Engagement Networks in Social Music-making

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ABSTRACT
Social music-making systems offer the possibility of accessible and engaging group experiences. In this paper we explore questions concerning the notion of 'engagement' in social music-making. In a recent user study of Viscotheque, an iPhone-based environment for group musical creativity, three different types of engagement were observed: individual, unilateral and bilateral. These results indicate that network-based approaches may be useful in analysing engagement relationships amongst participants in group music-making.

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Mutual Engagement

ACM Classification Keywords
H.5.5 Information Interfaces and Presentation (e.g., HCI): Sound and Music Computing—Methodologies and Techniques

INTRODUCTION

Multi-user Interactive Mobile Multimedia

Recent advances in technology present a range of new opportunities for group interaction in creative contexts, and mobile devices are being increasingly co-opted by musicians and visual artists (for example in (Gaye et al., 2006; Wang et al., 2008)). Mobile devices such as 'smartphones' contain an array of sensors and feedback mechanisms which enable complex interactions with a multimedia environment (Essl and Rohs, 2009). Their familiarity, ubiquity and ability to network with music performance systems can be exploited to enable increased access to a group music-making experience (Blaine and Fels, 2003).

Creating music can be an engaging activity - musicians devote years of their lives to learning musical instruments such as the violin or the piano. While individual motivations for this devotion may differ, many musicians are primarily driven by a sheer love of making music. This 'intrinsic motivation', that the motivation for performing the activity is that the activity is intrinsically pleasurable, is at the heart of Csikszentmihalyi's theory of flow (Csikszentmihalyi 1990) and musical instruments can be thought of as ancient examples of flow interfaces. In group music-making, each participant is not simply a passive consumer of some external stimulus, but an active contributor to the musical whole. Group engagement has been observed in music, including jazz groups (Monson, 1996) and string quartets (Seddon and Biasutti, 2009), as well as in improvisational theatre troupes (Sawyer, 2000) and even in street basketball (Jimerson, 1999). This can also be described as a state of group flow.

Compared to traditional creative practice, mobile devices have a very short history, with few entrenched traditions and cultures of use. The work described in this paper is motivated by the question: can group music-making with mobile devices provide participants with an engaging group experience which is somewhat analogous to participating in a traditional musical ensemble? By seeking to answer this question, we eventually hope to contribute to the design of social music interfaces to support an engaging and pleasurable group experience.

Concepts of Engagement

In Human Computer Interaction (HCI) the term 'engagement' can be broadly used in two different, but related, senses (Peters et al., 2009). Engagement can refer to (1) the initiation of an activity, or (2) the state of being occupied in, or involved with, a given stimulus or activity.

As an example, in human-robot interaction, engagement has been divided into three main phases: the *start*, *maintenance* and *end* of the interaction between individuals (Sidner et al., 2005). In the context of group music-making, the two senses of the definition of engagement are related in that the state of being involved can be accompanied by frequent engagement of aspects of system behaviour by the participants. However, being involved with an activity can be measured independently of matters of control and this will be the approach adopted for the remainder of this paper.

According to Csikszentmihaly, the flow state is associated with total immersion in an activity to the extent that participants lose track of time. Our treatment of engagement in this paper presents it as a superset of immersion – a participant can be engaged in an activity without being immersed but cannot be immersed without being engaged. It is important to note that other authors have adopted differing definitions, for example to classify engagement as one of three levels of involvement (engagement, engrossment and immersion) (Brown and Cairns, 2004) or even to place engagement on a different axis to immersion (Douglas and Hargadon, 2000).

Mutual Engagement

Engagement is often studied with reference only to the individual. In social music-making, it is necessary to

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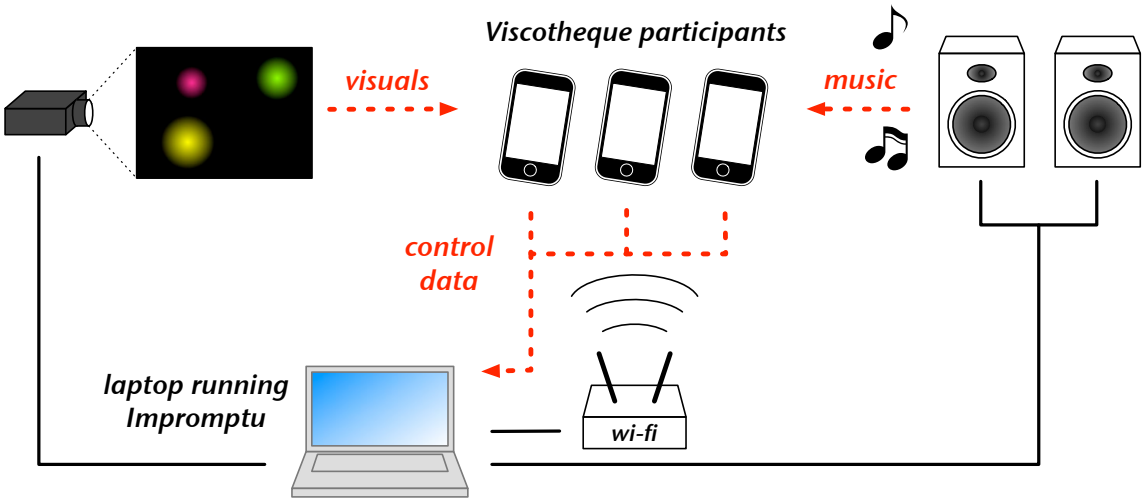

Figure 1. Viscotheque system architecture.

broaden our approach to address issues such as whether a group experience is perceived as being engaging by *all* members of that group or only by some.

In group music, participants do not 'play' in isolation. Each participant is involved in a complex dialogue with all the others, leading and responding to the actions of others in turn. Any study of the user in this context must therefore include the relational context in which each participant operates. Each participant contributes to the global output stream, so the performance is a collaborative activity. The overall 'success' is not wholly determined by any single user, but relies on the users working together.

One attempt to define engagement in the specific context of multi-user music-making is the concept of mutual engagement (Bryan-Kinns and Mary, 2004). In a user study involving their *Daisyphone* collaborative mu- sic tool (Bryan-Kinns and Hamilton, 2009), the authors documented several instances of mutual engagement between participants. Participants were given the opportunity to collaborate on a musical jingle using the Daisyphone's orbital step-sequencer interface, while different aspects of the interface were altered between trials. After each trial participants completed questionnaires related to engagement, and the Daisyphone interaction logs were examined by expert musicians to identify periods of engagement. In the study, examples of mutual engagement (including acknowledgement, mirroring and transformation) were observed between participants.

One aspect of mutual engagement which warrants further study is the possibility for different engagement relationships to emerge between participants. Breaking mutual engagement down into different categories, as described above, is helpful, but there is also much to be learned from studying the networks that are formed as participants engage with each other in mobile multimedia systems.

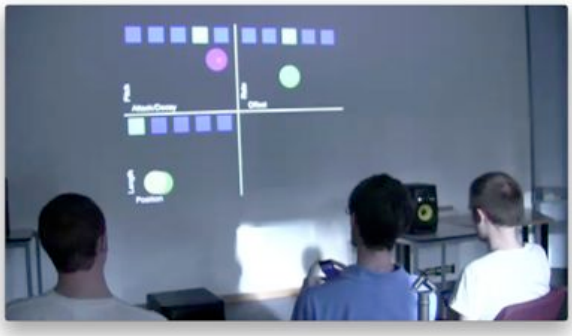

Figure 2. Three participants during a Viscotheque performance.

Studying Mutual Engagement in Viscotheque

In this paper, we examine the experience of group musical creativity in a multimedia setting through a user study of *Viscotheque*, a new iPhone-based social music-making environment (Swift et al., 2009). We provide a context for the current discussion of engagement in social music-making, as well as some initial results from our study.

The structure of this paper is as follows: we first describe the Viscotheque system itself, followed by the experimental procedure used in the study. The results of the study and their implications are discussed in the remainder of the paper.

THE VISCOTHEQUE SYSTEM

Viscotheque Architecture

The Viscotheque system allows multiple participants to simultaneously influence the playback of multiple audio loops. The Viscotheque system uses a client-server architecture. Using the Apple iPhone as a control device, each participant is assigned a unique 'sound', which they can then control in various ways using the touch screen. Participants are co-located, and receive audiovisual feedback through a shared pair of speakers and a projector screen. A diagram of the architecture of the system is shown in Figure 1.

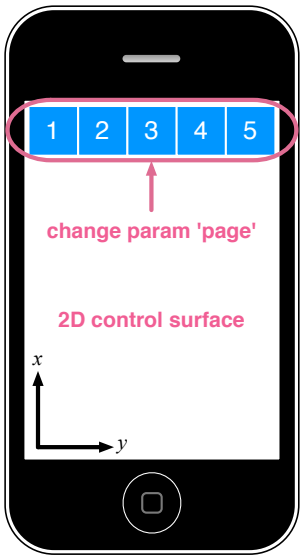

Figure 3. Viscotheque application interface. Buttons for switching between the 5 'pages' sit above a 2-dimensional touch zone.

Impromptu Server

The core of the Viscotheque system is a laptop running the Impromptu media arts programming environment (Sorensen, 2009). This laptop acts as a server for the iPhones, maintaining and managing connections with all the devices. Bi-directional communication between the server and the devices is done using the OSC (opensoundcontrol.org) protocol over UDP.

Parameter	Description
Position	Position of current selection in audio file
Length	Length of selection
Pan	Playback stereo position
Volume	Playback volume
Offset	Deviation of playback from 'downbeat'
Rate	Frequency at which section is looped
Attack/Decay	Attack/decay envelopes for playback
Pitch	Playback pitch
Cutoff	Cutoff frequency for lowpass filter
Resonance	Filter gain for lowpass filter

Table 1. The parameters available to each participant for manipulation with the Viscotheque app. Pairs of parameters (appearing on the same 'page') are grouped together.

Using Impromptu, Viscotheque provides visual feedback for each participant on the state of their sonic manipulations. This takes the form of an (almost) one-to-one visual representation of the iPhone interface and their current touch position. The screen is segmented so that each participant's screen is represented separately, each represented by a unique colour (see Figure 2).

Viscotheque iPhone App

Each participant is given an iPhone (or iPod Touch) running a custom Viscotheque application and each participant's task in a Viscotheque performance is to manipulate a loop of audio in a creative way (see Tanaka, 2004).

The interface presented to each participant is shown in Figure 3 and consists of 5 identical 'pages', each of which is essentially a 2D touch pad. On each page, the touch screen provides control of a pair of playback parameters (one mapped to x and one to y), with a different pair of parameters on each page (for a total of 10 modifiable parameters). A list of these parameters, and their effect on the output sound, is given in Table 1. The iPhone is used solely as a control interface with audio synthesis being left to the Impromptu server.

Because the sonic effects due to each participant are mixed together through the same pair of speakers, it can be hard for a given participant to distinguish their musical 'voice' from those of the other participants. The system has been designed, therefore, to produce effects which are immediately perceptible and which correlate well with finger movements on the iPhone touch screens.

Experimental Procedure

Participants played with the Viscotheque environment in groups of three. Each experimental session consisted of two phases: a performance, and an interview. Participants were located in the same room for the entirety of the performance, seated so that they could see each other, as well as see the shared screen and hear the shared speakers.

In the performance phase, the three participants were given an opportunity to 'perform' using the Viscotheque system. At the beginning of this phase, each participant in turn was given a three minute solo period in which to familiarise themselves with the interface and their sonic parts. During this period, the other participants' iPhones were inactive. Once each participant had completed their familiarisation period, the participants were given 15 minutes to make music together using the full capabilities of the Viscotheque system. For the full duration of each session, participants were recorded on video (Figure 2), and the participants were aware of this fact. As well as the video footage, logs from the iPhone interface were recorded for later analysis.

Immediately following the performance phase, participants were interviewed as a group while watching a video of their performance. This video-cued recall (VCR) technique has been used elsewhere (Costello et al., 2005) to aid participants in describing their experience with interactive multimedia. The VCR interviews themselves were also recorded on video, which were later used to produce complete transcripts of the interviews.

Each participant had at least one year of formal musical training. As noted in (Blaine and Perkis, 2000), participants with musical expertise have experience in situations where they are required to listen to an audio stream and identify their own unique part of that audio stream - discerning their own effects from the effects of

others. While it would be interesting to compare the difference in interaction patterns between musicians and non-musicians, this is an issue for future study.

Interview Procedure: Measuring Engagement

Our objective in this study was to search for indications of engagement as reported by the participants. As an 'affective state', the reported degree of engagement is highly subjective (Picard, 1999), and care must be taken when making comparisons between participants' ratings of engagement. In fact, research dealing with affective states suggests that asking specific questions of the participant (in a questionnaire) can be less useful than allowing them to describe their experience in a more open-ended fashion (Boehner et al., 2005). Accordingly, participants in our study were interviewed as a group, with the interviewer looking for indications of engagement (reported as 'awareness', 'involvement', 'immersion' and so forth). Rather than asking 'were you engaged?', participants were asked to simply describe their Viscotheque experience. As issues relating to engagement arose organically, the interviewer was able to ask follow-up questions to investigate these moments in greater detail.

Participants were provided with a chance to not only relate their own experiences and respond to, and comment on, particular interactions with other participants. When there was evidence of mutual engagement, questioning was directed towards finding out how many participants experienced mutual engagement and the specific details of this engagement.

Another difficulty in capturing a picture of participant engagement in Viscotheque is the dynamic nature of reported engagement: during a given 'session' the level and quality of engagement varied over time. The video-cued recall technique allowed the participants to comment at any time. Participants were encouraged by the interviewer to make specific comments about particular parts of the performance with more directed questioning when there appeared to be evidence of mutual engagement.

ANALYSIS

The study involved 9 participants (8 males and 1 female, aged 23 to 30) divided into 3 sessions with 3 participants each. The OSC communication logs constituted the quantitative data, while the interview transcripts provided the qualitative data.

In this paper we focus mainly on the interview transcripts as a measure of user engagement. However, as an example of quantitative data from the logs, traces of the interface activity of each participant are shown in Figure 4 and we observe that there appear to be several patterns in the styles of touch-pad usage.

Following the methodology used in Seddon and Biasutti's study of group interaction in string quartets (Seddon and Biasutti, 2009), the group interview transcripts were subjected to thematic analysis. In particular, emergent themes related to engagement were examined in relation to other categorisations of engagement, such as mutual engagement (Bryan-Kinns, 2004) and the high-level categories of engagement described in Patel et al. (2009). Care was taken in transcribing the interviews to avoid the 'deletion of the interviewer' problem (Potter and Hepburn, 2005), and interview excerpts have been provided with context where appropriate. In these excerpts, P1 to P9 represent participants 1 to 9, while INT is the interviewer.

Interview Themes

Being in the Groove

Overall, the participants described the Viscotheque experience as a positive one. Words such as engaging, immersive, fun were used to describe the experience at various points. The most satisfying and engaging moments of the performance were described independently by several group members (across different groups) as being 'in the groove'.

INT *So tell me about that communal... tell me about that sensation of the groove that you were mentioning...*

P8 *It's just a beat that resonates inside you, that feels right. And it has to be co-ordinated, even if it doesn't all happen at the same time then (claps)... I'm not sure. And even now [refers to screen], we sort of feel a groove happening*

P7 *Yeah.*

P8 *(makes rhythmic hand gestures in time with the music)*

P7 *We're a band now!*

ALL *(laughter)*

P7 *Bust out those iPods, we're going on a tour.*

Here the participants describe the sensation of being in a band together, demonstrating real enthusiasm about the shared experience, despite the fact that the participants did not know each other beforehand. It is encouraging to observe this quality of interaction even after a short period of using the system. The ability of Viscotheque to facilitate this level of engagement is crucial if the stated goal of studying engagement in social music-making is to be achieved.

Group Roles

The participants also noted the similarity between the group dynamics in certain parts of their Viscotheque performance and group dynamics in other group music contexts, such as a conventional rock ensemble.

P7 *Yeah. I sort of got really stuck into the rhythmic part, it was like, just trying to establish something - not a foundation, but a consistent stream, so that... if you were playing the drums, if you changed the tempo, it would just mess up everybody else's. So it was sort of like, that, adopting the role of the actual instrument, so, like, the guitar goes up and down and does these (mimes guitar playing)... the piano as well... but you know the beat has to be there, so it's like (claps rhythmically) 1...2...3...4..., 1...2...3...4..., 1...2...3...4... And I really felt embodied by that particular sample - having that role.*

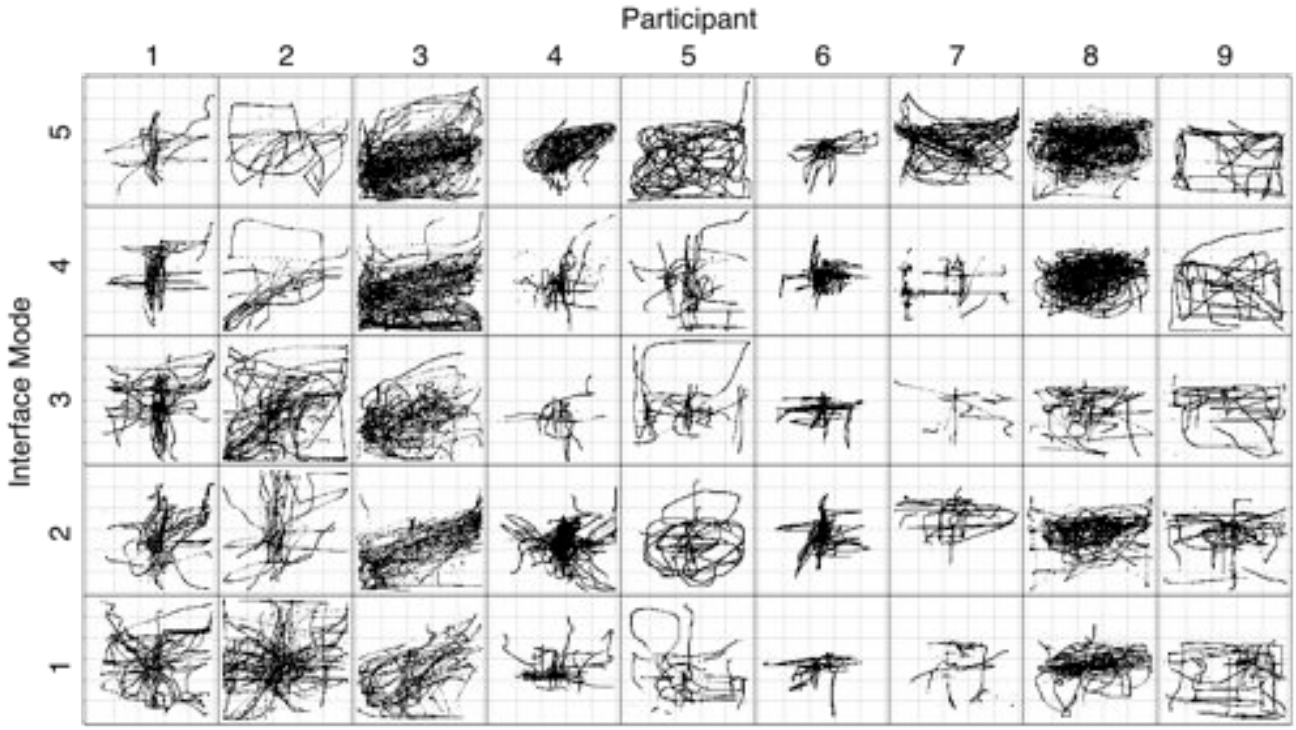

Figure 4. Finger traces on the iPhone interface. Each column represents a single participant, each row is a 'page' of the interface corresponding to a different pair of input parameters. Data processing and visualisation was performed using the R statistical environment (r-project.org)

P8 *So the role almost defines what you can actually do*

P7 *Yeah*

P8 *As in, like, I mean coming from a musical background, the rhythm section does keep things going, and they feed off everyone else and provide the support, and they're quite mindful of that, but when you have a soloist, they're going all over the shop, like, they know what everybody else is doing, but they sort of do their own thing.*

Here, we can see P7 identifies with the rhythmic role of the drummer, as distinct from the more melodic roles of the other participants. The claim to have embodied that rhythmic role is a particularly interesting one - suggesting an intimate connection between the participant and their sound, mediated via the interface.

The assumption of certain roles by the participants is also interesting because these roles were not imposed by the Viscotheque system. It raises questions about whether this 'division of labour' allows greater opportunities for group engagement. It is also intriguing to examine whether the different roles assumed by some participants can be inferred from the interaction log data, something that we plan to explore in the future using statistical clustering techniques.

DISCUSSION: THREE TYPES OF ENGAGEMENT

Specific moments of conscious interaction between different participants were reported in the interviews. Using the video recording of the performance as stimulus material for the interviews proved helpful in allowing participants to recall and explicitly describe their thought processes during these moments of interaction.

Engagement-related events were mentioned 54 times across all participant groups. Examining the moments of engagement reported by the participants revealed three qualitatively different engagement relationships: individual engagement, unilateral engagement and bilateral engagement.

Individual Engagement

This was the most common of the three different classes of engagement, being mentioned on 26 distinct occasions across all interviews (almost 50% of all mentions). The experience of individual engagement was characterised by a focus on the participant's own musical effects. This experience was described using words such as immersion, engagement, awareness and being 'in the groove'. This ex- perience was reported at various times by almost all (8 out of 9) of the participants. Often, this engagement involved the pursuit (and achievement) of high-level aesthetic goals, as described by one participant:

P7 *For me it was all about strategy, see - here's the bit that I really enjoyed (points at screen). So I was sort of finding the sound, and then I'd jump to number 5, and then I'd go back, high note... play around with the high note... and then I'd go back... and then a low note, and then a high note, and then (makes circular gesture with hands)... Strategy, you know? It was all about strategy.*

This type of individual engagement was described by the participants as a potential barrier to group enjoyment:

P1 *So if there were three people in the band, and there's one person just enjoying their socks off because they're just going off, but that is completely going in the wrong direction compared to the other people, well then that*

[enjoyment] may not be the case for the other people, so then they [the engaged participant] might enjoy their personal output, and not sort of be aware as to the outcome of the collective sound together.

In this case, a given participant's state of individual engagement renders them oblivious to the actions of the other participant and the collective sound.

Individual engagement is unique amongst the three types of engagement reported here in that it only involves one participant - the participant is simultaneously feeling engaged and responsible for the object (musical effects) of their engagement. The fact that the participant is part of a group activity is irrelevant, their current engagement state is completely introspective. Individual engagement is not, therefore, group engagement in the truest sense.

Unilateral Engagement

At points during the performance, participants reported a conscious period of following, or responding to the effects of another user. This type of engagement was mentioned 18 times during the interviews.

P6 *I think at this point I was trying to figure out how I could make the volume of my sample kind of play around with the volume of P5's. Like to try and get one to dominate at one time, then to dial mine back, the bring it up when his is going back down.*

This type of engagement is a unilateral engagement - in most cases, the participant whose effects were being responded to was unaware that they were the 'centre of attention' in this way. This is not necessarily a problem, participant A can follow the actions of participant B even if B is oblivious to the fact that they are the object of A's attention. It may even be the case that B is individually engaged in their own activity, unaware of any of the other participants - A can still allow B's actions to influence his own. For this reason, unilateral engagement is also fragile, as discussed in this exchange:

P6 *I think it might have been around this time that I was trying to sync up the beats between - is yours top left, whose is that?*

P4 *That's me.*

P6 *Yeah, between yours [P4] and mine.*

P4 *It's funny, because sometimes you move yours to sync with somebody else, but they've got a completely different thing in mind (laughs), moving it in a different way, or something...*

Here we see an example of acknowledgement, one of the types of mutual engagement presented in (Bryan-Kinns and Hamilton, 2009). Interestingly, although participant P6 was acknowledging (or perhaps even trying to mirror) the effects of P4, their synchronisation was hampered by the fact that this awareness was not reciprocated. In the binary relationship between the subject and object of engagement, the direction of engagement matters.

In contrast to the experience of individual engagement, during unilateral engagement a user was aware of and attending to the multimedia output of a fellow participant, rather than just their own. Unilateral engagement therefore precludes individual engagement. Here we see the potential confusion arising from a careless use of the word engagement - an experience can be engaging in completely different ways, depending on the nature and object of the engagement.

Several participants also reported a deliberate cycling between the individual and unilateral modes of engagement:

P4 *I think I was trying to make a conscious effort to listen to other people, but there was times when I was trying to figure out something, and wanting to just do a thing myself.*

P6 *I think it kind of went through cycles for me, like I noticed there were particular points where I'd bring the resonance out, and just try and hear what my sample was doing, and there'd be other times where I'd go back to, say, the volume, and just bring it back a little bit and try and make sure that it was... kind of... a bit more subtle, I suppose, and going under the beat rather than trying to dominate it. So I suppose it was kind of backwards and forwards for me, but it was usually quite distinct in that I'd think - 'ok, now I'm going to concentrate on what I'm doing', and then quite consciously switch back to 'now I'm going to try and make this work with the whole entity'*

P4 *Mmm.*

The type of engagement experienced by a given participant depended on which 'phase' of this cycle they were in. Each participant traversed a unique 'engagement trajectory' during the 15 minute performance period.

Bilateral Engagement

The third, and rarest, form of engagement mentioned by the participants was bilateral engagement (10 mentions). This is when two participants were consciously acting and reacting to one another in dialogue. Unlike unilateral engagement, both participants are aware of the interplay. The distinction between unilateral and bilateral engagement is one not made in (Patel et al., 2009) or (Bryan-Kinns and Hamilton, 2009).

Unlike the other types of engagement, which were connected to specific parts of the performance by the participants, bilateral engagement was more commonly referred to more generally, as some sort of vague goal state, or the sensation of being in sync:

P5 *I really like this bit, or the bit that just went*

INT *What did you like about it, do you think?*

P5 *Well, it sounded like it worked, like it actually fit together...*

P4 *Yeah.*

P5 *We managed to get the samples working in a way that wasn't completely fighting with each other.*

P4 *Yeah, like with any sort of music I suppose, if someone wants to dominate, or lots of people are trying to dominate, it all sounds like rubbish, but because*

everyone's sitting back just tweaking and trying to be more subtle, I think it works.

The closest the participants came to actually describing an exchange where participants were wilfully playing with each other comes from group 2:

P4 *I was trying to create a chord progression, but I wasn't (laughs) accurate enough.*

P5 *Yeah, I tried to do that too, I tried to go I → V, and that's why I was trying to multi-touch.*

P4 *Mmm.*

Even in this case, it seems that two of the participants were trying to do the same thing coincidentally, rather than as a result of a conscious exchange of ideas. Even so, a sensitivity and balance between all the different participants (which necessarily involves each participant being aware of the sound made by the others) was cited as a characteristic of the musical high points in each performance.

P3 *I think at this stage we were becoming more aware of each other. I think in the first little bit we were so concentrating... concentrating a lot on (hand gesture) our individual sound, and what we were doing, and how our manipulation was working, and at this stage perhaps we were becoming more aware of the other sounds, not that it consciously did that, but I think that's why it sort of, starts, maybe taking shape*

P4 *That sounds quite cool there, actually.*

P5 *Even there we seem to be able to, we're going with the same idea - which is interesting.*

The perceived 'quality' of the total musical output (which, while perhaps related to, is not the same as the depth of the participant's engagement) is here attributed to the harmonious synthesis of each individual's contribution to the larger whole. Of the three types of engagement, bilateral engagement seems the most likely to result in a truly productive awareness between the participants, even if bilateral engagement is comparatively rare 'in the wild'.

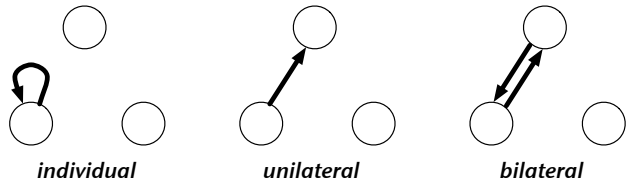

Figure 5. Engagement networks representing the three different engagement relationships observed in the Viscotheque study.

Engagement Networks

Each of the three types of engagement described above was felt *individually*. At any given moment, each of the participants may be engaged in a different fashion, or not engaged at all. Measuring the engagement of the group as a whole requires the construction of an engagement network, a directed graph representing all the different engagement relationships present at any given time (Figure 5). By examining how these networks change over the course of a performance, we can comment meaningfully on the engagement dynamics over time in a given group.

The distinction between unilateral and bilateral engagement is an important one. For engagement to be considered 'mutual', it is clearly important that the engagement relationship is bilateral. High degrees of unilateral engagement can occur without any mutual engagement being achieved. When considering mutual engagement, therefore, it is important to consider the direction of the engagement relationship.

Representing engagement as a directed graph also presents the possibility of applying techniques from graph theory to the analysis of engagement networks. Average connectivity, cycles and other metrics can provide helpful insights into the engagement relationships during a particular performance.

FUTURE WORK

The 'engagement network' concept and threefold division of engagement relationships presented in our Viscotheque study suggest ways of evaluating existing group music environments and lessons for designing new ones. One possibility is that mobile multimedia systems can be designed in such a way as to facilitate different types of engagement during different stages of the interaction. Plotting an interaction trajectory is an important part of designing a multimedia experience (Benford and Giannachi, 2008), and the 'engagement net- work' concept described here can be of use here.

A major focus of our future work will be to investigate correlations between the quantitative interview data and the quantitative log data. Are there quantifiable signatures of engagement and immersion, and if so, how do these measures compare with the subjective descriptions of engagement given in the interviews?

If these signatures of engagement can be found in the log data, this has several potential benefits. One of these is automated analysis of participant engagement, building an engagement network for a given performance from the interaction data. This could then be used to examine periods of optimum group engagement, and compare different performances between groups.

Another more exciting possibility is that of interactive systems which can detect the various engagement relationships on-the-fly, and adjust their effects to initiate and maintain periods of engagement between participants. Certain types of engagement, such as bilateral engagement, could then be made an explicit goal of the interaction, with real-time feedback on whether or not the goal was being achieved. Graphical representations of the current engagement network could provide a fascinating spectator experience, as different participants engage with one another in different ways during a performance.

CONCLUSIONS

In this paper we have raised some issues surrounding ideas of engagement in social music-making. In a user

study of engagement, we have examined the different engagement relationships which occur between participants, and proposed a network model of engagement to account for our findings. In particular, we have discussed the difference between 'unilateral' and 'bilateral' engagement in group music-making, which has not been noted in the literature previously.

As the appropriate technology becomes more commonplace and multi-user interactions become more common, we believe that a rich and nuanced picture of group engagement will lead to the development of better experiences for participants in social music contexts.

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