Towards an Interface for Music Mixing based on Smart Tangibles and Multitouch

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ABSTRACT

This paper presents the continuous work towards the development of an interface for music mixing targeted towards expert sound technicians and producers. The mixing interface uses a stage metaphor mapping scheme where audio channels are represented as digital widgets on a 2D surface. These can be controlled by multi touch or by *smart tangibles*, which are tangible blocks with embedded sensors. The smart tangibles developed for this interface are able to sense how they are grasped by the user. The paper presents the design of the mixing interface including the smart tangible as well as a preliminary user study involving a hands-on focus group session where 5 different control technologies are contrasted and discussed. Preliminary findings suggest that smart tangibles were preferred, but that an optimal interface would include a combination of touch, smart tangibles and an extra *function control* tangible for extending the functionality of the smart tangibles. Finally, the interface should incorporate both an edit and mix mode - the latter displaying very limited visual feedback in order to force users to focus their attention to listening instead of the interface.

Keywords

music mixing, tangibles, smart objects, multi-touch, control surface, graspables, physical-digital interface, tangible user interface, wireless sensing, sketching in hardware

1. INTRODUCTION

Mixing consoles as interfaces have not gone through much change the last 50 years. Analogue mixing consoles work by routing sound signals through dedicated channel strips, giving the user the ability to manipulate each audio channel in order to shape the overall mix. Each channel strip is physically manipulated using sliders, knobs and buttons using a one-to-one mapping. Digital mixing consoles present a number of benefits over the analogue consoles, especially when it comes to size, flexibility and detailed control of each channel. However, they tend to present the user with a steeper learning curve. Nonetheless, they are still based on the same control structure as each track is organised using the channel strip metaphor.

This research investigates the possibilities of manipulating each channel using the *stage metaphor* as control structure. In the stage metaphor each channel is represented by a virtual widget placed on a 2-dimensional surface, where it's position relative to a listening point determines its volume and panning in the overall mix. The stage metaphor has been explored in a number of other interfaces - as will be presented in Section 2. The interface presented here explores some of the control challenges associated with such an interface. Most *stage metaphor* mixing interfaces are implemented as graphical user interfaces (GUIs) either controlled traditionally using mouse and screen or controlled using a multi touch surface - see Section 2. This poses disadvantages compared to traditional mixing consoles where the tangibility of the controls provide haptic and tactile feedback crucial for expert use. We propose a tangible user interface that implements tangible blocks (tangibles) for controlling both the position and parametric manipulation of each channel coupled with multi touch control for additional functionality.

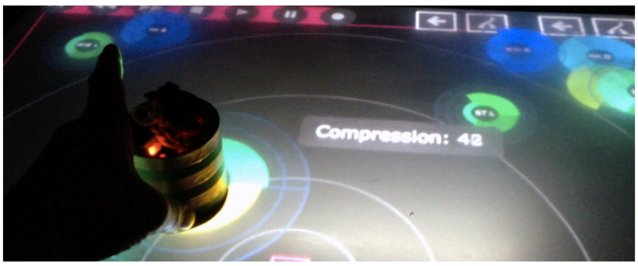

Figure 1: The smart tangible can be used to access different effect parameters depending on how you grasp it.

The target group for the interface is professional audio engineers and producers focussing especially on studio mixing — as opposed to live mixing. The evaluation of the interface

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presented later is carried out as an exploratory focus group session where *Tonemester* (sound engineer) students from the Royal Danish Music Conservatory are asked to mix two pieces of music with 5 versions of the prototype (including the one using smart tangibles).

The rest of the paper is presented in the following way: Section 2 presents related work, Section 3 presents the design of the overall interface including the smart tangibles. Section 4 describes the evaluation and results, which are discussed and concluded upon in Section 5.

2. RELATED WORK

Depth in music (defined here as *the separation of channels by perceived distance from the listener*) is an important and often underestimated factor when mixing music. Besides separating audio channels by the use of panning for greater width of the overall mix, an important goal is also to create depth in the mix by giving each channel a distinct perceived distance from the listener. This goal is seldom supported directly in common music mixing interfaces[1]. Several projects have examined the need for more intuitive control of depth in music by challenging the channel strip control metaphor used in traditional mixing consoles.

2.1 Music Mixing and the Stage Metaphor

Peter Gibson proposed the "Virtual Mixer" [3] - a virtual 3D mixing environment. Here each audio channel is represented by a 3D globe which can be positioned in three dimensions on a virtual stage. The z-position determines volume, the x-position determines panning and the y-position of each globe determines how the sound is filtered. This approach was one of the first to re-define the control metaphor for music mixing and has inspired related systems where the *stage metaphor* is used.

Diamante presents a GUI that not only implements the stage metaphor but also improves the visual feedback for the sound propagation of each channel [2]. Pachet and Delerue implemented the stage metaphor when developing a GUI for presenting music-end-listeners with capabilities of creating their own individual mix of a music track [14].

Closest to the work presented here is the mixing interface by Carrascal and Jordà [1]. It likewise explores the stage metaphor for controlling a mixing environment, focusing on a multi touch surface approach. They implement channels as virtual widgets, that are positioned relative to a listening position on a 2 dimensional surface. Like Gibson, they implement several stages each dedicated to controlling what one might refer to as an *auxiliary send*. They conclude with a preliminary usability test where they compare the interface to a more traditional digital mixer. The evaluation tentatively suggests that the stage metaphor using this multi touch surface approach is preferred over a traditional mixing console.

While the stage metaphor shows great potential for controlling the depth in music it also comes with a few obvious drawbacks. The most crucial of these is the organization and overview of the different channels. With the channel strip metaphor each audio channel is always located in the same place, which makes it easy to locate and control[2]. With the *stage metaphor* channel representations (virtual globes or widgets) are scattered around the virtual stage area and can be difficult to locate—especially since professional systems demand at least 24 channels (often more). This is most likely why the channel strip metaphor is still predominant in the industry today and why more flexible and experimental interfaces still keep this layout [8] for increased usability. Another issue also having to do with overview occurs if one wants to apply the same amount of panning and volume to two or more channels. In that case the virtual widgets will be placed directly on top of each other making it difficult to monitor and target specific channels.

[1]such as Ableton Live, Logic, Protools, etc.

[2]However, most digital mixers make use of fewer channel strip banks that the user can shift between. This nevertheless makes it easier to overview the various channels than the stage metaphor.

2.2 The importance of physical control

A major concern when developing the interface is how to physically interact with the underlying software. The stage metaphor described earlier demands that channels are somehow represented and manipulated by moving virtual sound sources on a 2D plane. Initially, a multi touch surface has was designed, but informal interviews with expert technicians underline the importance of tactile and haptic feedback while manipulating parameters. Therefor we have developed a Tangible User Interface (TUI) where virtual sound sources can be manipulated using tangible blocks (tangibles)—inspired by the work of Jordà et al. [5]. This however, opens up several challenges in regards to the flexibility of the system as is also emphasized by Kirk et al. [7], which present an excellent overview of the challenges involved in designing hybrid TUI surfaces. The major concerns deal with maintaining the flexibility of the system when physical objects are deployed. For instance, there might be a need for virtual widgets to change appearance or position at different stages in the work flow. A solution, as proposed by Weiss et al. [21] could be to make the physical objects translucent in order to be able to display state changes while still maintaining the passive haptic feedback of the tangibles. Another solution presented in [7] that we are inspired by is to use tangibles not as representation of underlying data as is often seen in TUIs. Instead we explore using tangibles only as manipulation tools that can be deployed when necessary.

2.3 Smart Tangibles

Additional challenges lie in the often constrained functionality of tangibles, where the only forms of manipulation are mostly reduced to positioning and rotation of the tangible. The approach pursued here involves embedding tangibles with micro controllers offering additional sensing for the control of additional functionality. Related projects that imbed tangibles with sensors include [18], which suggest using smart tangibles for controlling physical models on an interactive tabletop. [10] explore the z-dimension of a smart tangible that can be resized in the z-dimension for an added degree of freedom. [4] use a smart tangible to add a z-dimension (though not using height, but pressure) to the control of a wavetable synthesizer.

Other solutions to the challenge of providing haptic and tactile feedback while still maintaining system flexibility include adding active tactile feedback to touch screens [9] or giving the TUI objects the ability to change position [15] - aiding to the flexibility of the system (when for instance wanting to work with automation of specific channel parameters while using tangibles). Embedding tangibles with actuators may also aid in providing physical fine control of each channel as in [16].

3. DESIGN

The overall system is designed as a control interface for an underlying Digital Audio Workstation. The graphical front end is developed in Macromedia's Actionscript 3. All the audio processing is taken care of by the underlying DAW (in this case Ableton Live) and a two-way communication runs between Flash and Live via MAX6[3] using the *flashserver* object by Olaf Matthes[4]. The Max patch aids in translating parameter changes from Flash into MIDI CC messages received in Live and vice versa. Additionally, the Max patch is used to communicate with the underlying ReacTIVision software [6] for fiducial tracking[5], as well as for communication with the Smart Tangible described in section 3.2. Finally, a multi touch overlay[6] is used to capture finger touch events, which are received directly in Flash using dedicated Actionscript SDK library (one could also use ReacTIVision, but the G4 overlay is faster and not as sensitive to varying light conditions). A diagram over the system architecture can be seen in Figure 2.

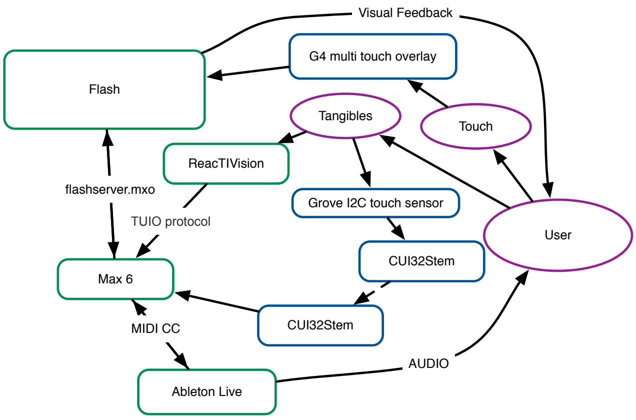

Figure 2: System architecture.

The main interaction area of the interface is presented as a semicircle where virtual widgets representing an audio channel can be placed. The virtual listening position is centred at the bottom. As discussed earlier the placement of the widget relative to the listening position determines the volume and panning of the audio channel. For the evaluation described later in Section 4 the listening position was kept fixed and only 8 audio channels were controlled at one point. This limitation was implemented in order not to overwhelm the participants with too much functionality thereby keeping their focus on control.

Each of the audio channel widgets implements 6 effect parameters: *low pass, high pass, compression, resonance, reverb and delay*. The value of each parameter is displayed by dividing a circle into 6 equally sized areas. How much the area is filled corresponds to the value of the parameter. This layout was chosen for its scalability and because the user intuitively can get an indication of how the channel is processed by looking at the form of the overall widget.

Additional elements include a transport control and buttons for randomizing/resetting position and effect parameter levels for each channel. The idea was to provide the user with a way of exploring alternative versions of the mix. Figure 3 shows the graphical user interface of the prototype.

3.1 Control technologies

In order to explore the different input types discussed earlier three different control schemes were designed for tangible

Figure 3: The graphical user interface.

interaction. One involves having a dedicated tangible for each widget—besides positioning the widget the user can rotate the tangible to influence a selected audio effect—the active audio effect can be set by rotating an additional tangible thereby toggling through an effects menu. The second control scheme implements a tangible for each audio effect. The tangible is placed on a widget in order to manipulated it, and then lifted again when done. Each effect tangible can also be used to set the position of the widget by placing the tangible on the widget, then dragging it to the desired position.

3.2 The Smart Tangible

The third control scheme involves the development of a *Smart Tangible*. The idea is to have a single tangible that can be used to set the position of a widget the place-move-lift action described above. Additionally, the tangible is able to control one of a number of effects by determining how the tangible is grasped by the user, using capacitive touch sensing.

The development of the capacitive touch-sensing technology for our smart tangibles was done through a two-stage rapid iterative prototyping process. This involved the use of an electronics toolkit specifically designed for sketching in hardware[7] called the CUI32Stem Grove Dash Kit[8]. The utilized elements include several CUI32Stem boards (latest version of the Create USB Interface [13, 12]), two sets of Grove I2C touch sensors[9], infrared sensors, and ZigFlea wireless transceivers [19]. The system setup includes a base-station and two smart tangibles, each powered by rechargeable lithium polymer batteries. The base-station is comprised of one CUI32Stem and a ZigFlea board (Figure 4 left), and the two smart tangibles each include these elements plus the aforementioned Grove I2C touch sensors (Figure 4 right) and infrared sensors. The infrared sensor is used to detect the presence of a user's hand over the top of the smart tangible, while the I2C touch sensors determine which of three rings of copper tape is in contact with the user's fingers.

The first (non-used) prototype of the smart tangible did not use rings of copper tape, but instead made use of the *feelers* included with the Grove I2C touch sensor board. These were spaced evenly around the top rim of the puck, as shown in Figure 5, right. This attempt was discarded, as it was unsuccessful at achieving the desired goal of determining how many fingers users were grabbing the puck with (fin-

[3]`http://cycling74.com`
[4]`http://www.nullmedium.de/dev/flashserver/`
[5]The camera used is a PlayStation Eye by Sony running at 30 frames per second
[6]G4 24" from PQ Labs - `http://multi-touch-screen.com`

[7]`http://sketching-in-hardware.com/`
[8]`http://www.seeedstudio.com/depot/cui32stem-grove-dash-kit-p-1179.html`
[9]`http://www.seeedstudio.com/wiki/Grove_-_I2C_Touch_Sensor`

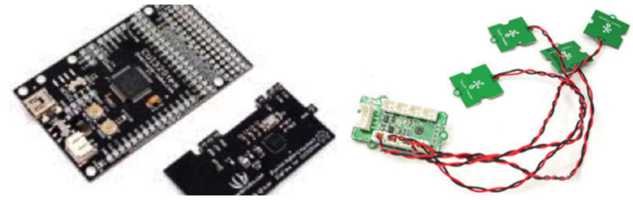

Figure 4: Left, the elements of the base-station, a CUI32Stem and a ZigFlea board. Right, the Grove I2C touch sensors with included touch sensor feelers.

gers could accidentally contact more than one feeler). Another possible approach was inspired by the Touché project [17], which would seem to allow reliable detection of the number of fingers via swept-frequency capacitive sensing. As we did not have easy access to actual Touché hardware, we tested a version of the Touché approach that had been implemented for the Arduino platform[10], but found that the resolution of this was not nearly precise enough to determine the number of fingers reliably. With this finding, we decided to move quickly to a second and final prototype using rings of copper tape, as shown in Figure 5, left.

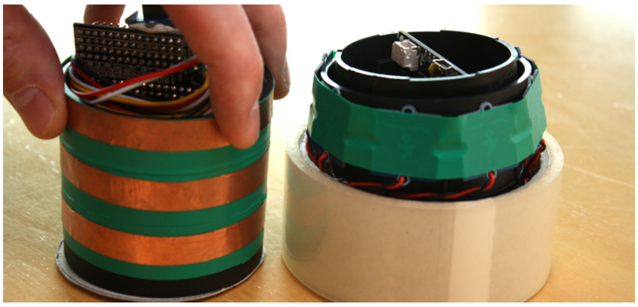

Figure 5: Right, the initial prototype using the *touch feelers* included with the Grove I2C touch sensor. Left, the final prototype utilizing rings of copper tape to detect contact with human skin.

Three channels of each Grove I2C touch sensor board are used in this final prototype design. Each channel is connected to an electrode consisting of layered rings of copper and insulating tape. One of the active sensing pins of the MPR121 IC (the capacitive touch sensing integrated circuit on the Grove I2C board) is connected to the outermost layer of copper tape, then insulating tape, and the inner layer copper tape is connected to ground. This approach makes a very reliable sensing electrode for detecting human skin contact. While the modality of interaction necessarily was changed to focus on which ring is grabbed (rather than the number of fingers in contact), we feel that such a requirement while interacting — grabbing one of the three rings to select which parameter one would like to control — was intuitive and fluid enough to be valid for user interaction. This said, future research may still be necessary to evaluate the differences in user interaction when comparing *ring-grabbing* techniques with *number-of-fingers* techniques. The infrared sensor at the top of the smart tangible enhances the interaction by doubling the number of possible parameters available to control (from three to six)[11]. Further expansion of channels could be accomplished by utilizing more of the MPR121's capacitive touch sensing channels; up to 12 rings could be implemented using this IC. In the current prototype, three parameters can be accessed directly by grabbing one of the rings from the side of the puck, while a further three parameters are activated by grabbing the puck from above, wherein the infrared sensor acts as a *shift key* by sensing the user's palm above the puck — Figure 1 shows the smart tangible used to manipulate an effect[12].

4. EVALUATION

The evaluation of the interface was carried out as an exploratory focus group session. Five *tonemester* (sound engineer) students from the Royal Danish Music Conservatory (all male, ages 25-35) were asked to explore 5 versions of the interface, each with a different control scheme:

1. Touch control - Each widget could be manipulated by dragging in different regions within the widget. Dragging from the circle would move the widget, dragging in one of the six effect-areas would set the effect parameter. Finally, double tapping the middle of the widget muted/unmuted the channel and double clicking in one of the effect-areas soloed/unsoloed the channel.

2. Tangibles on all widgets - The position of each widget could be controlled by a tangible. Rotating the tangible would change an effect parameter. Which parameter would be affected by the rotation was set using an additional tangible, referred to as *function control*, that would be placed in the lower right corner of the surface and could be rotated to toggle between the 6 effects.

3. Tangibles for each effect - 6 tangibles, one for each effect could be used to manipulate a channel widget of choice. The user would place the tangible on the virtual widget, which would then be "locked" to that widget, and drag to alter position or rotate to set the effect parameter represented by the used tangible.

4. A Smart Tangible for each hand - The user had two smart tangibles, each of which could be used to manipulate a channel of choice by placing the smart tangible on the widget and dragging it to alter position. The effect parameters could be manipulated by holding the smart tangible at one of three positions and rotating. The user was only able to adjust three parameters in this version due to technical limitations.

5.Tangibles on all widget with no visuals - As the discussion towards the end of the session fell on the importance of visual feedback, the test participants ended up exploring the interface with no visuals at all and tangibles on all widgets. This was not planned but was interesting enough to include here.

The session took place at the Royal Danish Conservatory in a recording studio and took 2.5 hours. It was conducted using a semi-structured interview guide where the overall focus was on *control*, but with underlying discussion points including *stage metaphor, functionality layering, creativity support, work process/integration and overall usefulness.* The participants were first introduced to the overall stage metaphor control scheme, after which each version was introduced, explored and discussed one at a time. In other words, the participants did not know of the later versions, while exploring/discussing earlier versions. The participants were given two tracks to mix, each with 8 channels of audio - a country-western track with drums, bass, acoustic and electric guitar, keys, lead vocal, slide gui-

[10]`http://dzlsevilgeniuslair.blogspot.it/2012/05/arduino-do-touche-dance.html`

[11]however, this was not used in the evaluation due to technical difficulties with infrared light interference from the interactive table

[12]see `http://youtu.be/9WAI3FCzugE` for a video of the prototype in use.

tar and fiddle, and a classical piece with left/right channels of marimba, strings, woodwinds and overhead. The session was video recorded and notes were taken during the session. The video was analysed using a grounded theory approach were each relevant statement or action was annotated and coded with an emergent set of category labels.

There were a few technical difficulties mostly influencing how exact the tangible objects aligned with the virtual widgets at certain times, and also how exact the touch points were in the touch version. Finally, the tracking when working with the drag/drop functionality of the "few tangibles"*(versions 3 and 4)* was not fast enough, resulting in one sometimes 'loosing' the widget when making fast translations of the tangible.

4.1 Results

The presented results should not be regarded as conclusive. They do however underline important focus areas for designing hybrid tangible mixing interfaces using smart tangibles.

4.1.1 Stage metaphor

Overall the test participants were very positive towards the stage metaphor control scheme saying that they couldn't wait to use the interface for exploring their own mixes. It was made clear that the stage metaphor was much closer to the way they would normally conceived an overall mix compared to the channel strip metaphor. In other words, the conceptual model of the system felt much closer to the mental model of the participants, which is an important goal in interface design [11]. However, the mental model of the participants also included the notion of reverb and filtering as parameters associated with moving sound sources away from the listening point. In order to accommodate this the interface should be extended with an option to map distance to a dry/wet reverb effect for each channel. A few of the participants also asked to be able to alter the dimensions of the overall stage as well as being able to alter the listening position for further exploration - as implemented in [1].

It should be mentioned that most of the time during the evaluation sessions was used discussing how to adjust effect parameters and not on the panning/volume associated with positioning of the widgets. This could indicate that the metaphor felt natural and that challenges lie more in *editing* of the different channels within this control metaphor.

4.1.2 Control

Overall the test participants found advantages and disadvantages with all 5 input technologies. The following discusses the pros and cons of using each version including how one might accommodate to these in future design of such interfaces.

1. Touch control - The touch interaction was not suited for fine tuning as small adjustments were difficult especially because of the resolution and what is referred to as the "exit error" [20]—as the finger is lifted from the surface the centroid of the tracked blob changes a tiny bit making it difficult to select a very specific parameter setting. All participants agreed that the tangible controls were much better for fine tuning parameters. Moreover, specific areas of the widgets could be difficult to access if multiple widgets were located on top of each other.

2. Tangibles on all widgets - When working with tangibles on all widgets there was a problem with tangibles occluding graphical elements associated with other widgets. Participants would often lift tangibles from the table to see what was underneath. In fact so much effort was used on this issue that one participant said that he had forgot to listen to the music in an effort towards reworking the system. Additionally, participants would often want to place tangibles at the same location and began to use compression as a way to fine tune the volume of each channel. Some of these issues could be solved by using smaller tangibles or having a larger control surface, but if the system was to be scaled to using for example 24 channels the problem would most likely persist. A suggestion to embed tangibles with LCD displays for visual feedback could also improve the problem with information clutter. Finally, some mentioned that it was a problem that the position of the tangible would remain fixed while rotating—perhaps a design that mechanically detaches a top part of the tangible for rotation from a fixed base combined with a heavier tangible could resolve the issue.

3. Tangibles for each effect - Most of the participants described how they normally work on each channel at a time, setting all effect parameters before carrying on to work with the next channel. This made them prefer version 2 (tangibles on all widgets) over version 3 (tangibles for each effect). In version 2 they were able to use what [20] refer to as *lateral sequential unimanualism* where two hands work sequentially on separate objects - right hand was fixed at the *function control* quickly shifting between different effects, while the left hand was used to adjust the effect that was active. A tangible for each effect demanded a lot more lifting and placing as more or less each tangible would have to be used for each channel widget (also a substantial amount of time was spent locating the effect tangible before being able to use it).

4. A Smart Tangible for each hand - Even before introducing the participants to version 4 (smart tangibles) some suggested how effects could be layered in a single tangible by stacking effect tangibles on top of each other. The smart tangible was appreciated for the naturalness and speed of adjusting the parameter. Additionally, it was emphasised that having only two tangibles to work with felt natural in the sense that you only had two hands to work with anyway. It also helped with the cluttering involved with having several tangibles take up a lot of space on the interactive surface. It was suggested that a combination of the smart tangible, the touch input, and a *function control*(as used in version 2) would be optimal. The function control could extend the functionality of the smart tangible, and the touch control could be used for setting additional features (for instance manipulating the transport controls, mute/solo or exploring channel layering similar to the approach in [1]).

5.Tangibles on all widget with no visuals - While exploring the interface without visuals a few very interesting observations were gathered. First of all, there was a very distinct difference in how the participants would concentrate on actually listening to what they were doing. There was an increased focus on the music instead of the interface (observed by them hardly looking downwards toward the table while adjusting tangible positions). Another interesting observation was that none of the participants had any problems with the cluttering problem, as it was not important for them to place the channels at exact positions. It seemed like they were more listening to each channel's relative position instead of placing them at positions they knew were optimal based on prior experience. Of course this version had no method for adjusting effect parameters which by default increases their focus on the mixing task. They all agreed that they preferred this over a traditional mixing console, suggesting that the interface should have the capability of switching to a pure mixing mode where all effects were locked and there were no visuals over a traditional mixing console.

4.1.3 Additional functionality

A lot of additional functionality was suggested by the participants. These include using an additional screen or additional region of the display for feedback on where in the track one was at a given time or for additional functionality for each effect. Suggestions also included various solutions to layer tracks in subgroups by zooming in or out, dragging functionality onto a widget such as routing tracks to different busses or improving the roughness of the surface for better touch control.

5. DISCUSSION AND CONCLUSION

The major outcome of the evaluation underlines advantages of the stage metaphor in the *mixing* situation especially due to the short distance between the mental model of the user and the conceptual model of the system. It also emphasises the importance of the TUI for direct and intuitive control. Challenges arise as the mixing interface must cater for a flexible and detailed *editing* functionality that exists for many systems that are based on the channel strip metaphor. It seems that the stage metaphor will fall short if the following challenges are not dealt with: *Clutter* - the interface should provide a way to easily locate and position the different channel widgets by for instance layering channels into sub groups—this was already an issue with 8 channels and will only increase with 24+ channels. *Incorporating the physical and the digital*—the flexibility of the digital domain does not map well to the physical domain. The use of smart tangibles deals with this challenge, however the need for a 'no-visuals' mixing mode is not supported well by the smart tangibles presented here. *Extended functionality*—the system evaluated here does not add a lot of extended functionality, but actually the stage metaphor can very well provide this, especially by incorporating a second screen.

Overall, the smart tangibles were successful in providing easy and natural access to effect parameters while adjusting position, however, there was a need for manipulating effects without moving the tangible and a need for extending the functionality of the smart tangible.

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