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OperaBooth - an Installation for Intimate Remote Communication through Music

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ABSTRACT

This paper describes the development and evaluation of an installation that explores intimate connections between remote strangers. The conceptual intension of the installation considers that music can be used as a universal language through which strangers can communicate. For that, several approaches have been taken to enhance the feeling of *intimacy* between the users of the installation. The paper describes related work within the field of mediated intimacy and musical interaction forming the initial goals of the system. It then describes the iterative development process, which includes two smaller prototype tests. The resulting installation implements two large human size boxes with a hole in each for inserting one's head. Inside the box users can view the face of the remote stranger. A special setup enables users to appear very close to each other while being able to look each other in the eye for an enhanced feeling of intimacy. Finally, a face-tracking algorithm detects when users open their mouth, which results in them triggering the voice of an opera singer. Thus, strangers (who are not musically skilled) are able to explore an opera-duet in a form of musical exploration and communication.

Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**]: Audio input/output.; H.5.3 [**Group and Organization Interfaces**]: Synchronous interaction.

General Terms

Design, Human Factors

Keywords

Mediated Intimacy, Interactive Installations, Musical Exploration, Music, Video Conferencing, Emotional Communication.

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Figure 1: The OperaBooth in use.

1. INTRODUCTION

OperaBooth is an interactive art installation that explores remote communication between strangers. Specifically, the motivation for undertaking this project was to explore how intimate communication can be mediated remotely through the universal language of music. While different mediation technologies have been considered for providing users with input possibilities (mostly through direct physical interaction), a system based on video conferencing was chosen as an addition to the musical interaction. The installation has been developed using an iterative human-centred design process, where several smaller prototypes have been developed and evaluated in an exploratory setting.

The paper is organised as follows: Section 2 reviews related works within the area of mediated intimacy and emotion as well as related musical interaction where the language of music is used in a collaborative context. The section outlines a set of challenges and goals meant to drive the development of the OperaBooth. Sections 3 and 4 present the design and evaluation of two prototypes of the OperaBooth. Finally, Section 5 discusses the major findings leading towards future challenges for dealing with intimate remote musical collaboration.

2. RELATED WORK

Understanding how technology can be used to mediate emotions between remote users is challenging. Saadatian et al. [15] provide a nice review of technologies for mediated intimate connections. In their paper specific mediation technologies are among other distinguished in regards to how abstract and poetically (as apposed to how literally and

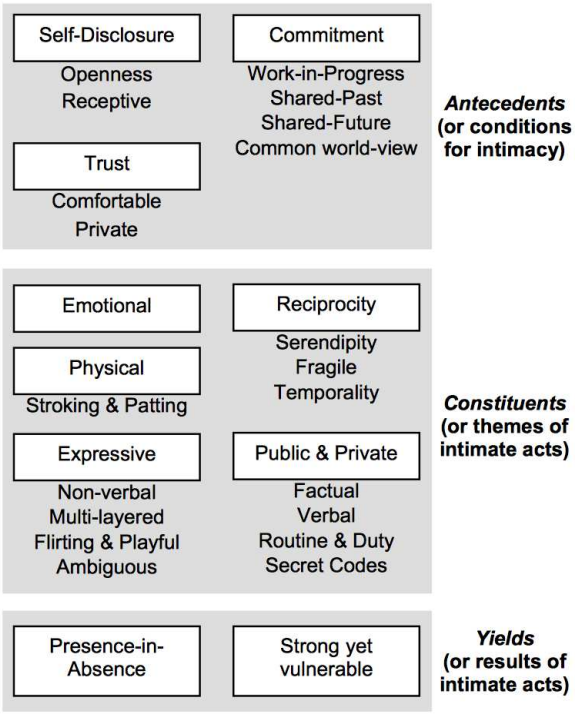

Figure 2: Model of central themes involved with mediated intimacy developed by Vetere et al. [18]

holistically) they convey the input from the sending user to the output experienced by the receiving user. Vetere et al. [18] use cultural probes [7] to study how interactive technologies mediate intimacy in our everyday lives. They state that intimacy is challenging to study for several reasons including privacy, richness, users' tacit understanding of intimate experience, idiosyncrasy, and *"no generally accepted language for describing and discussing intimacy, especially in relation to designing technologies for its support"*. They present a model defining several themes involved with mediated intimacy divided into three stages - prior to the act (Antecedents), the act itself (Constituents), and consequences of the experience (Yields)—See Figure 2 by Vetere et al. [18]. While the model attempts to outline themes of intimacy in an everyday context, which is quite different from the context of this paper, it provides a good framework for discussing design considerations involved with the proposed system.

Several input and output technologies have been proposed for computer-mediation of intimacy. Physicality (rather than graphical representation) of the mediating technology and non-verbal communication (for instance through peripheral awareness) is often emphasised for its ability to bring out emotional responses. Thus, haptic technology poses an effective communication channel [16]. Several projects explore touch as modality for social or interpersonal mediation of intimacy, affection or awareness including "Hug over a distance" by Mueller et al. [12], "Touch & Talk" by Wang and Quek [20], "ComSlipper" by Chen et al. [4] and many more. While haptic technology was considered at the start of this project (as explained later), it was considered to be more suited for subtle intimate communication between non-strangers. A goal of this project was to let users intrude the intimate space of each other through the installation, emphasising the **Fragile** and **Strong yet vulnerable** themes found in Figure 2. Note that Vetere et al.'s notion of Strong yet vulnerable refers to how established ties between non-strangers can be strong yet vulnerable. In the project presented here the term is used to suggest that users should be put in a position where they feel strong enough to dare interact, while still being vulnerable in order to let remote strangers intrude on their personal space. The idea of viewing each others faces up-close during interaction was considered and thus a combination of musical interaction and vision through video conferencing technologies was pursued. In that context it became important that any technological properties of the installation should not break the natural immersive experience of the users, which was important for the feeling of **Presence-in-Absence**.

Throughout the field of video conferencing technology a traditional goal is to enhance work efficiency for collaborating remote users. However, more artistic approaches have also been pursued where goals change towards more emotional aspects. "Carpe Diem" explores [17] so called near-eye displays as an alternative form of mediated communication. They consider related works from the field of video conferencing leading to design guides including *"physical distance, smiling, eye contact"* [1] and *"gestures, touching, vocal cues, turn-taking behavior in dialogues, the use of space, and verbal expressions directly acknowledging the communicative partner"* [10]. Finally, it is emphasised how important eye-contact is for interpersonal communication [8]. As will be presented later, the final prototype implements a custom solution for providing near field eye-to-eye contact between remote users.

An important part of the OperaBooth project is to enable musical exploration and communication between musically novice strangers. Musical interaction is often understood by dividing a system into three main parts: input (including understanding user gestures), output (the unit that generates the output sound) and the mapping (the layer that translates gestures into sound) [19]. While this works well as an overall model, different musical contexts demand more specific models. Musical interaction and collaboration around music has been studied extensively—Blaine & Fels [2] provide a nice overview of collaborative musical interfaces, arguing that especially there is a need to balance accessibility (for instance making the interface accessible for non-musicians) and expressive potential for virtuosity. Furthermore they state that especially for public exhibitions where most of the target audiences are musical novices, the challenge is to "limit rather than increase the number of features and opportunities for creativity". Hansen & Andersen [9] study how novice users collaborate, communicate and negotiate through novel musical interfaces. They suggest providing users with different roles (for instance roles that are either rhythmical or harmonic, or either play melodies or chords) for improved musical communication through for instance turn-taking. For many studies of musical collaboration it is often the musical experience or the musical expression that is in focus - see [2] for examples. In the OperaBooth project, music is more regarded as a mediator or commu-

nication medium where the primary goal is intimate communication, which is achieved partly through musical exploration. The OperaBooth focusses on understanding music as a language for universal communication [5] and sharing of emotion [11] and for providing users of the installation with an emotional experience. In an interactive installation context the mapping space becomes important. Here the goal is to balance the user interface in terms of how hidden or amplified it is in regards to (1) manipulations (is the user aware of the input possibilities?) and (2) effects (does the user understand how the output relates to their input?) [13]. Often somewhat hidden manipulations or effects can add a magical aspect to the interaction. However, if they are too hidden, the user will not understand the purpose of the installation and thus not engage.

Based on the review presented above, initial goals and challenges for the project can be summed up into the following 5 points:

- Provide intimate communication through musical exploration (non-verbal communication)
- Exceed the intimate space of the other user (explore vulnerability)
- Provide simple control mappings catered towards musical novices
- Make the control interface expressive
- Explore different roles for each user for improved musical communication

3. DESIGN AND IMPLEMENTATION - INITIAL PROTOTYPE

The overall context in which the installation was envisioned drove the exploration of the design together with the goals stated above. The project started with an idea of connecting participants in two culturally or politically diverse locations. The installation would then bridge this cultural gulf using music as a universal language and mediator. While several different technologies and forms of interaction were considered, we chose to work with facial expressions as the control interface for the cooperative exploration of music (various haptic interaction forms were considered ranging from small sized gestures of squeezing or pushing physical objects (as e.g. [21]) to larger body motion gestures as Dance Dance Revolution arcade machines or [3]). Finally, the choice was made to explore facial gestures in an attempt to increase the *intimate* connection between the participants.

An initial prototype was developed based on a webcam connected to a face-tracking algorithm by Kyle McDonald[1] called faceOSC. The open-source algorithm detects the face of the user and processes information such as size, position and orientation of the detected face; mouth height and width; eye-size; and eyebrow position. Besides providing an interesting controller for exploration of sound, face-to-face communication between remote strangers (similar to a Skype video conferencing application) would enhance the intimate connection - especially, since the initial idea was that users would have to make many different facial gestures to control the music.

Various gestures were explored together with different sound synthesis algorithms including modular synthesisers (combinations of AM and FM synthesis), granular synthesis and sample-based synthesis for simulating real instruments [14]. Not only was the goal to provide the single user with a meaningful and expressive instrument (while keeping the the interface as accessible as possible), but also to strive for musical communication between the two remote users. While controlling synths with one's face did provide for interesting musical explorations, there seemed to be a perceived disconnection between one's face and the musical output. Additionally, the worry was that novice users would find it difficult to understand how to control several parameters of abstract sounds [2].

A decision was made to simplify the interaction. Thus, gestures were limited to only opening and closing the mouth (for simple on/off triggering of sounds without possibilities of shaping the sound). In order to improve the connection between the gesture of opening the mouth and the resulting sound, different types voices were explored (voices that were explored included human singing, shouting, baby laughter, and bird song). Finally, two different initial prototypes were developed based on the simple open/close mouth gesture - one controlling opera voices, letting users experience singing an opera duet and another controlling a modular synthesiser. Through subjective personal experimentation it became apparent that the opera singing version worked considerably better so that was chosen for an initial evaluation.

A simple prototype was built using faceOSC and Ableton Live. A Max/MSP patch was used to handle communication between faceOSC and Live, and Jitter[2] was used for displaying live video of the face of the remote user. The Max/MSP patch converting Open Sound Control (OSC) messages received from faceOSC to MIDI messages used by Live for triggering audio loops. The audio included custom recordings of female and male voices singing "ahh", "ooh" and "bah" notes on a harmonic minor scale (three octaves). Providing one user with a male voice and the other with a female voice was chosen in order to enhance the negotiation involved with musical communication mentioned earlier [9]. Opening one's mouth sent a note-on MIDI message triggering a random sample, that was looped using Live's built-in Sampler[3]. Closing the mouth would send a note-off terminating the sound of said sample with an appropriate release. This was done for both male and female voices. Additionally, a background track was produced as a string section playing harmonic minor chords in the same key as the voices. The tracking ran at around 60 frames per second, which made it difficult to explore fast rhythmical musical structures using one's mouth. However, the chosen genre and the audio clips invited more for longer notes to be held.

[1]https://github.com/downloads/kylemcdonald/ofxFaceTracker/FaceOSC.zip

[2]Max/MSP's video processing and 3D rendering environment.

[3]https://www.ableton.com/en/packs/sampler

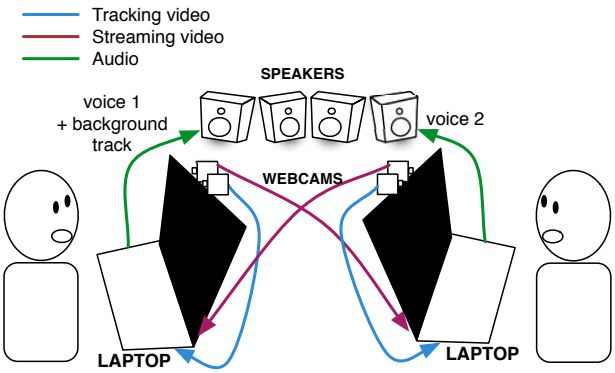

Figure 3: An overview of the system developed for prototype 1.

The initial prototype was built from cardboard boxes—see Figure 4. Each box contained a laptop computer running two webcams (one for tracking, the other for transmitting live video stream to the other laptop) and a set of speakers—see Figure 3. Simple lighting was adjusted in each box to optimise tracking conditions. For this prototype video was not transmitted from one computer to the other - rather, the webcam from box 1 was plugged into the laptop in box 2 and vice versa. This was done to avoid spending effort on networked video streaming for this first prototype.

3.1 Evaluation 1

The prototype was evaluated by inviting 4 pairs of test participants to explore the installation. All test participants were acquaintances of the test conductors, but not necessarily of each other (interesting, since eventually the goal was to explore mediated intimacy between strangers). One of the test participants had musical experience—the rest were musical novices. For each pair the evaluation took around 30 minutes, and was divided into 3 sessions. In the first session the participants were encouraged to explore the installation without any form of explanation. During the next session, participants were explained shortly what the purpose of the installation was and how they were supposed to control the interface (only two of the four pairs really needed help with this). Finally, participants took part in a semi-structured interview for discussing their experience. The interview was focussed on 4 major questions: (1) Were participants able to *understand* how to engage with the installation? (2) Did they experience a *connection* with the other participant? (3) Did they feel that they engaged in a *musical experience* together? (4) Did they experience an *intimate connection* with one another? For each overall question there was a discussion about why some things worked or did not and how improvements might be made to the current system. Observation notes were taken during the evaluation (for instance in regards to how well the tracking worked).

3.1.1 Results of Evaluation 1

Generally, test participants appreciated the concept of being able to sing opera with a remote stranger (it should of course be noted that even though some of the test participants were strangers, they were not remotely located - more about this later in the paper.) Without instructions, about half of the participants would put their head into the box, but simply

Figure 4: Shows the initial prototype being evaluated.

smiled at the other participant not knowing what was going on. If one participant opened their mouth and thus triggered the opera voice, the other participant would understand the interaction and try to do the same - leading to an understanding of the system. However, one participant tried to sing using his own voice thinking that he was controlling some aspect of the sound. Most tried to explore different mouth gestures and when asked afterwards about how they understood the interaction, they stated that they thought they were able to control some aspects of the sound with the shape of their mouth, but without being sure what.

Two of the four pairs expressed that they had a collaborative music experience. One pair never really achieved a strong interactive musical communication because of tracking issues, and the last pair expressed that they focussed too much on understanding the system instead of exploring its potential together. It was mentioned that most of the opera voice samples were beautiful and suited each other and the background track well, but especially the ”bah” sounds were odd and ill-fitting to the rest of the musical score breaking the immersive experience (because of the way the ”bah” sounds were sung during recording they would stand out as being slightly more aggressive and nasal).

On the technical side, tracking would not always work (mostly because of lighting conditions) leading to frustration. Furthermore, latency was perceived between opening of the mouth and initiations of the resulting opera voice, which made participants feel out of control (actual latency was never measured but it was around 60-100 ms). Finally (and most importantly), since this prototype simply worked by placing webcams above the viewing screen, the test participants were not able to properly establish eye-contact with one-another. This was given as the main reason for not experiencing an intimate connection with each other.

4. DESIGN AND IMPLEMENTATION - FINAL PROTOTYPE

After establishing a proof of concept with the initial prototype, a high fidelity prototype was designed and evaluated. The main features improved from the first to this second prototype included: (1) OperaBooth boxes now communicated with each other over network—dealing with latency issues and synchronisation. (2) Eye-contact between the remote users was enabled. (3) Recorded samples were improved. (4) Lighting conditions were improved for better tracking. (5) Perceived latency was reduced.

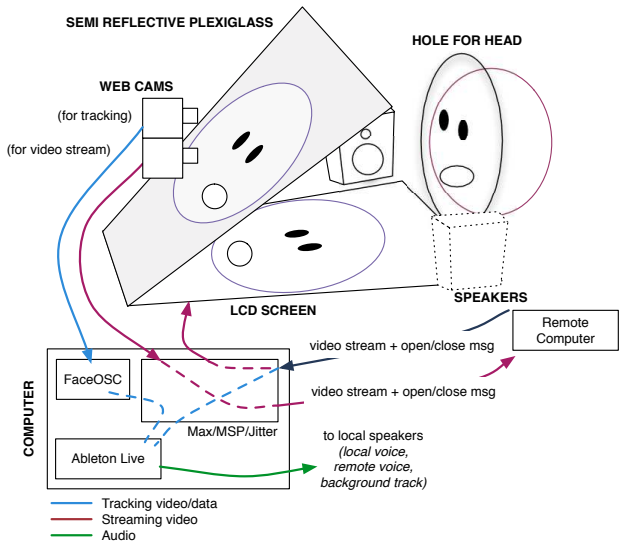

Figure 5: An overview of the system setup and data flow for the final prototype. The figure shows only the local box - the remote box is identical.

The new prototype was built by modifying two large wooden boxes. The prototype implemented the same software as used in the initial prototype, with the inclusion of networked video streaming using the Jitter part of Max/MSP. Ableton Live was run at both locations where one voice was triggered by local mouth open/close messages, while the other voice was triggered by mouth open/closed messages received from the remote box. Messages were synchronised to fit the latency of the networked video stream, which was around 25-30 ms. The perceived latency between the time when a user opened his or her mouth to the sound was heard, was reduced by improved editing and triggering of sound clips in Ableton Live.

The largest improvement was the development of an eye-to-eye webcam setup based on a teleprompter principle. The screen displaying the video stream of the remote face was placed flat pointing upwards. A plexiglass plate with a semi-reflective coating was placed at a 45 degree angle reflecting the image towards the user. The webcam could thus be placed behind the plexiglass plate at the position of the eyes of the remote participant enabling eye-contact. The screen displaying the remote user was placed as close as possible to the local user's face in order to enhance the perceived closeness. This resulted in a distance of approximately 30 cm between the eyes of the user and the screen.

Finally, lighting was improved by placing two LED strips at an angle on each side of the tracked face creating a soft uniform light suitable for optimal tracking. It was found that the faceOSC algorithm worked best if light was uniform and emitted from slightly above the face. See Figure 5 for an overview of the final prototype[4].

[4]A video illustrating the installation in use can be viewed at `http://media.aau.dk/~stg/operaBooth`

Figure 6: Shows the final prototype being evaluated. Top: Full view of the OperaBooth. Bottom: View from inside the box.

4.1 Evaluation 2

The final evaluation was carried out by setting up the two OperaBooth boxes in the large reception area of Aalborg University Copenhagen. The boxes were placed at opposite ends of the space in order to simulate distance (30 meters apart). However, as with the evaluation of the initial prototype, the participants were not remotely separated. The reason for choosing this setup included the following considerations: (1) The setup initially required technical monitoring, which would be difficult to carry out if the boxes were placed at separate locations. (2) There was not enough time to wait for participants to step up to the installation on their own - and to wait for a partner to join in the other box. (3) Participants were invited to try the installation in pairs for better control of the evaluation process, which would have been difficult if boxes would have been placed at separate locations. Thus, the goal of the evaluation was not to assess how the prototype created attention attracting users to interact with the installation. The goal was more to assess the user experience during the actual interaction. Overall questions were similar to the initial evaluation including: (1) How do participants *understand* the intended interaction? (2) Do they experience an *intimate connection* with one another? (3) Do they feel that they are able to *create music together*? (4) What would *improve* the experience?

Five pairs were tested. Two pairs did not know each other, while three pairs were friends. Two participants were musically experienced, while the rest had no direct musical experience. Each test lasted about 20 minutes—5 minutes of exploring the installation followed by a 15 minute interview session. Participants were not told what the installation was about until late in the interview session. Only one person

needed instructions beside the instructions that were written on an accompanying sign stating: "OperaBooth - insert head, open mouth, enjoy".

4.1.1 Results of Evaluation 2

Overall the installation was successful in giving the users a fun, aesthetically pleasing and intimate experience. The audio part of the installation was praised for being beautiful (participants stated that the background track would be appreciated as a mood-setting audio background even without anyone interacting with the installation) and at the same time being fun and dramatic. Observations showed that some participants would engage in a sort of theatrical facial mimicking of opera singers. When asked whether they felt they were making music together, four of the five pairs answered that they felt a musical connection with each other. Reasons for not achieving this were mostly of technical nature, where the tracking did not work properly breaking the feeling of control of the system.

Responses to the question about intimacy depended on whether participants knew each other or not. For the two pairs that did not know each other intimacy was expressed as an uncomfortable almost transgressive experience because of the perceived closeness of the other user. They stated that looking each other in the eyes was avoided because of the physical awkwardness. An assumption is that since participants were both located in the same overall space they were socially inhibited in a way they would perhaps not be if they were remotely separated. It is believed that the uncomfortable situation reported by the participants can be regarded as a sign of intimacy. Whether that intimacy is actually appreciated by remote strangers is yet to be discovered. The pairs who knew each other beforehand stated that the feeling of closeness was quite *intense* and that they would probably find it even more intense to experience the installation with a stranger. At the same time they argued that the installation was *humorous* leading to a break-down of inhibitions towards exploration.

As with the initial prototype, most participants thought they were able to control more than just on/off of the opera voices, but being unable to say exactly what. When asked if that was frustrating, participants agreed that it just made the installation more interesting. More control could perhaps be given to the participants by measuring the ratio between mouth width and height. Instead of triggering samples, the idea would be to let users control a physical model of a vocal tract (similar to [6]) producing "aahs", "oohs", and so on based on the shape of their mouth. There were slight problems with the tracking part of the installation, as the tracking would sometimes fail if participants placed their head too far into the box. Furthermore, one participant had a beard, which would confuse the tracking algorithm.

5. DISCUSSION AND CONCLUSION

In the following central issues discovered throughout the project will be discussed. The model of mediated intimacy by Vetere et al. [18] will be used to underpin these issues where relevant.

Self-disclosure or openness towards the installation was difficult to assess with the evaluation method used. As stated earlier, for practical reasons, participants were invited to try the installation, thus the openness was more towards helping with the evaluation.

The **emotional** properties of the experience were mostly observed as joy and playfulness but also **vulnerability**. In the approach taken here there was no **physical** interaction between users (for instance by using haptic technologies). However, because of the perceived closeness to the remote user, there seemed to be an almost physical reaction by the users as their intimate space was intruded.

In terms of **expressiveness**, the installation proved to enable users to engage in non-verbal, playful, and for some, musical expression. Perhaps providing more detailed control of the musical opera voice would lead to more expressive behaviour. The reason for not providing this, was that musically novice users, who only engage briefly with the system, require very simple forms of interaction [2]. One must be careful that more detailed control does not lead to difficulty understanding the system.

A future evaluation session is planned where the OperaBooth is to be implemented in two remote locations at two larger events. Here there will be more focus on the user experience as a whole. Where the evaluation sessions presented here have only focussed on parts of the user experience (intimacy, musical exploration and collaboration, usability in terms of how they understood the interaction, tracking precision, etc.), this next evaluation will investigate also the end goal of bridging the gulf between two culturally different locations. An important aspect to note in this respect is that choosing *opera* as a musical genre is quite biased towards Western music culture - especially in the way that tonality and harmony is controlled. This would have to change if the installation was deployed on a more global scale.

The research presented here underlines the importance of distinguishing between mediated intimacy between co-located and remote strangers, as mediated intimacy is achieved through interaction where the users are somehow **vulnerable**. If the users are aware that they will meet the other person face-to-face after having interacted together it can perhaps feel more uncomfortable to engage in this quite **private** intimate act - compared to knowing one will never see the other person again. Likewise it is important to distinguish between intimacy between strangers and friends, family or lovers, as there will be more openness towards this vulnerable situation if the partner is well-known.

For the OperaBooth, it can perhaps be argued whether intimacy was mediated through musical interaction or through virtual face-to-face non-verbal communication. While a large reason for why users of the OperaBooth did experience intimacy was because of the intrusion of their intimate space, the actual communication happened through musical exploration in a very musical context. Hopefully this research has helped with understanding how both exploration of music and personal/virtual space can improve remote mediated intimacy.

6. ACKNOWLEDGMENTS

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