DESIGNING INTERACTIVE AUDIENCE PARTICIPATION USING SMART PHONES IN A MUSICAL PERFORMANCE

Oliver Hödl, Fares Kayali, Geraldine Fitzpatrick

Vienna University of Technology
Institute for Design & Assessment of Technology, Vienna, Austria
{oliver, fares}@igw.tuwien.ac.at, geraldine.fitzpatrick@tuwien.ac.at

ABSTRACT

In this paper we describe the design and evaluation of an interactive system for audience participation in live performances using smart phones to control the stereo panorama of the lead guitar. The system was developed through feedback from both spectators and artists. The evaluation was conducted during a live concert and builds on interviews and video analysis. Findings include that musicians seem to be cautious about giving up control and that the audience at the same time wants a reasonable amount of control and clear feedback which in turn can be obtrusive to other spectators. We outline that balancing constraints with affordances is the key to both the audience's and musicians' acceptance of such a system and that a playful participatory design process can lead to better results in this regard. It is also shown that using smart phones opens up a large possibility space but at the same time their use has to be subtle to not distract too much from the music.

1. INTRODUCTION

Interaction within the context of musical performances has been subject to a lot of research over the last decades - mostly in combination with new technology which brought a variety of new ways of interactivity into musical performances. Just to mention a few, sensor-based systems allow the perception of bodily interaction (e.g. [6][16]), tangibles enable intuitive and appropriate interaction with digital devices (e.g. [13][23]), and network-based systems make collaborative performances possible where participants are getting closer to each other even though in some cases they are spatially divided (e.g. [20][26][29]).

However many of these applications rely on bespoke technologies for the interactivity. In this paper, we are particularly interested in exploring if and how we can exploit the ready availability of everyday smart phones, rather than some other bespoke device, to enhance the experience of live music performances. Modern smart phones already combine a wide range of these sensor and network technologies in one off-the-shelf device. The number of people having a smart phone is already high and still increasing and they have been used recently for studies in a music context [2, 22, 26]. However, little has been done using smart phones for letting the audience collaboratively participate in a traditional performance setting.

The broad area this paper addresses is understanding what it means when the audience participates in a musical performance. We talk about *interactive audience participation* when a spectator can take part or at least make a contribution in a live concert through a technically driven system. Regarding the *performance* itself it is becoming difficult to make "a neat distinction between interactive/real time performances and participatory installations" [30]. Thus we have narrowed our focus and concentrated on a musical performance of a rock band with the traditional distribution of roles where the musician plays actively in front of a passive spectating audience. Within this context the design of an interactive system is highly dependent on both the musicians' and the audience's desires. Hence this study builds on the following research questions: (1) What do audience and musicians expect from a system for interactive audience participation? (2) Considering both, how can these two be balanced out in terms of limitations and capabilities to facilitate meaningful interaction as well as aesthetically pleasant results? (3) Is smart phone technology an option for such a system?

For this purpose we conducted interviews, created a design, developed the technology and finally did an in-situ evaluation in a live concert. We decided to include the artist as well as audience members in the design process to let them "directly inspire and shape the technologies that are developed" [11]. In parallel we followed Kiefer et al. as they underlined the importance of pilot studies in the context of evaluating musical controllers [15]. Thus we did interviews with musicians and audience members first to get a real idea of their requirements. Based on these insights we developed a prototype system for interactive audience participation with smart phones involving artists and spectators in the design process. Finally we conducted an in-situ study at a live concert where the audience collaboratively influenced the sound. For the evaluation we conducted a video-based analysis and used questionnaires to query the audience directly [24].

Turino provides a good distinction between participatory and presentational performance in the context of musical styles and different cultures [28]. To be more specific audience participation has been done in previous research in various ways (e.g. [8, 20]). In a non-music domain Maynes-Aminzade et al. investigated various techniques for participation with a huge audience [19]. Their paper concluded with "a set of design principles for interactive crowd activities" which finally inspired us to use their approach in the field of musical performances for our in-situ study. In other studies sensor-based [16], wireless [6] and mobile phone technologies [17, 26, 22] were used for interactive and collaborative musical performances. The "reacTable" [13], for example, builds on a collaborative tangible interface which seeks to be "intuitive (zero manual, zero instructions), sonically challenging and interesting, learnable and masterable" [12], all relevant qualities of an instrument designed for adhoc participation. The musician Björk said she chose to use it on stage because "it also allows the audience to experience and understand electronic music and its performance on a whole new level"[1]. If we are talking about audience participation it also means making the playing of music available to non-musicians. This opens up the discussion about playing music in a more passive toy- or game-like sense [14, 25]. In his essay about the "composition-instrument" Herber [10] states that a system designed for this kind of musical play must maintain a delicate balance between "play" (freedom of expression) and "being played" (controlled and musically "safe" results).

The approaches to the field of audience participation are manifold. This paper takes inspiration from approaches towards music and participation in media and sound art, sound toys and even games and uses them in the setting of a live performance. The potentials and problems of this design strategy are then assessed taking a classic HCI approach to evaluation. The common denominator of the referenced examples and our research is a playful approach towards designing music and interactivity. The new ground covered is the evaluation of applying playful interaction to a contemporary live performance setting.

In considering this related work we argue that there is still more to be explored using smart phones for interactivity in performances. To explore this, we go on now to the interview study with musicians and audience members followed by the description of the in-situ study which includes study design, technical implementation, our methods and finally evaluation. The results suggest that using smart phones for interactive audience participation during a musical performance is a suitable method for engaging and entertaining the audience, however it is difficult to design an intuitive and easy-to-use system keeping in mind the wishes and needs of both artist and audience.

2. INTERVIEW STUDY

To get an initial idea of the musicians' and audience's behavior and habits concerning live concerts we conducted semi structured interviews. Hence our interviewees were able to talk freely at some points telling us about their experiences and desires in more depth than just answering closed survey or more structured questions.

The interview guideline included 38 questions divided into five groups: (1) a general overview about preferred music and live concerts, (2) personal views and general information, (3) details that happen during a live concert including mobile phone usage, (4) examples of particular behavior when thinking of a recently visited live concert, and (5) personal attitude towards technical developments. At the end we showed them examples of already existing systems for interactive and collaborative live music performances through sensor data [16], mobile phones [26] and the World-Wide-Web [29] and asked for their reactions and any further ideas these examples generated.

We interviewed eight participants between May and June 2011. Participants were recruited through social media, an online magazine for music and art, a university and two music labels. Four of them were musicians who play concerts regularly, defined as about 20 to 30 concerts a year. The other four persons were spectators who attend live concerts regularly, defined as 5 to 15 concerts a year. Each interview took between 45 and 60 minutes and was audio recorded. All participants were between 20 and 35 years old and three were females.

For the analysis all interviews were transcribed. Note that some excerpts quoted below have been translated into English as six out of eight interviews were held in German. We used the open source software Weft QDA[2] for a thematic and comparative analysis to find out the important as well as controversial themes of both groups in relation to their experience with live concerts. According to the scope of research we focused the analysis on statements referring to the musicians' motivation to play and the audience's motivation to visit live concerts.

2.1. Results

According to the participant's taste the different styles of music ranged from acoustic and jazz music to rock and electronic music as well as various hybrid forms. When talking about live concerts both musicians and spectators pointed out the special experience when music is played live and the importance of human elements in live music, most notably when computers are used. However, the spectators' motivations to go to live concerts varied widely as shown by the following statements: *"The show must be powerful and entertaining" (S1)*, *"I want them to play the music like on the record" (S2)*, *"The music should be real, not perfect" (S3)* and *"I most often ignore the show" (S4)*. Talking with musicians about their motivation to play live concerts revealed a tendency to enjoy the *"thrill" (M1)*, the *"atmosphere" (M2)*, *"to see excited people" (M3)* and even *"inspiration of the on-stage-situtation and the audience" (M4)*. The analysis of behavior and habits during concerts revealed a strong tendency among all spectators to use a mobile phone for text messaging, calling, taking pictures and videos or using social media to share the live experience. All of them indicated some action with a mobile phone at least once during a

[1] http://www.reactable.com/community/artist/3145 (last accessed May 30th, 2012)

[2] http://www.pressure.to/qda (last accessed May 30th, 2012)

concert but there was no pattern about when this happened during the performance. The spectators' opinions about technology used in live concerts in general were far more open-minded than the musicians' opinions. Interactive elements during a performance were even seen as a chance and opportunity by the spectators albeit in different ways: *"It could be interesting if the audience could steer the concert" (S1)*, *"I don't want to hold a device, I prefer a passive system" (S2)*, *"I would try it and form an opinion afterwards" (S3)* and *"I would definitely use such a device if I can see that something happens when I press a button" (S4)*. The musicians on the other side tended to skepticism and refusal: *"Maybe at selected passages of a song" (M1)*, *"I am the musician and not the audience" (M2)*, *"Maybe, if technically feasible" (M3)* and *"It's worth a try but query whether it works with a huge audience" (M4)*.

In summary, while the audience members frequently use their mobile phones during a concert, their opinion in relation to technically supported audience participation is ambiguous. The musicians on the other hand are far more skeptical towards new ways of audience participation.

We go on now to describe the design of an interactive system, informed by these findings, that we take on to study during a live performance. This serves two purposes: it allows us to develop and test a specific prototype application and it also provides us with another means to further explore the attitudes and requirements of both musicians and spectators through a provocative experience, using the prototype as a technology probe [11].

3. IN-SITU STUDY

As we wanted to conduct our study in a real-world scenario we collaborated with two artists, a guitarist and a drummer, and potential audience members. Together we designed an interactive system for technically supported audience participation in one particular song of the artists' live performance. During the design process we conducted two pilot sessions during rehearsals. The sessions each time also included two spectators which influenced the final design in a large part. We came up with a design solution where smart phones are moved left and right to control the stereo panorama of the guitar sound coming out of the PA speaker. For this design we had to consider two perspectives: the musician and the audience.

Considering the musician: The musician interviewees indicated they still wanted to be in control of the performance. The solution focusing on stereo control means that the musician's acoustic distraction is minimized and the artistic freedom untouched because the actual playing and sound effects are not influenced. Usually the sound of the PA mainly addresses the audience even though the musician is aware of this sound to some extent as well.

Considering the audience: As we found out previously mobile phones, and smart phones in particular, are widely used by spectators during a concert. Furthermore understanding and controlling the stereo panorama is very intuitive for the audience since acoustic stereo signals are ubiquitous (e.g. mobile music devices with earphones, computer speakers or TVs). Finally waving hands in the air back and forth is a common gesture in the context of a contemporary live concert.

3.1. Technical implementation

The technical implementation of our prototype is shown in figure 1. We refer to the major parts "Audience" and "Musician" as the *interaction layer* including visual and acoustic elements and refer to "Signal processing" as the *technical layer*.

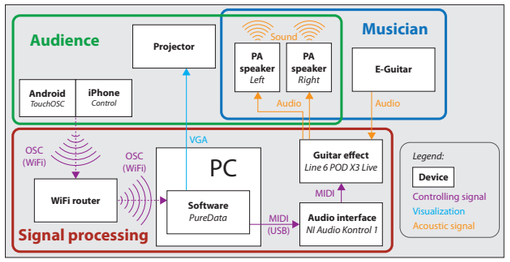

Figure 1. Schematic illustration of the interactive system for audience participation

Spectators download and install an app (which is described later) that enables them to interact with the stereo panorama. The audience gets visual feedback through a white dot projected on the screen behind the drummer at the back of the stage. The visual and interactive manifestation of sound or its parameters is called a sound object [27, 4]. Sound objects for example have also been used in networked performances by Barabosa and Kaltenbrunner [1]. In figure 2 (left picture) one can see the visualization (white dot) of the left-right-position of one smart phone which is identified by the unique number 8001. In the right image the white dot represents the average left-right-position of all participating smart phones. Thus everybody knows at any time whether his or her device is active or whether all devices are active and therefore all participants control the stereo panorama cooperatively. The acoustic feedback comes directly through the PA speakers situated at the left and right side of the stage facing towards the audience.

Figure 2. Two still pictures of the stage camera

To cover the majority of smart phone users we designed our system for Android-based phones as well as iPhones. We used the free apps "TouchOSC"[3] (Android) and "Control"[4] (iPhone). Both are able to send accelerometer data as Open Sound Control (OSC)[5] messages over WiFi. The wireless connection is handled by a WiFi router which transmits the OSC messages over a specified UDP port to a Pure Data (pd) patch running on a laptop.

The pd patch is the core of our system and does most of the work including the processing of OSC messages and sending out MIDI messages to the guitar effect device where the stereo panorama is applied. In pd the accelerometer data is normalized due to the different values ranges of the two apps. Because of limited capabilities in pd and the general study design the pd patch is predefined for twelve smart phones to connect and send accelerometer data. All data is summarized and divided through the number of active devices to get an average value which is then scaled to standardized MIDI values ranging from 0 to 127 and sent to the guitar effect device.

3.2. Study procedure

The venue for our in-situ study was a free public concert in the club B72 in Vienna, Austria, for standing only. We had a team of four people asking guests at the entrance whether they have an Android-based phone or an iPhone and were willing to participate. The people who agreed received a one-page sheet with a short explanation of the study and how to set up the smart phone. Every participant received the free app, inserted the given IP address to connect to the WiFi router and finally specified a unique UDP port. For testing purposes everyone had to check the correct configuration with the white dot individually as shown in figure 2 (left picture). They were not given any specific instructions about where to stand during the performance. We could only take twelve participants (about an eighth of the audience) due to technical limitations. This is reasonable given that that we are probe a system to explore the concept and learn about the characteristics and possibilities [11], not trying to generalize results.

We chose a song that was played twice at the end of the show. Everyone was told that the interaction would take place then and there would be an explanation beforehand. The first time the song was played without audience participation followed by a short explanation of the study and testing the system. Then the actual audience participation was done while the song was played for the second time. We did this to be able to compare the two versions as explained later during the evaluation section.

The song lasts about five minutes and is divided in two more or less equal parts. Each participant had the chance to control the stereo panorama individually for 13 seconds to get a "feeling" for controlling the sound of the guitar. With the beginning of the second part the signals of all participants were summarized to control the stereo panorama cooperatively.

3.3. Evaluation methods

According to an approach by Reeves we did a "hybridised form of video analysis" [24] combining video-based analysis and questionnaires. For this purpose we used two cameras to record the audience from two angles and one for the stage. Still pictures of the stage are shown in figure 2. We had a total of 45 minutes of video footage taken over a period of 15 minutes. Immediately after the second time the song was played, which was also the end of the concert, all audience members (no matter if they participated or not) were asked to fill out a short one-page questionnaire handed out by our team according to a similar approach done by Pedersen and Hornbæk [23].

We used our video recordings to analyze non-verbal social interaction among the audience interpreting body movement, gestures, expressions and gaze as done previously by Heath et al. [9] when studying social settings. Following their outlines we did a preliminary review for basic structuring, a substantive review to discover and annotate important passages and finally an analytic review to study specific parts in detail. We divided each of the three videos into parts to analyze them separately: (1) Five minutes while the song was played originally, (2) five minutes of explanation and testing with the audience, and (3) five minutes while the song was played with audience participation. Then each of the twelve participants was analyzed individually during both performances to find out important and obtrusive events. Additionally we picked out twelve non-participating audience members randomly to analyze their behaviour in the same way. While repeatedly watching certain occurrences in the video we focused on particular aspects of bodily interaction (e.g. synchronous moving of smart phones) and compared the three different camera angles (e.g. movement of the white dot compared with the view of the audience cams).

Additionally a total of 31 audience members filled out the questionnaire. Twelve of them participated with their smart phones and 19 did not. We handed out two different questionnaires: one for study participants and one for the other spectators. The short questionnaires were focused on their experience with smart phones, the procedure and the understanding of the study and their opinion about the audience participation. Finally we asked them which differences they could figure out between the two performances of the song. Combined with the video analysis this led to interesting and unexpected results.

3.4. Results

About half of the twelve participants were standing close to the stage and the others were distributed over the whole venue. By trend, participating audience members concentrated on the performance or rather the screen with the white dot whereas non-participants tended to observe the

[3] https://play.google.com/store/apps/details?id=net.hexler.touchosc (last accessed May 30th, 2012)
[4] http://itunes.apple.com/us/app/control-osc-midi/id413224747?mt=8 (last accessed May 30th, 2012)
[5] http://opensoundcontrol.org (last accessed May 30th, 2012)

study participants regularly and seemed to be a little distracted. This assumption was verified by statements in the questionnaire: *"I focused on the white dot most of the time"* and *"I prefer the version without [audience participation]. I could concentrate on the music more"*.

Participants standing next to each often had short comments and conversations while continuing to watch the stage or screen. Among the participants, we could identify essential differences concerning smart phone interaction in relation to speed, range and height when moving the device. Most obviously, there was a great disparity regarding stance and how the device was held. Audience members at the back held their phones up in the air whereas the girl and the boy in the front row moved their devices at breast height. Some even tried to "push" the white dot on the screen to a certain direction by shaking and moving the phone heavily. Again this behavior can be substantiated by statements from the questionnaire: *"I could hardly move the white dot"*, *"It was easy to see my influence when I had exclusive control but I could not really figure it out collaboratively"* and *"I have tried various different ways to control it"*.

Finally some participants tended to dance and synchronized their movement (including the smart phone gestures) to the rhythm of the music throughout the whole song. Others stood still and seemed to concentrate on the movement of the smart phone. In general there was no tendency towards synchronization of movement among all participants.

The statements about the audience's experience and their opinion about the smart phone based participation were mixed. Some were positive right up to enthusiastic: *"People were involved and therefore much more active"*, *"I felt honored to be part of the show"*, *"Funny!"*, *"I want to influence other effects that change the sound"* and *"Extremely cool. I am so sorry for not having a smart phone"*. Other audience members were critical and stated their negative experience clearly: *"Music suffered!"*, *"The band loses control. Not expedient"*, *"The collaboration was chaotic. I missed a coordinator"*.

Summarized it can be said that the comparison of the two times the song was played showed considerable differences in audience behavior and experience which were either stated explicitly in the questionnaire or indicated in the recorded video.

4. DISCUSSION

Using smart phones for interactive audience participation opens a wide range of possibilities because of their versatility. Nevertheless we found out that some people can be easily distracted from the actual performance by their use. With this in mind the application of sensor-technology could be regarded as far more subtle and "invisible" when utilized appropriately. In general audience members are not musicians and they do not intend to learn and practice for the purpose of participation. Magnusson refers to this as "affordances and constraints in musical instruments are two sides of the same coin" when talking about performing with digital musical systems [18] and the same can be seen in interacting with digital systems as spectator.

This leads to the question about the preferences of the audience and musicians and how these can be balanced out in terms of limitations and capabilities. Interviews have shown that musicians tend to keep the influence the audience has over their music low. Hence, we used the stereo panorama of the lead guitar for manipulation. We tried to support this using a visualization. This again led to a significant distraction although it did support the interaction in a reasonable way.

Furthermore some statements of participants of the in-situ study revealed deficiencies in our system relating to the importance of immediate and perceptible feedback. For a clear and unmistakable understanding of the control and functionality people want to have a "proof" that every individual influence has a reasonable effect. Further research could explore different ways to visualize each signal of the crowd separately. Traceability seems to be an important issue otherwise participants doubt their contribution and get frustrated and this could also be important for the artist. Here the importance of finding the right trade-off between artistic freedom of the musician and an intuitive system that engages the audience is crucial. While our study integrated the perspective of musicians in the interview study and design process, we did not include them in this study. Further studies could also evaluate a series of concerts with audience participation from the musicians' perspective.

Finally our results have shown expressive behavior and diverging reaction among certain participants during the collaboration. This indicates that a playful approach to interface design can lead towards a better understanding and more intuitive control regarding the interaction with the device. In HCI research the importance of playful interaction [7] has been emphasized especially in connection with the design of artifacts for social interaction. Social interaction of course also is an important attribute of our presented participative performance system. At the same time the design of the system itself is a playful exploration of technology [21]. The importance of ludic design processes to interactive and participative art is described in [21]. In a way both the act of playing our performance system and the act of playfully designing it can be regarded as acts of music making. In his essay on experimental music, Cage [3] describes the purpose of writing and making music as "purposeful purposelessness" and "purposeless play" which should not imply uselessness but to make use of the creativity and flow experience [5] facilitated by a playful approach.

5. CONCLUSION

In this paper we were concerned with new possibilities to enhance interaction between audience and artists using everyday smart phone devices. We conducted a preliminary interview study with musicians and spectators. On this basis we designed an interactive system with smart phones for audience participation in a musical performance using a playful approach to interaction and including spectators and musicians in the design process. Answering the initially posted research questions the evaluation of this system showed that (1) musicians seem to be ambiguous and cautious about giving control to the audience and that spectators want reasonable control and clear feedback when interacting with sound but that at the same time this feedback distracts the rest of the audience. (2) A good balance of constraints and affordances is crucial to both the audience's and musicians' acceptance of such a system and that this balance can be achieved by a playful design process which includes both artists and spectators. (3) Smart phone technology holds much potential in this regard because of its versatility and wide spread use but also has its problems because usage can be obtrusive to other spectators.

6. REFERENCES

[1] A. Barbosa and M. Kaltenbrunner, "Public Sound Objects: A shared musical space on the web," pp. 9–16, 2002.

[2] N. Bryan and G. Wang, "Two Turntables and a Mobile Phone," *Proc NIME*, 2011.

[3] J. Cage, *Silence: lectures and writings*. Wesleyan University Press, 1961.

[4] M. Chion, "Guide des objets sonores: Pierre Schaeffer et la recherche musicale," *Institut national de la communication audiovisuelle*, 1995.

[5] M. Csikszentmihalyi, *Flow: the psychology of optimal experience*. Harper & Row, 1990.

[6] M. Feldmeier and J. A. Paradiso, "An Interactive Music Environment for Large Groups with Giveaway Wireless Motion Sensors," *Computer Music Journal*, vol. 31, no. 1, pp. 50–67, 2007.

[7] F. Feltham, F. Vetere, and S. Wensveen, "Designing tangible artefacts for playful interactions and dialogues," pp. 61–75, 2007.

[8] J. Freeman, "Large audience participation, technology, and orchestral performance," pp. 757–760, 2005.

[9] P. Heath, C., Hindmarsh, J., Luff, *Video in Qualitative Research*. Sage Publications Ltd, 2010.

[10] N. Herber, "The Composition-Instrument: musical emergence and interaction," *Proc Audio Mostly*, pp. 31–36, 2006.

[11] H. Hutchinson, W. Mackay, B. Westerlund, B. Bederson, A. Druin, C. Plaisant, M. Beaudouin-Lafon, S. Conversy, H. Evans, H. Hansen, N. Roussel, B. Eiderbäck, S. Lindquist, and Y. Sundblad, "Technology probes: inspiring design for and with families," *Proc CHI*, no. 5, pp. 17–24, 2003.

[12] S. Jordà, M. Kaltenbrunner, G. Geiger, and R. Bencina, "The Reactable*," *Proc ICMC*, 2005.

[13] M. Kaltenbrunner, G. Geiger, and S. Jordà, "Dynamic patches for live musical performance," pp. 19–22, 2004.

[14] F. Kayali and M. Pichlmair, "Playing Music, Playing Games - Simulation vs. Gameplay in Music-based Games," *Proc FROG*, 2008.

[15] C. Kiefer, N. Collins, and G. Fitzpatrick, "HCI methodology for evaluating musical controllers: A case study," *Proc NIME*, 2008.

[16] R. Knapp and B. Bortz, "MobileMuse: Integral Music Control Goes Mobile," *Proc NIME*, 2011.

[17] G. Levin, "Dialtones (A Telesymphony)," 2001.

[18] T. Magnusson, "Designing constraints: Composing and performing with digital musical systems," *Computer Music Journal*, vol. 34, no. 4, pp. 62–73, 2010.

[19] D. Maynes-Aminzade, R. Pausch, and S. Seitz, "Techniques for interactive audience participation," pp. 15–20, 2002.

[20] G. McAllister and M. Alcorn, "Interactive performance with wireless PDAs," *Proc ICMC*, 2004.

[21] A. Morrison, P. Mitchell, and M. Brereton, "The lens of ludic engagement: Evaluating participation in interactive art installations," pp. 509–512, 2007.

[22] J. Oh and G. Wang, "Audience-Participation Techniques Based on Social Mobile Computing," *Proc ICMC*, 2011.

[23] E. W. Pedersen and K. Hornbæk, "mixiTUI," pp. 223–230, 2009.

[24] S. Reeves, *Designing interfaces in public settings*. Springer, 2011.

[25] D. Robson, "Play!: Sound toys for non-musicians," *Comp. Music J.*, vol. 26, no. 3, pp. 50–61, 2002.

[26] M. Rohs and G. Essl, "CaMus2: Collaborative Music Performance with Mobile Camera Phones," *Proc ACE*, pp. 190–195, 2007.

[27] P. Schaeffer, "Solfege de l'objet Sonore," 1966.

[28] T. Turino, *Music as social life: the politics of participation*. University of Chicago Press, 2008.

[29] J. Young, "Using the Web for live interactive music," pp. 302–305, 2001.

[30] V. Zappi, D. Mazzanti, A. Brogni, and D. Caldwell, "Design and Evaluation of a Hybrid Reality Performance," *Proc NIME*, no. June, pp. 355–360, 2011.