# The Reactable: A Collaborative Musical Instrument for Playing and Understanding Music

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RESUMEN: El *reactable* es un instrumento musical colaborativo que tiene como base una mesa, la cual emplea una moderna interacción digital y tecnologías multitáctiles para transmitir una experiencia visual y didáctica para quienes la utilicen. El *reactable* fue concebido por un equipo de «luthiers digitales» del Grupo de Tecnología Digital de la Universidad Pompeu Fabra, que han conseguido un alto grado de reconocimiento, no solo a través de la comunidad académica, sino también del público general. Este artefacto ha ganado diversos premios, como el Prix Ars Electronica, The City of Barcelona Multimedia 2007, el Premio D&DA o el de la revista *Rolling Stone* Hottest Instrument of the Year 2007, y ha sido mostrado nacional e internacionalmente en varios programas de televisión. Desde el principio ha atraído el interés de museos de centros de ciencia, que quieren ofrecer a sus visitantes una nueva manera, interactiva, educacional y social de explorar la música. Este artículo describe, por una parte, el desarrollo del *reactable* y sus aspectos tecnológicos y, por otra, nuestra experiencia con el *reactable* en el contexto de un museo, mostrando además aplicaciones adicionales de su tecnología.

PALABRAS CLAVE: interacción musical, exploración, intuitivo, multitáctil, tangible, interactivo, didáctico.

ABSTRACT: The reactable is a table based, collaborative musical instrument, which employs modern tangible interaction and multi-touch technologies in order to convey a visual appealing and instructional experience for those who play it. The reactable has been conceived by a team of «digital luthiers» at the Music Technology Group, Pompeu Fabra University. It has attained a high degree of recognition, not only throughout the academic community, but also in the general public. It has won several international prices such as the Prix Ars Electronica, The City of Barcelona Multimedia Prize 2007, D&DA award or the *Rolling Stone* magazine's Hottest Instrument of the Year 2007, and has been featured in various television shows, nationally and internationally. From the beginning it has attracted the interest of museums and science centers, who want to offer their visitors a new, collaborative, educational and social way of exploring music. This article describes on the one hand the development of the reactable and its technological aspects and on the other hand our experience with the reactable in a museum context and shows additional applications of the technology.

KEYWORDS: music interaction, exploration, intuitive, multi-touch, tangible, collaborative, didactic.

Figure 1

## Introduction

Since its theoretical conception in 2003 the reactable (Jordà, Kaltenbrunner, Geiger and Bencina, 2005) has undergone several stages of development, implementation, testing and integration until reaching the current state as an intuitive, robust and very intriguing musical instrument as well as a successful exhibition piece in museums all over the world.[1]

## Discovering the reactable

When approaching the reactable in a museum the first visual impact is caused by the illuminated table surface, a blue background, in the middle a white, pulsating dot and several transparent blocks placed on top of it. Most people are specially drawn into it, wanting to get involved immediately without reservation.

The reactable is conceived as an exhibition that invites to explore and create music. The application itself does not give instructions about how to proceed. The first thing a user might do (and actually does, as it seems the most logical thing to do) is to take one of the objects and place them on the table interactive surface. The feedback is immediate: the object is illuminated, a line appears on the table surface connecting the object to the center and the corresponding sound emerges from the speakers. At that point the user is intrigued by the immediate feedback.

The visual line connecting the object to the center moves in accordance with the sound and the whole setup invites to explore further. What happens if I take the object away? Or, if I just go on and put more of them onto the table? If I move them, rotate them? All of these actions influence the sound and its graphical representation. The result guides the user and and helps him to understand its function in an intuitive way.

On the following pages we will describe the concepts of the reactable and how they are applied in the context of museums, science centers and educational institutions. The first part describes the roots and the history of the instrument, followed by a detailed description of its functional parts. Examples of applications specially designed for museums and science centers will be given before we come to a conclusion.

## 1. The reactable as a musical instrument

### 1.1. DESIGN GOALS

The reactable project was started in 2003 by a team of researchers (Günter Geiger, Sergi Jordà, Martin Kaltenbrunner and later Marcos Alonso) of the

[1] For a complete list of museums with a reactable, please visit our website <www.reactable.com/reactable_experience>.

Music Technology Group in the Pompeu Fabra University in Barcelona. The project did not set out from the idea of exploring musical applications on tabletop interfaces, but rather from our long experience as digital luthiers and computer music performers. The objective was to conceive the best computer-based musical instrument we could imagine (Jordà, 2003). All technological problems, such as the now widely used open-source tracking library reacTIVision (Bencina, Kaltenbrunner and Jordà, 2005; Kaltenbrunner and Bencina, 2007), were faced and solved as the project evolved: first came the decision of what to build, later the discovery of how to build it.

The foremost goal was to design an attractive, intuitive and non-intimidating instrument for multi-user electronic music performance, suitable for everyone to start playing from the first minute and yet capable of the more complex. Creating music is fun, anyhow we were not conceiving a simple sound toy, something that could become boring and predictable after a few minutes. We committed to create a challenging, complex and endless device: capable of rewarding the effort and the time spent to master it, like a traditional music instrument.

To be successfully played and mastered we aimed for a new instrument that is instantly engaging and capturing the musicians' imagination from the first minute. As we aspired to create a «right-brained» computer-based musical instrument, «non-intimidation» and «naturalness» were important aspects to consider.

In order to be able to control a complex musical instrument as the reactable, we found the multi-user interaction quite useful. Intending collaboration of various users helps controlling what easily exceeds standard human capabilities and leads to communication in order to coordinate the interaction. Additional sharing between several players seems a very logical extension.

The tapletop interface fulfills most of the previous needs combining essential aspects of acoustic instruments and adding the potentials of computer-based music tools. Concerning the first, we focused on direct, simultaneous and fine control of several parameters, ideally using both hands; concerning the second, we concentrated on the possibility to share control between the user and the instrument over simultaneous processes, and the ability to easily monitor and quickly jump between these processes. A tabletop interface could enhance control, monitoring and feedback information, and also human collaboration. With the appropriate design, it could maximise communication bandwidth in every direction between the human players and the computer, between the computer and the players, between the players themselves and, why not, between the whole system and the audience.

As a first decision we opted for a circular table design in order to promote collaboration and eliminate head positions or leading voices.

### 1.2. THE MODULAR SYNTHESIS METAPHOR

Traditional modular synthesis interfaces, as well as visual programming languages, are usually controlled by connecting cables or patch cords between the outputs and the inputs of different modules. This approach is considered extremely flexible but not very friendly. As Davies (2001) points out commenting a museum exhibition of electronic music instruments: «[…] the more controls there are on an instrument, the easier it is for someone to make a few random adjustments that result in the sound disappearing, and to be unable to reverse the process. There is little point in providing an electronic instrument in a hands-on situation unless it will always produce a sound, even if many of its capabilities are thereby excluded». And yet, we felt that by using a tangible user interface the data flow model could be quite easy to understand, despite its complexities.

In the reactable, this modular approach is achieved by relating objects on the table surface, where each object has a dedicated function for the generation, modification or control of sound.

### 1.3. TANGIBLE USER INTERFACE

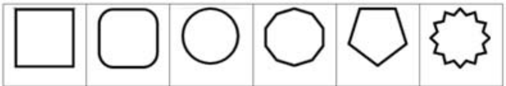
The most important difference in comparison to conventional multi-touch displays is the tangible user interface (Jordà, 2008). One cognitive problem, present in hardware-based modular synthesizers and in their virtual replicas, is caused by the overwhelming amount of modules, each one with its corresponding in-and-out holes and buttons. This problem is solved by using tangibles. Players only interact with the pucks that are used (i.e. posed on the table) at any moment.

The second interaction problem, «what to connect without going wrong», is solved in the reactable with what we call dynamic patching (Kaltenbrunner, Geiger and Jordà, 2004). Connections between the objects are managed automatically by the system without the explicit indications of the performers. This is achieved by means of a simple set of rules based on the types and affinities of the objects and on the proximity between them. As a result, only correct connections can be made.

Each reactable object represents a modular synthesizer component with a dedicated function for the generation, modification or control of sound. A simple set of rules automatically connects and disconnects these objects, according to their type and affinity and proximity with the other neighbors. The visual feedback around the physical objects bring information about their behavior, their parameters values and configuration states, while the lines that draw the connections between the objects, convey the real waveforms of the sound flow being produced or modified at each node.

*Objects*

Mainly there are four different functional object groups: generators, sound effect (audio filters), controllers and global objects. Each family is associated with a different shape and can have many different members, each with a distinct, human-readable symbol on its surface.



| Sound Generator | Audio Filter | Control Generator | Step Controller | Global Feedback | Global Control |
|---|---|---|---|---|---|
| Generator | Sound Effect | Controller | | Global Objects | |

Table 1

The square objects are sound generators, rounded squares are sound effects and the round objects are automatic controllers that can modify the primary parameters of all generators and effects. Additional object types are star shaped objects which allow to set global table parameters. The pentagon is a special sound generator that can feed back all generated sound to the system.

In order to begin playing it is necessary to place at least one sound generator on the table surface. The objects connect automatically depending on their function and distance. Placing and manipulating a simple chain of generators, filters and controls will visualize the sound and control flow between the objects, where a visual representation of the sound always travels from the sound sources towards the center of the table.

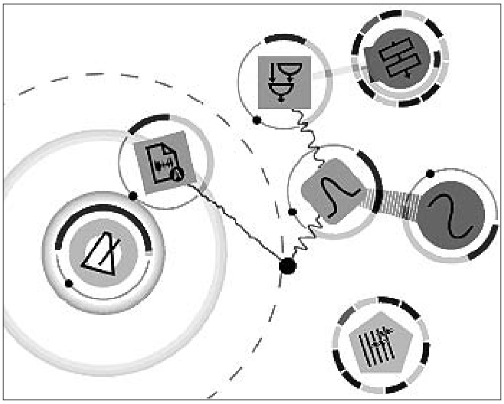


Figure 2

Each object can be controlled in various ways: its absolute position is not as important as its relative position to other objects. The relative distance to other objects decides which objects are connected to each other. The primary control of each object is its rotation. Additional important control gestures are the creation of permanent link by moving two objects towards each other and the disabling of the sound described below.

All objects have two types of symbols on each side in order to identify their individual function. The organic amoeba symbol helps the instrument to identify and localize each object on the table through a computer vision system (figure 3). Therefore it is necessary to place all objects with this symbol facing downwards to allow the system to identify each object correctly. The second symbol on the upper side shows the player the exact function of each object.

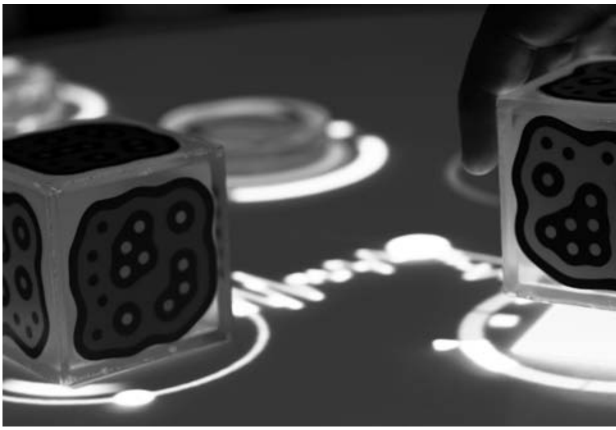


Figure 3

*Visual feedback and control*

As visual feedback plays an important role, we followed three important visual design guidelines to permit control: display all information in a simple and immediate way, to not show irrelevant information and achieve this without textual or numerical information.

As a result, only lines, dots, colors or graphical proportions evolving in time are projected on the reactable surface. The audio lines that connect the objects show the real resulting waveforms; control connections indicate the density and intensity of the values they transport; animated heartbeats reproduce the precise rates at which some «slower» objects pulsate (the ones, such as low frequency oscillators or metronomes, which vibrate at visible rates); the graphical auras around the physical objects convey all the information about the objects' state, configuration, instant parameter values, suggesting as well the interaction possibilities they afford.

The reactable objects are synthesizer modules, each with its own control parameters, so moving them on a two-dimensional surface seemed not sufficient for fully controlling them. As a result, all reactable objects can also be spun which is also reflected by a visual feedback. The area around the

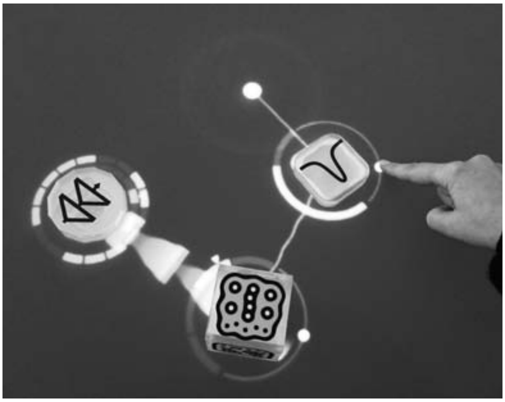


Figure 4

objects are reserved to modify the objects' parameter capturing multi-touch finger interaction (figure 4). On the right side of each object the parameter can be controlled with a fingertip. The left side of each object is a display for the primary object parameter, so any finger gesture does not have any influence on this side. Pushing the data flow metaphor in the more natural ways, fingers can also be employed for muting or temporarily intercepting and blocking audio connections. Visual feedback is again essential in all these cases: muted connections are represented by straight dotted lines; circular fuel gauges or discrete buttons and steps, surround many of the objects, indicating their rotational values and the possibility to click or drag with the fingers on several areas.

### 1.4. INTERACTING WITH THE REACTABLE

Since its first presentation at the Audio Engineering Society Conference in Barcelona on May 2005, the reactable has undergone a very active life outside of the laboratory. It has been exhibited in more than 100 occasions in 30 countries, where it has been played by dozens of thousands users,

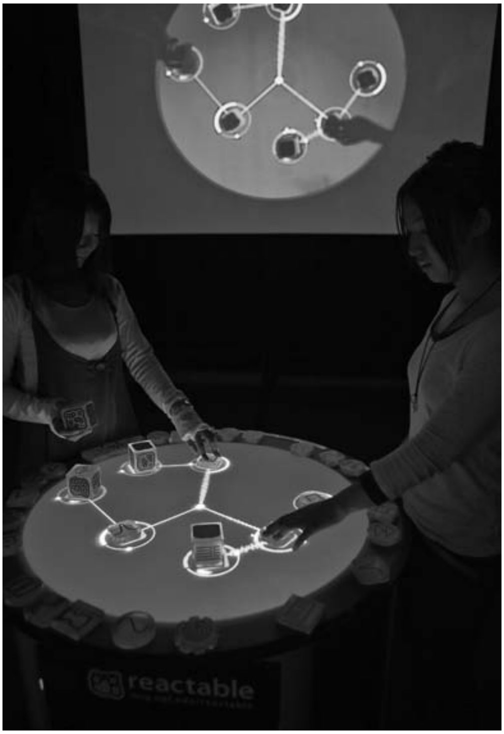



Figure 5

of all ages and different backgrounds (musicians, computer music and computer graphic experts; electronic music, digital art or fans of computer games; teenagers, families with children, etc.).

While we have not undertaken any serious user studies, feedback has always been very positive, often even passionate, showing that the reactable can be very much enjoyed even without being fully understood. We have estimated that interested people start grasping its basic principles after 10 or 15 min of completely unguided and joyful interaction. Users who spend more than 10 min often become «addicted», and come back again many times, trying to find the special moments in which the installation is empty or at least less crowded.

In parallel to these public installations, the reactable has been featured in concerts all over Europe, America and Asia, being performed both by its creator team, and since April 2007, integrated in Björk's Volta world tour 2007-2008, played by the musician and producer Damian Taylor. The instrument is used quite differently in Björk's tour and in our own concerts. Damian Taylor uses the reactable to play specific songs with quite predetermined parts, which although open to some improvisation, have to fit within the rest of the band sound and timing. Our concerts are much more open, often completely improvised, and the reactable, played by one to four musicians, is habitually the only instrument on stage. The stylistic range can also vary, depending on the venue, from strongly beat-oriented techno, to more experimental electronic music. These extremely demanding situations have certainly helped turning it into a fully mature musical instrument, a fact that is not incompatible with its continual design process refinement and evolution.

The reactable was not the first musical tabletop. Before starting the project we were indeed influenced by Patten, Recht and Ishii's (2002) Audiopad. But nowadays, the spread of the reactable ideas together with the availability of the open-source reacTIVision software (Kaltenbrunner and Bencina, 2007) for the visual tracking of objects on a table surface, have boosted the development of related music tables, some mere reactable clones, but with many others bringing fresh and exciting ideas to the field (e.g. Bischof *et al.*, 2008).

## 2. Reactable usage scenarios and configuration

The reactable, being a very complete and potentially complex instrument, offers a wide variety of configuration options, most of them just as easily to setup as the rest of the reactable. In order to make the reactable suitable for complete novices or children it is only necessary to select the appropriate objects and make only part of the set available in an installation. This way the exhibition itself can be adapted to different needs. In the following we will describe some of the usage scenarios — others can be attained by further configuring the reactable through custom samples and melodies.

Another important topic when using the reactable as an exhibition is visitor flow. Of course it is positive to have a popular exhibition, but on the other hand it is also important to keep the visitor flow going. It is not predefined how long the reactable can be played by each visitor, so it might easily happened that the exhibition gets blocked by users who get absorbed, forgetting space and time. For this case the reactable offers a timeout, which will turn off the interactive part and tell the user to put the objects on the border of the table. As soon as there are no objects on the table left, the screen changes and suggests to put objects back on the table in order to start.

### 2.1. MUSIC EDUCATION AND MUSIC

When we say the reactable is able to teach music, we are not referring to knowing how to read musical notation and not even to learning how to play an instrument. Learning a language is not mainly about reading and writing, but about expressing, listening and understanding. The same is valid for music, especially nowadays, where the tools for creating music are a lot easier to get hold of and creating music is not restricted to those who are able to play an instrument. The reactable shows how music is generated and treated in computers, it teaches what modern musicians know about music, without having to learn an instrument. Playing the reactable is more about musical creativity than playing an instrument, as the mechanical training is not necessary anymore.

### 2.2. GENERATING SOUND

As mentioned above, the reactable is based on the principles of modular synthesis. Therefore, it is also a perfect tool for showing just these principles to the visitor. Is there a better way to learn about sound than getting involved and trying to generate different types of sounds yourself? The visitor learns what the basic waveforms for synthesis are, how they sound, and also how filters can be used in order to change the quality of sound. Basic principles of synthesizer can be taught by showing the effects of changing the frequencies of sound generators and filters. Knowledge about sound generation is part of modern music just as knowledge about traditional instruments has been part of music during the past centuries.

| Cubes | Side 1 | Side 2 | Side 3 | Side 4 |
|---|---|---|---|---|
| Cube 1: Hip Hop | Drums | Bass | Harmony | Lead Synth |
| Cube 2: Classic | Bolero Drums 1 | Bolero Drums 2 | Bolero Harmony | Bolero Melody |
| Cube 3: Jazz | Drums | Bass | Piano | Voices, Effects |
| Cube 4: Blues | Drums | Bass | Piano | Instruments |

Table 2

### 2.3. Sampling and mixing

Another aspect of musical education is imparting knowledge about different music genres and origins. The reactable can be configured with a specific sound sets, which allows the user to play and manipulate sound samples from different genres, Hip Hop, Classic, Jazz and Blues. The harmonic and melodic progression for these samples is not predefined, so the user can improvise and experiment with these samples, create a Blues track with different harmonic parts, or even mix different styles, like incorporating Classic samples (in the following example Raval's Bolero) into a Hip Hop track or play Hip Hop drums over a Jazz bass.

This setup only requires the four cube-shaped objects. The cubes are an integral part of the object set and are usually preloaded with melodies and loops. The above described setup can be complemented with some effects like the delay. For a more advanced version, Sample Synthesizer modules can be added, which would be used in order to improvise over a given rhythmic base.

## 3. Reactable hardware and technologies

The reactable consists of a round table with a luminous surface. The table is 90 cm high and has a diameter of 95 cm. The whole structure consists of a robust aluminum frame closed with resistant plastic panels. It has a door that makes it possible to access the reactable electronic components installed inside the table. The table top is a special Plexiglas disc, specifically designed for the reactable to combine good object detection capabilities and a high quality back-projection image.

The electronic part of the reactable consists of a projector–mirror system which is connected to the video output of a computer. The objects and touch gestures are recognized by a computer vision system which uses a camera that is also positioned under the table. Positioning the electronic components under the table has the advantage that there is no occlusion or shadows as they would occur with top projected system.


Figure 6

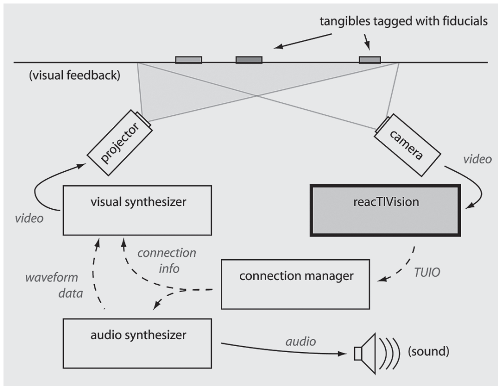



Figure 7

### 3.1. Other usage scenarios

The object and finger tracking technology used in the reactable can be applied to various other applications, where several users can interact at the same time. Specifically the object recognition is a field which lends itself to several interesting uses.

One of these uses could be the display of additional data or descriptions coupled to generic objects on display in an exhibition. In this case the objects would have tags on them which can be read by the reactable computer vision component (reacTIVision). As soon as the user puts the object on the table it gets recognized by this tag, and additional information regarding the object can be displayed on the screen.

## Conclusions

We described the reactable as a interactive installation used in public spaces. The reactable was conceived as a musical instrument, but because of its distinctive features it fits perfectly into the context of museums and science centers. It emphasizes on interaction, and is specially attractive to a young audience. The reactable is collaborative, it is easy to learn and highly configurable. It is fun to play and at the same time teaches concepts of music and sound generation. Although the reactable is a high-tech product, the technology used in the reactable invites the user to touch, play and participate. It is non intrusive but it still creates a truly fascinating experience for the user.

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