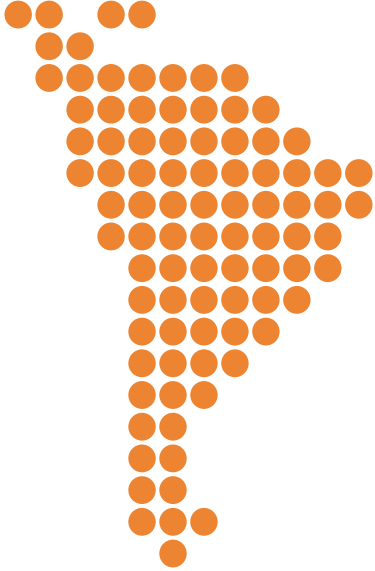

USER REQUIREMENTS FOR IMMERSIVE MEDIATED PERFORMANCE SPACES

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Abstract

Over the last two decades performance artists have made use of videoconferencing systems for installations, joint performances and rehearsals; often negotiating costly and bespoke (custom-made) soft and hardware. More recently, pervasive and low-cost videoconferencing technology has successfully been applied in mediated installations, paving the way for the technology to be incorporated into the curriculum of performance colleges thereby creating a need for systematic user requirement research. We report on a study in which theatre and dance students collaborated across a videoconferencing connection. The results highlighted different requirements for distributed theatre and dance practitioners and these findings form an input into an EU Framework 7 research program focusing on how to better support the mediated performance space and

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enable audience feedback and interaction. We highlight theoretical perspectives relevant to telepresence in performance. Lastly we describe how insights into user requirements for immersive mediated performance spaces led to building a prototype consisting of two Computer Aided Virtual Environments (CAVEs) connected via the Internet.

Keywords

Mediated Performance, User research, Videoconferencing, Telepresence.

Introduction

One of the aims of the Vconect program (Stevens, 2012) is to support the area of mediated performance for the purpose of remote teaching, rehearsals and performances through videoconferencing technologies featuring automated editing and composition of multiple live audio-video streams onto multiple screens. The orchestration of the video and audio streams will take into account a variety of editing cues originating from directional audio, face detection and physiological sensors augmenting audience feedback. (See:Vconect; for public response, see: http://www.youtube.com/watch?v=dUM-qqRsTx8).

Prior Performance Art

Performance artists have, through the ages, creatively made use of physical and, more recently, digital illusionary tools: "there is nothing in cyberspace and the screened technologies of the virtual that has not been already performed on the stage. The theatre has always been virtual, a space of illusory immediacy"(Causey, 1999: p 383-394). Birringer (2008) and Dixon (2007) provide comprehensive overviews of how artists have exploited technology to enhance performances. Where video applications are concerned, theatre pieces have made use of wearable cameras (StahStensley: http://www.youtube.com/watch?v=pE_uo_8CdBI) and virtual environments have been populated using motion capture (O'Conaill, Whittaker, Wilbur, 1993: 38-42), performing avatars and thespian robots (See: http://www.youtube.com/watch?v=e2jbQ8IRVZ). In addition, companies such as The National Theatre produce live streaming events, e.g. to cinemas (http://www.nationaltheatre.org.uk/). However in the current paper we narrow down the scope to interactive videoconferencing in the performance space. We give some examples of how, in the last three decades videoconferencing technology has extended the performance artist's palette, creating a new genre, often using dedicated hard and soft-ware. Carefully designed lighting was instrumental in creating an atmosphere that drew audiences in, enhancing a feeling of telepresence, i.e. co-presence across a virtual divide.

As early as 1992 Paul Sermon devised Telematic Dreaming (http://vimeo.com/20054617), an intimate interactive work, featuring two double beds in separate rooms linked via an audio and video connection. Using multiple cameras and screens this allowed the virtual sharing of beds. Pre-recorded video footage was mixed into the live projections. Visitors to the installation were free to interact with the performers. Most of the time the intimacy engendered trust but the virtual had the potential to shock as much as the physical as on one occasion: *"Someone took out a knife. I felt the predictable shiver;* [it] *set off alarm bells in my mind"* (Isaacs and Tang,1993).

Lisa Naugle (2008) introduced the term *"distributed choreography"* for a collaboration between connected dance studios across six universities in the USA that allowed performers in geographically distributed studio spaces to collaborate across a broadband network connection. The live choreography was complemented with other visual imagery and sound. The production highlighted logistical and technical problems: coordinating the geographical time differences, delays inherent to video conferencing, managing the choreography cues (knowing when to begin and when to end a section). Not having a clearly located audience, a "front" to play to, dispersed the energy and lift performers often get from an audience.

Similarly, Ivani Santana has been working extensively in the field of Networked Dance Performance connecting dance studios across the world in Brazil, Chile, Germany, France, Spain and the USA (http://www.poeticatecnologica.ufba.br/site/). Using the academic network JANET focusing on low latency audio and visual streaming (LOLA) has developed a tool for synchronous, real time performance in geographically distributed locations covering remote teaching, rehearsals and live performances. (For a technical description see: LOLA, sites given in references).

There is also commercial exploitation of these technologies in the creative industries. Musion (http://www.musion.co.uk/),using a combination of the 19th Century Pepper's Ghost illusion1 and video conferencing technology, creates interactive music performances, e.g. (http://www.youtube.com/watch?v=CRViE4N-u5Y).

Experimenting in the arena of multisensory communication Stahl Stenslie (See: References) has added haptic communication to the palette of distributed performance art.

However, with the emergence of pervasive low cost videoconferencing systems, such as Skype, perspectives in the mediated performance space have been broadened. With the technology becoming so much more accessible over the last years there has been an increase in mediated performances; we mention a few.

Skype Duet was a distributed live performance between New York and Berlin (Stinehelfer, 2012). Pushing the boundaries of interactivity, *Dimanche Rouge* by Panoply involved actors and dancers accompanied by pre-recorded video and other multi-media work streamed live

between Paris and New York providing opportunities to distributed audiences to interact, give feedback and even co-create. (See: References). Cinzia Cremona puts it succinctly: *"Skype communication and video-performance have been converging into a set of art practices that adopts the screen as a relational device"* (2011).

The rapid assimilation of Skype-like technologies into the performance space, might give the impetus for more and more performance art colleges to include mediated performance and teaching techniques in the curriculum. In this report we experimentally evaluate what some of the user requirements are in mediated performance art and how technology and design can support and enhance telepresence; in particular are there opportunities within the performing arts to attenuate the adverse effects of latency, which has traditionally been seen as videoconferencing's biggest bug-bear.

Round-Trip Delay Time (RTT)

During the chain of signal processing and networking in videoconferencing sessions an amount of round-trip delay time (RTT) is introduced which shuffles the conversational structure (Ruhleder, K., & Jordan, B., 1999), and has adverse consequences for the effectiveness and perceived quality of the interaction, especially in highly interactive situations [16]: *"the true killer is latency"* (Hammer, Reichl, & Raake, 2005; Satyanarayanan,1996).

Early considerations of the effect of RTT concerned telephone conversations. In order to maintain a high level of user interactivity it is desirable that RTT remains (relatively) small; 100ms was described as imperceptible, 200ms identified as the estimated perceptual tolerance of a user, RTTs of up to 600ms were, in some instances, considered acceptable, while RTT's greater than 600ms were likely to degrade the application's interactivity (Brady, 1970: 115-134; Klemmer, 1967: 1141-1147; Krauss, & Bricker, 1967: 286-292). However Cheshire (1996) argued that a delay of more than 100ms results in the breakdown of normal conscious etiquette. When telephone calls are made via satellite link, the RTT is typically 250ms (Zhang, De Lucia, Ryu, & Dao, 1997), which Cheshire stated results in stilted conversation full of awkward silences and accidental interruptions. Thus, while RTT is able to influence the interactivity of remote communications, there is a degree of uncertainty surrounding the critical point at which this begins to have an adverse effect.

Early user evaluations of video-based communication, although lacking in estimates of RTT's, applied Clarke's classification of conversational structures (Clark, & Brennan, 1991, in Resnick, et. al.; Clark, 1996) and identified a lower frequency of backchannels, speaker feedback, interruptions and longer turns with an increase in formal hand-over's and reduced ability to spontaneously take the conversational

floor (Cohen, 1982: 189-199; O'Conaill, Whittaker, & Wilbur, 1993: 389–42; Isaacs, & Tang, 1993; Whittaker, & O'Conaill, 1993), although Sellen found that for measures such as pausing, overlapping speech and interruption management there was no effect (1992: 49-59; 1995: 401–444). In addition people become aware of the effects of delay and learn to moderate their speech accordingly (O'Conaill, Whittaker, & Wilbur, 1993: 389–42). The adverse effects of RTT led researchers to believe that the value of videoconferencing was actually in the audio channel where the video channel augmented the communication by making visible the things being talked about (Sharpe, & Stenton, 2002; Whittaker, 1995: 501-529).

A discontinuity in the technology was introduced by Hewlett-Packard's Halo Telepresence studios, developed in collaboration with the animation company Dreamworks, featuring (private) high bandwidth communication, complete soundproofing, low-noise air-conditioning, high quality screens and cameras and, equally important, "film-set" discipline in lighting and (identical and symmetrical) room design, using neutral colours and non-reflective fabrics, ensuring consistency and continuity (Geelhoed, Williams, Albright & Hubley, 2007). Geelhoed and colleagues evaluated the effects of artificially adding 250ms and 2000ms to a Halo connection with an RTT of 720ms and found that with increased RTT simultaneous starts were affected more. Less affected were interruptions but overall, even at a RTT of close to three seconds, participants found the sessions productive, lively, participants still shared jokes and it was easy for people on either side of the virtual divide to take the floor. (Geelhoed, Parker, Williams & Groen, 2009: 120).

To explain how such high RTT's still did not "kill" the conversation, the research benefitted from theoretical perspectives on models of conversation outlining a temporally orchestrated, often unconscious, exchange of subtle facial expressions and eye gaze, body-language, stance, rhythm and sway (Shockley, Santana & Fowler, 2003: 326-332), oscillating brain activity and syllable production (Wilson and Wilson, 2005). Wilson and Wilson (2005) state that in order to facilitate a smooth handover a pause at the end of a conversational turn should not exceed 200ms which might explain the proliferation of simultaneous starts in videoconferencing. In addition there is the discovery of mirror neurons, present within the pre-motor and inferior parietal cortices, which are activated not only when an action is performed but also when it is perceived, including facial expressions (Leslie, Johnson-Frey, e Grafton, 2004: 601-607). The muscles of the tongue react when listening to other people talking (Fadiga, Craighero, Buccino, e Rizzolatti, 2002), and mirror neurons may prime mimicry to some extent, which may explain the occurrence of postural congruence across the virtual divide in telepresence sessions (Sas e O'Hare, 2003). If we assume that co-presence is associated with empathy (Rizzolatti e Craighero, 2004), which in turn is a product of mirror neuron activation and mimicry, then it seems that well-designed telepresence systems have the potential to support a richer degree of sensory information which helps to create

not only a significantly increased sense of co-presence but also facilitates a degree of grounding (Clark & Brennan, 1991) and comprehension compared to older lower quality systems (Geelhoed, Parker, Williams & Groen, 2009: 120).

It seems reasonable to assume that particular aspects of the mediated performance space, e.g. discussions during rehearsals, are similar to corporate meetings using video conferencing systems. On the other hand when precision timing is crucial, e.g. in mediated dance or music performances, a large RTT might have serious consequences. In the current study actors and dancers collaborated via a videoconferencing system with an RTT exceeding 500ms.

Method

Participants

Eight theatre performance students (5 males, 3 females, mean age 21.9 years) and 11 dance students (all female, mean age 20.3 years) took part. They were asked to give consent and received an hourly payment. All students had used Skype for personal use but were naive to using video conferencing technology in performance.

Apparatus & Studios

Two studios in the Performance Centre of Falmouth University were used, both measuring about 95 m2. These studios were located at opposite ends of a corridor, such that the participants could not naturally hear one another whilst separated, but it took only a couple of minutes to move from one studio to the other.

Two Polycom VS4000 units connected the studios via a Local Area Network. This equipment transports 4:3 video and monophonic audio. No picture-in-picture (PIP) facility was used. Two HD Panasonic – 3CCD P2 camera's with built in stereo microphones were connected to the Polycom units and recorded all sessions.

The mono audio originating from the Polycom units was played back in the remote rooms on loudspeakers at amplitudes close to face-to-face levels. The video was projected through Hitachi SXGA projectors on projection screens. The cameras were centrally positioned in front and (at the bottom) of the projection screens.

The projection screen in one studio measured 2 * 2 meter, and in the other studio this was a smaller 1.2 * 1.2 meters. Ceiling mounted neon strip-lights were used in the studios at a medium level to facilitate viewing the projection screens but still maintaining adequate lighting conditions to carry out the experimental tasks. There was no discernible extraneous noise during the experimental sessions.

The RTT of the Polycom system was measured using a stereo recording of the monophonic input from the camera microphone (the stimulus was the sound of a handclap) in one studio into the left channel and the mono output from the Polycom unit in the other into the right channel. The difference between the start of the peaks of the waveforms of the top and bottom channel of the stereo recording was 273ms, signifying the one way trip from one studio to the other. RTT was estimated as double that of a single trip, i.e. 546ms.

Procedure

Participants took part in both experimental conditions, face-to-face and mediated. They were free to choose the type of exercise they wished to carry out. The dance students chose to rehearse a piece they had performed at a local festival, whilst the theatre students experimented with impromptu improvisations. As such, the experimental design allowed for a degree of ecological validity, i.e. referring to real world events. To safeguard external validity (referring to the generalizability of the findings), we controlled the experimental settings, carried out semi-structured interviews and gathered quantitative data through questionnaires.

Measures and analysis

In addition to the HD camera recordings, sessions were video recorded using a small camcorder by the experimental leader. The video footage provided materials for observational analysis. Interviews were transcribed and analysed. Graphic rating scale questionnaires (Stone, Sidel, Oliver, Woolsey, & Singleton, 1974: 24-34), in which participants were asked to make a mark on a (100mm) line between two extremes, e.g. between "not at all" and "very much", were analyzed using SPSS (Statistical Package for the Social Sciences). Given the ratio scale nature of the questionnaire, we applied various forms (using a mixture of within and between subject factors) of the Analysis of Variance (ANOVA) and a Multi Dimensional Scaling (MDS) cluster analysis based on correlations.

Results

Interviews

Social media, including Skype, are interwoven into participants' lifestyles. They record their rehearsals and performances regularly. For organizational purposes they use a combination of Facebook, Drop-box and YouTube; the latter was used to store video footage of rehearsals and performances:

"We always record the video [of rehearsals] and watch it afterwards." --- "Basically at the moment we are using the YouTube as a sort of dumping ground."

Even so, the mediated condition felt less natural:

"In *there you feel like, I didn't feel like I was next to them, I felt like looking at them on the screen too much."*

Performers needed to make an effort to communicate across the virtual divide, which often distracted from the performance:

"I kind of over compensated for the fact that they weren't in the room, I felt like all my energy was there and I almost forgot about the people in the same room."

Simultaneous starts, typical for video conferencing, crept in:

"And as soon as you start speaking at the same time it was confusing us all, there has to be one at a time."

The dancers liked the fact that the mediated condition doubled the performance space:

"It gives you more room as well as to move about in with them still doing it with you but they are not in your way."

As in future experiments we aim to use multiple cameras (and screens), we asked them about this value-proposition. The dancers quickly understood the point and suggested useful camera angles.

"It could be helpful, because when C. did something on the floor and we were like: "WE CAN'T SEE YOU!" so like different angles to see what you are doing --- higher up or actually on the floor to see like the same level as them --- a side camera that can see your whole body --- a zoom in of one person doing it and then the whole group do the same thing."

Actors needed some form of Picture in Picture display as: "It would be a lot easier to work if we could see ourselves as well."

The question of where an audience would reside came up:

"The thing that I was thinking about was:, where is your audience? It has to be kind of participatory in a way; so there is audience on both sides and performers on both sides, somehow integrated."

Rehearsals would not need to end when term ends:

"For holidays and stuff, so if this would be actually available so we can actually still rehearse whilst being in our own homes outside of Falmouth that will be really useful."

Soon the topic of remote teaching, e.g. following master classes was touched upon:

"To be able to see the movement from different angles is good if you wanted to try it yourself, or the friends you are with."

The dancers commented that, although they noticed the delay, they thought that somehow they would be able to work around it:

"Definite delay problem, but if we just kept listening to the music, like obviously it was earlier here and later on in there."

The delays made them take deliberate turns, pay more attention to detail:

"That was quite good, take it in turns, because it's slower, you're trying to concentrate, like we're strapped in and you can take your own time with, so it was like nice, to have a few phrases that way."

Observations

Dancers would use all of the large studio spaces (Fig. 1), rapidly dancing from one corner of the room to a diagonally opposed one, turning their back to the cameras and carrying out floor exercises. The observations complemented the interviews in pointing to the need for a variety of camera positions (and screens): low down to capture floor exercises and positioned around the room as regularly they had to turn their back to the projection screen and therefore could not follow their counterparts in the remote studio. See Figure 1.

Moving across the studio made it difficult to keep the participants "live" size and mimic mutual eye gaze as moving towards the far end they became smaller on the screen, but maintained eye gaze. Conversely as they moved close to the camera they started to appear like giants to the remote room, dancers needed to look up and all suggestion of eye gaze was lost.

These sorts of "distortions" almost became a feature in some of the theatre students' improvisations as in spite of how much hard work the mediated condition posed, they adapted quickly and seemed inspired by the technology to device a new style of performance. See Figure 2.

The actors "worked" the camera, sometimes they were close-up, sometimes further away or they linked the two connected studios with the help of a tablecloth acting out a dating scene; they gave each other virtual kisses or "passed though the divide" as, with the help of "out-of-shot" actors, they shook each other's' hands, although this was at the expense of maintaining eye contact (Fig. 2). One particular improvisation worked really well. This was a house of parliament scenario with the "government" and the "opposition" on either side of the virtual divide debating with great vigor but taking deliberate conversational turns and using formal handovers, rather than interrupting each other.

Figure 1. Using the entire studio space

Figure 2. On a virtual date

Questionnaires

The statistical analysis of the questionnaire resulted in a number of highly significant effects. Here we mention some salient ones. For the following graphs red bars or circles refer to the face-to-face condition, green to the mediated own studio aspects (this relates to another face to face situation for that half of the participants they were in the same studio with) and blue denotes aspects of the remote studio. See Figure 3

In figure 3 we depict mean ratings of group performance in the face to face and mediated conditions; actors on the left and dancers on the right. There was a significant main effect for the difference between the three conditions, $F(_{2,26}) = 5.841$, $p = .008$. Not surprisingly group performance in the face to face condition was rated highest than in the remote condition.

Interestingly the lowest group performance ratings originated from the dancers in the mediated condition about their performance in their "own" studio. This was irrespective of which studio they were in, even though the music originated from one studio and as such the dancers in that studio saw the dancers in the other studio trailing behind by good 0.5 seconds.

In addition the actors rated their group performances consistently higher than the dancers, $F(_{1,13}) = 9.348$, $p = .008$.

Carrying out a paired comparisons exercise (details available from the first author) we were able to identify four distinct blocks of variables (see Figure 4).

Using a scale of 100, most mean ratings fell within the 25-75 range. As can be expected, high ratings were given to the face to face condition: how close the group felt, how well the group performed and how well they performed themselves. In addition there were high ratings for how aware they were of the group in the remote room in the mediated condition.

Then there is a band of scores for how well the remote groups performed, how well they saw the remote group, how close in the mediated condition they felt to performers in their own studio, how well they performed individually and as a group in their own studio in the mediated condition.

A third group of lower scores is formed by how lifelike remote performers were, how close remote performers felt, how well they could hear remote performers and how well performers felt they came across.

All questions were phrased such that a high rating indicated more favorable circumstances to perform in, with the exception of noticing the delay and finding the delay disruptive, where a high score indicated an undesirable aspect. Therefore, for clarity, we reversed the scores, i.e. subtracted the actual scores from 100, and we present the questions as if we had asked how unnoticed and how non-disruptive the delay was. It is easy to see in the graph that the effects of delay contribute strongly to unfavorable circumstances to perform in.

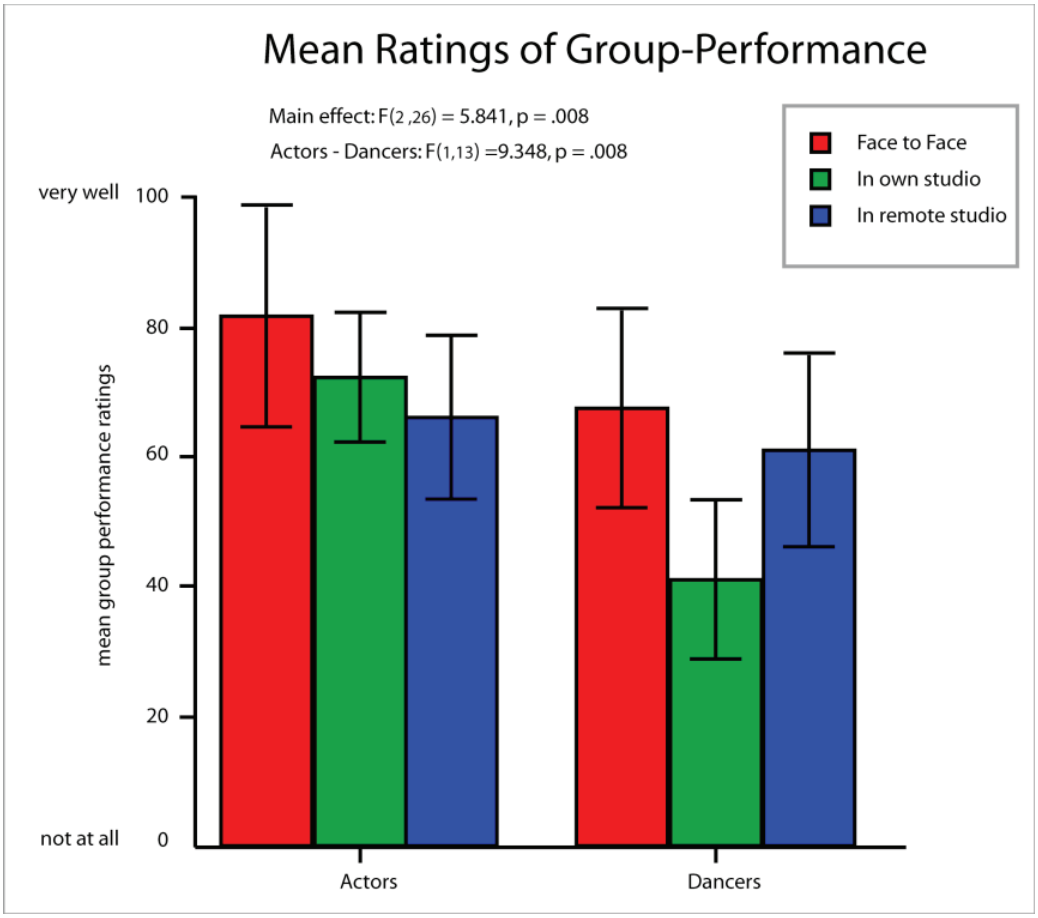

Figure 3. Mean ratings of group performance across experimental conditions

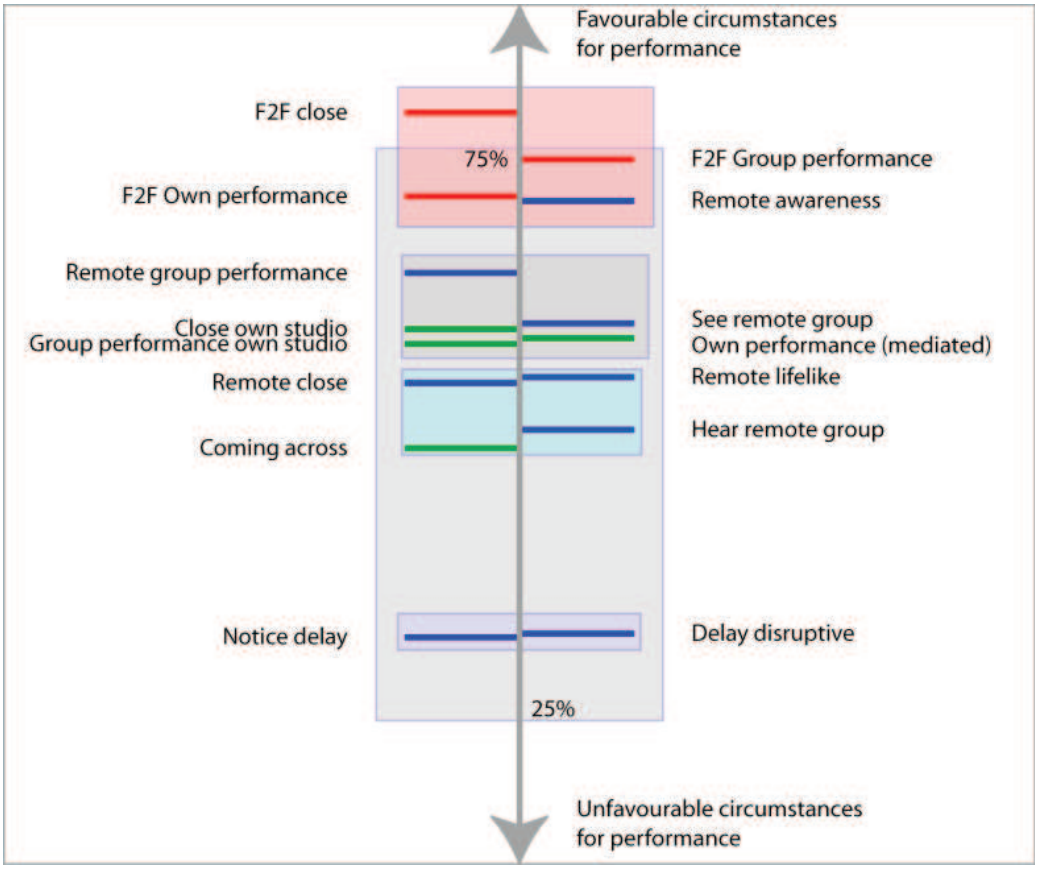

Figure 4. Paired Comparisons questionnaire variables

Based on correlations we carried out a MDS cluster analysis. The size of a circle in figure 5 reflects the number of inter-correlations; the variables with more inter-correlations might prove to have more predictive value.

This graph can serve as a baseline against which we can measure changes as a result of implementing Vconect technology-modules in future experiments. We use the original delay ratings (rather than the inverse) here and omit depicting the face-to-face variables.

A (perpendicular) projection of the variables onto the X-axis corresponds to a large extent with the paired comparisons results and we therefore labelled the X-axis circumstances (running from non-favourable to favourable) to perform in.

The Y-axis signifies more the amount of extra communicative effort performers had to make in the mediated condition: closeness and performance in the performers' own studio required little extra communicative effort. Following the group performance in the remote studio did not call for active communication, but remaining aware and establishing closeness with the remote group required higher communicative effort, in particular for those who noticed the delay more and found the delay disruptive. See figure 5.

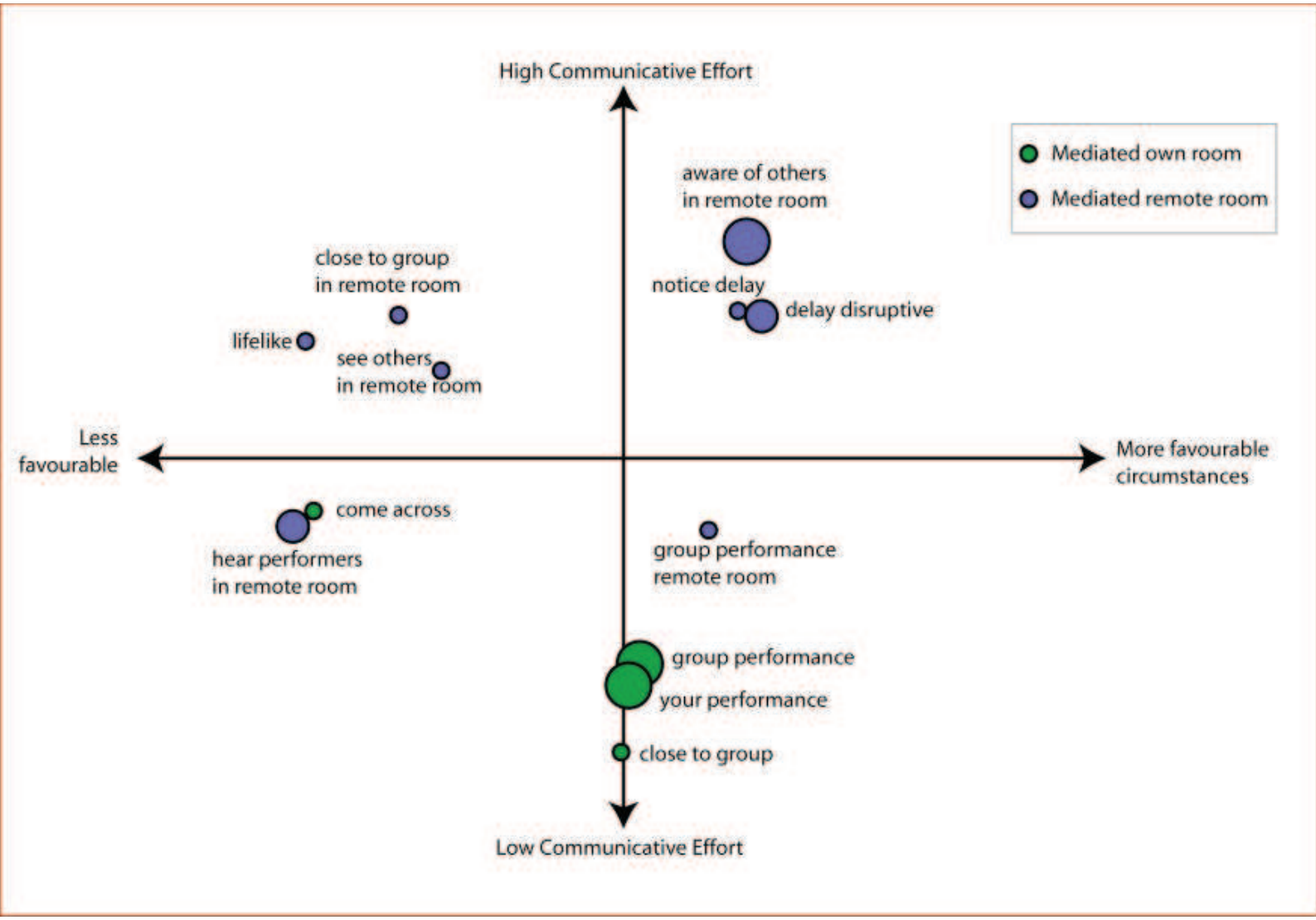

Figure 5. Mediated Performance Cluster Analysis

Discussion

Over the last twenty years there have been interactive art installations as well as explorations in distributed performance using videoconferencing technology. This meant that artists and collaborating technologists regularly had to negotiate bespoke and expensive technological applications, pushing technology boundaries and reporting back on what their experiences were. As such artists have an important role to play in technology development.

Currently, consumer electronics can deliver videoconferencing at a fraction of the price and, equally important, people are familiar with technologies such as Skype; social media are integrated into many people's lifestyles. It is no surprise then that the Skype-mediated performance space is "hotting up".

Research into Telepresence has demonstrated that it is possible to buffer the adverse effects of delay on the efficacy of the communication through a combination of advanced technologies, film-set discipline, careful design and user evaluations.

We experimentally evaluated the difference between a face-to-face condition in dance and theatre performance and a simple mediated condition. We interviewed participants, observed the sessions and administered questionnaires.

As expected, the face-to-face condition was the most favorable circumstance to perform in where closeness between performers is of the essence. In the mediated condition performers were highly aware of the performers in the remote studio, signifying a keenness to reach across the virtual divide, to keep track of the performance in the remote studio but, partly due to the inherent delay in the communication, they did not feel they came across well to the remote studio creating a tension, which distracted from the performance.

On the other hand students quickly and with enthusiasm took to performing across the audio-video mediated connection, making creative use of the experimental set-up. One improvisation by the actors seemed tailored to mediated performance, as they acted out a Prime Minister's question time improvisation set in the House of Parliament, a location that is by its very nature divided between government and opposition. In addition whereas in meetings interruptions are the rule, for most theatre plays, improvised or scripted, actors take well-defined uninterrupted turns with clear hand-overs, which can help to overcome adverse effects of latency in mediated performance. Such conversational characteristics also make it feasible to support the type of automated editing technologies Vconect aims to deliver.

There were various differences between the actors' and dancers' experiences and requirements for further technology development,

although this is more likely to reflect differences in how the performers used the space rather than differences between dancers and actors per se.

In the current experiment dancers used all of the space and would benefit from multiple cameras and displays. The actors worked more statically and close to the camera losing eye-gaze with the remote studio. They wished for a Picture in Picture facility to monitor themselves and it is possible that automatically zooming in on those who speak as well as those who nod would enhance dramatic effects.

All performers stated that advanced videoconferencing technologies would mean that rehearsals need not end when term ends as they would be able to keep on practicing remotely. In addition they would be able to follow master classes.

When participants used the connection for discussion, many issues associated with 1990's video-conferencing technology came to the fore. They found it hard to understand each other, there were simultaneous starts, they needed to repeat themselves and on occasion raise their voices.

The question of where an (interactive / integrated) audience would be and how performers would be able to interact with them came up several times. Future experiments will evaluate sensor technologies to gauge audience engagement and we aim to benefit from the innovative work in this area by, amongst others, Latulipe and colleagues (2011).

As far as improvements on the design of mediated performance spaces is concerned performance colleges, staff and students alike, have an advantage as they understand stage and film-set discipline; they understand the profound effects of lighting, or a (neutral) background, simplicity etc. on performance, on communicating to an audience. In future developments we aim to apply this wisdom.

We described three theoretical perspectives which might have different relevancies for different types of performance and audience involvement. Clarke's classification of conversational components (Clark and Brennen, 1991; Clark, 1996) and Wilson and Wilson's neurological basis of conversation (2005) may be more relevant within the domain of the spoken word, whereas mirror neuron theory as it stands applies more to physical movement and postural congruency,i.e. dance.

To conclude: participants' feedback in this experiment identified differential effects of mediated performance resulting in technology and design requirements informed by recent theoretical backgrounds.

Vconect CAVE's

A recent study [48] demonstrated how a live performance not only resulted in an immersive experience with its focus on performers (on stage) literary in the spotlight but also how the majority of an audience responded second by second physiologically in a highly correlated way, i.e. Galvanic Skin Response (GSR) taken every second (across a 28 minute period resulting in over 1600 data points for each participant) produced

an average correlation of .82 in 66% of the audience members (Wang, Geelhoed, Biscoe, Cesar & P. Stenton, 2013). It is highly speculative but all the same worth considering, as GSR is a measure of the activity of the sympathetic branch of the autonomic nervous system, there might be some relationship, direct or indirect, with mirror neuron activity in response to, at least, the physical movement of the actors. Above we postulated how mirror neuron activity is involved in engagement and empathy and how important the theory is for explaining different levels of Telepresence in videoconferencing. As such mediated performance is likely to benefit from the way theatre traditionally has drawn people in: through a shared focus, lighting, sound effects, illusions such as Pepper's ghost etc.

Computer Aided Virtual Environments (CAVE's) concern spaces with wall and ceiling projections, accompanied by relevant audio and typically are restricted to one location; Sermon and Kozel's installation concerned two audio-video connected rooms in one location. To our knowledge there are as yet no CAVE's that are connected via the Internet (1992, *Telematic Dreaming*: http://vimeo.com/20054617).

One of the aims of the Vconect program is to use the rollout of superfast broadband in Cornwall to connect performance spaces, e.g. village halls, in remote rural areas in Cornwall. At Falmouth University we developed a computer based prototype system comprising of three screens, three cameras and three projectors (per location) that allows for an immersive CAVE-like performance studio to be connected via superfast broadband to another (CAVE) performance studio. Such a system can be used for remote performances, rehearsals and teaching. In the case of dance performances it will go some way to accommodate dancers being able to see each other from different angles as they move around a studio space (Fig. 6). In addition this CAVE environment allows for the level of immersive-ness to be enhanced through lighting, audio as well as somehow representing (e.g. visually) audience feedback. See figure 6

1. *The diagram below explains the set-up in more detail (see figure 7), also see http://www.youtube.com/watch?v=jq98zb2tkj4*

Fig 6. Remote dance teaching

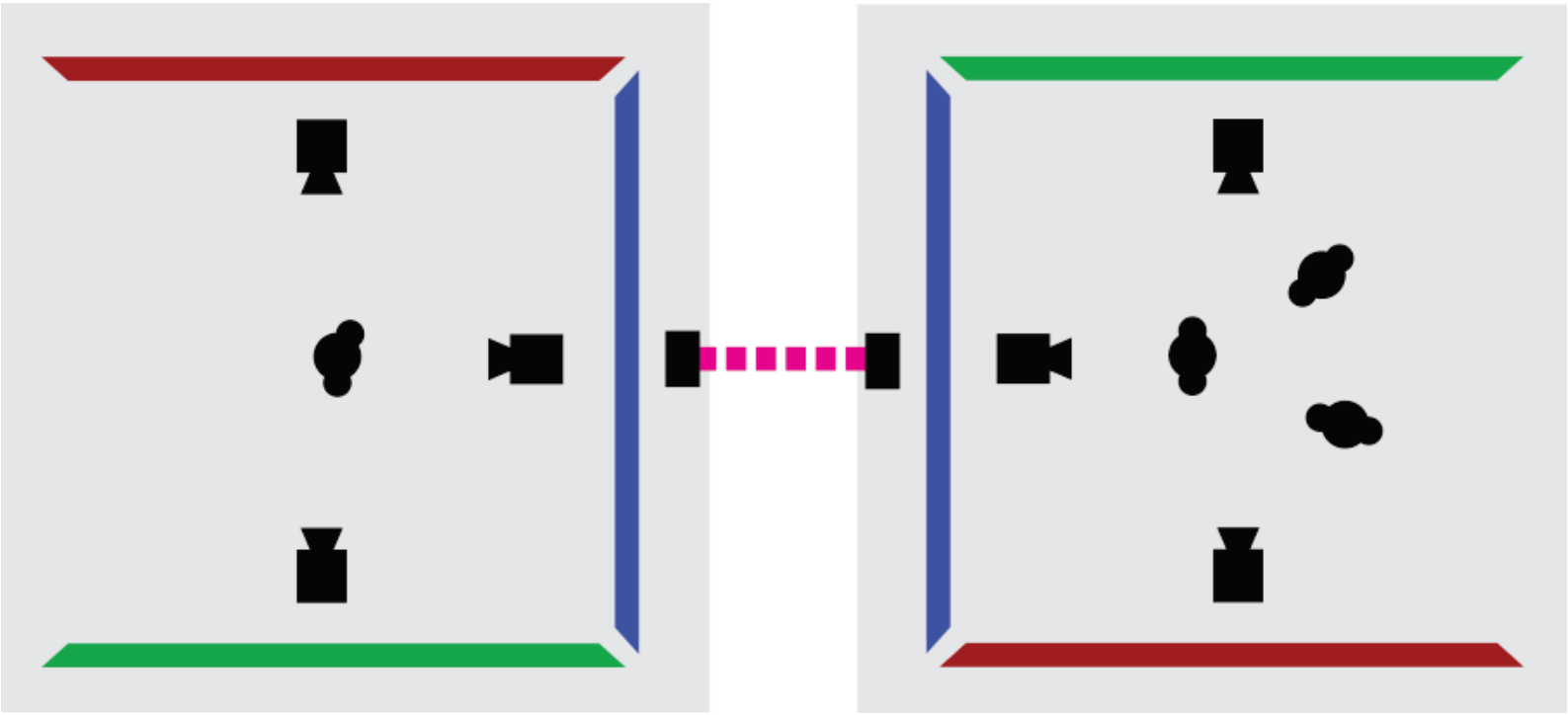

Figure 7. Diagram of Vconect on-line CAVE's

For each dance studio, the system consists of a high-end computer with a video card that can process at least three video streams in (cameras) and three video streams out (back-screen projectors). In a studio there are three screens, a screen in the centre, one on the right and one on the left. In front of each screen there are (centrally positioned) cameras. At the back of each screen there is a projector. Cameras and projectors are connected to the computer in each studio. The computers in the two studios are connected via superfast broadband.

As such there is a consistency of space, i.e. the video stream originating from the camera in front of the left screen in studio A is routed to the projector behind the left screen in studio B (and vice versa). Similarly, the video stream originating from the camera in front of the right hand (green) screen in studio A is routed to the projector behind the right hand (green) screen in studio B (and vice versa). The central screen projectors and cameras are also linked.

Thus, our Internet connected CAVE's have come about through a creative and technological process that has benefited from the Vconect's technical program, the roll-out of superfast broadband and user feedback in the current design requirements exercise and has been inspired by prior performance art and our knowledge of human factors in video-conferencing.

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Endnotes

1 Pepper's Ghost is a technique used in the theater of illusion, in haunted houses, and in some magic tricks, through the use of glass, acrylic or plastic film combined with special lighting techniques, special plate, creating the illusion that objects appear and disappear, become transparent, or turn into something else. The ghost got the name from John Henry Pepper, who popularized the effect in nineteenth century London. *(en.wikipedia.org/wiki/Pepper's_ghost)*

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Biographies

Erik Geelhoed has a background in psychology, along with extensive expertise in qualitative and quantitative research methods, including statistical analysis. He has worked for Hewlett-Packard Research Labs Bristol for almost 20 years carrying out user evaluations in a plethora of technology settings, including research in technology use in the performing arts (audience and performers). Currently he is working on a EU research program (Vconect) with the aim to connect performance spaces and remote audiences using broadband video conferencing technologies. Email: erik.geelhoed@falmouth.ac.uk

Ian Biscoe's background as an entrepreneur, engineer and raconteur has seen him build a number of companies in Europe and the Americas. His business and engineering activities have straddled electronic, mechanical and software expertise in the fields of aerospace, process control, entertainment and telecommunications. In between his own business ventures he has served on the boards of FTSE100 and Fortune 500 companies. He more recently studied Architecture and Landscape Architecture before coming to University College Falmouth as a PhD researcher investigating Cognitively Enabled Built Environments. He maintains a blog on his research activities at: cognitiveenvironments.wordpress.com. As a part of his research at Falmouth, he is currently designing and equipping the new AIR (Academy for Innovation & Research) building with a network of wireless enabled environmental sensors, enabling the building to perform as a living laboratory, investigating the potential for improved communications between buildings and their inhabitants. He is also designing and building a Bee Research Facility which will be fabricated using engineered timber and erected at the Tremough Campus.

Kuldip Singh-Barmi (Senior Lecturer, Course Co-coordinator for BA Dance & Performance at Falmouth University) trained at The Northern School of Contemporary Dance and has been performing, teaching and facilitating workshops ever since. He was a founder member of CandoCo Dance Company and has worked with choreographers and companies such as Emilyn Claid, Lloyd Newson (DV8), Siobhan Davies, Darshan Singh Bhuller (Singh Productions), Annabel Arden (Theatre de Complicité), Kwesi Johnson (Kompany Malakhi) RJC Dance Company, Fidget Feet Arial Dance/Theatre Company, Attik Dance and Company Pyke. Kuldip has taught and performed extensively nationally and internationally. Current research interests are centered on improvisation and its role in training/ performance and in in using digital technologies to enhance remote teaching and mediated performance, in particular applying video – conferencing technologies and modifying motion capture environments to widen the potential in movement related performance art.

Phil Stenton is Professor of Pervasive Media and Associate Dean for Research and Innovation in the Graduate School at Falmouth University. He is also a Director of Calvium Ltd, a high tech start-up in Bristol. Prior to moving to Falmouth he co-founded the Pervasive Media Studio www.pmstudio.co.uk, a joint venture between

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