BendableSound: A Fabric-based Interactive Surface to Promote Free Play in Children with Autism

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Figure 1. The BendableSound prototype. A screenshot of the first activity available in BendableSound demanding a user to tap and touch on top of the fabric to erase the black smog covering the space nebula (left). A user interacting with the space nebula seeking and moving hidden space digital elements to make sounds (center) A screenshot of the third activity demanding a user to play a song by following the notes specified by the astronaut (right).

ABSTRACT
Children with autism found free play difficult. Free play is important for children with autism to help them develop social, communication, and expression skills. Interactive surfaces (IS) offer a casual and natural collaborative and engaging experience adequate to promote free play for children with autism. In this poster, we present the design and development of BendableSound, a fabric-based IS that allows children play music when tapping and touching on digital elements appearing on top of the fabric. To design BendableSound, we followed a user-centered design process involving interviewing, observation, and design sessions with caregivers. We close discussing directions for future work.

Categories and Subject Descriptors
K.4.2 [Computers and Society]: Social Issues – Assistive technologies for persons with disabilities; K.8.0 [Personal Computing]: General – Games.

Keywords
Bendable interactive surface; free play; autism; young children

1. INTRODUCTION
Free play represents an opportunity to teach children with autism social skills, creativity, and expression [4]; but, their limited social functioning and lack of predisposition to spontaneously play prevents them from participating during free play activities. Free play is voluntary, spontaneous, engaging, pleasurable, open-ended, and sometimes involves collaboration and physical movements. These characteristics teach children with autism how to set goals and define rules when interacting with others. Music-based activities are often used during free play to promote social interactions for children with autism [3].

It has been proved that interactive surfaces (IS) are appropriate to support typical children during free-play, because they promote creativity [2], support open-ended interactions [6], and provide visual and auditory feedback to maintain their engagement [5], specially during music-based activities [2]. Although almost all IS follow an open-ended interaction model, little has been said about what open-ended mechanisms are appropriate to support children with autism during free play: How can IS enable open-ended interactions while at the same time providing a fun experience to children with autism during free play? This work contributes with a design case study showing a novel fabric-based IS prototype (Figure 1) that enables children with autism improvise music and rhythmical sounds in an open-ended manner during free play.

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2. RELATED WORK
Research has explored how to design IS to assist neurotypical children during music-based activities, mainly for learning music, and fostering creativity (*e.g.,* Vuzic [2]). However, these IS have not been evaluated with children with special needs. Other musical IS have explored how to support individuals with disabilities to assist music therapy sessions (*e.g.,* Movement-to-Music [1]), but IS supporting children with autism is still scarce. Most of the research in IS to support children with autism mimic the structure of a therapy session (*e.g.,* SensoryPaint [6], Mediate [5]); but, has not yet explore the design space of open-ended mechanisms to support children with autism during free play.

3. DESIGN METHODS
For 4 months, we conducted a contextual study in a school-clinic of children with autism. During this time, we conducted 20 semi-structured interviews and observed 4 classrooms of children with autism during free play activities, to observe the problems children with autism face during free-play and understand the everyday practices of children with autism during free-play open-ended instruction. All interviews and observations were transcribed and analyzed with techniques to derive grounded theory and affinity diagramming. We conducted 5 design sessions

to iteratively design low-fidelity prototypes of IS supporting children with autism during free play, define the interaction gestures, and discuss animation and sounds arrangement.

4. BENDABLESOUND DESIGN

We designed BendableSound (Figure 1), a novel fabric-based IS that allows children with autism to make music when tapping and touching on digital elements appearing on top of the fabric. The fabric is a digital matrix arranging the pitch of musical notes in a descending scale on the vertical axis; and the musical tempo in the horizontal axis. BendableSound uses a dodecaphonic technique of 12 musical notes arranged on a chromatic scale. This technique has a dual function; first, a dodecaphonic technique allows controlling a finite and small numbers of notes to help children with autism gradually accept different sounds; second, with the dodecaphonic technique we can build different harmonic compositions and sounds arrangements even if users have limited music knowledge. Every time a child taps, grasps, or touches an element it will play a sound according to its location pitch.

4.1 Activities

BendableSound supports two open-ended activities, and one activity combining step-by-step guidance with an open-ended interaction modality. In the first activity (Figure 1, left), children must erase a huge layer of "black smog" by tapping, touching, ripping or grasping the fabric canvas to discover sounds and a background animation of space nebula. In the second activity (Figure 1, center), children must seek hidden musical space-based elements, like spaceships or stars, that will reproduce sounds when touched or moved. During the third activity, an astronaut appears to give children guidance on how to play a song by touching on an appearing and blinking star. The star appears according to music tempo, but children are not penalized when missing a beat. Song lists that children could play with the fabric include nursery rhymes like "twinkle twinkle little star". The background animation and the digital elements change according to the theme being used. The design supports three themes: space, snow, and sea; but only the space-theme is currently available.

4.2 Gestural Interactions

The design of BendableSound ideally might have four interactions gestures available when playing with BendableSound; but only two are fully available. These interaction themes take advantage of the affordances provided by the fabric (Table 1). A user's gesture will determine the displayed animation and the sounds of the musical instrument. For example, when tapping, BendableSound will sound like a piano or a drum and the element will bounce; in contrast with pinching that will sound like a guitar or a harp and the element will swing.

Table 1. Affordances provided by BendableSound and its possible effect.

Gesture	Instrument	Example
Tap	Piano/Drum	The element will **bounce**
Drag	Piano/Drum	The element will **move**
Rip	Harp/Guitar	The element will **swing**
Pinch	Harp /Guitar	The element will **appear or disapper**

5. THE BENDABLESOUND PROTOTYPE

BendableSound uses the Kinect sensor and the TSPS[1] library to detect when users' tap or touch the fabric (Figure 2 left). The rest of the gestural interactions are still under development but are available in the fabric through wizard of oz. In the current version also only, the guitar and the piano sounds are available. BendableSound's multimedia interfaces were developed with QML and JavaScript and are projected in the fabric by an ultrashort-throw projector (Figure 2 right). The Kinect sensor and the projector are behind the fabric surface. In case some children do not tolerate the sounds of some musical instruments, due hypersensitivity issues, teachers can manually configure from BendableSound the sounds children may tolerate, the instruments available, and the interaction time (Figure 2 left). Teachers could also adjust the duration time on each activity.

[1] http://tsps.cc/

6. CONCLUSIONS AND FUTURE WORK

In this work, we showed the design and partial development of a novel fabric-based IS to promote free play by enabling open-ended musical activities for children with autism. The main contribution of this poster is the BendableSound prototype. We plan to implement the other gestural interactions available in the design of BendableSound (Table 1) and conduct a deployment study with children with autism to investigate the impact of BendableSound in supporting free play activities.

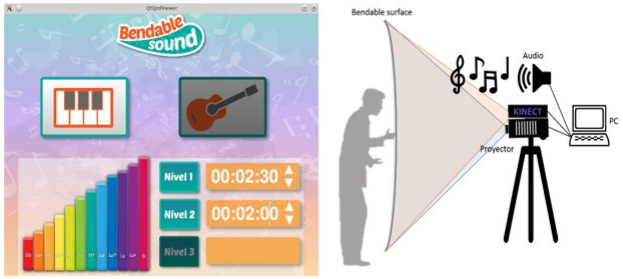

Figure 2. Setting up BendableSound. A screenshot of the settings interface where colors represent notes and icons represent available musical instruments (left). A mockup representation showing the hardware installation of the BendableSound prototype (right).

7. REFERENCES

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