# Flag beat

*A novel interface for rhythmic musical expression for kids*

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# Flag beat: a novel interface for rhythmic musical expression for kids

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## ABSTRACT

This paper describes the development of a prototype of a sonic toy for pre-scholar kids. The device, which is a modified version of a football ratchet, is based on the spinning gesture and it allows to experience four different types of auditory feedback. These algorithms let a kid play with music rhythm, generate a continuous sound feedback and control the pitch of a piece of music. An evaluation test of the device has been performed with fourteen kids in a kindergarten. Results and observations showed that kids preferred the algorithms based on the exploration of the music rhythm and on pitch shifting.

## Keywords

Sonic toy, children, auditory feedback.

## 1. INTRODUCTION

In the last two decades researchers and designers have increasingly explored the role of novel musical instruments, tangible interfaces [13, 11] and sonic toys for children. Academic or Industrial projects developed a considerable amount of devices, which go from simplified reproductions of musical instruments to elaborated and multimodal sonic toys[1]. An important contribution in this field is given by Toy Symphony[9], an international music performance and education project led by Tod Machover at MIT Media Lab. As a matter of fact, in this project many innovative interfaces have been developed, such as Beatbugs, which is a network of eight hand-held percussion instruments, or Music Shapers [15], squeezable instruments that give the possibility to a player to transform and explore prepared musical material and compositions, or Hyperscore, which is a graphical composition software that allows children to create musical structures by drawing on a device. Another interesting example of a musical interface is PebbleBox [10], where the sound is a product of a continuous interaction between the hands of a user and the manipulated auditory feedback obtained by moving people inside a box. By considering the above mentioned devices, which are just few of the total amount present in the market, it can be observed that some of them are collaborative and rhythmic, others are gesture based. Unfortunately, in the majority of the cases the interfaces developed for kids use pre-recorded low quality sound samples, which are triggered through the gesture of pushing a button. Thus, they suffer of poor interactivity and annoying sonic feedback. In this paper we are interested in exploring the possibility of building devices for kids where the interaction happens in the same way as with everyday objects [4]. This yields the possibility to develop interfaces in which the information is given through different sensory channels and thus, enhancing an enactive approach [6] of learning. Therefore, it has been chosen to develop a sonic toy in which classical trigger techniques of sound production are combined with continuous and non-continuous interaction and expressive sonic feedback.

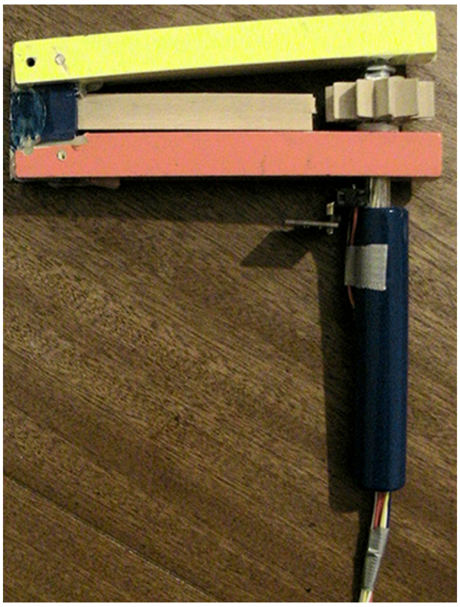

**Figure 1: Flag Beat Tangible Interface**

## 2. INTERFACE

The main purpose is to develop a sonic toy that plays sounds and rhythmic patterns and provides children a funny and enjoyable first contact with music. Moreover, the toy we aimed to implement must have continuous (and non) interaction, expressive auditory feedback, and be suitable for kids.

Studies from the Interaction Design field suggest that an ideal device for continuous control [14] is the handle. Therefore, three devices inspired us for the design of our sonic toy, specifically a ratchet, a prayer wheels and a danish flag. These objects are interesting because they are all built it with a handle, which produces the gesture of spinning or

[1]An accurate list of tangible interfaces can be found at this link: `modin.yuri.at/tangibles/`


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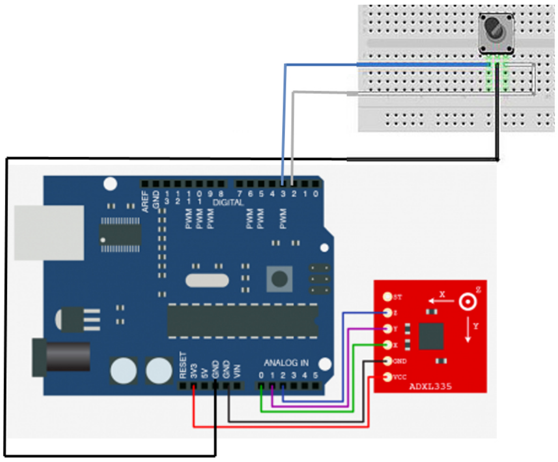

**Figure 2: Scheme of sensors' connection**

waving, which is an interesting gesture for kids.

An essential characteristic for our device was to be based on an enactive approach (learn by doing) and it must provides expressive sonic feedback. In order to achieve this goal we decided for the first prototype to develop several audio feedback algorithms controlled by the same gesture which is spinning.

We decided to implement an interface focused on the exploration of some basic rhythmic patterns, seeing the fact that development of temporal structure of music has suggestive parallels in human motor development confirmed also by previous studies of audio-haptic interaction [12].

## 2.1 Target group

The target chosen for our device is ranged from three up to five years old. Kids of these ages are inside both the pre-scholar phase and pre-operational stage [8] where kids start learning language. The inferior limit of three years old has been chosen because kids in this age can manage the device easier than when they are two years old due to body dimension. Moreover, they have already started to develop some basic auditory skills [3]. The limit of 5 years old has been chosen because it is the limit for the pre-scholar age. As a matter of fact, at six years old some kids start playing a musical instrument thanks to the pressure of their parents. Our main goal is to introduce the toy in a phase where kids are growing and where they have not received yet any kind of formal musical education yet and they can naturally fall in love with music.

## 2.2 Hardware design

A rotary encoder (COM 10596), and an accelerometer (ADXL 335) were embedded in a an original ratchet. The rotary encoder was placed inside the gearwheel of the ratchet with the functionality of mapping the position of the stiff board. The accelerometer instead, was placed outside the handle and attached to its top part. It mapped the placement of the handle of the device in respect to the centre of the earth. The data acquisition (DAQ) from both sensors was done with Arduino Duemilanove.

The final device is shown in Figure 1.

# 3. AUDITORY FEEDBACK

Four different kinds of auditory feedback were implemented, which are described in the following subsections.

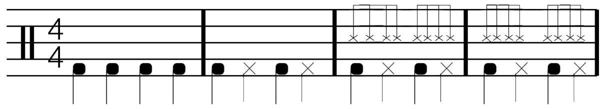

**Figure 3: Rhythmic Patterns - Drum machine algorithm**

## 3.1 Drum machine

The main purpose for this algorithm is to give the possibility to kids to explore the rhythm of the music by using the device. Thus, we mapped every two turns[2] of spinning of the device with a drumbeat. In this way by spinning the device fast kids can explore a high tempo and when they are spinning slow a different tempo is immediately produced. Musically speaking we designed 4 bars patterns. In the first and second one we put a crotchet note every beat (two turns), while in the last two bars we introduce also quavers note, as shown in Figure 3. Moreover, in the first bar appears only one kind of sound that could be a drum kick sample or also an everyday sound. In the second one we introduced another sound to the first and in the last two we have a total of three sounds used per time. The main principle is to build a system formed by level in which more you play more you discover. Concluding, we design the algorithm to play two basic rhythms.

## 3.2 Smash the piano

With this algorithm we introduced the concept of music rhythm in a different way. As for the drum machine, the algorithm every two turns creates a beat. The main difference is that this time the beat trigger a chord of a famous song: Let it be, by The Beatles. Thus, the kid by playing with the toy should be able to play the entire song.

## 3.3 Continuous interaction

Continuous interaction algorithm is based on physics-based model sound synthesis, specifically maracas sounds using particle models [2].

## 3.4 Chumpkin

This algorithm is a real time pitch shifting of a piece of pre-recorded music for danish children. The faster the kid rotates the device the higher is the pitch of the song. With this algorithm we just wanted to understand if the kid is interested in controlling a common parameter, which is the pitch, with the gesture of spinning.

The algorithms are very different from each other. Some of them explore the rhythm of music while others explore different characteristics of the sound and music world. The choice of designing many and different algorithms it has been done in order to make more observations during the test phase.

# 4. DEVICE EVALUATION

The goal of the evaluation was to understand if it is possible to use a non-traditional instrument to give notion of rhythms. Moreover, we wanted to investigate if kids were more attracted by the use of a sonic toy to control a continuous sound feedback or if they preferred more traditional auditory feedback. We tried to determine the quality of the prototype as well as the quality of each sound algorithm

[2]In fact, if we mapped every turn with a beat we would have a minimum tempo of 240Bpm while for faster spinning we could have also 350Bpm, which is quite insane and useless for children to play.

**Figure 4: Kids during the final evaluation of the device**

implemented into the device. This has been done by letting each kid play through all the sound algorithms of the sonic toys. This test was based on general observations combined with some answers given by kids to simple questions. A total of fourteen children took part to this test session, divided as follows: three kids were three years old, eight kids were four years old, three kids were five years old. In total, there were 10 boys and 4 girls. All the children had normal hearing as well as normal motor ability. No one of the participant was forced to play with the toy. For this reason during the test section some of them just watched the others playing with the toy without participating to the test.

## 4.1 Procedure

We designed a test in which we focused on personal observations and analysis of the behaviour of children with regard to the gesture, the use of the device and how much they enjoyed the sounds feedback yielded by different algorithms. The procedure was divided in four main sessions.

1. Set-up and Planning. All the equipment necessary for the test was positioned inside a room of the chosen kindergarten[3] in an effectively and unobtrusively way. Moreover, the playing of the various algorithms was done in randomized order around different children so that the same algorithm was not always coming at the end of the test when children were tired. Switching between algorithms was performed by using an Apple remote controller.

2. Introduction. Thanks to a danish facilitator, we first established a relationship with children by engaging them in some small talk to find out more about one another. This was the icebreaker time seeing the fact that younger or shyer children might be uncomfortable alone with the tester [5].

3. The actual test. Preschool-aged children usually may need a little warm-up with the device that has to be test [1]. For this reason children at the beginning of the test were warmed up and guided by the facilitator, who showed briefly how to handle and use the device. This has been done by asking the children question such as: Can you hold the toy as I did? and, Are you good as me in spinning?. This task gave us also some indication of their competence with the handle of the device.

4. End of the test. In order to understand which sounds algorithm was preferred between the four ones and also to have some feedback about the design of the sonic toy, some specific questions were asked, which are:

   - Which sound did you like more?
   - What was your favourite sound?
   - Was the toy heavy?
   - Was difficult to spin the device?

[3]The kindergarten was Ungdomsgårdens Børnehave - Smørumvej 197, 2700 Brønshøj

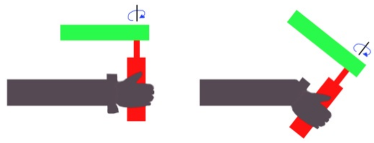

**Figure 5: In the right part of figure it is represented the best position for spinning the device. In the left part the one adopted by kids during the use of the tangible interface.**

# 5. OSERVATIONS AND RESULTS

Starting with the observations for the tangible interface, what was interesting is that many of the kids had troubles figuring out how to handle the sonic toy. The main problem was that the toy was too heavy and so they were not able to hold it in the vertical position. This situation is illustrated in Figure 5. Another important observation is that kids were tired after few minutes of spinning. This of course was due to the weight of the device but also could be due to the use of the spinning gesture, which is not common in our everyday life. Moreover, the cable used for the connection between computer and device limited the exploration and the use of the device.

Beside these design problems, all the kids where quite concentrated in playing the sonic toy and they kept on using it till when either they got how it works or were tired. Concerning the sound algorithms implemented, the majority of children enjoyed playing the drum machine algorithm. When playing that algorithm they were able to keep a certain rhythm, dependent on the speed of spinning. Some of them span the toy fast and others slow. However, almost all the kids could play the algorithm till the end of all the four bars. Only the three years old ones did not succeed. It was interesting to observe that while someone was playing with the device others were almost dancing or shaking in synch the head with the beat and showing a certain involvement in the performance. Moreover, one of the five years old kids while playing this algorithm improvised a rap piece. He was trying to synchronize some rhymes with the beat of the sonic toy, figuring out a new and possible use. With smash the piano algorithm none of the kids has showed some interest in playing it. Furthermore, they could not go through all the songs because they stopped playing before the end. Actually, there is a problem about this algorithm that we faced during the test phase. Unfortunately the algorithm was based on MIDI output and thus the volume was not that high compared to the other algorithms. This for sure spoiled the performance. Concerning the continuous interaction algorithm, none of the kids enjoyed it. They all found the auditory feedback given by the spinning of the sonic toy

| 3 Years Old | 4 Years Old | 5 Years Old |
|---|---|---|
| Lots of difficulties in holding the device | Difficulties in handling | No difficulties in holding the device |
| Not able to spin the device | Spinning easy but was not regular | Spinning was perfect and regular. |
| Null speed of spinning | Slow and not regular spinning speed | Slow and fast spinning speed |

**Figure 6: Observations done by age**

quite boring. However, we could observe that the spinning of the device with this algorithm resulted easier compared to the other algorithms seeing the fact that none of the kids had problem in spinning or making sound with that. They were more concentrated in performing the action instead of paying attention to the auditory feedback yielded by the device.

We can assert that children did not like the algorithm because it was not that rich of variables that they could control but the main point is that the action of spinning was obtained from all the targets. This led us to think that the continuous interaction algorithm was not enjoyable but was at least helpful if we consider the motor aspect of the device. The last algorithm in exam was the chumpkin and it had an unexpected result. As a matter of fact, the first kid that tried the system was quite excited and started laughing a lot. At the same time, all the children inside the room started laughing as well, and this might biased and influenced the test sections. As known in children psychology [7], kids grow up and start learning by imitating actions made by adults or other children. Thus, if the first kid showed to love the playing with the tangible interface with a specific algorithm also the others younger will probably think and act in the same way. For this reason we believe that this result is not clear as for the other algorithms. We could also observe how the kids interact differently with the device due to their age. We could trace and summarize those behaviors in a simple table shown in Figure 6.

## 6. CONCLUSION AND FUTURE WORKS

In this paper we presented a work in progress tangible toy, which aims at using kids ability to learn musical skills. What appeared by observing and analyzing kids while playing with the prototype that we built was that among four different auditory feedback algorithms they preferred the one based on the exploration of the music rhythm and the one based on the pitch shifting. Moreover, as we could observe the algorithm based on continuous feedback helped more the coordination between body movements and gesture to be done with the device. This is very important because with further improvements a sound designer can figure out new ways of sound production in toys increasing the multimodal experience that can be done with enactive interfaces. Future works must be done in the sound synthesis direction. The results of the evaluation with kids provided us with suggestions for a new prototype, which should include different auditory feedback, and a lighter and wireless data acquisition system.

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