jamTable: Can Physical Interfaces Support the Collaboration between Novice and Experienced Musicians?

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Abstract. This paper introduces jamTable, a system that enables the collaboration between users playing a standard musical instrument and users interacting with a tangible musical sequencer. In an introductory study both qualitative and quantitative data were collected from eight participants in two setup conditions: Musician-Musician and Novice-Musician pairs. By comparing the performance of participants in these two groups, this paper gathers relevant insights regarding the ability of a tangible musical application such as the jamTable to support musical collaborations between novice and experienced musicians – in both learning or performance activities.

1 Introduction

Music has been moving from a social to a personal experience, from the concerts halls to the iPods, while technology has been doing exactly the opposite – moving towards the Web and towards the group [15]. One of the latest instantiations of this trend in technology has been the tangible interaction paradigm, where the digital is mapped to the physical, allowing for several concurrent users to engage directly with information through a rich sensorial experience (see Fig. 1). As such, tangible interaction has been associated with several benefits that seem appropriate for a musical context, such as: support for seamless collaboration, visible interaction, increased levels of engagement and enjoyment, and of being highly effective in learning scenarios [11, 18]. Several tangible musical applications have been developed that strive for these qualities, including the popular reacTable [10] or the Audiopad [17]. Research on such applications normally reports on their ability to support a wide range of users in learning and performance tasks [e.g. 3, 5, 10, 12, 15], and while they do provide an unique musical experience, most of these claims stem from subjective and qualitative metrics. In order to look into how quantitative data can be obtained to back up such claims, this paper presents both the jamTable, a tangible system designed to support the collaboration between novice and experienced musicians, and an introductory study that captures both quantitative and qualitative data to gather insights in the true benefits of tangible musical applications.

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Fig. 1. On the left: A set of physical artifacts to control pitch in MoSo Tangibles, a system for children's musical education [2]; on the right: the Audiopad [17], a tangible music controller that employs knob-based tokens for fine control over the interaction

2 Related Work

Links between music and HCI can be traced back to as early as the 1970s and 1980s, mostly in the work of William Buxton [e.g. 4]. Similarly, musical applications are amongst the oldest and most popular forms of tangible interaction [18]. This can be explained by the fact that interactive tabletops have been found to seamless support collaboration between users, allow several pieces of information to be controlled simultaneous and in real-time, and ultimately provide an environment for skilled, creative and explorative interaction [9]. As with the system described in this paper, these benefits have normally been explored in the context of two specific areas within tangible interaction: systems for musical education, and for musical performances. The remainder of the section will briefly review these two fields.

Researchers have long linked the physical manipulation of objects with the development of children's cognitive capabilities [13]. As such, many studies in tangible interaction [e.g. 6, 20] have discussed the potential of this interaction paradigm to promote learning and development, either by contributing to self-reflection [24], providing more appealing experiences [1], or by facilitating autonomous and personal activities [16]. As a result, numerous tangible applications have focused exclusively on musical education for children. One prominent example is Tangible Notes [21], a system that allows children to explore musical notes and scales through tokens on an interactive tabletop. Another example is MoSo Tangibles [2], a tangible application that presents abstract audio concepts through different body-based mappings. With this system, children can physically and haptically manipulate sound properties like pitch, volume, or tempo in order to learn about them (see Fig. 1). Similarly, SOUNDGARTEN [22] is an interactive toy that allows children to apply sound effects to either pre-recorded sound samples, or to sounds they record in their environment. Children can create and arrange different sound scenarios, and control the volume and pitch of the final result. Finally, Marble Tracks [7] combines electronic artifacts that can be added to physical marble tracks to create a musical sequencer that children can manipulate through play.

These examples illustrate systems that were designed and studied in regards to their capabilities to actually motivate musical learning in children. While to some extent beyond their scope, these systems nevertheless fail to explore how they could be used by adults in pursuit of musical education. Furthermore, the remainder of this section includes several examples of musical applications that argue for applicability in learning scenarios for adults. Despite this, they lack the focus and grounding generally found in systems that promote music learning in children [e.g. 3, 10].

As such, this section closes with musical performance applications, a popular application domain for tangible interaction. Such applications are normally divided into three categories: musical sequencers, which allow audio samples to be mixed and played; musical controllers, which serve as interface for random sound synthesizers; and musical instruments, capable of synthesizing and generating sound [18].

Examples of musical sequencers include Audio d-touch [5], a tangible framework that enables collaborative sequencing through customizable tokens; and Block Jam [15], a tangible polyrhythmic sequencer that relies on 26 tokens to promote collaboration and social interaction. In terms of musical controllers, a popular example is Xenakis [3] (which can also be seen as a musical sequencer). Xenakis uses mathematical models to create music, relying on tangible interaction to offer users a simple and accessible interface to its complex automatic composition techniques. Another popular example of a musical controller is Audiopad [17], a sophisticated, real-time musical application that combines the precision of knob-based tokens with the unconstrained interaction enabled by interactive tabletops (see Fig. 1). The last category of musical instruments is well characterized by the work of Levin [12], who developed a spectrographic instrument capable of supporting both pondered composition and live improvisation. Another prominent example is the reacTable [10], arguably the most successful tangible musical application to date. The reacTable offers users a robust interactive tabletop environment for both electronic and acoustic musical composition. This is complemented with very strong collaborative capabilities, allowing for several users to play simultaneously, either locally or remotely (through the use of additional reacTables).

A common thread with these examples regards their proposed target population. Most conclude that their tangible music application supports both novices and experienced musicians, and that it provides users with a musical platform that affords both learning and performing activities [e.g. 3, 5, 10, 12, 15]. This paper argues that such conclusions are normally drawn from qualitative studies or questionnaires, and suggests they comment on the natural qualities of tangible interaction – not on the particular characteristics of the tangible application in question. Examples of such conclusions that might indeed be rooted in the natural benefits of physical interfaces include: reports of intuitive and easily accessible interfaces [18]; of a fun and improved user experience [23]; and of interaction that is visible and expressive [18]. While these systems rely on the particular qualities of tangible interaction to deliver unique musical experiences, this paper argues that more empirical evidence is still required to validate their claims of universal applicability. But if indeed physical interfaces can mediate the collaboration between novice and experienced musicians, the design of these systems must rely on a broader, and still to be attained body of work. Only then can both types of users experience a seamless and sensory-rich interaction between themselves, and between them and the system.

3 jamTable

The jamTable is a tangible system that was developed with the goal of lowering the entry bar for novice users who want to perform and learn with more experienced musicians. This is enabled by allowing two users to collaborate in real-time over an interactive tabletop: while one plays a musical instrument, the other controls a simple tangible musical sequencer (in the likes of the Audio d-touch [5]). The interface for this sequencer relies on a grid of 24 music tiles, seven control tiles (one for each of the music tile columns), and a record tile (see Fig. 2). The interaction relies solely on tangible actions, with users having two sets of tokens to manage: music and control tokens. Users can start or stop recording an instrument's output by placing or removing a music token on the recording tile. Likewise, users can play recorded sounds by simply adding the corresponding music tokens to any vacant music tiles. Furthermore, by using a control token, users can change the volume and pitch, or apply the popular drive effect to any set of music tokens playing in parallel above the control tile just occupied (see Fig. 2).

The jamTable was implemented using conventional technologies, such as the Processing programming language, the reacTIVision tracking software, and the TUIO messaging protocol. It runs on an interactive tabletop based on the Diffused Surface Illumination (DSI) method, relying on a near throw projector and an IR camera positioned underneath the tabletop's screen, and a set of 850nm IR diodes around it. The surface has an area of 120 by 70 centimeters, and each token is a cuboid of 8 by 8 by 1 centimeters. These are built out of standard PVC, with iconic labels affixed to their uppermost surface and reacTIVision fiducial markers on their base. Twenty tokens were deployed: 15 music tokens that enable users to record and play sound clips; and five control tokens that can alter the playback through higher and lower pitch and volume, or through a drive effect (see Fig. 2). Finally, recording is enabled through a small directional microphone capable of recording most musical instruments. Its sound is played through four small speakers and a subwoofer.

Fig. 2. From left to right: the jamTable's interface with 24 music tiles (on top), seven control tiles (on the bottom), a record tile (on the bottom right corner), two music tokens playing in sequence (highlighted in red), and a control token (highlighted in blue) applying a higher pitch to the sound being played by the first music token of the sequence; the popular drive effect being applied to two music tokens playing in parallel; and, a closer look at a control token to lower the pitch of a recording, and three music tokens

4 Method

The goal of this paper is to present an introductory study that can provide researchers with insights regarding the real applicability of tangible applications in musical performances between novice users and experienced musicians. This was achieved by examining the performance of two distinct participant setups: Musician-Musician (MM), and Novice-Musician (NM) collaborations.

4.1 Experimental Design and Participants

The study followed a between subjects design based on two setup conditions: MM and NM paired collaborations. There were eight participants in total: six experienced musicians, and two novice users. As such, there were two MM and two NM pairs. From the eight participants all but one were male, with their ages ranging from 17 to 58 (M = 28.38, SD = 12.69). The musicians experience with guitars ranged from 2 to 43 years (M = 14.83, SD = 14.30). Finally, four of the participants were university students, two were programmers, one a guitar teacher, and one a researcher.

4.2 Procedure

Each study session consisted of two participants: one playing an instrument while the other operated an interactive tabletop. A session would start with the assignment of these roles by the researcher, respecting the experiment design and previous information regarding the participants' musical expertise – information that was not shared amongst participants. Both participants would then be given a quick introduction to the jamTable, both in terms of the tabletop's interface and how it can interact with a musical instrument. Both an acoustic and an electric guitar were made available to participants, while they were also allowed to bring their own guitars. Participants would then be allowed to casually test the system for five minutes, before the study commenced. Once started, participants had 15 minutes to accomplish a single qualitative goal: to produce a music sequence to their liking. At the end of the session participants completed a range of subjective measures.

4.3 Measures

To better gain insights in the differences in performance between pairs of MM and NM participants, both quantitative and qualitative measures were obtained in this study, as described bellow:

Quantitative. Several events were automatically recorded by the system, such as: the highest number of music tokens used simultaneously by a participant (only music tokens containing a sound clip and located on a music tile were accounted for); the number of control tokens applied; how many unique control tokens were used; the amount of time these control tokens were active (time spent in a control tile); the number of recordings performed; and the duration of such recordings (time spend by a music token in a record tile). Participants also completed the NASA TLX [8], Hart and Staveland's six-item workload questionnaire.

Qualitative. Participants were asked to report on their experience by writing up to three positive and negative remarks. They were also video-recorded while performing, with the focus being on how pairs of participants communicated between themselves, and what kind of collaborative profiles they adopted [19].

5 Results

This section includes the quantitative results from the study presented in this paper. Being an introductory study with a limited amount of participants, this section limits itself to reporting on individual values (with the exception of the mean results from the NASA TLX, shown in Fig. 3).

Table 1. Individual values for all participants interacting on the interactive tabletop (in both MM and NM pairs). Results include interaction with music and control tokens, and how sound clips recorded. All mean times are in seconds, with standard deviation in brackets.

	Musician-Musician		Novice-Musician	
	Pair 1	**Pair 2**	**Pair 3**	**Pair 4**
Most music tokens used simultaneously	2	3	6	4
Control tokens used	6	0	5	4
Unique control tokens	1	-	3	4
Duration of effects used	98.17 (104.63)	-	49.2 (55.58)	11 (4.08)
Recordings performed	8	26	11	23
Duration of recordings	24.86 (20.78)	6.57 (2.56)	15.08 (6.23)	15.25 (12.97)

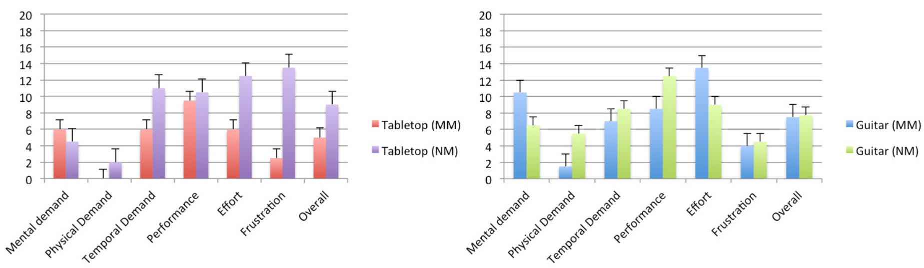

Fig. 3. The mean results of the NASA TLX. On the left the data from participants interacting on the tabletop, on the right the data from participants that played guitar.

6 Discussion

As with other work in the field of tangible musical applications [e.g. 3, 10, 12], the reaction to jamTable was generally very positive. Users found the interaction easy and fun, and appreciated how it enables and promotes the communication and collaboration between participants. But as this paper argued before, it is hard to judge the nature of such reports. While users are describing their experience with the jamTable, they are also be reporting on the natural benefits of tangible interaction (e.g. improved user experience, seamless collaboration) [18], or are simply being influenced by the novelty effects of physical interfaces [23]. As such, the following three sections provide relevant insights through the combination of qualitative and quantitative data gathered from the study with the jamTable. These are aimed at helping other researchers in the design of future studies and the musical prototypes to support them.

6.1 Learning with the jamTable

Shaer et al. [19] developed four collaboration profiles to help understand the process of collaboration on a tabletop. While these profiles are directed at participants collaborating in the same interaction space, they seem appropriate in the context of the jamTable. Through video analysis it was clear that all four pairs of participants adopted what is called as the Driver-Navigator. In this profile both users are engaged, with the driver (the participant at the tabletop) listening and discussing with the navigator (the participant playing an instrument) before committing most actions. The navigator adopts a series of actions to ground the collaboration, which in the case of the jamTable included: direct voice commands (e.g. "can you remove the last token?"); simple gestures (e.g. a nod or pointing to instruct a start or end of a recording); or a combination of both (e.g. defining a count down to start recording). This consistent behavior from participants seems to indicate that music applications like the jamTable can support a collaborative profile akin to a Student-Teacher relationship. Furthermore, by supporting a symbiotic interaction between students and teachers, the jamTable can strengthen both the motivation and commitment to learning or teaching [14].

The next natural question is of what musical concepts can actually be taught through the use of tangible musical applications such as the jamTable. While the data presented is not conclusive, it still provides valuable insights. The first refers to the different use of the control tokens by MM and NM pairs. Individual data from both participants operating the tabletop in MM pairs shows that only one used control tokens at all, and always the same one: the control token for "Higher volume". This can be partially explained by the fact that this participant was collaborating with the only musician in the study that played an acoustic guitar. On the other hand, both participants operating the tabletop in NM pairs used at least three different control tokens (from a maximum of five). Furthermore, through video analysis it is possible to observe that the decision to use or experiment with such effects came, on most occasions, entirely from these novice participants. A last observation relates to how some pairs opted to record multiple music tracks (of sometimes over 60 seconds each), while others confined themselves to recording small guitar riffs or solos (of as a little as four seconds each). This suggests that, apart from music effects, concepts such as tracks, arrangements or riffs can also be taught through the jamTable.

6.2 Performing with the jamTable

This paper argues that the key to understand how successful the jamTable was in supporting collaborative performances between novice and experienced musicians is by looking at how different were the interactions between the participants in the MM and NM pairs. Through video analysis it is possible to conclude that, despite the task's open-ended goal, all four pairs of participants managed to create a sensible musical arrangement within the time limit. Furthermore, there was no observable differences found in the Performance means of the NASA TLX: for both the novice and experienced participants using the tabletop, and the musicians playing guitar. There was an observable difference in the way paired participants would communicate though. MM pairs would rely mostly on musical terms (e.g. "Take the electric guitar out so that we have only the main riff", "Can you play that track again?"), while NM pairs would rely mostly on terms pertaining to the interface (e.g. "Remove the third token", "Leave the one in your hand out"). This seems to indicate that the physicality of the interaction (e.g. by simply being visible [11]) was indeed of great importance in supporting collaboration during the task, as it provided novice and experienced musicians with a common ground for their communication.

6.3 Future Work

Several improvements can be suggested to the jamTable. Through video analysis it was possible to observe the guitar players experience sporadic difficulty in understanding the current state of the tabletop (e.g. by peeking over). Thus, additional feedback could be created for the system, which in conjunction with an additional visual output such as a projection could improve the harmony between the users at the tabletop, the musicians, and ultimately the audience. On the other hand, by looking at the participants' qualitative feedback two more improvements can be drawn. The first relates to the control the tabletop has over the musical outcome, with participants commenting on the lack of fine tune options available (e.g. being able to trim a recording, apply more than one effect to music clips playing in parallel, or apply an effect to only one of the music clips playing in parallel). While the jamTable should remain approachable and intuitive for novice users, both multi-touch controls and a dynamic interface (instead of tile-based) could be deployed to provide features that address these comments. The second improvement is based on qualitative feedback from the experienced musicians at the tabletop who indicated that they felt unchallenged and even unnecessary at times. While the jamTable used in this study relied on only one microphone, the interface could be easily adapted to support multiple units and thus multiple musicians playing together. This adaption would create a richer and more demanding interaction between the musician at the tabletop and those on traditional instruments; the increased challenge and complexity this would result in may ameliorate such concerns.

While the possibilities mentioned above are relevant for the improvement of the jamTable, pressing future work should extend the preliminary study presented in this paper so that formal statistical analysis can be conducted. Furthermore, the contrasting NASA TLX means between novice and experienced musicians that operated the tabletop needs to be addressed (see Fig. 3). These include higher perceived effort (12.5 to 6), frustration (13.5 to 2.5), and overall workload (9 to 5, respectively). Future studies need to isolate why such contrast exists, either by exploring other learning scenarios and performance activities, or how appropriate really are physical interfaces in enabling the collaboration between novice and experienced musicians.

7 Conclusion

This paper presented the jamTable, a tangible musical application that aims to create an appealing experience that connects novice and experienced musicians. The study presented focused on how these two types of users collaborated in an unconstrained composition task. While the initial reaction to the system was broadly positive, preliminary quantitative data provided additional insights on how appropriate tangible interaction is in the support such activities. While the study presented still lacks the necessary depth (and participant numbers) to fully characterize this broad and complex topic, it provides what it argues is a necessary step towards empirical validation of many of the benefits still taken for granted in the field of tangible musical applications.

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