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# TOWARDS A PRACTICAL APPROACH TO MUSIC THEORY ON THE REACTABLE

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## ABSTRACT

This paper builds upon the existing Reactable musical platform and aims at extending and improving its approach to music theory<sup>1</sup>. Sections 1 and 2.2 explain the motivations that led to the development of this proposal from a musical point of view while also giving a music education perspective. In section 2 we'll see a brief survey on tabletop and tangible multi-user systems for audiovisual performance and we'll also briefly introduce the process of implicit learning, we'll formulate a hypothesis about music as a natural language, and describe how the work hereafter presented can help music education. In section 3 we'll describe the current state of the art about music theory on the Reactable, followed by an original proposal about a way to extend and improve it. Finally we'll see how people who had a chance to test the system found it interesting and playful, while also giving important feedback that can be used to improve many practical aspects of the implementation.

## 1. INTRODUCTION

The Reactable is a digital musical instrument with a multi user tabletop and tangible interface, designed to explore and perform experimental electronic music giving users the highest possible degree of freedom. Therefore it is a precise design choice to give it no knowledge of any form of music theory.

As the Reactable became widely known, it attracted interest from both experimental and traditional musicians, these latter complaining about the lack of a way to include “traditional” music in a performance, where “traditional” music means melodies made of notes.

In response to this, a set of objects was developed. This set includes a “sequencer” (fig. 2) that pilots waveform generators by telling them which notes of the western chromatic scale to play, and an object called “tonalizer” (fig. 1) that constrained all waveform generators to play only a

<sup>1</sup> **Disclaimer:** the results here presented reflect my personal research and opinions on the topic and, although being done in collaboration with the creators of the Reactable, they don't necessarily express the opinions and visions of the original team. Therefore all the developments I proposed are to be considered as a possible direction to be thoroughly examined, evaluated and validated through experimentation involving potential users of the system.

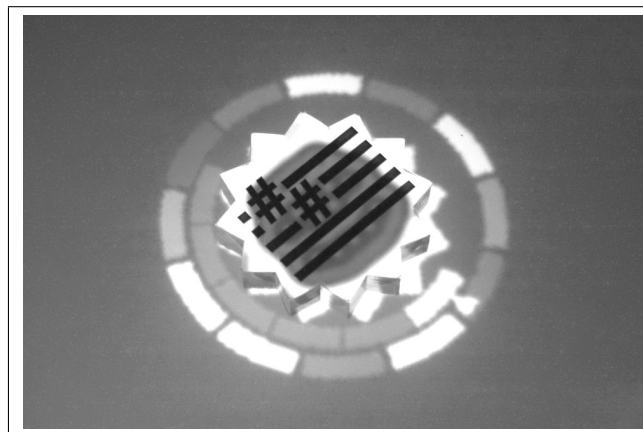


Figure 1. The current tonalizer.

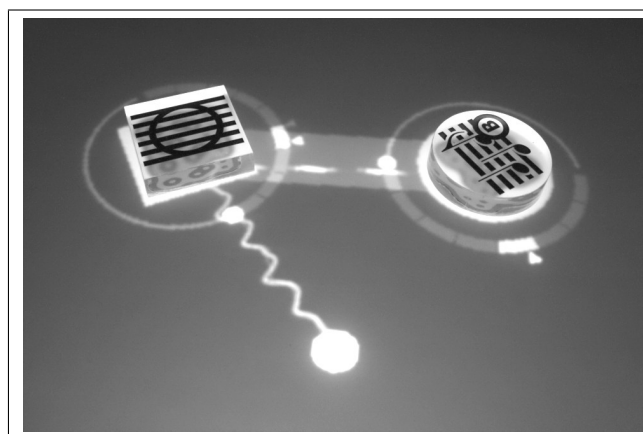


Figure 2. The current sequencer “playing” a plucked string instrument synthesizer.

limited set of pitches, from the whole chromatic scale to its subsets.

Since traditional music was not a priority for the Reactable, these two objects were developed to the minimum level of functionality. For example, melodies have to be stored in advance and can only be selected by rotating the object. On the other hand, the tonalizer allows for “live” setting of a number of presets, but it basically allows to select any note on the scale, without any form of correction or automatic suggestion, thus requiring performers to have a certain level of music knowledge. Given tonalizer's target audience, such an assumption seems reasonable, but it can have unexpected – possibly unpleasant – results when used by unexperienced performers.

In section 2.1 we'll briefly cover the history of audiovisual and tangible interfaces, starting from the first experiments in audiovisual performance, to the most recent developments in computer-based tangible and multi-touch interfaces for sound and music manipulation. Section 2.2 presents a perspective about implicit learning, arguing how music can be considered a natural language, thus the knowledge about language learning can be applied to music in a similar way. This will be the key point in claiming that the work presented in section 3 is an approach to music theory on the Reactable, and eventually an effective aid to explicitly learn abstract music theory concepts, as we shall see in section 4.2. Finally, section 4.1 will present an overview of the main results that emerged from preliminary tests with users, covering both strong and weak points that will guide the future development phases.

## 2. BACKGROUND

### 2.1 Audiovisual and Tangible interfaces

As a tabletop and tangible interface for music performance with visual feedback, the Reactable puts together ideas that date quite back in time. If we think of a visual analogous to music, probably the earliest known machinery was built in 1734 by Louis-Bertrand Castel [1]. Later examples, which appeared during the early twentieth century, were the Clavilux by Thomas Wilfred (1919), and the Lumigraph by Oskar Fischinger (1955).

In recent years computers became more and more involved in music performance and production, and a number of different programs and interfaces were developed. One interesting example is Music Mouse by Laurie Spiegel (1985), which is a software intended to turn a personal computer into a musical instrument capable of being performed live by one user. In fact it turns motion of the computer's mouse into harmony and melody patterns, thus requiring virtually no music knowledge to the user, whom in turn can entirely focus on direction of the performance. Another interesting example is Instant Music by Electronic Arts (1986), which is a software explicitly aimed at musicians to assist them in creating original music, or even support them in a live performance on other instruments. The software allows users to "draw" melodies with no apparent limit, while a background correction process ensures that no "wrong notes" are played. Once again we have a system that applies harmony rules to allow users with even limited experience to proficiently create music.

Last but not least, tabletop and tangible computing has received lots of attention in the last decade, but the concept itself can be tracked earlier in time, for example in popular science fiction. An early notable example of Tangible User Interface is the "Urban Planning Workbench" [2], but more music-oriented works exist, such as the Jam-O-Drum [3], a gaming platform for up to twelve contemporary players, and the Audiopad [4], a musical instrument that replicates a modular synthesizer using RFID-tagged pucks.

As it is common in modern translucent tabletop interfaces, the Reactable also employs multi-touch interaction, thus allowing to perform gestures with fingers, other than

with tangible objects. This makes it possible to develop interactive visuals that arguably allow to control many parameters using little space and a "familiar" interface<sup>2</sup>.

### 2.2 Music education

Implicit learning is the process through which an individual becomes sensitive to the underlying regularities of highly structured systems, like language or music. Even if such knowledge remains at a level such that one is not able to explicitly describe the rules, it influences perception and interaction with the environment [5]. The most prominent real-life example is natural language. Babies learn to speak at an early age by imitation, then later they explicitly learn why and how concatenation of some particular sounds conveys a meaningful message. More information about this topic is provided in [5] and [6].

It's been argued that the origin of music itself may be similar to that of natural languages [7]. If we think of music as a natural language then we can suppose it comes with its own set of symbols, words and sentences, all tied together by a grammar, a set of rules of a given harmony system. In this sense, each harmony system is a different natural language as much as English and Italian are. Also, generative grammar approaches have been used in musicology to analyze musical pieces [8] though the idea of a "universal grammar"<sup>3</sup> has not received much consensus while evidence of author specific, or even period specific, grammars is much more accepted.

In the hypothesis of music as a natural language, we can go further into assuming the existence of an associated transformational grammar through which it is not only possible to understand new and meaningful sentences, but also to produce them. More information about such grammars and their relationship with languages is provided in [9].

Assuming this hypothesis holds for music, we may start to see how the Reactable, with the modifications hereafter proposed, can prove<sup>4</sup> to be a valuable aid to music education. In fact, music is usually taught through teaching a musical instrument. While this is actually something a music student expects, it is also a time and resource intensive process. Moreover, empirical evidence among music instructors seems to suggest that learning a second, possibly quite different, instrument when a first one is already mastered, is usually easier. The most likely explanation seems to be that a student approaching a second instrument already knows abstract concepts of music theory, so he or she may find it easier to relate to a new instrument when already knowing what it is to be musically expected. Despite

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<sup>2</sup> Of course most of the parameters can be controlled with other tangible objects – in fact some of them are. Nonetheless some metaphores are more appropriate in some cases, for example users tend to be more used to a button other than the presence or absence of some specific tangible object when it comes to determine an on/off state of some sort.

<sup>3</sup> The term "universal" most reasonably refers to all music compositions under a single harmony system instead of a grammar that describes all the possible harmony systems, the latter being a fascinating hypothesis, though still unproven.

<sup>4</sup> It shall be clear that this is a proposal that can be taken into consideration only after the system is fully developed and evaluated, and its usability is strongly assessed. In fact such assessment requires an extensive experimentation phase involving music teachers and students on many levels, therefore the instrument is required to not pose significant difficulties that can invalidate the eventual findings.

seeming reasonable, this hypothesis merely comes from empirical observations and so far it seems it's not been formally assessed<sup>5</sup>.

### 2.2.1 The Reactable as a learning aid

As it's detailed in [6], regularities and relations between tones, scales, chords, etc, are important when it comes to implicit learning, and learning in general. This is the key point being used to argue that learning western tonal music can be optimised and improved using multimedia tools that emphasize such structures.

As we shall see in the next section, this paper's proposal can be effectively turned into such a system by integrating notions of musical structures and presenting them as an optional operating mode. In fact the system we're going to describe, together with the whole Reactable platform, is intended to be a non-intimidating, easy and playful musical instrument that can give students the ability to experience musical concepts by reducing the complexity of learning a traditional musical instrument, while leveraging on the implicit experience of music theory one may have unconsciously acquired.

It's finally worth noting that even if [6] only analyses western music theory, it can be argued that regularities and relations between other cultures' notions of musical structures exist, though they can be quite different from those existing in western music. However, if a tool is properly designed to be flexible and extendable enough, it should also be easy to adapt it to different rules, and this is one of the main goals that drove the design process we'll briefly see in the next section.

## 3. DESIGN AND IMPLEMENTATION

In section 1 we've briefly seen the current implementation of tonalizer and sequencer objects. Without further ado, let's examine the new implementation proposed in this work. While this paper only focuses on the finished proposal, an in-depth discussion of the proposal and design process that led to it can be found in [10].

### 3.1 Tonalizer

The "new" tonalizer was initially quite different from the original object, both visually and conceptually. It started as a round object surrounded by an arbitrary number of concentric rings, each divided into 12 sectors – one per tone in the chromatic scale, each tone representing a chord by its tonic. Each ring could be rotated in order to align different tones, thus allowing users to activate them by drawing a single stroke passing over each of them. This design had the potential to express progressions and transpositions, and it also could have worked as a melodic sequencer, except for the fact that it could potentially take a very large space on the Reactable. Therefore the original idea of chord slots came back and, with appropriate modifications, the design in figure 3 was eventually chosen.

<sup>5</sup> Such assessment is obviously far beyond the scope of this paper, but it can be taken into further consideration as a future development.

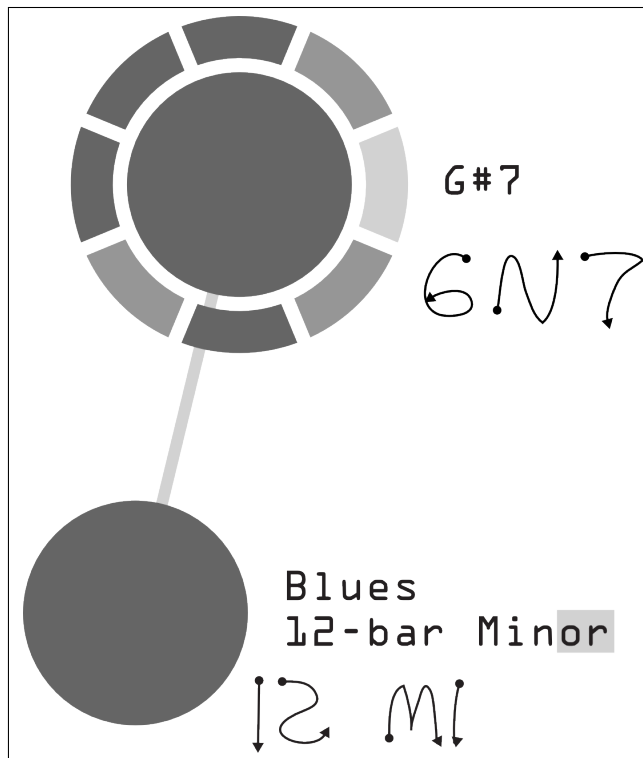


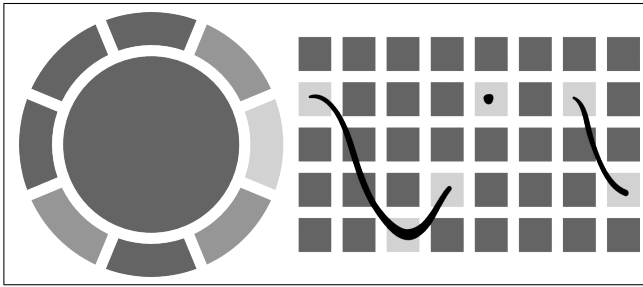
Figure 3. The new tonalizer.

The design depicted in figure 3 features the new tonalizer's most complex configuration, the simplest being only made by the top round object and its surrounding button ring. While the original tonalizer uses a similar ring to choose which notes are to be allowed, this proposal uses it as a storage for "chord presets". A chord preset is an usual chord, such as the G#7 shown in the figure. This chord is used to derive a number of scales whose notes can be played along with the chord without resulting in "unpleasant" combinations. Users may then select which scale should be used with that particular chord, and from that moment on the notes of that scale become the only playable notes by any other waveform generator. Furthermore, some sort of "progression" object – the bottom one in figure 3 – can be used to produce an entire progression of chords starting with the chosen one and following the chosen specification – in this example a 12-bar minor blues progression in G# should be selected, and eventually "played" according to an external timing source.

Last but not least, this proposal introduces the concept of handwriting recognition. This feature was introduced as a compact yet powerful way to create chord presets. As we will see in section 4, it turned out that users liked the idea, and mostly found it funny and helpful – even if the actual implementation had some glitches and didn't always work as expected.

### 3.2 Sequencer

After the "unified" design was discarded – as described in 3.1 – the idea of a piano-roll like interface was immediately considered. In fact this idea went under a number of feature additions remaining almost untouched in its visual



**Figure 4.** The new sequencer in editing mode with some gestures being performed.

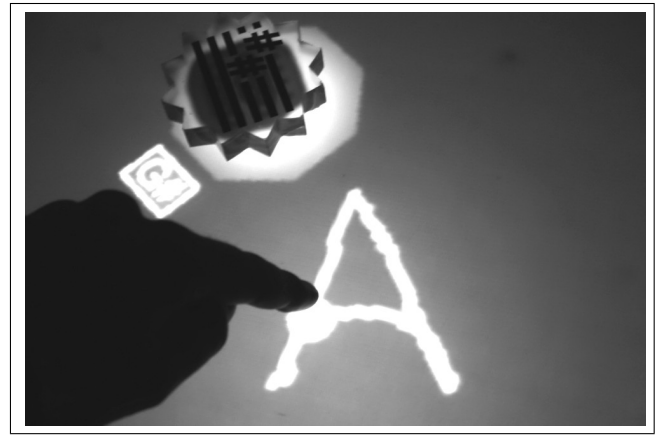
appearance.

Figure 4 depicts the proposed melodic sequencer while editing a sequence. Like the tonalizer, it has a button ring around it as a sequence preset storage. On the other hand, unlike the current sequencer, these presets can be modified on the fly during a performance, rather than being pre-loaded. This is performed using the grid that's shown in the figure. The  $x$  axis represents time, while the  $y$  axis represents the notes of the scale that's currently chosen – for example, the scale in the figure may be a major pentatonic so, assuming the chord is the one of figure 3, the notes would be  $G\#$ ,  $A\#$ ,  $B\#$ ,  $D\#$  and  $E\#$ . Strokes and taps are used to turn on and off notes in the sequence. While a simple tap results in the obvious trigger of a note, the way a stroke acts is a bit more complex. In figure 3 we see that notes are triggered on some special points, namely stroke's extremes and "zero derivative" points – where the "derivative" is considered relatively to the  $x$  axis of the grid. Arguably some other cues can be used, such as speed of the finger, but this initial set proved to be sufficient most of the times.

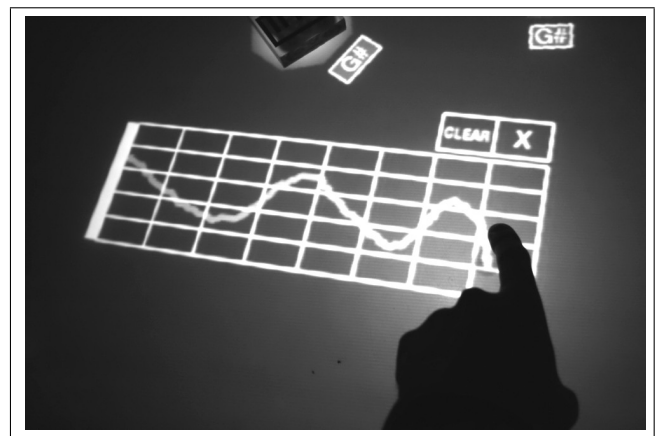
## 4. RESULTS AND FUTURE DEVELOPMENT

### 4.1 Testing and evaluation

The whole design process went through a series of iterations which subsequently integrated suggestions from people familiar with the Reactable itself and with usability and HCI topics. In addition to that, two informal sessions with users were performed. The first one involved a few people who were familiar with the Reactable and HCI topics, and it was performed using the actual Reactable hardware running a proof-of-concept implementation of this proposal. The second one has been performed with users who were mostly unaware of both the Reactable and HCI, but with a basic to high level of music knowledge. This second phase was conducted with a slightly modified version of the proof-of-concept implementation running in a simulator, since the actual hardware was not available. Both groups of people were told about the Reactable, the purpose of the system here presented and its basic concepts – such as handwriting recognition and stroke-based composition – but not how to actually perform tasks such as chord and melody creation. They were told to perform a series of tasks, from creating a chord preset to composing a simple melody, and their reactions were recorded.



**Figure 5.** The action of drawing the letter A. Since there's no edit action associated with letter A, a new A major chord is going to be created.



**Figure 6.** The piano-roll like interface with the stroke gesture used prior to analysis.

Although few data was gathered, these two phases reported mixed yet interesting results.

- Most of the people familiar with the Reactable regarded this proposal as an interesting development, mostly because of the possibility to choose a subset of notes that ensures that no mistakes are made, while also doubting that this whole renewed Tonalizer could really add some significant value to the Reactable as an instrument. On the other hand, some of those who weren't familiar enough with the Reactable didn't always get how this was an improvement at all, being just more fascinated with the original Reactable and its sound exploration freedom.
- Regarding the overall simplicity of task performance, most of the people – both familiar and not – reported that some actions weren't that obvious to perform, for example the gesture that opens the piano-roll (figure 6).
- They also reported that the reason because some slots around the tangibles were filled or empty was not really clear, although finding it reasonable when told.

This suggests that a more expressive visual feedback may be developed for greater clarity.

- Almost everyone noticed that the piano-roll didn't always work as expected. This was absolutely expected due to the unrefined implementation of the algorithms.
- Nonetheless almost everybody found the handwriting idea (figure 5) pretty interesting in perspective, even funny, although it didn't always work as expected, but this is again due to unrefined implementation.

All these observations suggest a number of practical improvements that'll be addressed in the future. For a complete review of the improvable aspects of this proposal, see [10].

#### 4.2 Future developments about different musical cultures and music education

Western tonal music, not unlike many other musical systems, features relations between chords, scales and tones. The key point that would make this proposal a valuable aid to music education is the integration of such structures into the two proposed objects. Thinking in the western tonal music framework, a Tonalizer that can communicate concepts like the circle of fifths or the relations between chords in a progression, and a Sequencer that highlights whose tones are stable, whose are passing, and whose are consonant/dissonant, would be helpful in internalizing music theory.

However, as already hinted in subsection 2.2, not all the musical systems rely on the same concepts found in western music theory. The integration and effective conveyance of these different sets of rules using the objects proposed in this paper is a challenging development that would involve an extensive study of the musical systems to be integrated, followed by the design of a proper interface that can proficiently help to understand the desired concepts.

There is a final note that's worth making about subsection 2.2. Music education is not the entire story. In fact, during the development process there had been contacts with people involved in education and assistance to people with disabilities, such as physical handicaps, or even autism and learning disorders. None of them knew about the Reactable, yet it extremely fascinated most of them as a tool to make disabled people approach music and possibly help them express themselves. Though extremely interesting, this is far beyond the scope of this work. Nonetheless, with a more developed and assessed system, further investigation may be possible.

### 5. CONCLUSIONS

In this paper we've seen how the Reactable's existing approach to pitch-based music can be extended and eventually generalized to approach music theory in a broader sense. Even if not all the possible directions and ideas have been implemented and tested, they will be addressed in the future.

The objects here presented proved to work<sup>6</sup> and people involved in informal testing sessions expressed interest in the project and provided useful feedback to start a new development phase.

An extensive formal testing and assessment phase will also be required, first during the development process, and second after the system is mature enough to start experimenting in real world music education situations.

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<sup>6</sup> An early demonstration performed on the actual Reactable hardware is available at <http://vimeo.com/4325822>.

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