mixiTUI: A Tangible Sequencer for Electronic Live Performances

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ABSTRACT

Tangible user interfaces for manipulating audio and music focus mostly on generating music on the spot, but rarely on how electronic musicians balance preparation and improvisation in staging live performances or on how the audience perceives the performances. We present mixiTUI, a tangible sequencer that allows electronic musicians to import and perform electronic music. mixiTUI is developed in collaboration with electronic musicians, with a focus on live arranging, on visualizations of music, on tokens that represent key elements in live performances, and on how the audience experiences the tangible interface. We present an evaluation of mixiTUI in a concert with 117 participants and argue that mixiTUI improves both the audience's and the musician's experience.

Author Keywords

Tangible user interface, user-centered design, tangible sequencer, evaluation

ACM Classification Keywords

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems. H.5.2 [Information Interfaces and Presentation]: User Interfaces. H.5.5 [Information Interfaces and Presentation]: Sound and Music Computing

INTRODUCTION

During the last decade much work has explored the use of tangible user interfaces for audio and music. Tangible user interfaces have enabled physical control of actions and parameters, resulting in interaction styles that appear more attractive than using a mouse or an USB controller [2].

The tangible interfaces for audio and music may be divided into two groups: exploratory musical system designed for novice users and systems designed to support electronic musicians in live performances. The systems in the first group include [6–8]. The focus in these systems is on designing tangible interactions that allow users to explore the creation and manipulation of audio and music in an intuitive and entertaining way. The goal is improved user experience and to a lesser degree better musical outcomes. The systems in the second group focus on musical outcomes and on supporting electronic musicians in front of an audience. This does not imply that the user experience cannot be both entertaining and intuitive as well: [2, 10, 14] are examples of system that appeal to both performers and their audiences. These systems allow the musician to create their music on the spot, using the tangible interface to control sound generators, filters, effect patching, etc.

While research has mainly focused on supporting live creation of music, many electronic musicians do not create their music on the spot. They work on digital audio workstations for long periods of time to create rhythms, motifs, effects, and parameter automation. We aim to help such musicians better engage in arranging their music in live performances. We introduce mixiTUI, a tangible user interface that provides sequencer facilities for playing precomposed electronic music in a tangible and visual manner (see Figure 1).
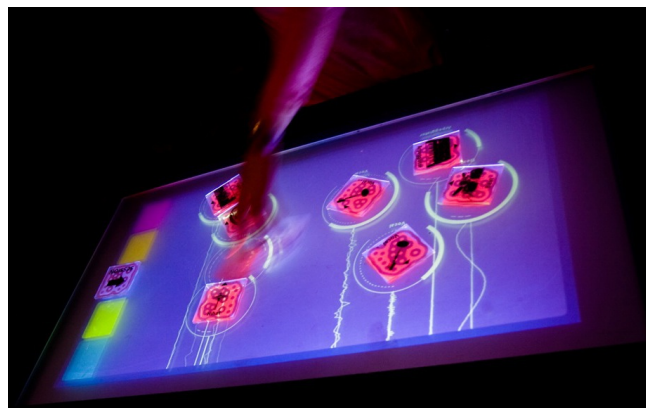
Figure 1. mixiTUI used by an electronic musician

The present paper makes two contributions to tangible user interfaces for performing electronic music. First, we use interviews and contextual inquiries [9] to study how electronic musicians work and how they think about live performances. Based on this information we create a tangible user interface that provides most of the benefits of other tangible interfaces (dynamic patching, spatial parameter manipulation), while also allowing the musician to benefit from the effort made before the performance. Second, we report a qualitative evaluation of the interface from a live concert with 117 persons, focusing on the experience of the audience. We are aware of no other empirical systematic and large-scale evaluations of how the audience experiences concerts where the music is performed with a tangible user interface.

RELATED WORK

The literature on tangible user interfaces for generating, manipulating and performing music is extensive [2,6–8,10,14]. Below we describe some of the most influential systems and discuss what we see as the limitations of earlier work.

The reacTable [2] is a collaborative musical instrument for live performances. The reacTable is a tabletop tangible user interface controlling a modular synthesizer, where tokens represent the sound generators, filters and modulators that usually comprise a synthesizer. The system we propose and reacTable share several interaction mechanisms. However, reacTable is a tangible instrument and not a tangible framework for performing precomposed music.

Audiopad [10] is a loop-based tangible sequencer, using samples as sound basis. Audiopad is operated by manipulating small round pucks, each representing a loop. By moving a modification puck close to a puck, the manipulation options of the puck are shown. The musician uses the modification puck to navigate through the options and tree-structured menus, allowing addition of effects and changing of loops.

Overall, it seems that the main focus of related work has been on developing novel tangible user interfaces that allow the musicians to explore the music in new ways [4, 8, 14]. This seems to best suit the needs of improvising electronic musicians, resulting in unique and vivid performances. However, musicians who do not mainly improvise are rarely mentioned. Moreover, while the tangible user interfaces are often subjected to informal evaluations and performances [2, 8, 10], we are unaware of systematic evaluations of live performances. Our work depart from these limitations to interview electronic musicians, conduct user-centered design of a non-improvisatory tangible user interface, and systematically evaluate a live performance with the interface.

INTERVIEWS WITH ELECTRONIC MUSICIANS

To understand better the nature of non-improvisatory electronic music and how it may be composed and performed with a tangible user interface, we conducted interviews with three professional musicians. Two of the musicians have been playing concerts for the last three years, whereas the third musician has been publishing and playing electronic music since 1992.

The interviews were done as a combination of contextual inquiries [9] and unstructured interviews [13]. The interviews were conducted in the usual work environment of the musicians, their music studios. Thereby, all of the musicians' equipment was available (e.g., software, controllers, laptops). The interviews were transcribed and analyzed to find the most frequent and important issues.

The main conclusion from the interviews was that the musicians regard the act of creating electronic music and performing it live as two distinct activities. Consequently, the musicians prepare and rearrange their finished songs in advance of the performance.

For the electronic musicians, the composing of music is much more technical and less spontaneous than, for instance, the creation of rhythmic music. They describe the process of composing as tinkering, where samples are rearranged and effect parameters are programmed and fine tuned. Thus, creating electronic music is a slow and time-demanding work of precision, which is not possible to do live. The easy solution in a live situation would be for the musicians to just press play. All three musicians mention that they have done this, but that the ensuing performance has been unsatisfactory. One of the musicians explained the following:

> "Sometimes when I play one of the songs where I do not control anything, I feel like a stupid DJ. I am mostly just dancing, then, because there is not much else to do."

To make the performance more interactive musicians report that they – after having composed a song – begin to mix down or cut up the tracks for live performance. The musicians use different software for composing the music, but all import their tracks in Ableton Live [1] for live performances. Ableton Live is a popular application, which allows musicians to do live rearranging and effect adding/manipulation. It differs among musicians which of the features in Ableton Live they use. One musician allows the length of the song to be dynamic; others set up effects, which can be turned on, off, and changed by a USB controller. In that way the musicians may become part of the performance; something that they all say is more satisfactory than merely pressing play.

All musicians mentioned that they would like their live performances to be more interactive than they currently are. The reason for not doing so with their current tools is that the musicians fear the risk of increased interactivity in performing their music. Every time a computer controlled parameter is made manual, the risk increases that something is forgotten or a button is not pushed at the correct time. One of the musicians describes it the following way:

> "The more advanced and brave one is, the more naked one leaves the basic track."

The interviews also showed that the musicians felt unsure about whether or not their effort in shaping the performance is appreciated by the audience. One of the musicians told:

> "To be honest, I don't think they grasp the fact that I'm actually arranging the song on the spot."

In one case this led the musician to keep the effect parameters automated and simply pretending to be in control.

Overall, the interviews have led us to conclude that the system needed must (a) be compatible with the way musicians export their composed music, (b) support live rearranging and manipulation of effects, (c) allow a high degree of interactivity without imposing stress on the musician, and (d) ensure that the musicians' interactions are legible - in the sense of Ishii et al. [10] - and understandable to the audience.

DESCRIPTION OF THE mixiTUI SYSTEM

The mixiTUI system consists of both a software sequencer used for importing, arranging, and playing loops, and a tabletop tangible user interface for controlling the sequencer. The user interface is a square tabletop (120 cm x 120 cm) with an active surface measuring 100 cm x 56 cm. The screen is placed with a 10 cm border to three of the table edges. Thus, mixiTUI is most naturally played from one side of the table. This spatial configuration limits the number of simultaneous players to three, if every player is to have a reasonable interaction space.

mixiTUI uses computer vision to track tokens, extending the reacTIVision [2] facilities for tracking. Briefly, reacTIVision monitors the video stream from a camera situated underneath the active surface of the table and tracks specially designed symbols (fiducials) pasted on to the bottom of every token. The active surface of mixiTUI is made up by a frosted glass plate on which a digital image is projected. The resolution of the screen is 1280 x 720 pixels. Three IR LED arrays ensure that the surface is well lit, making the token tracking independent of the light emitted from the projector.

Tokens

The tokens used for mixiTUI are made out of acrylic glass and measure 8 cm x 8 cm x 0.5 cm. All tokens have a descriptive picture and text on top (see Figure 2). Figure 2 shows that some tokens also have an indicator mark. The mark is used for parameter manipulation (volume, effect parameters, etc.), which will be explained in a later section.

A token becomes active as soon as it touches the screen. Whenever a token becomes active, the system projects a digital image underneath and around the token. This image gives the musician information on the state of the token (e.g., parameter values, volume, loop progress).

Physical/digital coupling

The tokens of mixiTUI are divided into three categories: *loop tokens, effect tokens,* and *control tokens*. Every token is coupled with a piece of digital information or a digital function. The coupling is controlled by the musician and is set
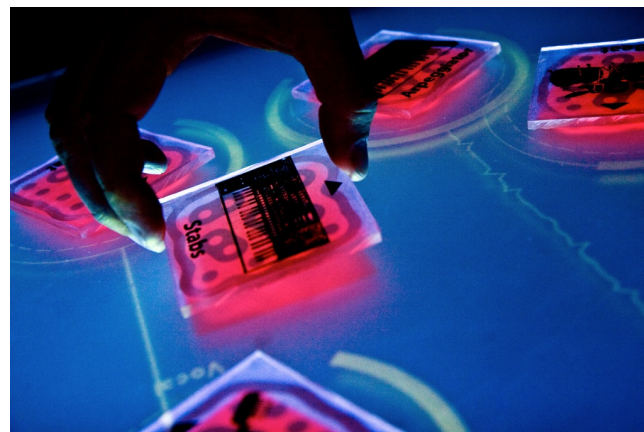

Figure 2. Loop tokens in action

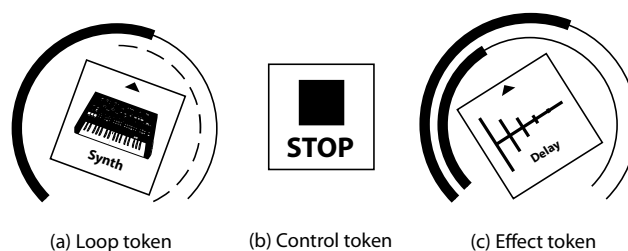(a) Loop token   (b) Control token   (c) Effect token

Figure 3. Example of tokens

up in an independent program. The three token categories are explained below, and an example token from all of the categories can be seen in Figure 3.

Loop token: The loop tokens are the sound producing part of mixiTUI, and these tokens are coupled with digital sound files or loops. The loop tokens use dynamic bindings, as a token can be associated with up to five loops. Which loop that is current is controlled by the *session token* (a control token). For every active token the musician receives graphical information about the volume, total duration, and current progress of the loop. The duration and progress are shown in terms of beats and bars in order to assist the musician in keeping track of time.

Control token: In contrast to the loop token and the effect token, the control token is not coupled with a digital entity. Instead the control tokens represent digital functions that affects the state of the other tokens. mixiTUI has two control tokens: the *session token* and the *stop token*.

Effect token: The effect tokens are coupled with digital sound processing effects. Effect tokens use static bindings and an effect token can only be coupled with one digital effect. By placing an effect token near a loop token or another effect token, a new dynamic binding is created. The bindings between tokens result in new routing of the sound signal, which is visually supported by the virtual wires (waveforms). Digital information about the parameters of the effect is shown around the token as well.

INTERACTION DESIGN OF mixiTUI

In terms of the taxonomy by Ishii et al. [11], mixiTUI is a mixed contructive, spatial, and relational system. The musician uses the tokens in a constructive manner when arranging the signal routing, effect parameters are manipulated through spatial gestures, and the loops are controlled by the abstract relation between control tokens and loop tokens. The following section explains the interaction design of mixiTUI and how it is based on the interviews with electronic musicians.

Loop tokens

The interviews made it clear that time critical situations imposes stress upon the musicians. If buttons were to be pressed at an exact time, it imposes a fear of not being in time, causing the musicians to minimize the degree of interactivity. This observation formed the basis of the interaction with loop tokens.

A loop is added by placing the associated token on the table; a loop may be removed by removing the token. A loop does not neccessarily start immediately after being placed on the table. Rather, this is determined by the *start* and *stop* *settings* of the loop. Start and stop settings use information about bars and beat in order to provide a musically intelligent start/stop mechanism. mixiTUI has two start settings (*next beat* and *next bar*) and three stop settings (*next beat, next bar* and *loop end*). These settings are decided on by the musician when coupling token and loop. Figure 4 shows an example of three loops with different start and stop settings. The loops all have a total duration of two bars. The blue marking indicates when a token is present on the table whereas the waveforms show the resulting sound.
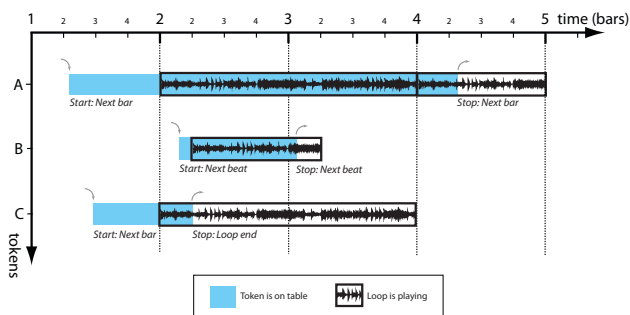

Figure 4. Start and stop settings in mixiTUI

mixiTUI keeps track of beats and bars, and uses the information to maintain musical syncronization among loops, even if a loop token is being placed on the table in the middle of a bar. This can be seen by observing token B in Figure 4. The loop associated with token B does not start from the first beat of the loop, instead it starts playing from the second beat, so that musical synchronization is kept.

The start and stop settings allow the musician to setup every loop in a way that meets the need of the song being performed. The musician can use the delay that the start and stop settings introduce to add or remove more tokens than

otherwise possible, thus reducing the stress that the otherwise time critical situation would have imposed. For instance, if the musician has two synth motifs that replace each other, he can pick *next bar* as start and stop setting for both and get an entire bar to do the token exchange. Note, this improves musicians' control over their performance at the expense of direct manipulation.

If a loop is placed on the table in advance, mixiTUI shows a graphical countdown in order to give the musician instant feedback. The graphical feedback also supports the audience in understanding the irregular delay between action and sound. Furthermore, the graphical wires/waveforms visualize the audible content of the loop, making it easier for the audience to determine which loops and tokens are coupled.

Control tokens

The interviews showed that the musicians generally use one set of instruments throughout a song. The instruments, however, have different motifs according to what part of the song is being played (verse, chorus, bridge, etc.). Usually, the motifs change simultaneously. Even though the musical delay introduced by the start and stop settings allows the musicians to perform more actions than otherwise allowed, there is a physical limit as to how many tokens that can be replaced in one bar.

To eliminate this limit we have introduced the notion of *sessions*. Each of the current five sessions of mixiTUI allows the musician to make an independent token setup. A token can be associated with a different loop (and start/stop setting) in every session or be set as inactive (muted) in some sessions. The musician choses the current session by placing the session token on one of the five differently colered tabs on the right side of the screen (Figure 7). This causes the background to change to the same color as the chosen session and the coupling of tokens and loops to change according to the preliminary setup.
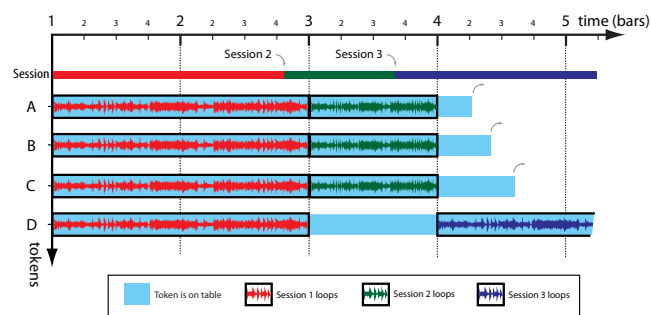

Figure 5. Sessions in mixiTUI

Figure 5 shows a live performance using four tokens in three different sessions. The first session change causes a change of loops for tokens A, B, and C, while D is being muted. In the subsequent bar the musician changes to session 3, where a breakdown has been set up. In session 3, tokens A, B, and C are muted, whereas D starts playing again with a different loop. This leaves the musician with plenty of time to remove

token A, B, and C. As Figure 5 shows, these bars are done with only five actions. If playing these bars had not used a session token, it would have required twice the number of tokens and 11 actions.

The session funcionality of mixiTUI allows the musician to carry out a vast amount of loop changes or deactivations in a single action. The musician is thereby capable of doing complex loop changes, for instance going from a verse to a chorus by changing all the loops at once. To make the changing of sessions more legible to the audience, all sessions are represented by their own color. Whenever a sessions is chosen, the background of the screen changes accordingly, thereby coupling between colors with sessions or, consequently, different parts of the song.

The other control token is the *stop token* (Figure 3). The stop token deactivates all loop tokens, allowing the musician to add several tokens to the table and starting them off simultaneously by removing the stop token from the table.

Effect tokens
The interviews showed that the most frequently used interaction in live performances are the adding of effects and manipulation of their parameters. The effect tokens of mixiTUI meet this need.

Adding effects
Effects are added through dynamic patching, so that the musician can add effects without having to set up or change the digital patchway. Dynamic patching was first described by Geiger et al. [12], and is now used in most tangible music systems. All the digital effects have one stereo input and one stereo output. An effect is added to a loop by bringing an effect token into proximity of the waveforms from a loop token. This action causes the output from the loop to be patched to the input of the effect token. The processed audio is being played from the output of the effect and shown as waveforms on the screen. The output from one effect may be patched to the input of another effect, creating serial connection of effects.

Changing parameters of an effect
The parameters of an effect can be manipulated by two methods: *rotation* and *proximity*. Figure 6 shows them in purple and blue colors respectively.

When manipulating the parameters through *rotation*, the musician uses the token as a dial similar to those on everyday objects like radios, stoves, etc. The current value of the parameter is shown as a graphical arc around the token. When manipulating parameters by *proximity*, the value of the parameter is determined by the distance from the effect token to the source (loop token or effect token). This kind of interaction was used in the Theremin in 1928, and is being used in a lot of spatial TUI systems today [4, 10, 14]. The maximum parameter value is obtained when the effect token is situated just next to its source, whereas the minimum value is obtained when the effect token is moved all the way to the screen border (see Figure 7). If two effects are patched
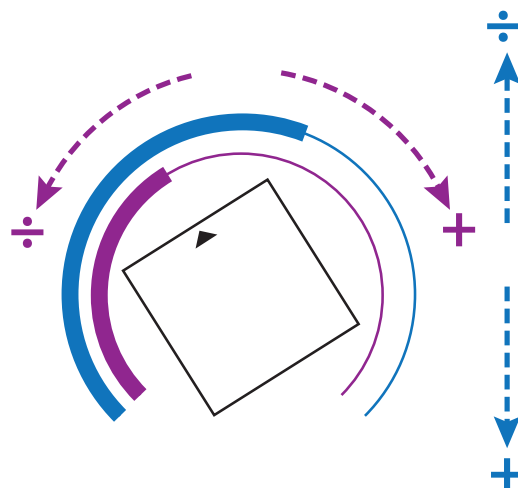

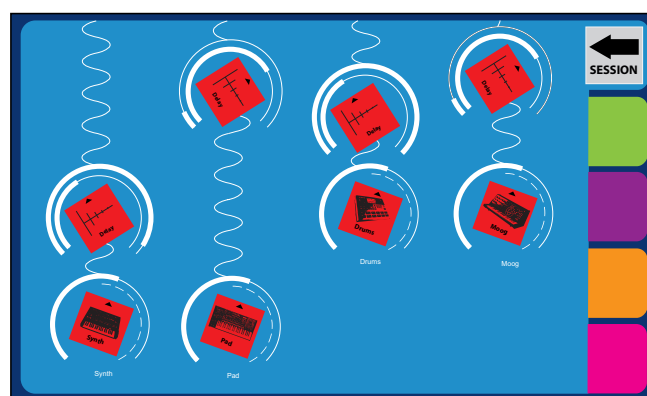
Figure 6. Changing the parameters of an effect

Figure 7. mixiTUI sketch

together, the minimum parameter value of the first effect is obtained by moving the first effect token close to the second effect. The spatial distance between the maximum position and the minimum position is therefore directly related to the distance from the source to the screen border (or subsequent effect). This feature gives the musician the opportunity to determine the size of the scale. If the musician wants his gestures to have great impact on the parameter value, he can reduce the distance between the source and the screen border (or a subsequent effect token). If the musician, on the other hand, wants a high precision scale with a small effect, the musician can move the source to the lower screen border (or preceding effect token). Figure 7 illustrates this.

Both ways of manipulating parameters may be used for effects with only one parameter, but may be combined in digital effects with two parameters. The combination of gestures allows the musician to manipulate two parameters at once using just one hand (turning and moving). Rotation is primarily being used for parameter where only slow but precise changes are needed. Promiximty is well suited for rapid movements that use the whole scale within a short period of time.

The addition and manipulation of effects are also designed to be legible and understandable to the audience. The visual wires ensure that the audience can keep track of which tokens are connected. The proximity gesture involves rather coarse movement and should be easy to see. In [10], Ishii et al. argued that rotatory movements were unsuited for live systems. They reported that spectators had a hard time detecting the gesture, as it was too delicate and the musicians hand might block the view of the puck. However, the tokens in mixiTUI are considerably larger than the pucks of Audiopad, forcing the musician to use all fingers to grab the token. This necessitates more coarse movements, and should make the interaction visible to onlookers.

EVALUATION BY LIVE PERFORMANCE

The aim of the evaluation by live performance was to get insight into the experience of the audience when listening to musical performances with mixiTUI. We believe the experience of the audience is one important parameter on which to evaluate a tangible user interface for music.

Setting

The live performance was held in an auditorium as a concert. The concert was performed by the electronic musician called The Mad System [15]. The music of The Mad System is very danceable and is best described as electro pop. Four songs were performed: two songs on traditional equipment (song 1 and 3) and two songs on mixiTUI (song 2 and 4). The songs were picked out so that they were comparable in style as well as tempo and length. The traditional equipment consisted of the usual setup of The Mad System, which is composed of a laptop with Ableton Live and a USB controller. When using mixiTUI to perform a song, the necessary samples had been imported into mixiTUI and assigned to tokens and sessions. Two video cameras filmed a close-up of the active surface of mixiTUI, which were projected on a wall behind the musician (see Figure 8). This allowed all members of the audience to observe the musician's actions properly.

Audience

The audience for the live performance was 117 persons between 18 and 40 years (44% female). Most persons in the audience self-reported that they had previously attended a concert with electronic music; data from Statistics Denmark confirm that the audience was representative in terms of age and gender for people who attend electronic concerts [5].

Procedure

The procedure for the live performance was as follows. First, the audience was explained the aim of the concert. Second, The Mad System performed four songs, two with his traditional equipment and two with mixiTUI. Third, participants were given a questionnaire with 20 questions about their concert experience and the legibility of the mixiTUI and the laptop performance. Finally, the audience was thanked and invited to a presentation of mixiTUI and to try it out. In all, the concert lasted about 30 minutes.

Figure 8. Evaluation by live performance

Results

Below we discuss the feedback from the questionnaires about the experience of the performance and of mixiTUI. In addition, we discuss a set of suggestions for redesign of mixiTUI that was put forward in the questionnaires.

To find out if the interactions were legible and understandable, the participants were asked to explain the interactions observed. The questionnaires showed that some interactions were more legible than others: the participants had no problem describing the interactions concerning the loop tokens, as both addition, removal, and volume adjusting were grasped. However, the relational binding between session token and loop tokens were not legible to all users. Most users observed that the session token could change in sound, but only 10 participants were able to explain interaction correctly. Even though the use of the session token were not legible to all participants, the color effect introduced by the changing of sessions seemed appealing. For instance, one of the participants commented:

"Awesome visuals! Loved the colors!"

The evaluation supported the assumption that laptop interactions were not legible and understandable to the audience at an electronic concert. 101 participants reported that they had previously attended an electronic concert where they had experienced the performer as being passive. When asked what this meant to their experience of the concert, most of the participants concurred that they had turned indifferent to the concert. Twenty-six persons had suspected, when attending previous concerts, that the musician had just pressed play.

When being asked to compare the two performance styles and rating them, our evaluation shows a rather unambiguous result; 103 subjects rated the mixiTUI performance higher than the laptop performance, 12 subjects rated them equally, while only 2 subjects favored the laptop performance. The visualization of the audible content of the loops seemed appealing to the audience. One participants wrote:

"It is very cool that one can visually observe what is happening in the music."

Participants seemed to like the fact that they could observe the musician's interactions and that the interactions where understandable:

"I really liked the fact that I, as a member of the audience, could observe the act of creation."

Several participants reported that the performance on mixi-TUI had enriched their musical experience, making it more satisfying. For instance:

"It was awesome to be a part of the concert. I felt more stimulated than at a "traditional" electronic performance"

The design ideas put forward by the people in the audience were grouped using affinity diagramming to arrive at 24 design ideas. Among these three stand out: (a) larger symbols on the loop tokens, (b) the possibility of adjusting the tempo using a tempo token, and (c) the possibilty for a VJ to use the filled backgrounds of mixiTUI for live performance.

Suggestion (a) was the most frequent design idea, suggested by 13 independent participants. While this points out a weakness in the token design, it also argues that the audience is indeed concerned with the legibility of the performance. Suggestion (b) is a feature often used by DJs, and is an obvious idea for mixiTUI. The tempo token could both serve as an effect or be used to gradually increase/decrease the tempo at the end of a song, allowing the musicians to tie it together with the next song. (c) would presumably result in a more compelling and vivid visual appearance. However, it may make the visual feedback of mixiTUI less visible to the musician, thereby introducing a risk of confusion.

In our opinion, evaluation by live performance is a very useful evaluation method for tangible music systems. It has shown to produce valuable, constructive criticism and novel design ideas. The evaluation method is less time demanding than traditional evaluation, as it allows a great number of simultaneous participants, making it an appealing supplement to traditional user testing.

CONCLUSION

Tangible user interfaces are attractive for creation and manipulation of audio and music. However, existing tangible interfaces support mostly improvisation and unique musical performances, leaving the needs of electronic musicians who prepare their music in advance unaddressed. We introduce mixiTUI to address their needs. mixiTUI allows musicians to couple effects and sounds to tokens, visualizes the waveforms of the sounds and the relation between sounds and effects, and permits complex manipulations of the relation between tokens and sounds.

We designed and iterated mixiTUI in cooperation with electronic musicians, and evaluated the system in an electronic concert with 117 participants. The iterations and the concert show that mixiTUI supports electronic musicians in balancing preparation and improvisation, and that it gives audiences at electronic concerts a better experience. Future work needs to explore how to make tangible interfaces more visually interesting in a live situation and how to match the capabilities of the mixiTUI even more closely to the needs of electronic musicians.

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