Playful Interaction: Designing and Evaluating a Tangible Rhythmic Musical Interface

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Abstract.

In this paper we introduce the Drum Duino, a type of tangible actuated musical instrument. The Drum Duino allows fun, playful interaction for children to compose and explore rhythms played on different objects, inspired by traditional methods of play, while emphasizing collaborative participation. We present an iterative research through design approach and evaluation with 10 preadolescents using the co-discovery method. Our results highlight the benefits of tangible interfaces such as collaboration and low thresholds of interaction and exploration.

Keywords: Tangible user interfaces; sound creation; drum patterns; Arduino.

1 Introduction

Non-traditional musical interfaces have gained much attention as a way to allow fun and playful musical interaction beyond the desktop. Additionally, advances in DIY hardware prototyping (e.g. laser-cutting, 3D printing and electronics platforms such as Arduino) are simplifying the design and development of such physical interfaces. Furthermore, these physical interfaces are enabling new creative forms of education and interaction. Combined, these tangible interfaces may create new opportunities for teaching abstract concepts due to its benefits it offers in sensory engagement, increased accessibility, and group use (Zuckerman, Arida, and Resnick 2005). Another benefit of tangible interfaces, according to Xie et al. (2008), is their ability to facilitate increased interaction and concurrent use, whereas in a traditional desktop interface context, active use is often restricted to one person.

The benefits of tangible interaction is also noted by Antle et al. (2009), concluding that a tangible based approach is more successful and faster than the mouse based variant when solving puzzles. These results argue for increased use and exploration of tangible tools for fun, play and learning.

With this paper we explore a musical instrument that is related to what Overholt, Berdahl and Hamilton (2011) has coined actuated musical instruments: *physical instruments that have been endowed with virtual qualities controlled by a computer in real-time but which are nevertheless tangible*.

While Overholt et al. (2011) emphasizes equipping traditional instruments (i.e.: a violin, or piano) with additional abilities, we emphasize the use of everyday surfaces or objects as musical instruments. This principle is recalled by composer Tod Machover (2007) as looking for *household objects that make interesting sounds, that could in turn be combined to create new textures, emotions and narratives.*

The rest of this paper is structured as follows: in section two we describe the Drum Duino. Following this, we present similar work. Section four focuses on the method used to test the system. Finally, we report on the results, discussion and outlook.

2 System Description and Development

A distinguishing attribute of the Drum Duino is that it does not generate sound through digital sound synthesis, but through physical impact of a push rod, actuated by a solenoid, with another surface or object. The speed and rhythm of the solenoid's pulse can be changed via a circular control panel that mimics the visual language of a Djembe drum. A potentiometer in the centre of the control panel will allow changes in speed, while rhythm can be changed by adjusting the flaps situated around the control panel. Adjusting the flaps (up or down) changes the pattern that controls the rhythm of the pushrod against the surface.

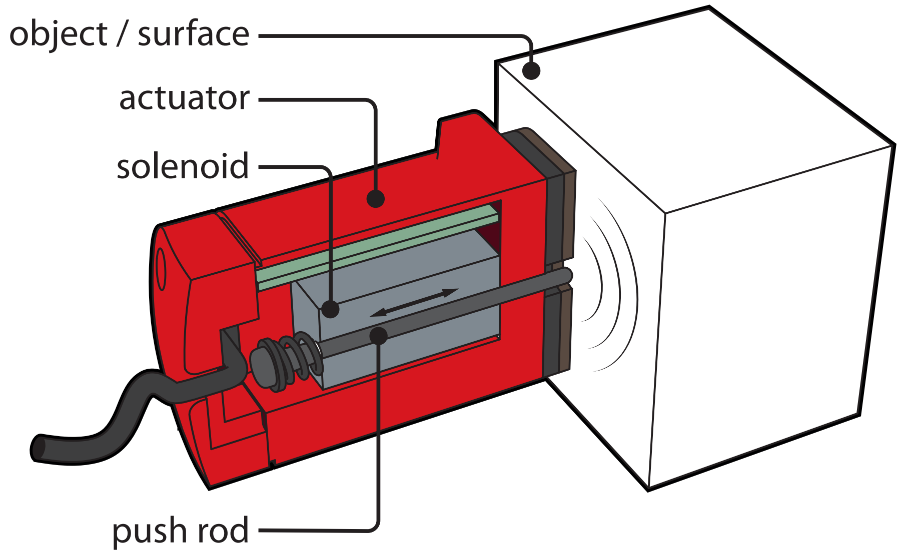

Fig. 1. Overview of the actuator, pushrod and solenoid

Actuators are colour coded (red, green and blue), and the control panel also allows storing a flap-pattern to a particular actuator via an associated button. For example, if all flaps are down, and the red button is pressed, the red actuator will play no pattern. Respectively, if only flap 4 is down, and the blue button is pressed, the blue actuator will skip the 4^{th} tap. The control panel remembers the pattern for each actuator; changing the red pattern does not impact the blue or green sequence. As such, combining different actuators with different materials allows different rhythms to be played. The rhythms are repeated indefinitely as long as the Drum Duino is turned on. The interaction with the Drum Duino is very similar with methods of sound creation that many people will recall from their childhood: the banging of fingers, rods or batons against hard surfaces to generate rhythmic sound.

The current design of the Drum Duino was inspired by two earlier iterations that followed the same basic premise, as described by Saldien and De Ville (2013). The design was an improvement, based on the feedback and results of informal tests at the TEI 2013 Works in Progress. The result of these changes is a simplified and more robust device, which was used in an evaluation with preadolescents presented in this paper. As the design of the Drum Duino progressed, our manufacturing techniques evolved from relying solely on manual tools to incorporating digital fabrication to a large extent. The reason for this evolution is twofold. Firstly, manual tools offer a great deal of flexibility in the front end of the design process: they allow quick modifications based on input from early, informal user tests. As the design of the Drum Duino matured, we gradually moved toward digital fabrication techniques such as laser-cutting and 3D printing. These techniques can create more robust, better functioning, and better-looking parts, but require that more time be spent on CAD design. Though, the biggest advantage of digital fabrication techniques in our situation is the speed at which complex components, such as the actuator housing, can be reproduced. We intend to continue this trend in future Drum Duino prototypes by moving toward a modular kit where users are not limited in number of channels or in the length of the beat patterns.

Fig. 2. Moving the flaps on the Drum Duino control panel with all three actuators in view

3 Related Work

The Drum Duino is based on the premise of physical sound generation, rather than sound control or synthesis, and builds on the principle of equipping instruments with computerized components to allow alternative ways of sound generation that is not synthesized.

This is a departure from novel tangible devices such as Block Jam (Newton-dunn and Gib 2003), that produce digital sound by combining, or manipulating physical artefacts to generate or manipulate digital sound. Similarly the Radio Baton (Mathews 1991) uses two batons containing radio transmitters, allowing x, y and z coordinates to be synthesized into music notes to generate music, when tapping or moving the batons across a square. Commercially, the FirstAct electronic drumstick (Small and Izen 2011) is an instrument that simulates drumming sounds when tapping the drumstick against any surface, while Sounds Pegs (Brennan 2013) also turns everyday objects into sources of synthesized music. O'Modhrain and Essl (2004) translate the properties of sand and grain into sound, by combining bags with sand, cereal or Styrofoam with a microphone.

These examples can be contrasted with actuated instruments (Overholt, Berdahl, and Hamilton 2011) such as the Overtone (Overholt 2005), an augmented violin, or the Haptic Drum (Holland et al. 2010), where the frequency of hitting the drum can be increased. In these projects, the emphasis is physical sound generation with traditional instruments.

However, the Drum Duino remains different from both tangible musical interfaces and actuated instruments in two respects. Firstly, it does not digitally synthesize sound and secondly, it allows everyday surfaces and objects to be transformed into sources of music, thus departing from traditional instruments such as drums. In this, it is most similar to DrumTop (Troyer 2012). This device allows the player to put down objects on a table-like surface. Pushing down objects in certain rhythm allows patterns to be recorded. Objects are tapped physically to generate sound. The DrumTop is limited to the size of the objects that can be placed on its surface.

These examples show the possibility of (digital) sound generation with everyday objects, but also the possibilities of augmenting existing instruments to change interaction with music.

4 Method

As stated, the goal of the Drum Duino was to allow fun and playful interaction for children to compose and explore rhythms together, inspired by traditional methods of play, with a low threshold of use, while emphasizing collaborative participation.

In order to evaluate this, we used the co-discovery method, also known as constructive interaction (Kemp and van Gelderen 1996; Als, Jensen, and Skov 2005). According to Kemp and van Gelderen (1996), it is specifically useful to understand experiences and impressions of new products, noting its usefulness in exploring novel artefacts. Using this method, children interact together with the product. Researchers evaluate with questions about use and experience, while observations during co-discovery are also a valuable source of insights. Although Van Kesteren et al. (2003) note that co-discovery results in less verbal comments, when compared with related methods such as think aloud protocols or peer tutoring, Als et al. (2005) found no significant difference between think aloud protocols and co-discovery. However, they stress the benefit of co-discovery since children may have trouble following instructions for a think aloud test. Furthermore, co-discovery has been used in similar projects where the usability of non-desktop based interfaces were evaluated, including a tangible interface for child story telling (Cassell and Ryokai 2001), and tools for children to program physical interactive environments (Montemayor et al. 2002). Given this, we chose to use co-discovery as our evaluation method.

Fig. 3. Setting up the Drum Duino together with two participants

Preadolescents were recruited through a technology hobby club for children. Following the recommendations of Van Kesteren et al. (2003), we formed 5 pairs of two children. Participants were socially acquainted through regular attendance of the hobby club and were aged between 8 and 11. Five males and five females took part.

Initially, we demonstrated how the actuators and flaps can be used to trigger sounds and rhythm. Following this, children were handed the actuator and allowed to interact freely with the Drum Duino. The only instruction given was “To create a rhythm”. The children’s interactions were recorded using a camera for later analysis. After being given 10 minutes of free exploration, we started posing some general questions about their experience with the Drum Duino. While we aimed to evaluate the Drum Duino as a device for fun exploration of music, rhythms and materials, our focus for this paper is also to explore the benefits of tangible interfaces (accessible, conducive to group learning and sensory engagement) as described by Zuckerman et al. (2005).

5 Results

After our demonstration of the Drum Duino, children started a 10-minute free exploration session. This involved turning up the speed, moving the flaps up and down or putting the actuators to the ear as a way to understand the source of the sounds. Additionally, they were asked to associate certain rhythms with familiar sounds (jackhammer), or creating a ticking clock.

The actuators captivated the attention more than the control panel. The groups all explored the various sounds that could be made with the Drum Duino, through variation of objects, ranging between metal tubes, glass bottles, the table surface or other household objects such as tin cans. A preference was given to loud surfaces. Combinations were also tried: placing the actuator against a block of wood attached to a piece of metal as opposed to a block of wood alone.

While we anticipated children strapping the actuators to various surfaces and then adapting the rhythm by moving the flaps, children preferred much more to hold the actuators against particular materials as a way of exploring sounds and rhythms. This further enforces the exploratory nature of the actuators: they can be quickly attached to any surface to generate sound. Only after many surfaces and objects were inspected did participants turn to changing the rhythm and playing more complex patterns.

Notable enthusiasm for the Drum Duino was due its ability to *turn everything into music* as a participant in the second group remarked. When asked whether they would classify the sounds as music all the groups agreed, although with differing levels of confidence: *it would be hard to make music, but with enough practice, it should be possible.*

6 Discussion

Following the remarks of Zuckerman et al. (2005), we can conclude that tangible interfaces present certain advantages when compared with desktop interface. These include increased accessibility, sensory engagement and group learning. With the Drum Duino, we created a device that has a specific focus on these factors.

6.1 Group use

Especially notable during our evaluation of the system was how concurrent use was facilitated by the separate actuators. Children freely experimented with the actuators and sounds and there was no disagreement between partners about rhythm creation. Arguably, this might be contributed to the fact that each actuator can be programmed individually, but that the rhythm will always stay in sync during play. Children can thus adapt their own rhythm and sound, using their own actuator, rapidly changing sound by alternating surfaces and objects, without impacting their playing partners' fun.

6.2 Accessibility

In contrast with actuated musical instruments discussed by Overholt et al. (2011), the actuators presented new types of instruments. Striking was the ease with which children interacted with the actuators: while the device itself is completely novel, children had no trouble playing and generating sounds. This low threshold of use makes it possible for children to explore patterns and rhythms of ever increasing complexity, with a flat learning curve. For example, even before changing speed or rhythm, it is possible to explore sound and materials, while manipulating the rhythm using the flaps. This allows infinite possibilities in music creation. Rhythm and music discovery is thus presented in a very playful way, with no prior experience of use needed.

6.3 Sensory Engagement

Lastly, from the point of sensory engagement, the Drum Duino presents clear advantages. A central tenet in the design of the Drum Duino is its auditory engagement, achieved through physical contact of the pushrod to various surfaces. As mentioned, for the participants, the easy control of the sound generated by the pushrods combined with assorted objects was the most important aspect of the system. There was an agreement by all participants groups that the device was fun to play with, while simultaneously conceding that the noise generated might become annoying for parents.

From the perspective of physical interactive play, the Drum Duino presents a compelling example of a physical musical interface that allows fun exploration of rhythms and music, while simultaneously understanding the material properties of every day objects. Central to its design is the idea that tangible interfaces have the opportunity to be accessible, be conducive to group use and engage the senses.

7 Future work

Given the focus on the actuators during our tests, we think there is merit in further exploring this type of interaction in future versions of the Drum Duino. This also confirms more to the metaphor introduced earlier by Machover (2007) of simple tapping to produce music. As such one concept is to create stand-alone solenoids that can detect and repeat knock patterns, while focussing more on the actuators as main tool for interaction.

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References

Als, Benedikte S., Janne J. Jensen, and Mikael B. Skov. 2005. “Comparison of Think-Aloud and Constructive Interaction in Usability Testing with Children.” In *Proceeding IDC 2005*, 9–16. New York, New York, USA: ACM Press. doi:10.1145/1109540.1109542.

Antle, AN, Milena Droumeva, and D Ha. 2009. “Hands on What?: Comparing Children’s Mouse-Based and Tangible-Based Interaction.” In *Proc. IDC 2009*, 80–88. Como, Italy: ACM.

Brennan, Nick. 2013. “Sound Pegs.” https://www.youtube.com/watch?v=aMymyn9soiU.

Cassell, J., and K. Ryokai. 2001. “Making Space for Voice: Technologies to Support Children’s Fantasy and Storytelling.” *Personal and Ubiquitous Computing* 5 (3) (August): 169–190. doi:10.1007/PL00000018.

Holland, Simon, Anders J. Bouwer, Mathew Dalgelish, and Topi M. Hurtig. 2010. “Feeling the Beat Where It Counts.” In *Proc. TEI 2010*, 21. New York, New York, USA: ACM Press. doi:10.1145/1709886.1709892.

Kemp, J.A.M., and T. van Gelderen. 1996. “Co-Discovery Exploration: An Informal Method for the Iterative Design of Consumer Products.” In *Usability Evaluation In Industry*, edited by Patrick W. Jordan, B. Thomas, Ian Lyall McClelland, and Bernard Weerdmeester, 252. CRC Press.

Machover, Tod. 2007. “My Chello.” In *Evocative Objects: Things We Think With*, edited by S. Turkle, 12–21. MIT Press.

Mathews, MV. 1991. “The Radio Baton and Conductor Program, or: Pitch, the Most Important and Least Expressive Part of Music.” *Computer Music Journal* 15 (4): 37–46.

Montemayor, Jaime, Allison Druin, Allison Farber, Sante Simms, Wayne Churaman, and Allison D’Amour. 2002. “Physical Programming: Designing Tools for Children to Create Physical Interactive Environments.” In *Proc. CHI 2002*, 299. New York, New York, USA: ACM Press. doi:10.1145/503376.503430.

Newton-dunn, Henry, and James Gib. 2003. “Block Jam: A Tangible Interface for Interactive Music.” In *Proc. NIME 2003*. Montreal.

O’Modhrain, Sile, and Georg Essl. 2004. “PebbleBox and CrumbleBag: Tactile Interfaces for Granular Synthesis.” In *Proc. NIME 2004*, 74–79. NIME ’04. Singapore, Singapore: National University of Singapore.

Overholt, Dan. 2005. “The Overtone Violin: A New Computer Music Instrument.” In *Proc. NIME 2005*, 34–37. Singapore, Singapore.

Overholt, Dan, Edgar Berdahl, and Robert Hamilton. 2011. “Advancements in Actuated Musical Instruments.” *Organised Sound* 16 (02) (June 28): 154–165. doi:10.1017/S1355771811000100.

Saldien, Jelle, and Jolien De Ville. 2013. “Drum Duino: A Tangible Interface to Create Rhytmic Music with Everyday Objects.” In *Proc. TEI 2013*, 1–7. ACM.

Small, C, and M Izen. 2011. “Electronic Drumsticks System”. Google Patents.

Troyer, Akito Van. 2012. “DrumTop : Playing with Everyday Objects.” In *Proc. NIME 2012*. Ann Arbor.

Van Kesteren, Ilse E. H., Mathilde M. Bekker, Arnold P. O. S. Vermeeren, and Peter A. Lloyd. 2003. “Assessing Usability Evaluation Methods on Their Effectiveness to Elicit Verbal Comments from Children Subjects.” In *Proc. IDC 2003*, 41. New York, New York, USA: ACM Press. doi:10.1145/953536.953544.

Xie, Lesley, AN Antle, and Nima Motamedi. 2008. “Are Tangibles More Fun?: Comparing Children’s Enjoyment and Engagement Using Physical, Graphical and Tangible User Interfaces.” In *Proc. TEI 2008*, 191–198. Bonn, Germany.

Zuckerman, Oren, S Arida, and Mitchel Resnick. 2005. “Extending Tangible Interfaces for Education: Digital Montessori-Inspired Manipulatives.” In *Proc. CHI 2005*. Portland, OR.