eTheatre: Connecting with the Remote Audiences

Chen Wang [1 2] , Erik Geelgoed [3] , and Pablo Cesar [1 4]
[1] CWI: Centrum Wiskunde & Informatica, [2] FMCI: Future Media Convergence Institute, [3] Falmouth University, [4] Delft University of Technology
Amsterdam, the Netherlands; Peking, China; Falmouth, United Kingdom
chen.wang.tudelft@gmail.com; erik.geelhoed@falmouth.ac.uk; p.s.sear@cwi.nl

ABSTRACT
In September 2014, a local theatre company performed "the Tempest" simultaneously at two different locations to two separate audiences. Both audiences were linked together using an advanced video system, where several cameras captured the play. This is just one example of the radical shift in performing arts, where small theatre companies can use the Internet and a range of digital tools for reaching a wider remote audience. The question remains: what is the influence of this shift on the experience of the audience members? In order to better understand the problem space, we conducted two experiments focusing on two common current scenarios: remote asynchronous and synchronous watching of a theatre play. First, a theatre play was recorded and shown at a later date in a cinema to an audience. Second, a play in one theatre was broadcast to another theatre in real time. This paper reports the results of the experiments and discusses the implications towards the audience when bridging technology and performing arts. According to the results, a shift in time has a deep impact, with the audience rating their watching experience less intensive by 25% to the audience at the live venue. In the second experiment, on the other hand, both audiences reported fairly similar experiences, but different parts of the play had significant different impacts depending on the location where the audience was (in front of the stage or at another theatre). In particular it seems that lacking a way to show appreciation to the play e.g., applause has a big impact on the watching experience. The main conclusion though is that better mechanisms for including remote audiences in the experience are needed.

Author Keywords
eTheatre, Performing Arts, Audience engagement; Galvanic Skin Response

ACM Classification Keywords
H.1. Human Factors, J.4. Psychology, J.5.Performance arts.

General Terms
Human Factors; Design; Measurement.

Chinese CHI 2017, June 08-09, 2017, Guangzhou, China
 ACM ISBN 978-1-4503-5308-3/17/06…$15.00
http://dx.doi.org/10.1145/3080631.3080633

Figure 1: A remote theatre play performed simultaneously at two different locations to two separate audiences.

INTRODUCTION

One-Way delivery of live theatre performances to other cinemas or theatres is a relatively recent phenomenon, as well as still relatively small scale. However, it has already been a commercial success for well-funded companies 1 using expensive and not readily available infrastructure (e.g. satellite communication). The long-term vision is that over the next years smaller companies will follow suit reaching wider audiences than their local community. In addition, we foresee accelerated technology development to enable remote audiences to play a much bigger role during live performances by providing audience interactivity with and feedback to the theatre of origin and to remote audiences elsewhere promoting a large scale sense of audience community.

This paper represents a first step in such direction by exploring, together with a small theatre company, two common current scenarios: asynchronous watching (encore) and synchronous watching (live streaming) of a theatre play. In the first case, the event where the recording of the live

Figure 2: Asynchronous experiment; the recorded version of Waiting for Godot was shown at a later date at a theatre.

streamed performance, including the auditory presence of the co-located audience, was later shown in a theatre. In the second case, a remote audience at another theatre attended the live-streamed event. While a number of previous works have focused on how to enable distributed performances and how to better incorporate the audience in the play, this article tries to better understand the effect that remoteness has on the audience.

In particular, this paper addresses the following research questions:

R1: How does asynchronous watching compares with a live performance?

R2: How does remote real-time watching compares with a live performance?

For answering these questions we performed two experiments in highly realistic conditions – two theatre plays. The first one, Waiting for Godot, was recorded by three cameras (Fig. 2). After some time, the recording of the live performance was shown at a local theatre. The experience of the live audience was compared to that of the asynchronous audiences. The second play, "Styx Boat on the River", was conducted at the same location as the first play (Fig. 3). The difference is that the live performance was live streamed into another performance studio located at the same building, which meant the audiences at the two locations watched the same performance at the same time. In the first case, we conducted a survey at the end of the performances. In the second one, we measured the audience GSR response, we made video recordings, and we performed group interviews.

This paper is structured as follows. The next section revises recent relevant research works, highlighting the novelty of our work. Then, the methodology employed during the experiments is described and the results are analyzed. A discussion concludes the paper.

RELATED WORK

The last two decades have seen a number of synchronous collaborative performances between two or more locations, i.e. mediated productions between performers in distributed locations. Although lacking the commercial success of streamed live performances, this is an area that has a longer and innovating history resulting in new genres of performance art. We have no intention of enumerating all of them in this short section, but can highlight some musical events where both audience and players were geographical distributed 2 or geographically distributed tele-immersive dancing 3. This group of performances challenges artists, which is the focus of most of the previous research works, but also the audiences. The effect of remoteness has not been studied in detailed by the research community. In particular, we have not found quantitative and qualitative studies that analyze the difference experience of audiences at distributed locations. The only studies about distributed audiences we have found are in the e-learning scenario (if we consider that teachers in a way are performing) 4, 5, 6. But these tend to focus only on evaluating the usability of the learning platform.

Audience Response

In the broadest sense, audience response can be considered as the feedback from users, participants, or players 7, 8, 9. Moreover, some studies further described audience engagement as perception, cognition, experience, and action 10. Furthermore, different applications defined audience response according to application requirements. For example, for online environments, O' Brien et al. regarded the audience response as the perceived usability, aesthetics, focused attention and felt involvement 11. Similar, for video consumption, audience response was referred to players' state of awareness and synchronization 12, 13.

In affective computing, audience affective states, i.e., happiness or sadness, were also used to define audience response to a specific application 14, 15, e.g., a video clip. One of the most famous emotional models, developed by Peter Lang 16, was widely applied in many studies 17, 18, 19. Normally a two-dimensional graph was established,

Figure 3: The synchronous experiment; the first row shows the live venue including (left) part of the audience and (right) one of the artists performing with a smog effect. The second row shows the remote venue where the performance was displayed in the screen in front, and the audience at both side screens

where the x-axis indicates the user valence, and the y-axis represents the user arousal level. Recently, machine-learning technique combined with user annotations and physiological data, has become common for classifying user emotional states. For example, Guo et al. 20 successfully used one single GSR sensor to classify four emotional states.

Audience response in performing arts

There are few studies on audience response regarding to performing arts 17, 21, 22, and all these studies were conducted at one location. For example, Chen et al. and Latulipe et al. combined GSR sensors and subjective methods to measure audience response towards a live performance and a recording performance respectively. Furthermore, a portable Audience Response Facility (Parf) was developed to obtain audience continuous feedback to a play 23.

Measuring audience response by using surveys

Surveys are the most common method to measure audience response. In Latulipe et al. studies 17, surveys were used to measure audience feedback towards the performance by using the different technological effects. Another example is about a real-time 3-D virtual room where dancers at multiple locations could interact with each other, and Sheppard et al. and Yang et al. used surveys to explore the different performance experiences 24, 25.

Measuring audience response by using physiological sensors

GSR sensors have been proved as a valid approach for measuring audience engagement, and researchers in affective computing and HCI have shown interesting links between GSR and engagement 32, 37

Physiological sensors have been widely applied as an objective method to measure audience response. In particular, in video game applications, the combination of GSR sensors and other physiological sensors have successfully defined users' involvement during a game 26, 27. Similarly, others 28, 29 have used such sensors to evaluate the quality of a game design, while studies focused on the interactivity between users and game content by applying physiological sensors 30, 37.

GSR sensors

GSR, is also known as galvanic skin response, electro dermal response (EDR), psych galvanic reflex (PGR), skin conductance response (SCR), or skin conductance level (SCL) GSR sensors measure the users' electrical conductance of the skin, where users' sweat glands are varied and controlled by the sympathetic nervous system. Therefore, GSR sensors are normally considered an indicator of psychological or physiological arousal or stress. When users are highly aroused, users' skin conductance is increased in turn.

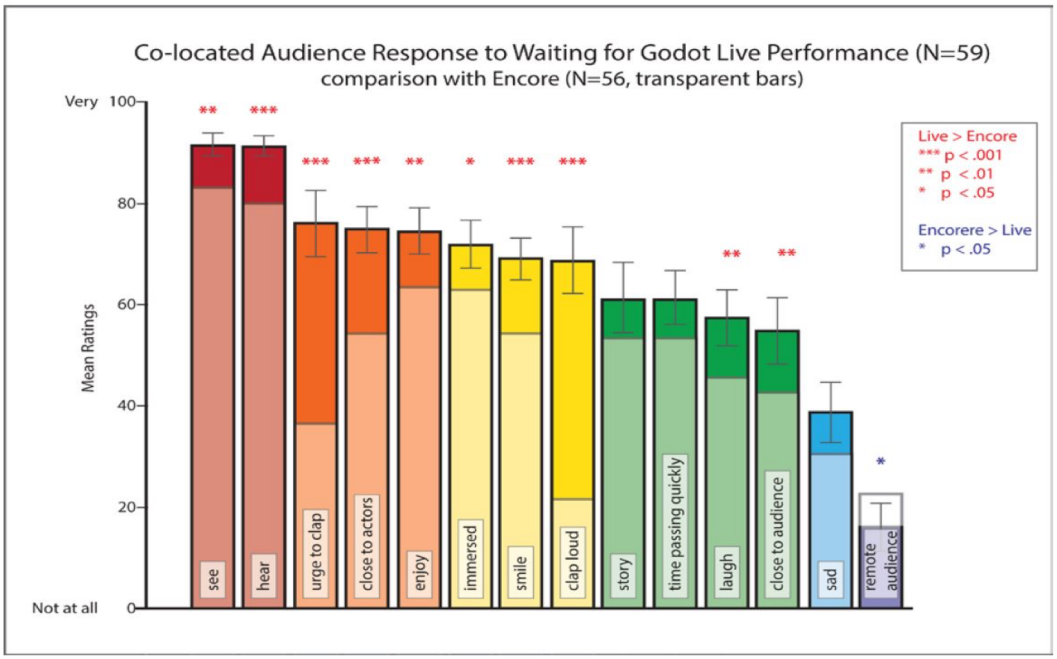

Figure 4: The live audience experience and significant differences with the Encore.

METHODOLOGY

Experimental settings

The first play, Waiting for Godot, was performed under two "conditions": a live performance and the recording of a live performance (an Encore) at a later date. The live performance happened at performance center of one university of UK, and was recorded by three cameras. The video-mix of the cameras was shown at the local theatre.

The second play happened at the same location as the first play. This time the performance was live streamed to another performance studio located in the same building, which meant that the audiences at the two locations watched the same performance at the same time. The technical research team developed the live streaming platform. At each location, there were three cameras deployed, so that the remote audience could see the actor and the live audience through three projector screens. At the live venue, there were only two projector screens installed, so that the actors could see the reaction of the remote audience during the performance. During the rehearsal, the latency was tested: around 150 mili seconds, so that two locations audiences could hardly feel the influence of a delay.

Experimental procedures

For the first play we followed the same procedure at each location. Before the performance started, we introduced the purpose of the experiment, and then the audience watched the whole performance. After that, we provided the questionnaires with the consent form attached.

For the second play we used as well our own GSR sensors. At both locations, the audience members attached the sensors to their left palm, before the play started. At the end of the play, there was small group interview conducted at each location. The whole performance was video recorded in order to analyze the sensor readings.

Performers, Performances & Participants

The Miracle Theater staged a performance of Waiting for Godot by Samuel Becket at the performance center of one of the university in the UK. All the participants that joined the first play were the local audience from three different cities in the UK. During the live performance, 59 participants (Mean 42.84, SD: 15.1) attended, and 56 participants (Mean 41.81, SD: 19.62) joined to see the recorded version of the play (Encore).

The synchronous experiment was a solo performance devised by a university student, majoring in performance studies. The play, called "Styx Boat on the River", was interactive including a number of pieces like singing, an smog effect or a (vacuum) sound effect. The play was also conducted at the same performance studio as the first play. All the participants, 12 at each location, were university workers and their partners.

Questionnaires

The questionnaires were distributed after the first performance and the questions probing the audience experience consisted mostly of questions in graphic rating scale format. An example of a graphic rating scale is shown below:

How much did you enjoy the performance?

Not at all Very

|_____V_____|

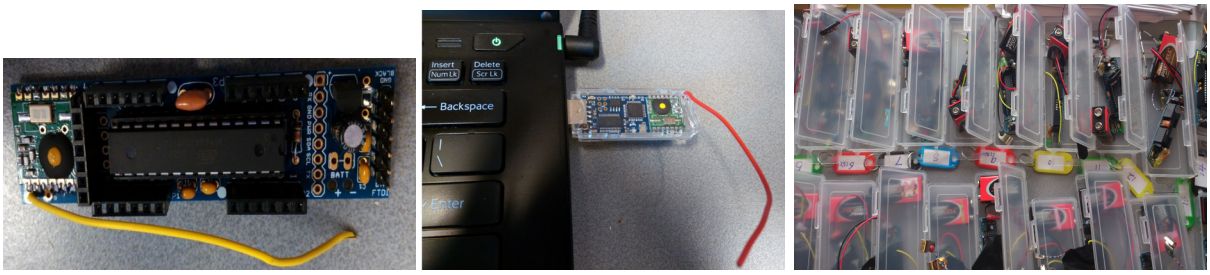

Figure 5: The GSR sensor measuring system used during the second performance: (left) the front side of the sensor board; (middle) the sink node is connected with a laptop; (right) the complete sensor sets

Participants were asked to make a mark on the line, which could include the extremes ("not at all", on the left and "very" on the right). The scale measured 112 mm and the responses were measured using a ruler to a 1mm accurate.

Apparatus

There are several commercial GSR sensors, e.g., Q sensors. However, these sensors use Bluetooth as the communication protocol, which makes them not that useful for group experiments, where simultaneous readings are needed. We thus decided to build our own GSR sensor by using an Arduino board, a RF12 wireless module, a low-pass filter, and several accessories (Fig. 4: e.g., the wristband won at a palm). Before we used the sensor in the experiment, we had them extensively tested in a lab environment. We validated the well functioning of our sensors by two key parameters: testing the noise they produce and checking the readings data distribution. In our case, our sensors are noise proof, and sensor data has a pattern of a linear distribution. When analyzing the data, we applied the averaging method in order to remove the effects of hand movements.

In terms of communication protocol, we installed a polling mechanism between a master node, collected with a laptop, and slave nodes, attached with a user. In a lab environment, the sampling rate can reach 7 or 8 packets per second, but it is reduced to 3 or 4 samples in a field experiment.

Methodologies

In terms of comparing the audience response from the different locations, t-test was applied. The normality and equal variance were both checked before running the algorithm. In addition, t-test method was also applied to examine the effects of the different types of performance during the second play, e.g., whether there is a significant different on smog effect at the two locations.

For the surveys data, we also applied Multidimensional Scaling (MDS) method to cluster questions at the two locations. MDS has been widely used in psychological research 34，35，and recently we have seen that some studies applied this method to analyze the closeness of audience responses and the effects of different types of performances 21, 36. Furthermore, unlike analysis of variance (ANOVA), MDS is a method that explores data, and thus it is not necessary to check the normality and equal variance when dealing with data. However, in terms of validating how good the algorithm is on the tested data, the Kruskal's Stress and R Square are necessary, and the former value should be less 0.15 and R Square should be higher than 0.8.

The Pearson product-moment correlation coefficient was used to check whether there was a significant correlation between the responses from the audiences at the different locations. In the results, one star "*" indicates 95% confidence level, while "**" represents 99% confidence.

In terms of validation of the assumption from GSR data, our data are normality with equal variance, which is rather robust to apply t-test. In addition, we used the first sensor readings as the baseline to normalize the sensor data.

Both experiments were a simple within subject design, and the within variable locations had two conditions during the first play: a live and Encore (recording video). While in the second play, the within variable had the two levels: a co-present and a live.

The configuration of the hardware and the software was written in C and Python, and all the data analysis was done using SPSS.

Table 1: The subjective results of the second play

		The Live Audience	The Remote Audience	The Actor
Video Recordings	Eyes Contacts	Constant eye contacts.	Constant eye contacts.	Constant eye contacts with the two locations audiences
	Interactions	6 times.	6 times.	6 times.
	Laughters	2 times.	3 times.	NA
	Smiles	Most of time.	Most of time.	Most of time.
	Applause	They applaused at both ends of the plays	They applaused at both ends of the plays	NA
	Closeness to the actors	Being connected.	Being connected.	NA
Interviews	Closeness to another location audience	being connected.	Being connected.	Being connected.
	Summarized opinions	The play was interesting and entertainment, and we felt invloved as one part of the play. We like the play , because we could interact with the actor during his performance, and it was also funny to see him singing a song with a vacuum sound as a background.		I could sense audience involvement during the play, and the only drawback was I had to intentionally turn my head to either left or right to see the reactions of the remote audience.

RESULTS

The first study (R1)

By examining the questionnaire data, we did not find a significant correlation between the live audience and the audience at Encore. However, we found significant differences on the audience experience between the live performance and the performance at Encore (Fig. 5). Three stars (***) indicates a very strong significant differences and one star (*) a less strong but still significant difference.

For most of the self-report questions, the Encore audience experience was significantly lower than the live performance. In Figure 5, the red colors indicate the high scores, in which audience rated their ability to see and hear the play very high and the Encore audience rated these significantly less high. Furthermore, the orange colors, high-mid scores, meaning that the audience reported a strong urge to clap (significantly higher than they rated how loud they actually clapped), felt very close to the actors and enjoyed themselves thoroughly. The Encore audience rated these questions significantly lower. While the mid scores, yellow colors, representing scores above the 50% mark, indicate that the audience was immersed in the performance, and they clapped loud and smiled. They smiled significantly more than they laughed. The Encore audience experience was significantly lower in all respects. In terms of green colors, low mid scores still above 50% mark, the audience rated their ability to follow the story line lower, and time did not really drag on but did not pass quickly (not straight forward to interpret). The live audience laughter was less frequent than their smile and they did not particular felt close to the rest of the audience, which might be a sign of immersion (a focus on the stage and actors). The lowest scores, pale and dark blue colors, indicates that Waiting for Godot did not make the audience feel sad (overall) and significantly lower still were the ratings of how close they felt to the remote audience. The Encore audience felt significantly closer to the remote audience elsewhere than the audience that was at the live performance.

The plot below (Fig. 6) shows how the various questions, collected from the live audience, correlated with one another. The size of a circle indicates how strong the correlations were (as well as how many were significant). We maintained consistency with the bar chart above (Fig. 5) where questions received high ratings were shown in red, hi-mid ratings in orange etc. Obviously Clap Loud correlated at $p = 0.000$, (signified by thick red lines) with the urge to clap, being immersed in the play, how close they felt to the actors, how much they enjoyed the performance, how quickly time seemed to pass, how often they smiled and laughed. In total, there were 38 correlations significant at $p<0.01$ and 17 significant at $p <= 0.05$.

Thus there is a strong cluster for instance around enjoying the performance (and remember from the bar chart that enjoyment received high-mid ratings) i.e. those that enjoyed the performance also felt close to the actors, were (deeply) immersed in the play, felt time pass more quickly, clapped

loud etc. This may sound like common sense, but there were also some interesting additional correlations. Hearing the play was significantly more connected to clapping loud and more connected (at p = .082) to enjoying the play than seeing it. Age correlated positively with being immersed and time passing quicker. More emotional items - smile, laugh, sadness correlated closely with being able to follow the story line. However, at the core of the audience experience for Waiting for Godot was how loud they clapped at the end of the performance.

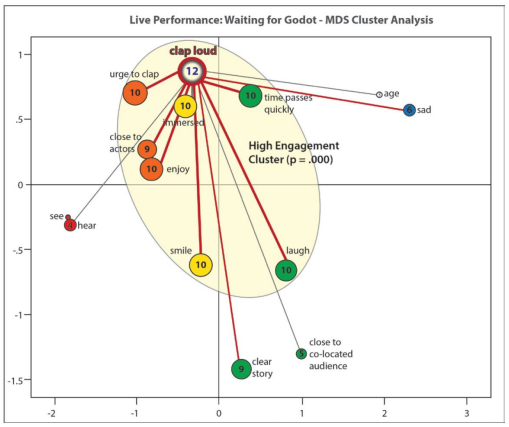

Figure 6: Cluster analysis audience reaction to live performance.

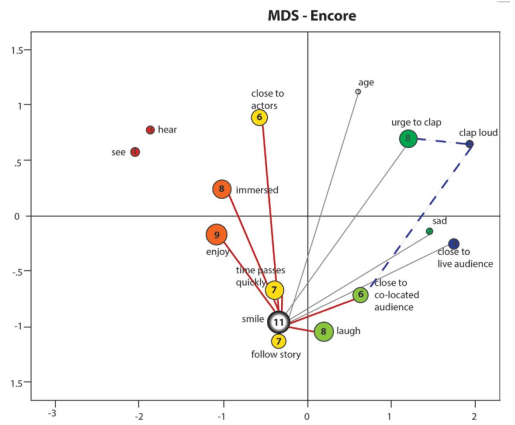

Figure 7: Cluster analysis audience reaction to Encore

Figure 7 shows that the audience response to the Encore is slightly more dissipated (less strong correlated) than the audience response to the live performance. There still were 27 correlations significant at p<=.01 and 17 significant at p<=.05. The variable with the strongest (and most) correlations concerns the frequency of smiling during the performance. Clapping loud only correlated significantly with the urge to clap loud and feeling close to the co-located audience. In addition, "hearing" the play is so much less tied in with the experience as a whole. This may point to the audio reproduction and synchronization with the video needing some attention.

Table 2 displays the mean audience ratings differences (only significant differences items were considered) between the live venue and the Encore, where the partial eta square values are ordered according to the effect sizes. We can see that the Encore theater experience is almost 25% "less" than going to see Wating for Godot live.

Table 2: Core live experience Vs. Encore

Item	Live	Encore	E -L%	Eta-squared
Clap	69.31	20.5	-0.70423	0.392
Urge to Clap	76.23	36.7	-0.51856	0.303
See	91.78	83.27	-0.09272	0.254
Hear	91.53	79.61	-0.13023	0.252
Close actors	74.39	54.18	-0.27168	0.23
Enjoy	75.18	64.3	-0.14472	0.18
Immersed	72.49	63.31	-0.12664	0.18
Simile	69.79	54.42	-0.22023	0.079
Close to remote audience	15.88	23.66	0.489924	0.047
Close to co-present audience	55.18	41.74	-0.24357	0.039
Laugh	57.64	45.93	-0.20316	0.038
Total differences			-24.25%	

Whilst there is, without a doubt value, in a recording of a performance, this results in a less intense experience, which can be typified by saying that an audience is more likely to smile than to laugh. In addition, there is a marked lack of opportunity for an audience to express their appreciation of the performance through applause.

The second study (R2)

In this experiment, we analyze the video recording and group interviews as our subjective methods. We found that the results of subjective measurements at the two locations were both rather positive- indicating an engaging play was performed (Table 1). In addition, the actor also described the whole performance was rather successful, as he could sense the reactions of two locations audiences.

We found that there was a strong positive correlation between the audiences at the two locations: r = 0.535, n = 12, p< 0.01, which indicates that the sensor pattern of the live audience was synchronized with the remote audience. In addition, the whole trend of GSR distribution showed a steady increase at the two locations, although the remote audience had a gradual decrease at the beginning of the performance (only for 3 minutes).

In terms of audience arousal level, the t-test result showed that there was no a significant difference between the live audience and the remote audience: $t = 1.18$, $p > .05$. This is a rather interesting result, compared to subjective reports at the first play, where audience rated the experience at the live venue was higher than at the remote location. However, we noticed that the experimental settings in the two studies were fair different: the first study the remote audience watched a recording video, where they hardly feel the existence of actors. On the contrary, the second experiment the remote audience watched a live streaming play, where the audience could interact with the actor, and feel the presence of actor. The different environmental settings seem to have the different impact on audience experience.

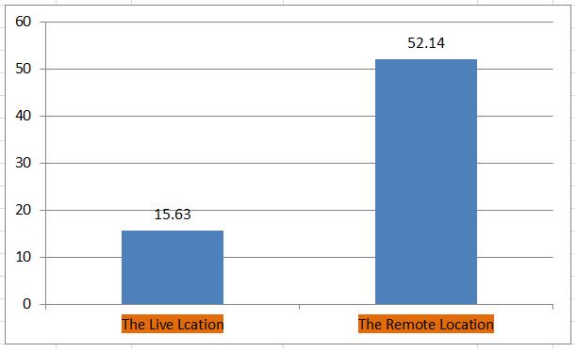

Figure 8: The GSR arousal difference during the actor singing. (*t =-4.04, p =0.001*)

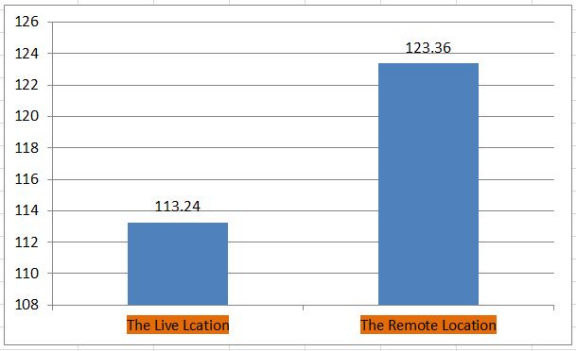

Figure 9: The GSR arousal difference when the actor singing with a vacuum sound as a background. (*t =-0.529, p= 0.625*)

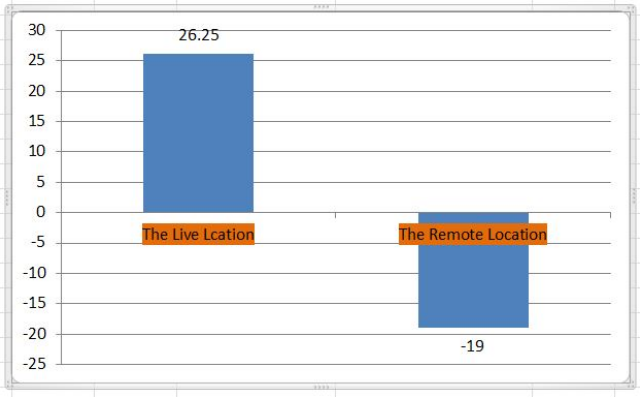

Figure 10: The GSR arousal difference during the interaction. (*t =4.37, p= 0.001*)

Although there was no significant difference found on the two locations audiences, across the performance, we found that the two locations audiences responded significantly difference to the different events, and these findings may help performers to think what kind of effects could arousal a remote audience. Figure 8 and Figure 9 display that the remote audience was more sensitive to hear the actor singing, but not with a vacuum sound. In addition, it seems that both the interaction and smog were more effective to audience at the live venue rather than the remote audience (Fig. 10, 11).

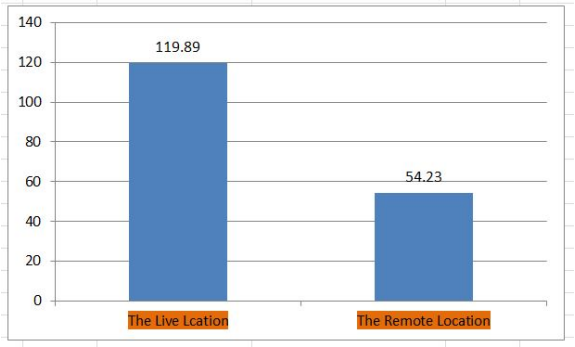

Figure 11: The GSR arousal difference during the smog event. (*t =3.35, p= 0.007)*

DISCUSSION

In this paper we reported two studies that aim at investigating the effect that distributed theatre plays have on the experience of the audience. Based on two common scenarios (watching a recorded version of the play and watching a real-time streamed version of the play), we could analyze the effect synchronicity has on the experience. Remote audience that watched the recorded video rated the experience as significantly less intensive than the people that watched live. Surprisingly, the audience members watching a live-streamed play reported a similar experience than the people in situ. In the last case, the arousal level of the audiences was similar at the two locations.

The experimental settings for the two experiments were different, so we would not aim at directly comparing. Nevertheless, an indirect comparison (remote asynchronous vs in situ; and remote synchronous vs in situ) is reasonable, and provides interesting and valuable results. This paper represents one first step in the long way of investigating audience response for distributed performing performances. They have some implications as well regarding studies that study audience response from watching a video of the performance, instead of in situ situations.

CONCLUSION

This paper explores the effect of remoteness on audiences of theatre plays based synchronicity. In our studies, we found that audience rated a much significant lower experience (rough 25%) when watching a recorded video from the performance than when seeing the performance live. Nevertheless, the audience had a similar experience when the performance was watched remotely in real-time than when it was seeing in situ. According to the results, the lack of feedback mechanisms for recorded performances was an extremely limiting factor.

We suggest a feedback channel should be provided for a remote audience to express their appreciation, i.e., clapping, so that the remote audience experience may be enhanced. Furthermore, sound effect plays an important role to raise arousal of a remote audience, which can be taken into account for the design of a distributed performance.

REFERENCES

1. http://timeandspace.org/ntlive
2. http://www.sciencefestival.co.uk/
3. Renata M. Sheppard, Mahsa Kamali, Raoul Rivas, Morihiko Tamai, Zhenyu Yang, Wanmin Wu, and Klara Nahrstedt. 2008. Advancing interactive collaborative mediums through tele-immersive dance (TED): a symbiotic creativity and design environment for art and computer science. In *Proceedings of the 16th ACM international conference on Multimedia* (MM '08). ACM, New York, NY, USA, 579-588.
4. Jeremy Birnholtz. 2006. Back to school: design principles for improving webcast interactivity from face-to-face classroom observation. In *Proceedings of the 6th conference on Designing Interactive systems* (DIS '06). ACM, New York, NY, USA, 311-320.
5. Cha Zhang, Yong Rui, Jim Crawford, and Li-Wei He. 2008. An automated end-to-end lecture capture and broadcasting system. *ACM Trans. Multimedia Comput. Commun. Appl.* 4, 1, Article 6 (February 2008), 23 pages.
6. Kathryn Faulkner and Linda McClelland. (2002). Using videoconferencing to deliver a healthy education program to women healthy consumers in rural and remote queensland: an early attempt and future plans. Aust. J. Rural Health 10, 65-72.
7. R. Mandryk. Objectively evaluating entertainment technology. In CHI'04, pages 1057–1058. ACM Press, 2003.
8. Guillaume Chanel, Cyril Rebetez, Mireille Trancourt, and Thierry Pun. 2008. Boredom, engagement and anxiety as indicators for adaptation to difficulty in games. In *Proceedings of the 12th international conference on Entertainment and media in the ubiquitous era* (MindTrek '08). ACM, New York, NY, USA, 13-17.
9. Darren Lunn and Simon Harper. 2010. Using galvanic skin response measures to identify areas of frustration for older web 2.0 users. In *Proceedings of the 2010 International Cross Disciplinary Conference on Web Accessibility (W4A)* (W4A '10). ACM, New York, NY, USA, Article 34 , 10 pages.
10. Christopher Peters, Ginevra Castellano, Sara de Freitas. An exploration of user engagement in HCI. AFFINE '09, November 6,2009. Boston,MA, USA.
11. Heather L. O'Brien and Karon E. Maclen Measuring the User Engagement Process. Engagement by Design Preconference Workshop, CHI 2009 Digital Life New World, Boston, MA, April 5, 2009.
12. Anmol Madan, Ron Caneel, and Alex "Sandy" Pentland. 2004. GroupMedia: distributed multi-modal interfaces. In *Proceedings of the 6th international conference on Multimodal interfaces* (ICMI '04). ACM, New York, NY, USA, 309-316.
13. Shigeru Sakurazawa, Naofumi Yoshida, Nagisa Munekata, Asmi Omi, Hideki Takeshima, Hiromi Koto, Kaori Gentsu, Keita Kimura, Kiyhiro Kawamura, Masaki Miyamoto, Ryota Arima, Taiki Mori, Tetsuya SekIya, Toru Furukawa, Yusuke Hashimoto, Hiroshi Numata, Jun-ichi Akita, Yasuo Tsukahara, and Hitoshi Matsubara. 2003. A computer game using galvanic skin response. In *Proceedings of the second international conference on Entertainment computing* (ICEC '03). Carnegie Mellon University, Pittsburgh, PA, USA, 1-3.
14. Shengsheng Ruan, Ling Chen, Jie Sun, and Gencai Chen. 2009. Study on the change of physiological signals during playing body-controlled games. In *Proceedings of the International Conference on Advances in Computer Enterntainment Technology* (ACE '09). ACM, New York, NY, USA, 349-352.
15. Jeff Sauro and James R Lewis. (2008)Quantifying the user experience: practical statistics for user research. ISBN-13: 978-0123849687
16. Peter J. Lang. The Emotion Probe: Studies of Motivation and Attention. *American Psychologist, May 1995.*
17. Celine Latulipe, Erin A. Carroll, and Danielle Lottridge. 2011. Love, hate, arousal and engagement: exploring audience responses to performing arts. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11). ACM, New York, NY, USA, 1845-1854.
18. Mohammad Adibuzzaman, Niharika Jain, Nicholas Steinhafel, Munir Haque, Ferdaus Ahmed, Sheikh Ahamed, and Richard Love. 2013. In situ affect detection in mobile devices: a multimodal approach for advertisement using social network. *SIGAPP Appl. Comput. Rev.* 13, 4 (December 2013), 67-77.
19. Christian Martyn Jones and Tommy Troen. 2007. Biometric valence and arousal recognition. In *Proceedings of the 19th Australasian conference on Computer-Human Interaction: Entertaining User Interfaces* (OZCHI '07). ACM, New York, NY, USA, 191-194.
20. Rui Guo, Shuangjiang Li, Li He, Wei Gao, Hairong Qi, and Gina Owens. 2013. Pervasive and unobtrusive emotion sensing for human mental health. In *Proceedings of the 7th International Conference on Pervasive Computing Technologies for Healthcare* (PervasiveHealth '13). ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), ICST, Brussels, Belgium, Belgium, 436-439.
21. Chen Wang, Erik N. Geelhoed, Phil P. Stenton, and Pablo Cesar. 2014. Sensing a live audience. In *Proceedings of the 32nd annual ACM conference on*

Human factors in computing systems (CHI '14). ACM, New York, NY, USA, 1909-1912.

22. Jacek P. Dmochowski, Matthew A. Bezdek, Brian P. Abelson, John S. Johnson, Eric H. Schumacher and Lucas C. Parra. 2014. Audience preferences are predicted by temporal reliability of neural processing. *Nature Communications 5. Article number 4567*. DOI = 10.1038/ncomms5567.
23. C.J.Stevens, E.Schubert, R. H. Morris, M. Frear, J. Chen, S. Healey, C. Schoknecht, and S. Hansen. (2009). Cognition and the temporal arts: investigating audience response to dance using PDAs that record continuous data during live performance. Internationsl Jounal of Human Computer Studies, 67(9): 800 -813.
24. Renata M. Sheppard, Mahsa Kamali, Raoul Rivas, Morihiko Tamai, Zhenyu Yang, Wanmin Wu, and Klara Nahrstedt. 2008. Advancing interactive collaborative mediums through tele-immersive dance (TED): a symbiotic creativity and design environment for art and computer science. In *Proceedings of the 16th ACM international conference on Multimedia* (MM '08). ACM, New York, NY, USA, 579-588.
25. Zhenyu Yang, Bin Yu, Wanmin Wu, Ross Diankov, and Ruzena Bajscy. 2006. Collaborative dancing in tele-immersive environment. In *Proceedings of the 14th annual ACM international conference on Multimedia* (MULTIMEDIA '06). ACM, New York, NY, USA, 723-726.
26. Lennart Erik Nacke, Michael Kalyn, Calvin Lough, and Regan Lee Mandryk. 2011. Biofeedback game design: using direct and indirect physiological control to enhance game interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11). ACM, New York, NY, USA, 103-112.
27. Regan L. Mandryk, M. Stella Atkins, and Kori M. Inkpen. 2006. A continuous and objective evaluation of emotional experience with interactive play environments. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '06), Rebecca Grinter, Thomas Rodden, Paul Aoki, Ed Cutrell, Robin Jeffries, and Gary Olson (Eds.). ACM, New York, NY, USA, 1027-1036.
28. Kai Kuikkaniemi, Toni Laitinen, Marko Turpeinen, Timo Saari, Ilkka Kosunen, and Niklas Ravaja. 2010. The influence of implicit and explicit biofeedback in first-person shooter games. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10). ACM, New York, NY, USA, 859-868.
29. Pejman Mirza-Babaei, Lennart E. Nacke, John Gregory, Nick Collins, and Geraldine Fitzpatrick. 2013. How does it play better?: exploring user testing and biometric storyboards in games user research. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '13). ACM, New York, NY, USA, 1499-1508.
30. Shengsheng Ruan, Ling Chen, Jie Sun, and Gencai Chen. 2009. Study on the change of physiological signals during playing body-controlled games. In *Proceedings of the International Conference on Advances in Computer Enterntainment Technology* (ACE '09). ACM, New York, NY, USA, 349-352.
31. Joel E. Fischer and Steve Benford. 2009. Inferring player engagement in a pervasive experience. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '09). ACM, New York, NY, USA, 1903-1906.
32. R. Mandryk. Objectively evaluating entertainment technology. In CHI'04, pages 1057–1058. ACM Press, 2003.
33. R.W. Picard. Affective computing. MIT Press, Cambridge, MA, USA, 1997.
34. Schiffman, Susan S., M. Lance Reynolds, and Forrest W. Young (1981), *Introduction to Multidimensional Scaling: Theory, Methods, and Applications*, NY: Academic Press.
35. Young, Forrest W., and Robert M. Hamer (ed.) (1987), *Multidimensional Scaling: History, Theory, and Applications*, Hillsdale, NJ: Erlbaum.
36. Chen Wang and Pablo Ceser. 2014. Do we react in the same manner? Comparing GSR patterns across scenarios. *NordiCHI, October 26-30 2014, Helsinki, Finland. ACM 978-1-4503-2542-4/14/10*
37. Jeff Sauro and James R Lewis. 2008. Quantifying the user experience: practical statistics for user research. *ISBN-13: 978-0123849687.*
38. Jacek P. Dmochowski, Matthew A. Bezdek, Brian P. Abelson, John S. Johnson, Eric H. Schumacher & Lucas C. Parra. 2014. Audience preferences are predicted by temporal reliability of neural processing. *Nature Communications 5, Article number:4567.*