Video Analysis for Evaluating Music Interaction: Musical Tabletops

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Abstract There is little evaluation of musical tabletops for music performance, and current approaches tend to have little consideration of social interaction. However, in collaborative settings, social aspects such as coordination, communication, or musical engagement between collaborators are fundamental for a successful performance. After an overview of the use of video in music interaction research as a convenient method for understanding interaction between people and technology, we present three empirical examples of approaches to video analysis applied to musical tabletops; firstly, an exploratory approach to give informal insight towards understanding collaboration in new situations; secondly, a participatory design approach oriented to improve an interface design by getting feedback from the user experience; thirdly, a quantitative approach, towards understanding collaboration by considering frequencies of interaction events. The aim of this chapter is to provide a useful insight into how to evaluate musical tabletops using video as a data source. Furthermore, this overview can shed light on understanding shareable interfaces in a wider HCI context of group creativity and multi-player interaction.

1 Introduction

In recent years the number of shareable interfaces for music performance has increased rapidly as is evidenced in conferences in the field such as International Computer Music Conference (*ICMC*), New Interfaces for Musical Expression (*NIME*) or Sound and Music Computing (*SMC*). A potential problem is how to assess reliably these interfaces, and what are the most appropriate methods to be ap-

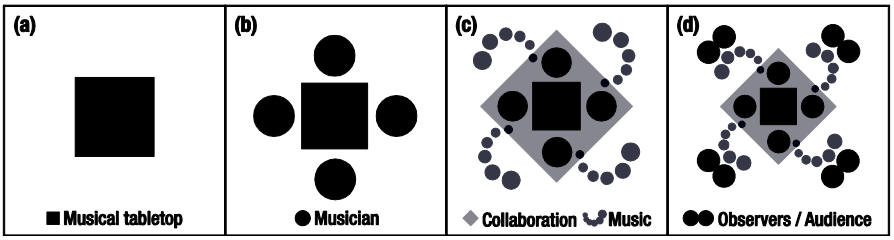

Fig. 1 (a) A musical tabletop. (b) A group of musicians interacting with a musical tabletop. (c) Collaboration and musical engagement of a group of musicians interacting with a musical tabletop. (d) Understanding music interaction by observing collaboration and musical engagement of a group of musicians interacting with a musical tabletop

plied. Assessing music interaction using these shareable interfaces involves understanding musicians interacting with the interface, as well as the social interactions between them when making music. This additional layer of complexity of understanding interactions between collaborators, apart from the interactions of the musicians with the interface, can also be seen as a convenient approach for investigating certain collaborative aspects such as interface design or different usages of the interface from a participatory perspective (Bau et al. 2008), collective musical engagement (Bryan-Kinns and Hamilton 2009), or peer learning processes (Xambó et al. 2012), among others. Musical tabletops are a representative example for understanding these interactions because, in this scenario, musicians can be face-to-face using the same interface. Furthermore, this scenario enables direct observation by the researcher of a focused point of the musical activity (see also Fig. 1). In this setting, both verbal communication (e.g., conversations, utterances), and nonverbal communication (e.g., music, gestures, eye-contact, face expressions), can happen and be observed.

Video analysis is a method of human-computer interaction (HCI) research that can help assessing shareable interfaces for music performance because it aims at understanding human interaction with technology, which can be verbally and nonverbally mediated. Video analysis is convenient to overcome the say/do problem of differences between what people say and what they actually do (Jordan 1996). Accordingly, the analysis of video material, in contrast with other methods such as field notes or interviews, provides a more detailed account of what happened compared to what participants report that happened. Thus, even though video analysis can be highly time consuming, results can be richer and more detailed than using other techniques such as note taking, questionnaires or interviews. This method is flexible because, first, it can be qualitative (Heath et al. 2010) and/or quantitative (Martin and Bateson 2007), second, it can record verbal and nonverbal communication (Jordan and Henderson 1995), and, third, it can be analysed both as a single data source or combined with other data sources such as interaction log files (Hagedorn 2008). In the music performance domain, the music/sounds produced can be recorded, and again reproduced, in real time, together with conversations and gestures. Thus, we believe that the use of video in research

can be a convenient tool for understanding music interaction in general, and musical tabletops in particular.

In this chapter we first provide a general overview of how the evaluation of novel interfaces for music in general, and musical tabletops in particular, has been tackled so far with an HCI approach. Next, we outline the use of video in music interaction research in terms of visual anthropology and video analysis, and the practical issues implied. Then, we present three examples of video analysis that we conducted on different musical tabletops; firstly, an exploratory approach for giving an initial insight on a minimal and highly constrained interface; secondly, a participatory design approach for documenting users' thoughts about the interface design of TOUCHtr4ck, also with a highly constrained interface; thirdly, a quantitative approach, as complementary of qualitative findings, for measuring frequencies of behaviour patterns when interacting with the Reactable, a commercially popular musical tabletop. We conclude with a discussion on the implications of this approach for the communities of sound and music computing, and, more broadly, HCI.

2 Evaluating NIME with HCI Methods

In this section, we overview different approaches undertaken for evaluating new interfaces for musical expression (NIME) that borrow tools from HCI. Then, we present musical tabletops that have been designed and evaluated for collaboration.

2.1 Task-Based vs. Open Task

In sound and music computing, the evaluation of new interfaces for music is considered a novel field of research: an analysis of the NIME conference proceedings (Stowell et al. 2008) shows that since the beginning of the conference in 2001 (Poupyrev et al. 2001), few of the papers have applied HCI methods thoroughly to evaluate new music instruments. However, the benefits of adapting HCI evaluation to these novel interfaces for music may benefit both the designers who can improve the interface design, and the musicians who can discover or expand on the possibilities of the evaluated tool (Wanderley and Orio 2002). Of those studies which incorporate HCI methods, the majority are task-based, that is, focused on how musical tasks are performed. Possible metrics evaluated might be how precisely musical tasks are performed (Wanderley and Orio 2002); the quality of the user experience and the degree of expressiveness obtained (Bau et al. 2008, Kiefer et al. 2008, Stowell et al. 2008); or the usefulness of the tool (Coughlan and Johnson 2006). Another approach which is more open task-oriented stresses the collaborations among the participants building on empirical studies of mutual engagement (Bryan-Kinns and Hamilton 2009). The recent BCS HCI 2011

Workshop on Music Interaction[1] and this subsequent book illustrate that there is a general interest on the intersections between HCI and sound and music computing, and one of the main issues raised is how to evaluate music interaction as open-ended tasks using HCI methods.

2.2 Collaboration with Musical Tabletops

Even though there exists a number of musical tabletops, only a subset is specially designed for multi-player collaboration, which implies a higher level of complexity, such as The Jam-O-Drum (Blaine and Perkis 2000), AudioPad (Patten et al. 2002), Iwai's Composition on the Table (Iwai 1999) or the Reactable (Jordà et al. 2005, Jordà 2008). In general, there is a lack of evaluation, although there have been isolated attempts, such as the assessment of Ensemble (Fiebrink et al. 2009), a task-based study focused on the performance and use of the controllers, and the evaluation of the Reactable, with task-based studies focused on usability assessment (Rauh 2009), or performance and motivation (Mealla et al. 2011).

With the above studies, arguably there is little mention of social interaction, which, as seen earlier, plays a key role in co-located face-to-face settings. In another study (Klügel et al. 2011), a set of terms is borrowed from the computer supported cooperative work (CSCW) discipline, in order to understand collaborations in co-located settings. Some of the terms are group awareness (i.e., mutual understanding about the tasks performed), group coordination, or tailorability (i.e., level of adaptation of the technologies). Nevertheless, the authors adopt a traditional approach of supporting music composition and notation with less consideration to contemporary music practices. A contemporary music approach tends to use alternative musical instructions more focused on the music process (Gresham-Lancaster 1998, Cox 2004), a practice close to the notion of unpredictability and uncertainty, which arguably tends to be present in music performance with novel interfaces for music. Thus, there is little research on the collaborative aspects of using musical tabletops for music performance.

3 Video in Music Interaction Research

In this section, we first introduce the practices of visual anthropology and ethnographic film, which use video for documenting, and we describe how music interaction has been approached. Afterwards, we present the aims, benefits and limitations of video analysis, a research method which uses audiovisual material for

[1] BCS HCI 2011 Workshop - *When Words Fail: What can Music Interaction tell us about HCI?*: http://mcl.open.ac.uk/workshop

studying human interaction with technologies and artefacts, and we then see how video analysis can be appropriate for studying music interaction.

3.1 Visual Anthropology: From Film to Digital Media

The use of audiovisual material to capture music interaction phenomena is closely linked to social sciences disciplines such as visual anthropology or ethnomusicology. Visual anthropology refers to the use of audiovisual media such as video to understand social or cultural phenomena (Pink 2006, MacDougall 2006, Ruby 2000), whereas ethnomusicology examines music of different cultures.

Visual anthropology dates back to the 1890s using film and photography to support academic anthropology (Pink 2006), also known as ethnographic film to define one audiovisual method for representing a culture (Ruby 2000). Since the very beginning we find anthropological research that evidence rhythmic and musical activities. An example is the work of Franz Boas, a German-American anthropologist who used film in the 1930s to document native dance while recording sound simultaneously with a wax cylinder sound recorder, with the aim of complementing these data with other materials (Ruby 1980). We also find a number of examples of ethnographic films related to music interaction; among them is the presentation of Canadian Kwakiutl's rituals and cultural aspects in the early silent film *In the Land of the Head Hunters* by Edward Curtis (1914), so the film documents music aspects of this community only by visual means. The use of film as a scientific tool for research purposes was debated for a long period after these early attempts (Pink 2006). This applied approach to anthropology was accepted again in academia as a reliable method by the 1990s: a subjective reflexive approach was included in the anthropology agenda, and also digital media became more popular (Pink 2006). For example, music, dance and culture of the Alaskan Eskimos Yup'ik is shown in the participatory film *Drums of Winter* by Sarah Elder and Leonard Kamerling (1988), where the subjects of the film were also involved in the editing process. This collaborative filmmaking approach was in tune with other anthropologists and documentary filmmakers such as Jean Rouch or Sol Worth, an approach that addresses ethical and political questions about filmmaking (Ruby 2000).

Rethinking the role and future of visual anthropology has been discussed in recent years. An approach is to combine audiovisual media with new media to represent anthropological knowledge (Pink 2006). Another insight is to build a specific genre of anthropological cinema (Ruby 2000). Furthermore, it is also proposed to explore areas of the social experience that suit well the audiovisual media; those areas related to topographic, temporal, corporeal or personal aspects which can show the implicit from the explicit (MacDougall 2006), such as music interaction. However, as seen in these examples, in visual anthropology the video data is used for documenting, but rarely is used as a data source to be analysed, a practice which is explained next.

3.2 Video Analysis

In recent years, the use of video as a research tool for understanding everyday social activity which implies human interaction has increased. We find video used in qualitative research (Heath et al. 2010), as well as in quantitative research (Martin and Bateson 2007). For example, Heath et al. describe how the advent of digital video has facilitated a wider access to and use of this technology in social sciences (e.g., ethnography or sociology). Within this context, collective music performance, as a social activity which implies human interaction with objects or artefacts, can be addressed using video analysis methods.

Video analysis offers advantages when dealing with data: Firstly, it allows multiple reproducibility (i.e., the same source can be watched several times, rewound, shifted forward, or even seen frame by frame). Secondly, it allows multiple views (i.e., different observers, even the subjects of the video, can view and discuss individually or in collaboration, the same source; or multiple cameras can be set to capture the same event from different angles). Nonetheless, video transcription can be highly time-consuming. This can be coped by transcribing selected extracts only: those more relevant to the defined focus of analysis (Heath et al. 2010). Another issue is that the methodologies of video analysis are not formally established in the social sciences yet (Heath et al. 2010), partly because ractitioners are more focused on the practice than on describing the method (Jordan and Henderson 1995).

Having said that, in the mid-1990s, Jordan and Henderson presented a set of interaction analysis principles for analyzing video excerpts based on years of practice for studying interaction between humans, and between humans and artefacts in an environment (Jordan and Henderson 1995). The proposed focuses of analysis of this type of audiovisual material are: the timeline of the events (e.g., beginnings and endings, internal structure of events); the temporal organization of the activity (e.g., rhythmicity or periodicity, talk vs. nonverbal activity, low activity vs. high activity, participation patterns); the spatial organization of the activity (e.g., public vs. private space, personal vs. shared space, body distance); whether there are breaches and repairs; and what is the role of artefacts and technologies during the interaction. The authors make a distinction between talk-driven interaction and instrumental interaction related to verbal and nonverbal activities, respectively. The latter refers to activities mainly driven by the manipulation of physical objects (e.g., technologies, artefacts) and where talk may happen as subsidiary to the physical activity.

Audiovisual recordings of music interaction often deal with little verbal communication; thus the instrumental interaction approach may provide a theoretical ground for studying these data. Some researchers have used video analysis in different settings for understanding tabletops and this continuum from talk-driven interaction to instrumental interaction (e.g., Hornecker et al. 2008, Hornecker 2008, Marshall et al. 2009, Marshall et al. 2011, Rick et al. 2011, Tuddenham et al. 2010). Evidence has been found which shows that collaborative music perfor-

mance on musical tabletops can be seen as a clear example of instrumental interaction (Xambó et al, 2012). Thus, empirical work using video analysis can help an understanding of collaboration with musical tabletops from an instrumental interaction perspective.

Working in a group is a recommended practice in order to discuss the audiovisual material (Heath et al. 2010, Jordan and Henderson 1995). The aim of such research discussions is to confirm the individual findings and develop themes from repetitive patterns. In addition, the participation of the subjects of the video is a recurrent practice (Jordan and Henderson 1995), close to the ethnographic approach of collaborative filmmaking of involving the subjects (Ruby 2000).

3.3 Practical Issues

Using video raises a set of practical issues in the three sequential stages of research of, first, collecting audiovisual data; second, analyzing these data; and, third, disseminating the results (Heath et al. 2010). When collecting data, depending on the location, permission may be needed. Also, before video-recording participants, an informed consent form is necessary. Furthermore, other decisions have to be taken and justified such as the position of the camera/s, or what period of action will be recorded. As Jordan and Henderson argue, those verbal and nonverbal interactions that precede the official beginning and come after the official ending may have crucial meaning (Jordan and Henderson 1995). At the stage of analysing data, some questions that emerge are: what is the focus of analysis; what are the selection criteria of the extracts to be analysed; or how can the verbal vs. nonverbal activities be transcribed, among others. Finally, when disseminating the results, the question of how to best show video-based results is raised.

In music interaction, when collecting data there exists the additional problem of dealing with music creation and intellectual property rights. In most jurisdictions, musicians have the copyright protection to their music by default. Thus, a question that arises is how to deal with audiovisual material derived from musical sessions when disseminating the results. In this case, a license grant to be signed in the informed consent form could be considered, that could be chosen from the Creative Commons[2] licenses, which provide a varied range of protections and freedoms for creatives. In this case, the license grant in the consent form should permit the researcher using and excerpting (in whole or in part) the music content for research purposes.

[2] http://creativecommons.org

4 Example 1: Exploratory Research Approach

In this section, we first present the notion of exploratory research as a research method that allows one to acquire preliminary data on an undefined problem. Afterwards, we reveal the video analysis process undertaken in a study of a multi-touch musical tabletop adopting this approach.

4.1 Exploratory Research

Exploratory research allows us to build an initial understanding of an undefined problem with preliminary data, and helps to identify how to further approach that problem (Lazar et al. 2009). Exploratory research is a research method applied in the social sciences (Berg 2001, Murchison 2010). It can be seen as a type of case study where gathering data may be undertaken before defining a research question, which may be useful as a pilot study or as a prelude of longer research (Berg 2001). In ethnographic research, exploratory research may be appropriate when starting a topic with no previous experience, no hypotheses, and no prior research questions, and the research tends to be more open-ended with outcomes more descriptive rather than analytical (Murchison 2010).

4.2 The Study

The purpose of this study was to design and evaluate a musical tabletop prototype. The team was formed by people with interdisciplinary backgrounds e.g. computer science, music, education, anthropology, or interaction design. The motivation was to design a simple and collaborative tabletop interface, in order to have a first insight on how beginners, experts, or both, collaborate. For detailed information of the study, refer to (Laney et al. 2010).

The design of the prototype was highly constrained. There were four identical areas distributed in each side of a rectangle interface, each area with five buttons, four triggered one different pre-composed sound each, and the fifth switched between speakers and headphones mode. The interface had only discrete parameters, with affordances for up to four players given this strict division by the sides of a rectangle. The interaction was multi-touch[3].

We worked with twelve participants (beginners and experts), in three groups of four users. The approach was exploratory as an initial step for understanding collaboration and collective musical engagement using this prototype (see Fig. 2).

[3] Multi-touch interaction refers to the detection of multiple (two or more) points of contact on a touch sensing surface.

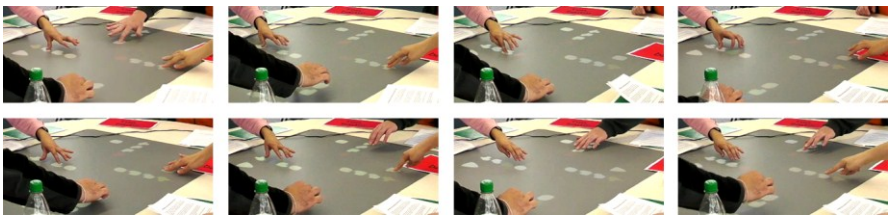

Fig. 2 Sequence of gestures when interacting with the multi-touch prototype

The evaluation was task-based, with a final individual questionnaire about the experience. There were three main tasks to be performed with time constraints, which were: sound exploration (3 min.), structured composition with a coordinator (seven parts of one minute each, thus 7 min. in total), and free improvisation (5-10 min.). Each participant had two signs with the messages of "sounds good" and "sounds bad", which could be raised at any moment of the performance to facilitate participants to give their opinion about the musical results. During the sessions, it was noted that participants tended to use verbal communication for decision making, mainly to discuss the different musical tasks (before but also during their performance). After the musical tasks performance, we asked them some open questions about the collaborative musical experience, which animated discussion. We videoed all the sessions.

4.3 Video Analysis

For building our own coding scheme of themes and as a first insight to the data, we adopted an inductive procedure of, first, transcribing the video interactions identifying key moments (e.g., verbal and nonverbal communication); second, grouping the transcripts by codes; and third, generating themes as general explanations from the categorization of the codes (Laney et al. 2010). This approach was adapted from grounded theory (Glaser and Strauss 1967, Lazar et al. 2009), which is a research method used in the social sciences that derives theoretical explanations from the collected data with no hypotheses in mind. We contrasted these results with existing coding schemes in order to strengthen the emergent themes. Refer to Table 1 to see a sample extract of the video transcription and categorization.

We recognised initial themes as concepts and dichotomies present in collaborative music making such as beginners vs. experts' goals; individual vs. shared controls; awareness of others; and private vs. shared spaces. In the case of private vs. shared spaces, for example, participants reported the need of more features for individual expressivity such as previewing the sounds. In the case of awareness of others, users requested the need of global and shareable controls for mutual modi-

fiability (i.e., capability of modifying others' actions) and mutual awareness (i.e., presence of visual feedback of what others were doing).

Table 1 Video transcription sample: free improvisation task performed by a group of 4 users

TC	User	Verbal	Nonverbal	Codes
00:16:56	#2	Let's go with the bass	-	roles, decision making
00:17:00	#2	I like it, it has some electronic beats	-	aesthetics, music results
00:17:26	#2	I think we are improvising	-	music results
00:17:26	#4	I like the bass	-	aesthetics
00:17:38	#4	-	“Sounds good” up	musical engagement
00:17:40	#2	-	“Sounds good” up	musical engagement

4.4 Findings and Challenges

We found that a minimal and highly constrained musical tabletop prototype can be engaging for beginners, but less for experts, who tended to ask for a broader set of features for promoting their personal musical expressivity. Arguably, video analysis has revealed an initial set of themes related to collaboration and musical engagement between beginners and experts on musical tabletops.

With respect to the evaluation, an exploratory approach with four groups of participants may be useful but vague. Thus, a larger-scale task-based evaluation with varied groups of musicians would help to collect more detailed and significant data. Of the three tasks planned for the evaluation, the structured composition with a coordinator was the most difficult to follow by participants because time was very constrained. Sound exploration and free improvisation were closer to the open-ended task approach, where tasks are less tied to specific actions to be performed with specific time constraints. A further exploratory approach using video analysis could be to just evaluate open tasks less tied to time, and in more realistic settings, named *in situ* or in the wild studies (Rogers 2007, Marshall et al. 2011). This approach could attenuate the stress of finishing tasks on time, and promote more creative and spontaneous interactions, in tune with creative activities such as music.

5 Example 2: Participatory Design Approach

In this section, we describe the participatory design approach, which attempts to establish an active collaboration between users and designers. After, we distil from a participatory design perspective, how audiovisual material of users' interactions with the TOUCHtr4ck prototype is used for further video analysis.

Fig. 3 A group of two people playing the TOUCHtr4ck prototype

5.1 Participatory Design

Participatory design is a term that refers to a design approach that invites users—who are not necessarily designers—to become part of the design process of a product (Schuler and Namioka 1993). Participants may be experts or potential users of the product, for example. Participatory design is used in a wide range of disciplines which depend on creative processes, design iterations, and users interactions e.g. software design, product design, graphic design, web design or urban planning, among others. Participatory design dates back to the 1970s in Scandinavian countries with the practice of cooperative design (Bødker et al. 1995). Accordingly, cooperative design tended to happen in trade unions where there was active cooperation between users and designers as part of the design process of computer applications for the workplace, with the notion that designers had to make sure to incorporate users' contributions. In both cooperative design and participatory design, there exists a more decentralised and democratic approach to the design process, when compared to more traditional approaches. This collaborative approach engages different opinions and perspectives which might improve considerably the design of the artefact discussed.

Understanding the interactions between people and computers forms part of the HCI discipline. An example of participatory design in HCI and music technology is the A20 (Bau et al. 2008). The authors collaborated with users in order to design and test the A20 musical device, a prototype with a tangible interface that has audio input and output. The aim of the device is to allow users to explore music and sound. The evaluation consisted of two parts; firstly, there was an assessment of the perceptual characteristics of the device (sonic and haptic) by performing a set of tasks; secondly, users and designers were invited to imagine new interfaces of the instrument based on several interaction mappings of gesture-based interaction. This approach allowed researchers to share with users the iterative design process of their prototypes. Moreover, it was a channel for discovering expected and unexpected functionalities when using the novel device.

5.2 The Study

The purpose of this study was to design and evaluate TOUCHtr4ck, a musical tabletop prototype, taking into consideration the lessons learned in the previous exploratory study. The team was formed by people with interdisciplinary backgrounds e.g. computer science, music, anthropology, interaction design, or philosophy. The motivation was to design a simple, collaborative, tabletop interface for creating real-time music, with enough freedom to engage experimentation, and with division of tasks in order to engage egalitarian collaborations between users. For detailed information of the study, refer to (Xambó et al. 2011).

The design of TOUCHtr4ck was based on a constrained interface. It consisted of a four track recorder, which allowed musicians to record up to four sounds. It was also possible to modify the musical result adding some effects and/or global controls. The available tasks of recording/playing and transforming/mixing were visually divided into two main circles. The concept of flexible layout was introduced allowing participants to show or hide the different tracks or effects. The interface had both discrete and continuous parameters, with affordances for two to four players mainly because of the presence of these two main circles in a square surface. The interaction was multi-touch.

We gathered two groups of two people for an informal evaluation: one beginners' group, and one experts' group. The experts' group experimented with an early version of the prototype during ten minutes using pre-built and recorded sounds of their choice, and then they informally commented about the experience—with suggestions on interface design close to participatory design practices—, and their comments were annotated. For instance, experts indicated the need of more precision for the recording controls. The experts' group also stated the usefulness of the flexible layout approach. Beginners were first introduced to the music technology concept of multiple track recording. Then, they were supplied with a Stylophone, an easy-to-use musical instrument, in order to facilitate the recording of their own sounds, and to let them be focused on the musical tabletop interface. The beginners' group was asked to play, and their musical exploration and spontaneous thinking aloud were videoed with a handheld camera. This group of beginners had the option of comparing between one version with flexible layout vs. one with fixed layout. Beginners also gave feedback about the interface design and using a participatory design approach (see Fig. 3).

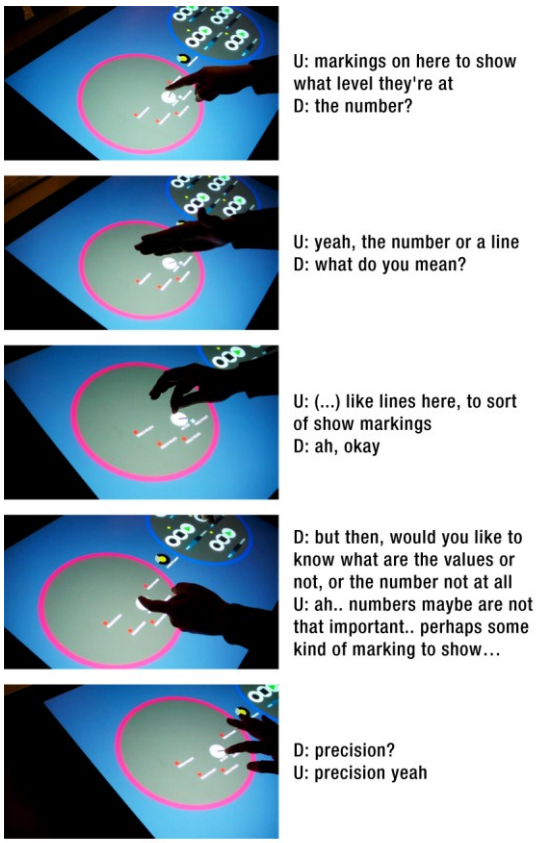

Fig. 4 Representative sequence of a user (U) suggesting the researcher/designer (D) the addition of markings to the effects knobs

5.3 Video Analysis

We first transcribed the conversations and interactions held during the video recordings of the beginner group, with special attention to interface design comments. From these data, we identified some features that should be changed, improved or added. For example, participants manifested the need of more accuracy when controlling the synchronization of sounds. Also, more graphical precision with the effects knobs was suggested, as shown in Fig. 4. Furthermore, when comparing between a fixed and a flexible layout, the beginners chose the flexible option because it facilitated them to adjust the musical interface to their needs.

5.4 Findings and Challenges

Video analysis has provided a series of opinions and suggestions about how to improve further iterations of the interface design. In addition, this flexible layout approach seems convenient for defining the level of constraint related to the expertise of the user. We conclude that video analysis has informally revealed an insight on what to do next in the design process of the prototype.

As a current methodological challenge, we need to conduct a more formal evaluation of this prototype to confirm our results, with groups of both beginners and experts. This would imply, firstly, the implementation of a minimum of suggested features such as better recording control or track synchronization, in order to fulfil the expectations of the participants, but without losing the experimental character which features the actual version. And, secondly, the musical interface should be tested with more participants applying similar conditions (e.g., similar open tasks, data gathering and data analysis).

6 Example 3: Measuring Frequencies Approach

In this section, we see how a quantitative approach, complementary to qualitative findings, may be applied to video analysis in order to measure frequencies of behaviour patterns. Afterwards, we exemplify this approach in an ongoing study of a commercial product, the Reactable.

6.1 Video and Quantitative Analysis

Sometimes, a quantitative approach can be useful as complementary of qualitative findings in order to, for example, assess results or confirm explanations. From this perspective, using video may serve to measure behaviour quantitatively (Martin and Bateson 2007). Accordingly, the video recordings may be coded by transcribing the behaviour into quantitative measurements such as frequencies of events. There exists a varied range of software available that support this quantitative approach to video annotation. An example is VCode (Hagedorn 2008), which allows one to mark events by type over time, by distinguishing between momentary events (i.e., a moment in time) and ranged events (i.e., a moment in time with a certain duration). This interest in temporal events recalls the foci of study of interaction analysis, based on spatiotemporal units (Jordan and Henderson 1995).

Fig. 5 Sequence of a group of three musicians improvising with the Reactable

6.2 The Study

The purpose of this ongoing study is to conduct a formal evaluation of the Reactable, a commercially well-known musical tabletop developed in the Music Technology Group - Universitat Pompeu Fabra, in Barcelona (Jordà et al. 2005, Jordà 2008). The team is formed by people with interdisciplinary backgrounds e.g. computer science, music, psychology, anthropology, or interaction design. The motivation of this study is to understand what are the collaboration strategies that happen when using a complex and successful tangible musical interface such as the Reactable in two representative contexts: museums with visitors, and music labs with musicians. So far, we have collected empirical data in both settings, and analysed the data of the latter, which informs this subsection. For detailed information of the music lab study, refer to (Xambó et al., 2012).

The Reactable has a sophisticated design, with both discrete and continuous parameters, and with affordances for one to multiple players given its round shape. The interaction can be both using tangible objects and multi-touch. This use of tangible objects is also known as tangible interaction or tangible user interfaces (TUIs), which refers to the use of physical artefacts which both control and represent digital information on an interactive system (Ullmer and Ishi, 2000).

For the music lab study, we videoed four open-task improvisations performed by four different groups of musicians, from two to four members each group (see Fig. 5). The collected audiovisual material consisted of sixteen sessions of music improvisation with the Reactable, where the groups tended to play for 45 min., which was the maximum time allocated for each session.

6.3 Video Analysis

Since we ended up with ca. 180 min. for each group and camera, we first synchronised the two cameras in a single video source in order to facilitate and reduce the potential time of analysis; where the close-up view was the main data source for the interactions on the table, and the large shot view was used to identify additional data such as people's gestures or eye-contact. For the coding scheme, three of

the researchers of the team analysed and discussed the video data in order to develop and iteratively refine the themes, and then confirm them on more extracts, as recommended by (Heath et al. 2010, Jordan and Henderson 1995).

As we were interested in understanding the evolution of collaboration over time, we analysed whether there were significant differences between the sessions. We specifically explored whether collaboration among musicians increased or decreased over time, and whether the proportion of interaction strategies between participants changed over time. For that, we complemented qualitative findings with a quantitative approach of first identifying patterns of events, and then counting their frequencies using VCode. We identified some patterns of events such as invasions (rejected and accepted), takes (active and passive), and shared threads[4].

6.4 Findings and Challenges

We found that the main change between sessions was qualitative. Whilst at the first sessions there was more collaborative exploration and serendipity, at the end there were more sophisticated interactions, which could be individual or collaborative, depending on the temporal unit of the session. For example, the endings of the sessions became particularly collaborative and sophisticated towards the last sessions. We conclude that video analysis has revealed how musicians' interactions with a tabletop TUI such as the Reactable exemplify what Jordan and Henderson describe as an instrumental-driven interaction (Jordan and Henderson 1995). The evidence has shown that interaction analysis using significant video extracts can help to explain these phenomena of nonverbal interaction, where music is the main channel of communication, and the interaction is artefact-driven by the manipulation of a tabletop musical tangible interface.

With regard to the methodology, using a quantitative approach with a small sample of groups (four in this case), can be useful when complemented with qualitative findings. In order to obtain significant results, though, a large-scale study should be conducted. However, the amount of video evidence can become enormous in that case, so strategies for less time-consuming video analysis techniques are required. Interaction log files may help by providing a complementary layer of information, if they were adapted to provide meaningful and higher-levels of information about collaboration (e.g., users' identification against objects' identification, users' identification against threads' identification).

[4] In the Reactable, each audio thread represents an audio channel, which are all in sync. It is possible to build threads by interconnecting tangible objects.

7 Conclusion

In this chapter, we showed that the use of video in music performance can be a convenient and flexible tool for understanding interaction with musical tabletops, which can be used from a range of perspectives (e.g., exploratory, participatory, improvisational, quantitative vs. qualitative). The lessons learned from the examples presented of collaborative music interaction on musical tabletops may be relevant to both, the sound and music computing, as well as the HCI communities, about how to deal with multi-player and complex interaction. For the former, a number of reliable HCI methods can help to evaluate and improve the interface design of novel interfaces for music, whilst for the latter the results can inform about how to deal with creative multi-player activities on interactive tabletops, which is currently a major topic of research in HCI. At present, the main corpus of video in music interaction research emerges from the long tradition of video-based studies of interaction in social sciences (Heath et al. 2010), with a wide range of analytic and methodological applications that we can borrow. We believe that a significant number of video-based studies that explore the issues of music interaction in general, and collaboration on shareable interfaces in particular, would help to build a specialised methodology of practice, which could be useful not only for the sound and music computing community, but also for other disciplines related to understanding group creativity and multi-player interaction.

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