 7 pc. In order to be able to film the audiences during the dark periods of the performance, two infrared lights were used, pointing to the part of the audiences we wanted to film.

The camera and one IR light were placed in the right front box (small separated seating area) both angled to a sample of audiences seating in the 1st circle while the second IR light was placed in the left front box pointing again in the right direction (see diagram in figure 2 below).

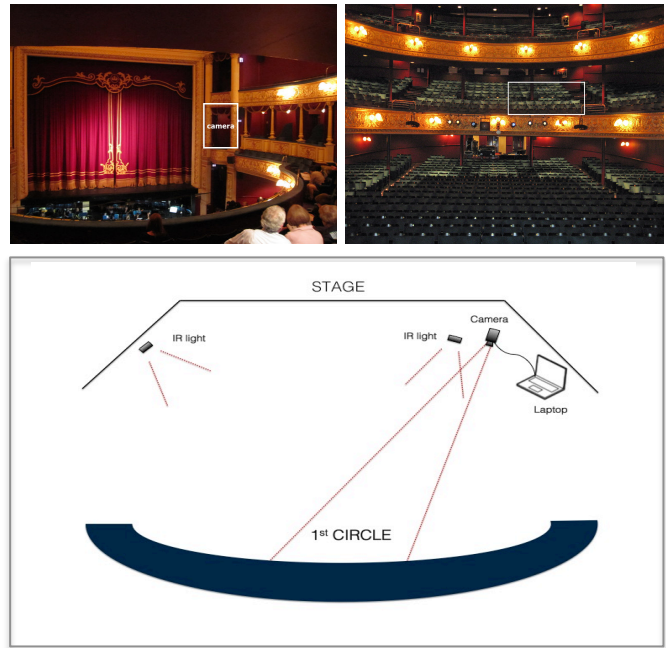


Figure 2. From top to bottom: a. Image of the Theatre Royal in Glasgow b. Camera and Infrared lights set-up

In order to ensure people were aware that we were filming the performance a sign was placed in the foyer of the theatre to inform audience members that filming was taken place for research purposes. The study was reviewed and approved by the Ethics Committee of Queen Mary University of London (Ethical approval reference number: QMERC1432a). Following informal observations of the video footage we collected during the performance, we decided to focus the analysis on responses that might have been perceptible by the dancers; hand-to-face gestures, upper-body movements and the facial expressions of the audience members.

Data was coded using the following tools: 1) ELAN, a professional tool for the creation of complex annotations on video resources, was used to code the hand-to-face gestures of each individual audience member, 2) Optical flow algorithm in Greg Borenstein’s implementation [2] was used to calculate the upper-body movement of the audience members and 3) SHORETM, a facial analysis software made by the Fraunhofer Institute for Integrated Circuits, used to provide continuous data on the facial expressions of each audience member during the performance [5],[10].

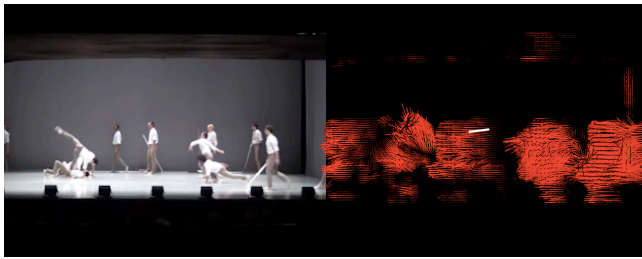


Figure 3. Optical flow algorithm running on performance video

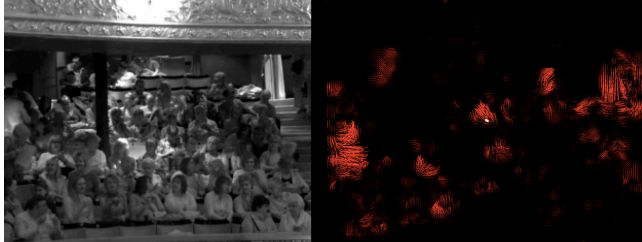


Figure 4. Optical flow algorithm running on audience video

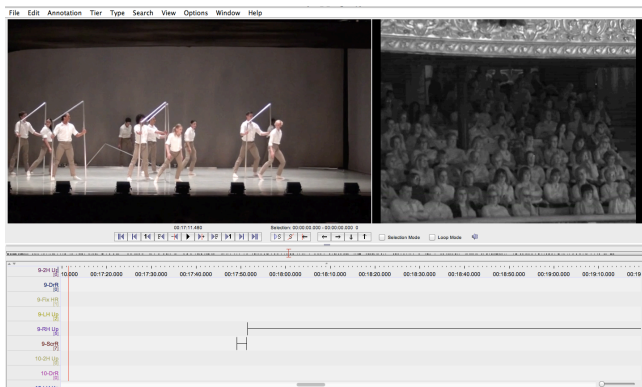


Figure 5. Screenshot of an analysis section from ELAN software

To simplify the data analysis we opted for a simple categorization of hand-to-face gestures:

Hands still on face	One or both hands of the audience member are positioned on his/her face
Hands moving on face	Audience member is drinking, scratching his/her face/head or fixing hair
Hands down	This category was found by isolating the periods when there are no hand-to-face gestures
Other movement	The audience member is waving his/her hand or both hands while talking

Table 1. Hand-to-face gesture categorization

RESULTS

The informal observation of the video footage showed that there were very few overt responses in the audience; the most salient identifiable movements that could be potentially detected by the dancers were those of bringing the hands up to the face. Overall, 33 audience members (30 females and 3 males) were captured on camera. Their hand-to-face gestures were coded in ELAN.

The box-plot in figure 6 indicates that people keep their hands still on their faces about equal amount of time compared to keeping their hands down (40 seconds on average) while the duration of hands moving on face (drinking, scratching their face/head or fixing their hair) is much shorter compared to hands down and hands still on face (4 seconds on average).

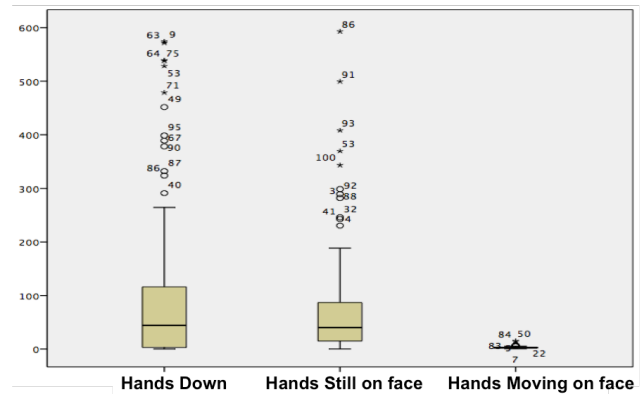


Figure 6. Box-plot of the median values of duration for three actions: a. Hands down b. Hands still on face c. Hands moving on face

Figure 7 shows the number of times people perform the three actions (Still on face, Moving on face and Other movement) for the duration of the whole performance. “Other movement” is used to code co-speech gestures that people produced while talking.

The x-axis represents the timeline of the performance in seconds and it starts approximately three minutes before the beginning of the performance. The y-axis shows the number of times people perform the gesture. From the overall graph it is clear that people move (wave) their hands (other movement) much more before the beginning of the performance when they interact or talk with each other while during the performance they mostly have their hands still on their faces.

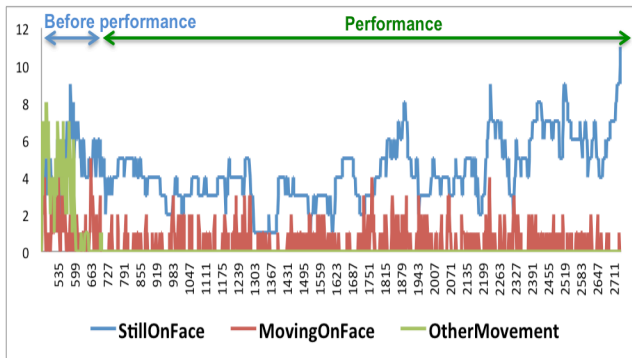


Figure 7. Number of people performing the actions before and during the performance

The data in Figure 7 suggest that hand to face gestures may be an important aspect of audience behaviour during the performance. In particular there appears to be a general trend for hands to move to the face more as the performance continues. These body parts can move more easily than legs and torso and the pilot observations show frequent motility of the hands during the performance. The small sample size makes it difficult to draw any strong conclusions about the significance of these behaviours but make them an interesting target for further work (see future plans section for more information).

The second section of the analysis concerns the upper-body motion data extracted using the optical flow algorithm. Figure 8 shows the average body movement of the audience for the whole duration of the video, starting from the interval, before the performance and finishing with the applause of the audience members. From the diagram, we can see the most salient movement in the audience is during the interval and applause sections while movement is more limited during the performance (Interval from 2-718 seconds, applause from 2668 -2792 seconds). Interestingly, while the hands appear to move to the face more toward the end of the performance, upper movement as a whole appears to decrease.

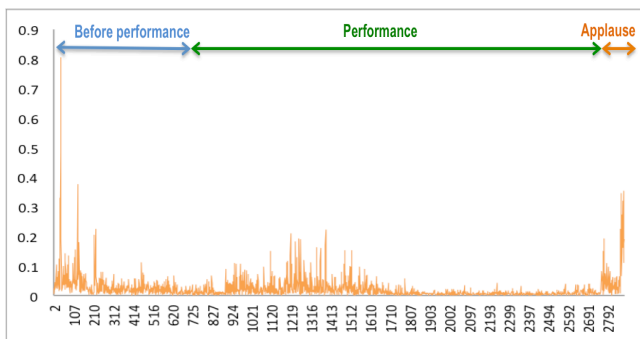


Figure 8. Average upper-body movement of the audience before and during the performance

This is more clearly depicted in the box-plot in figure 9 which shows the median values of the average body movement of the audience members during the non-performance (sum of the interval and the applause data), the pre-performance and the performance. From this graph, it can be seen that the median value of duration of the audiences' body movement is greater during the interval and the applause (non-performance) and decreases during the pre-performance and the performance.

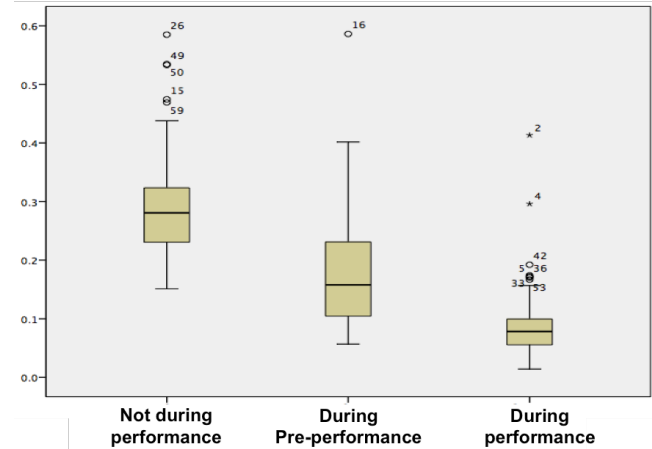


Figure 9. Box plot of the median values of audience body movement before the performance, during the pre-performance and during the performance

Finally, the last section of the analysis focuses on the facial expression data. Figure 10 shows the average levels of 'happiness' and 'anger' responses as well the times when people have their mouth open before, during and after the performance. As seen in the graph below, the data that represent 'anger' increase during the performance while there is a slight decrease in the happiness data. After several observations of the output of the SHORETM software applied to the audience footage we found that in this context it tends to report anger when audiences have blank faces. We speculate that in the context of a social interaction a blank face can easily be interpreted as angry.

However, it may be that during the performance people do not consider themselves to be actively socially engaged and in this context a blank face is more plausibly interpreted as a signal of attention or concentration. It is clear from the Figure 10 that people generally have blank ('angry') faces during the performance while before and during the applause section there are some overt facial expressions. It should be noted that these estimates are not always reliable, since there are video segments in which the software was not able to detect enough faces however the measure appears to be robust over extended periods.

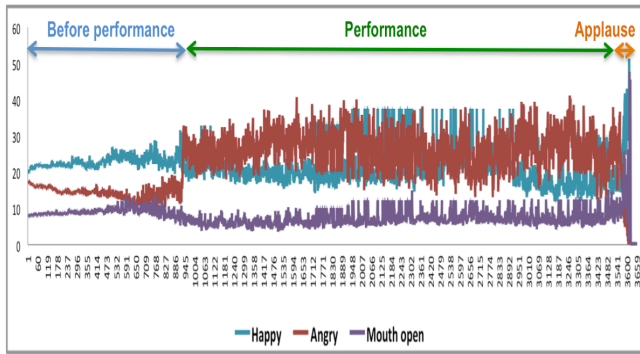


Figure 10. Average facial expressions of the audience members before, during and after the performance

To assess the statistical reliability of the patterns suggested by Figures 8 and 9 statistical tests are applied to examine the relationships between audiences' and dancers movements. To test for the presence of a global relationship between audiences' and dancers' body movements, a Spearman's rank-order correlation was run to determine the relationship. In order to do this, we compared the audience and dancers motion data obtained from the output of the optical flow algorithm as described above. Regarding the audience data, we had to isolate the data from the performance section to end up with an equal and comparable set of data.

The results indicate that there is a positive correlation, which is statistically significant ($r = .142, p < .001$). This suggests some sort of mutual influence between the dancers and audiences' movements, an interesting but quite unexpected outcome. However, it has to be said that the correlation does not show us the direction of causation, it only shows that more movement by either one (the dancers or the audience) predicts more movements by the other. The general relationship can be seen in the plot in Figure 11 which represents the average movement of audiences and dancers during the performance period. From this chart, it can be seen that both audience and dancers data follow a broadly similar pattern, with the audience to move much less on average compared to the performers.

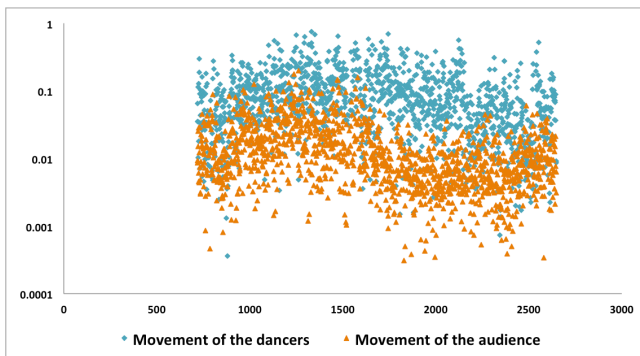


Figure 11. Plot of the audience and dancers body-movements during the performance with sampling interval of 500ms (y-axis is represented in a log scale)

DISCUSSION

The results of this pilot study provide us with some initial clues to the importance of overt audience reactions. The clearest and most obvious finding apparent from even a casual inspection of the video footage is that audiences move very little and have predominantly expressionless faces during the performance itself. This is in clear contrast to the animated facial expressions and body movements that are apparent before and after the performance. This observation is underlined by a feature of "Frames" in which the opening sequence (pre-performance) is designed to be ambiguous as to whether the performance has actually started (see methodology section). The audience movements and expressions observed during this opening sequence are correspondingly mixed reflecting an uncertainty in the audiences' responses as to what is happening on stage.

Interestingly, our results indicate that the movement of the audience tends to decrease as the performance progresses. These results can be seen both from the hand-to-face data (see figure 7) in which the number of hands that are still on face increases during the performance and from the audience upper-body movement (see figure 8) that decreases as the performance progresses. If people become progressively stiller over the duration of the performance this raises the question of whether it is actually lack of movement that is a key signal of how engaged people are in the performance.

Although there is no obvious relationship visible to an unaided eye, the data suggest a reliable overall correlation between dancers' and audiences' average body movement during the performance. This aggregate movement could also be something that the dancers can detect - possibly unconsciously - as a signal of how engaged the audience is with their ongoing performance. However, some caution is required in interpreting this result since the synchronization between the audiences and dancers videos was not always accurate due to limitations of the acquisition hardware. These limitations will be addressed in future experiments.

Following the audience movement analysis, one surprising finding emerging from the hand to face gesture data is that the duration of time that peoples' hands were down appears to be equal to hands being up on their faces. This finding suggests that hands play an important role in audiences' behaviour.

CONCLUSION AND FUTURE PLANS

Understanding audiences and designing for them is a very significant concern to many disciplines from performance studies, theatre and dance to social sciences, HCI and advertising companies. Our research is based on the intuition that one of the defining features of live performance is the interaction between performers and audiences. We are specifically interested in the overt

responses that could be detected by the performers on stage. While the interaction between audience and performers is especially explicit in genres such as stand-up comedy [6] our first study shows that it is much more subtle in genres like contemporary dance.

The main aim of this exploratory research is to identify the overt audience reactions that can be detected by the performers during contemporary dance performances.

In order to reach reliable conclusions more studies are necessary and will be conducted in the near future. Data will be collected from different contemporary dance performances, with the use of more accurate computer vision methods for the data extraction. The adoption of reflective bracelets worn on both arms by the audience members will allow precise detection of hand-to-face gestures. We also plan to use a twin camera setup to allow synchronized sampling of a wider subset of the audience.

The aim of these studies will be to validate the results presented above using a bigger sample and to compare data among different contemporary dance performances. This comparison will give us stronger evidence for our findings rather than focusing only on a single dance performance. We also plan to investigate the hypothesis that the relevant feature of audience behavioural cues may consist in the relative timing of their movements, e.g. in synchronisation among the audience members with the performers.

Overall, the study presented in this paper gave us some initial results about the physical responses of an audience during the contemporary dance performance “Frames” directed by the choreographer Alexander Whitley.

The results show that audiences generally move very little and have expressionless faces during the performance. In addition, hands seem to play a significant role since contrary to the rest of the body they are able to move more freely. The preliminary results presented point to interesting open research questions; these we will address in further studies, that will extend and refine the methodology developed for this work.

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