ISSUES AND TECHNIQUES FOR COLLABORATIVE MUSIC MAKING ON MULTI-TOUCH SURFACES

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ABSTRACT

A range of systems exist for collaborative music making on multi-touch surfaces. Some of them have been highly successful, but currently there is no systematic way of designing them, to maximise collaboration for a particular user group. We are particularly interested in systems that will engage novices and experts. We designed a simple application in an initial attempt to clearly analyse some of the issues. Our application allows groups of users to express themselves in collaborative music making using pre-composed materials. User studies were video recorded and analysed using two techniques derived from Grounded Theory and Content Analysis. A questionnaire was also conducted and evaluated. Findings suggest that the application affords engaging interaction. Enhancements for collaborative music making on multi-touch surfaces are discussed. Finally, future work on the prototype is proposed to maximise engagement.

1. INTRODUCTION

Applications for collaborative music making on multi-touch surfaces are an ideal setting for creative collaboration because they afford group participation and immediate music playing. According to Blaine and Fels [1], musical collaboration systems commonly restrict musical control, which facilitates novices' participation in the musical experience. The authors argue that the quality of the experience of using a collaborative music system takes precedence over the music produced: specifically that opportunities for social interaction, communication and connection with other partners is key to a satisfactory user experience. According to Mercer and Littleton [2], this provides us with a distinctive opportunity to foster learning and meaning-making through social interaction.

An analysis of the issues and techniques of music interfaces for multi-touch surfaces can provide us with a better understanding of these systems and help us to improve collaborative interaction. For that purpose, an exploratory user study was conducted and videotaped using a prototype application for a musical activity. Besides, qualitative evaluation was undertaken adapting Grounded Theory and

Content Analysis. Quantitative evaluation was also undertaken based on questionnaire results. The main focus of the analysis is on the evaluation of the collaborative interactions enabled by the application. Enhancements for multi-touch applications for collaborative music making are discussed. Future work on the prototype is proposed to maximise engagement.

2. BACKGROUND

In this section we consider ways to address how people engage with technology in creative settings and musical multi-touch surfaces.

2.1 Creative engagement

There are numerous theoretical accounts of the nature of creative engagement with art and artefacts. Current models are based on a pragmatist view, which conceptualises the aesthetic and affective value of an object as lying not in the object itself, but in an individual's or a group's rich set of interactions with it [3, 4]. The phenomena of personal full immersion in an activity, also known as "flow" [4], has been extended to groups as means of heightening group productivity [5]. Facilitating productive conversation is a key way to achieve such "group flow". In the context of collective composition of music, Bryan-Kinns et al. [6] see attunement to others' contributions as the central principle of creative engagement.

2.2 Musical multi-touch surfaces

Musical tabletop applications are not new. A pioneering work is the ReacTable [7, 8], which allows a group of people to share control of a modular synthesizer by manipulating physical objects on a round table. The Music Table [9] uses a tangible interface based on cards representing notes or phrases laid on a table. Audiopad [10] uses the tracking of physical objects on a tabletop to access samples, cut between loops and carry out digital signal processing. Audiocubes [11] enables users to configure a signal processing network through the placement of physical cubes containing digital signal processors. In Xenakis [12], Markov Models are induced by placing stones on a tabletop interface. In contrast to all these systems, where movement of tangible objects is key, there are other systems centered on multi-touch interaction. Iwai's Composition on the Table [13] allows users to create music and visuals by interacting with four tables which display switches, dials, turntables and sliders. Stereotronic Multi-Synth Orchestra [14] uses

a multi-touch interface based on a concentric sequencer where notes can be placed. The work presented here is the design and evaluation of a simple multi-touch system which allows a group of people to create music by interacting using buttons. By keeping the system minimal, we are able to investigate the essential aspects of engaging interaction.

3. DESIGN CONSIDERATIONS

In this section we describe the properties and issues of multi-user instruments and of multi-touch systems.

3.1 Multi-user instruments

According to Jordà [15], multi-user instruments are tools that not only facilitate responsiveness and interaction between each performer and the instrument, but also between performers. The degree of interaction between performers is a key factor in achieving an engaging collective interplay. New digital instruments are especially suited for music collaboration because they are multi-process oriented supporting multiple and parallel musical processes [15] as well as their interface layouts being flexible enough to be able to exploit several strategies of collaboration by distributing the controls [16]. Thus, issues to be considered in multi-user instruments are shared versus local control as well as complexity versus simplicity.

3.1.1 Shared vs. local control

Shared controls, local controls or both are traditionally accommodated by collaborative multi-user instruments. Shared controls allow users to have a common display where the control is shared and can be the object of group discussion, whereas local controls consist in replicated controls which tend to be easier to reach for users and are identified with territoriality [16]. However, in the latter there is a design challenge when the number of replicated controls is large. The controls of a multi-user instrument may afford flexible or fixed number of performers; fixed or dynamic roles; and democratic or hierarchical relationships among users [15].

3.1.2 Complexity vs. simplicity

According to Blaine and Fels [17], collaborative musical interfaces engage social interaction. This facilitates both novices and experts to make music. A tradeoff should be considered between enabling virtuosity (appealing to advanced musicians who prefer to have free rein to exploit the expressivity of the instrument), and limiting the features offered to enable simplicity of use (important to enable novice musicians to participate easily).

3.2 Multi-touch systems

The properties of multi-touch systems are specially suited to the key design needs of musical instruments in general, and multi-user instruments in particular. In 1985, Buxton [18] introduced a set of properties, issues and techniques in multi-touch systems, later reviewed in 2007 [19], which

have been applied to the question of multi-user musical instruments in this paper. In summary, the features considered are discrete versus continuous actions, size of display and context, sense of touch enabled and multiplicity of interaction opportunities.

3.2.1 Discrete vs. continuous

Multi-touch interaction can support both discrete and continuous actions. An example of a multi-touch interface using discrete actions would be an audio mixer, where one or more fingers push buttons or switches. An example of a continuous action could be also an audio mixer, but where one or more fingers move sliders, dials or knobs; or a waveform editor, where two fingers stretch a waveform.

3.2.2 Size and context

Display size is a decisive factor in how many fingers or hands can be used as well as how many performers can interact. Given that there is no mechanical intermediate device such as a mouse or a stylus, multi-touch systems are useful in tough environments such as classrooms or public spaces where these additional input devices can get damaged.

3.2.3 Sense of touch

Contact and position are traditionally those most used aspects of touch in multi-touch systems. Other features exploited are the degree of pressure; the angle of the finger relative to the surface; or the frictional force. However, there are some issues to be considered such as having lower precision than pointing with a stylus that can be solved, for example, by integrating physical controls with the interface [20, 16]. Besides, although the features of a physical input device are emulated, the interaction is actually with a virtual device where the visual supersedes other senses such as kinesthesia. As a result, users typically pay more attention to audiovisual feedback, which therefore should be reinforced in these systems.

3.2.4 Multiplicity

In multi-touch systems, some considerations to take into account are the following: first, even though the manipulation of a single point of contact can be exploited, multiple points are easier to use. Second, many of the interaction techniques from GUI (pointing at, dragging, clicking down or double clicking, for example) can be applicable in a multi-touch context using gestures based on discrete and continuous actions. Similarly, the same interaction technique can be split into multi-hand or multi-finger, depending on the granularity of the interaction sought. Lastly, where there are multiple users, the system should be able to distinguish the gestures and touches of the users from one another.

4. PROTOTYPE

In 2009, a project was undertaken in collaboration with the Milton Keynes Art Gallery under the theme of galleries and musical engagement. A prototype was developed with

the aim of enabling up to four users to collaborate on a composition.

The system needed to engage advanced musicians as well as novices given the emphasis on collaborative interaction. To this end, a simple prototype for a multi-touch tabletop was built where users could develop a musical composition using a palette of pre-composed samples. The system was populated with musical phrases in a traditional pop-contemporary musical style, emphasising harmony and rhythm, instead of complex melodic evolution (such as in jazz or classical music). Each user controlled a set of four graphical buttons which corresponded to four looping samples representing an instrument (bass line, drum line, keyboard line and percussion line). Each sample in the set consisted of a single musical phrase, consistent with all the others, which went from less to more complex. This evolution was shown in the buttons of the interface with a rounded shape from less to more filled. An additional button was also controlled by the user which toggled between either playing the sound through headphones in a private space or publicly through speakers (see Figure 1 the corresponding interface diagram). This switch icon changed shape and pulses when public mode was selected. The user was able to contribute by deciding which sample loop of his or her corresponding instrument was played and when it was triggered. Although each user could only play four samples, which meant there were only 256 combinations of loops, it represented an initial context for observing the processes of collaborative composition.
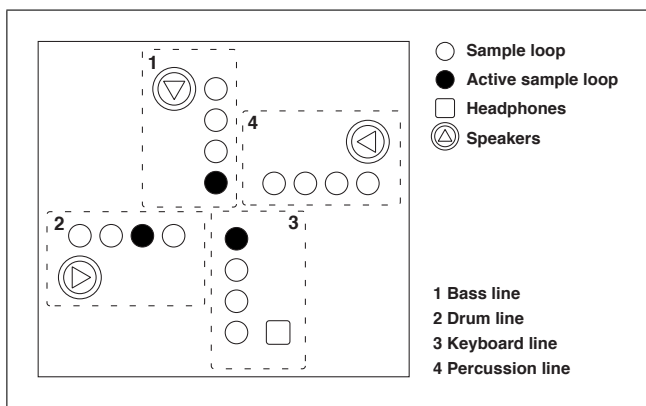

Figure 1. Interface diagram.

Regarding the hardware and software of the system, fingers are illuminated using diffuse infrared illumination and tracked with a camera underneath the table which encodes the information as a real time video stream. The reacTIVision [21] vision engine processes the video stream identifying the position of the finger tips. This data is encoded with the TUIO protocol over OSC and sent to a multi-touch software application (MTS). The MTS manages both visuals and audio: whereas the visual feedback, which is projected on to the surface, is defined using the programming language Processing [22]; the audio component is built using the visual programming language for music MAX/MSP [23].

5. METHOD

In this section a case study protocol is described which serves as a framework for an exploratory multi-case study. Afterwards, the qualitative approach to the analysis of the data is explained.

5.1 Exploratory multi-case study

A case study protocol was designed with the aim of studying the above prototype for collaborative music making. The approach was exploratory [24], in order to build an initial understanding of the situation. Video was chosen as the primary data source, given its advantages of multiple replay and closer multimodal analysis of interaction and also because the full range of behaviours and speech can be recorded easily, compared to other possible approaches [25]. Case studies of three groups were conducted in order to work with an initial phase of evaluation (see Figure 2).

Figure 2. Four users playing with the prototype.

The aim of the case study was to examine the extent to which the application enabled users to collaborate and the degree of mutual engagement in the creative process it afforded [6]. Involving participants with a range of levels of self-rated music knowledge was expected to provide a deeper insight into the situation because we would be able to examine the perspectives of both novices and experts. A number of features were observed: the ease of learning to use the application, the establishment of various roles for participants in the collaborative setting and how decision making was handled. Public spaces were ideal settings for carrying out this study for two main reasons: first, the physical proportions of these tabletop applications require ample space; and second, if they were to be used in performance and music learning, they would require shared spaces of similar size, with room for a group of participants and perhaps an audience. Thus, the user studies were conducted in a spacious atrium. Next, the musical tasks and questionnaire are described.

5.1.1 Musical tasks

With each group, three musical tasks of different character as well as an informal discussion were video-recorded in

order to generate sufficient data to analyse several aspects of behaviours using the prototype application. We were interested in any difficulties users might experience with the application, to what extent it enabled them to collaborate, and the degree to which it engaged them.

The tasks to be performed were the following:

1. T1. Initial period of sound exploration (3 min).

2. T2. Structured task with a score and a coordinator (7 min).

3. T3. Unstructured task of free improvisation (5-10 min).

4. T4. Informal discussion.

Each user had two signs with the messages of "sounds good" and "sounds bad" which could be raised at any moment of the performance.

Firstly, the explorative task was devoted to taking first steps with the tool. Participants were encouraged to switch between phrases, create solos and even make mistakes intentionally in order to learn how to control their own instrument. Secondly, the structured task was designed to produce a collaborative piece of music following a score (see Figure 3) and led by a coordinator who gave instructions during the interpretation of the musical score. The musical structure was built according to a traditional approach of musical dynamics, consisting of an introduction (two instruments), a crescendo (three instruments), a resolution (four instruments, but one is present sparingly), a diminuendo (three to two instruments), a more intensive crescendo (four instruments), a finale (four instruments) and, afterwards, a coda (decreasing one by one from three instruments). Each part lasted one minute, and a sign was given 30 seconds before the next move. In this task, the team was expected to decide which instruments should take part in each phase. This task was intended to help participants become accustomed to working together, in order to prepare them for the next task. Thirdly, an unstructured task of free improvisation without a coordinator and with no imposed rules was performed. In a more experimental fashion, the team was expected to decide not only the musical content but also the structure. Fourthly, an informal brief focus group discussion with the participants was held about the music compositions and how the music application could be improved.

5.1.2 Questionnaire

After that, a short text-based questionnaire was administered in order to collect information about the participants' profiles with questions about age, gender or previous music knowledge as well as the user experience with questions about the level of collaboration, difficulty, enjoyment or concentration.

5.2 Data analysis

By analysing the data from each set of observations, general patterns were extracted. These generalisations facilitate a better understanding of collaborative music making
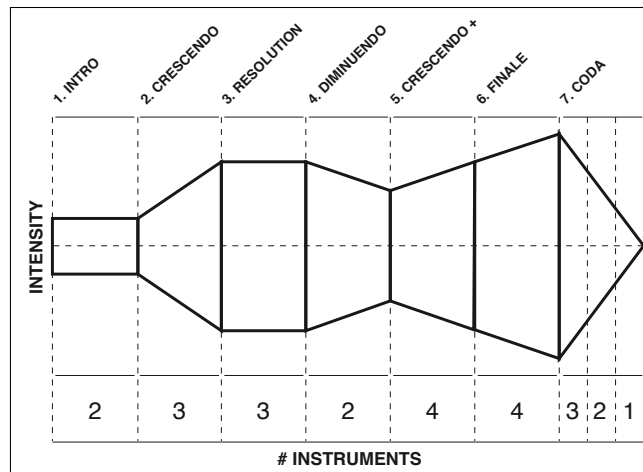

Figure 3. Graphical score of the structured task.

on touchable surfaces in particular, and collaborative interaction in general. For that purpose, two complementary qualitative approaches for data analysis were adapted: on the one hand, Grounded Theory, where open coding is applied to the data collected in a bottom-up fashion; and on the other hand, Content Analysis, where structured coding is identified taking a top-down perspective. By using two complementary analytical techniques a more rounded understanding could be achieved.

5.2.1 Open coding

Grounded Theory (GT) [24] is a qualitative research method employed in the social sciences that derives theoretical explanations from the data without having hypotheses in mind. In the initial stage of analysing the experiments, GT was adapted to offer a first insight to the data. According to this inductive procedure, the steps taken are: first, open coding of the video interactions identifying key moments (e.g. behaviours or opinions); second, grouping the codes by concepts; and third, generating general explanations from the categorisation of the concepts. Given that this approach is based on creative interpretation, we add more evidence by complementing GT with Content Analysis.

5.2.2 Structured coding

Content Analysis (CA) is defined by Holsti (1969) as "any technique for making inferences by objectively and systematically identifying specified characteristics of messages" [24]. This definition includes content analysis of text, videos, music or drawings. There are varied approaches to CA using quantitative, qualitative or both techniques. Our approach is derived from ethnographic content analysis or qualitative content analysis [26], an approach to documents that emphasizes the role of the investigator in the construction of the meaning of texts. The steps taken are the same as those explained in the open coding section, but with a difference in the first step: structured codes help us identify key points of the video-recorded interactions. The nomenclature is chosen from two existing theoretical frameworks. The first one is a general framework of tan-

gible social interaction [27]. The second one is focused on the engagement between participants in music collaboration [6].

6. FINDINGS

In this section we present the results obtained from the exploratory multi-case study. Participants, tasks, open coding, structured coding and the questionnaire are described.

6.1 Participants

We recruited 12 people. We conducted sessions with three groups, each with four participants, made up as follows:

- Group 1 (G1) contained fairly experienced musicians, with a combined level of skill (based on a self-assessment on a scale of $1 - 5$) of 16;

- Group 2 (G2) comprised one experienced musician and three novices; the combined self-assessed rating was 8;

- Group 3 (G3) consisted of less musically adept participants, with a combined self-assessed rating of 9.

6.2 Tasks

All the sessions were videotaped. After each, we held an informal discussion with the participants around the table, talking through questions such as their feelings about the exercise, the quality of the composition they had evolved, and how the application could be improved.

In general, the three groups alternated between deciding some collaborative strategies before playing with deciding while playing. For example, the group with more advanced skills planned the unstructured task whereas the other two groups planned the structured task.

6.3 Findings from open coding

From transcription of the video speech and behaviours, and then the process of open coding, we identified the following concepts: collaboration, musical aesthetics, learning process and system design.

6.3.1 Collaboration

Collaboration in terms of awareness of other instruments was a challenge: "I think to be really aware of what we do we need to have maybe more time" (G1); "Should I concentrate on my own tempos or be aware of the other tempos?" (G2); "I think I hear all of them, maybe not the bass but it is fine" (G3). More visual feedback was requested: "I think it could be interesting to have a visual control of what is going on" (G1); "Adding a metronome, and maybe a different colour for the first bit, would help everyone to follow all the loops, the patterns" (G1); "We have to count each other and see what to do (...) a metronome at a right place" (G3).

In all three groups there is speech evidence of collaborative decision making before starting the musical tasks or while playing, with beginning sentences such as "I suggest, Shall we?, Should I?, Who's gonna?, Are we?, I think, Do we?, How about?, We can, Let's" (G1); "We can, I think, What do you think?, Let's, Can someone?, Can we?, You can" (G2) and "I suggest, Let's, Who?, Do you want? We can, Why don't you, I think, We could" (G3).

6.3.2 Musical Aesthetics

Emotiveness was expressed mostly with body gestures: all three groups voted regularly either "sounds good" or "sounds bad"; there were applauses at the end of the pieces (G1, G3) and one user even imitated a bass guitar player (G2).

Playfulness was conveyed with sentences such as "It was enjoyable" (G2); "I think I am having too much fun" (G3); and "It was very funny, I liked it a lot" (G2).

6.3.3 Learning process

The different parts of the structured task were understood with difficulty: "I found that it was difficult to figure out how to do the crescendo and the diminuendo" (G1); "Too much rules" (G2); and "I haven't understood what is the difference between finale and crescendo" (G3).

6.3.4 System design

The system responsiveness determined the expressivity: "The only difficulty that I had was switching" (G1); " I was too slowly, I'll try again" (G2) and "[When pressing a button] stays on and doesn't go off immediately was difficult" (G3).

Several improvements were suggested regarding individual expressivity with the presence of more features such as volume control (G1, G3); more samples (G1, G3); better responsiveness of the system (G3); a preview for the next sound to be played (G1) and a visual distinction between the active sound and the preview sound (G1). These features would provide more support to advanced users. Other suggestions were about improving the collaboration among the users with the presence of global shareable controls such as capability of modifying others (G3) or visual feedback such as the tempo (G1) or what other users where doing (G1). Another aspect commented on was how to improve the communication between users with the presence of virtual buttons for voting "sounds good" or "sounds bad" (G1) and also a big screen for visualising the music (G2).

Fun and social interaction were associated with the system. Possible contexts in public spaces were suggested such as a pub (G2) or a radio station (G2). Its use as a tool for composing was also mentioned (G3).

6.4 Findings from structured coding

Below we look at the concepts in [27] of tangible manipulation, spatial interaction, embodied facilitation or expressive representation (6.4.1 – 6.4.4) and the features in [6] of mutual awareness, shared and consistent representations, mutual modifiability and annotation (6.4.5 – 6.4.8). We found that some of the content analysed was already discussed in the open coding process (6.3), which provides consistency.

6.4.1 Tangible manipulation

The system provided a clear relationship between actions such as selecting a sample and effects such as listening to the sound selected: "It was not difficult (G1)"; "The technology was quite easy to get used to" (G3). However, rapid feedback during the interaction should be improved in terms of responsiveness (see quotes in 6.3.4), in order to facilitate expressivity and collaboration.

6.4.2 Spatial interaction

The space where the user studies were conducted facilitated a meaningful public space where people met and made music collaboratively with the system. However, the reciprocal fact of seeing and being seen could be improved with more visual cues of what was happening (see quotes in 6.3.4) The large size of the table with the display divided into four replicated controls allowed communication using body movement while interacting with the system (see quotes in 6.3.2).

6.4.3 Embodied facilitation

The set-up size as well as the form and location of the controls determined the way users collaborated. The options of manipulation were constrained to a single sound for each user. This aspect could be improved allowing multiple access points for each user: "Would be nice if you could play two [samples] at the same time" (G3). A representation built on users' experience should also be developed in order to connect not only with the skills of novices but also with experts (see quotes in 6.3.4).

6.4.4 Expressive representation

Users talked while interacting with the system, and they made decisions (see quotes in 6.3.1). Legibility of system reactions could be improved with visual feedback and better responsiveness (see quotes in 6.3.4).

6.4.5 Mutual awareness

The awareness of who was contributing and what they were contributing was difficult (see quotes in 6.3.1). This could be solved by strengthening with visual feedback the representation of both the identity of the contributor and of what kind of contribution it was. The awareness of where they were contributing was partial given that users only had individual controls and they reported difficulty in concentrating on both the individual contribution and the collaborative music piece (see quotes in 6.3.1).

6.4.6 Shared representations

A consistent view of the shared activity, independently of the user, is equivalent to the discussion conducted in spatial interaction of the previous theoretical framework (see quotes in 6.4.2).

6.4.7 Mutual modifiability

In a collaborative setting the presence of roles can imply an undesired hierarchical approach. The capacity of mutual modifiability, thus, can be a mechanism for having democratic roles. Thus, the system should incorporate this feature (see quotes in 6.3.4): "Sometimes I missed pushing the buttons of other people" (G3). That could avoid situations such as: "I feel that this one [keyboard] is having a lot of impact on the other sounds" (G1) or "[keyboard] is the most influencer" (G3).

6.4.8 Annotation

All tasks engaged conversation and the mechanism of voting specially contributed to supporting mutual engagement (see quotes in 6.3.2).

6.5 Findings from questionnaire

Data was also collected using a questionnaire, which was designed to probe such issues as how aware each participant had been of other instruments; the difficulty of the tasks, and how much they felt they had enjoyed and concentrated on them; and the extent to which they considered they had operated as a team and felt part of a collaborative process. Responses were recorded using numerical scores, but the questionnaire also asked for qualitative feedback on how participants organised themselves as a group and the nature of any rules they created. Although questionnaires were anonymous, we recorded the participants age, gender, previous experience, love of music, and the instrument they had been allocated on the table.

The questionnaire included the following five statements, with participants asked to give a score of between 1 and 5 (1 = strongly disagree; 5 = strongly agree).

- Q1. I felt we operated as a team.

- Q2. I felt part of a collaborative process.

- Q3. It was difficult to play.

- Q4. I enjoyed the music making task.

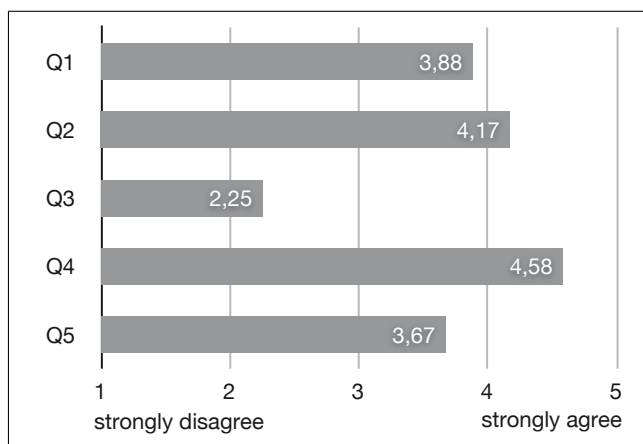- Q5. I concentrated intensely on the music making task.

Figure 4. Averages for the 5 statements.

Satisfaction with the level of participation was generally high, with Q1 scoring an average of 3.88 and Q2 scoring

4.17. The difference between the team and collaborative scores may be of some interest, but was relatively small. No participant found the game especially difficult. To the Q3 statement the average response was 2.25. Participants reported high levels of enjoyment (Q4 average 4.58) and concentration (Q5 3.67). The fact that enjoyment and concentration were rated high and difficulty low is promising (see Figure 4).

7. DISCUSSION

Our appraisal of the three sessions focuses on three aspects of the groups performance:

1. the modes participants found to collaborate with one another;

2. difficulties that participants encountered and the extent to which they found the exercise engaging;

3. the degree of satisfaction at the end result. The perceived value of the musical product is obviously of importance.

In the actual sessions, four broad modes of interaction were used:

1. Visual. Participants were standing around the four sides of the table, and were thus able to look at each other.

2. Talking. Participants were free to address comments and suggestions to one another.

3. Auditory. Participants could choose to listen carefully to the patterns created by the other instruments and to concentrate on blending their own instrument with these.

4. Gestural. Participants could indicate suggestions and emotions by body motion.

As might be expected, groups used all four modes of interaction. Strategies of collaboration were suggested either before playing or during the music making tasks. Participants looked at one another consistently, in part probably influenced by the distribution of the setting. Similarly, the participants listened during all tasks, but with the support of other modes of interaction given the expressed difficulties in distinguishing each instrument. Body gestures were manifested constantly in pointing, voting "sounds good/bad", laughing or applauses.

Another interesting aspect of the groups possible collaboration was whether leaders emerged, or whether the collaborations were egalitarian. In Group 2, in particular, we anticipated that the experienced musician might take the lead. Perhaps surprisingly, in none of the groups did any dominant figure emerge, although one or another participant occasionally took the lead.

The findings of this study help us understand engagement in music collaboration. Qualitative video analysis and the questionnaires provide indication of participants

having mutual engaging interaction in terms of being engaged with the music collaboratively produced and also being engaged with others in the activity. High degree of satisfaction at the end result is evidenced mostly by the gestural mode. The evidence found of participants exchanging ideas constantly indicates that the application strongly facilitates conversation, which, as noted earlier, is important in terms of group productivity. Within a user-centered design approach of active participation of users in the process of designing the system, the most two prominent aspects that have emerged as enhancements of multi-touch systems in music collaboration are:

- Responsiveness. The responsiveness determines the perceived emotiveness. This parameter should be adequately related to the system performance in terms of time and computer resources used. A consistent audiovisual feedback will enhance the perceived response of the system.

- Shared vs. individual controls. Both shared and individual spaces are needed. Shared features would strength mutual awareness and mutual modifiability. Individual spaces would strength personal opinion, musical identity and musical expression.

8. CONCLUSIONS AND FUTURE WORK

In this article, we described multi-user instruments and multi-touch systems, by enumerating their most prominent properties and issues. Then, we presented a simple and constrained prototype and explained the qualitative evaluation methodology undertaken in order to evaluate its creative engagement. Besides, we provided evidence of engagement and satisfaction with the end result. However, this initial exploratory case study should be complemented with a more formal study adding a control group in order to confirm that a minimal and constrained instrument as such can successfully engage. Finally, we proposed what design aspects should be considered in multi-touch surfaces for collaborative music making in order to support engagement. So far, this evaluation method not only provides us evidence of creative engagement but also an approach which can help us improve the prototype design.

We are interested in how many, and what type of, affordances such systems should offer in order to maximise engagement. At present the touchable nature of the table surface is not fully exploited, and there is scope to improve the responsiveness of the system and to redesign the distribution of shared versus individual controls. Furthermore, there is a plan to add individual continuous controls for sound parameter modifications in order to both encourage a process-oriented composition and improve engagement of advanced musicians. The mutual experience might be enhanced and collaboration deepened, by adding common controls – such as a metronome, through which global tempo could be displayed and altered. A balance between adding more features and keeping simplicity must be kept in order to attract both novices and experts alike.

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