A Musical Interactive Surface to Support the Multi-Sensory Stimulation of Children

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Abstract
Interactive surfaces are promising to support multi-sensory stimulation during early development of children and for therapy for children with autism, as they offer a casual and engaging experience in a multi-sensory environment. In this paper, we present preliminary results of two field deployment studies of the use of BendableSound, a fabric-based interactive surfaces that allows children to play music. The first study was conducted at a school-clinic specialized in the care of children with autism in north-western Mexico, and the second study was conducted at an early education center in San Diego, California. Our preliminary results indicate that BendableSound is successful when used in both contexts to support specific development areas. We discuss implications of the introduction of BendableSound and we illustrate future work.

Author Keywords
Musical interactive surfaces; multi-sensory stimulation; children.

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

Table 1. Summary of the activities available in BendableSound

Bendable-Sound	Description	Picture
Activity 1	Children must illuminate the fabric and erase a huge layer of "black smog" by tapping, touching, or grasping the fabric canvas.	
Activity 2	Children must seek hidden space-based elements, like spaceships or stars that will reproduce sounds when touched or moved.	
Activity 3	An astronaut appears to give children guidance on how to play a song by touching on an appearing and blinking star.	

Introduction

Multi-sensory stimulation may help children to learn, gain body awareness, support self-expression, and socialization [6]. It frequently uses music-based activities to simultaneously stimulate all the senses, [3]. Music-based activities provide a unique experience to children helping them to develop age-appropriate skills related to communication, socialization, cognition and sensory-motor processing [3]. These techniques are frequently used during the first years of children life as early stimulation [6] and as a therapy for children with autism [5], who may have cognitive, social, and sensorimotor impairments, to encourage them to develop knowledge, skills, or behaviors by exploring their environment [5, 6].

Interactive surfaces (IS) are promising to support multi-sensory stimulation as they offer a casual and engaging experience in a multi-sensory environment. For the last year, we have been developing BendableSound [1], a music fabric-based IS. In this paper, we explore the use of BendableSound in two different contexts: (1) a school-clinic specialized in the care of children with autism located in north-western Mexico, and an (2) Early Childhood Education Center supporting the development of toddlers located in San Diego, California. Our preliminary results indicate that BendableSound is easy to use and useful for both contexts, and both populations successfully integrated BendableSound into their practices. For toddlers it now serves as an additional activity being used during free-play time, and for children with autism it could be instrumental in supporting music therapy sessions [1].

Related Work

Interactive surfaces (IS) —tables, walls, and other surfaces augmented with multi-touch capabilities— are promising to support musical interventions. Previous research on musical IS explored innovative ways to support the music training of (*e.g.,* Andante [8]), fostering creativity (*e.g.,* Vuzic [4]), or create a multi-sensory environment (e.g. SensoryPaint [7]). This projects emphasize the importance of using multiple sensory stimuli to improve the experience of playing music. Recent research has shown that deformable IS are usefulness to create music and could be a multi-sensory environment needed to maintain engagement and attention for children (*e.g.,* NoiseBear[2]). In this work, we explore a fabric-based IS augmenting with interactive projections.

BendableSound

BendableSound [1] is a fabric-based IS that enables children to play piano sounds by interacting with the bendable fabric. The system stores sounds representing the pitch order of musical notes arranged in an ascending scale on the vertical axis. Every time a children taps, or touches the fabric, it plays a piano sound. BendableSound displays a 3D animated background of a space nebula with translucent space-based elements. BendableSound supports three activities (Table 1) and uses a Microsoft Kinect sensor and the TSPS[1] library to detect interaction gestures. Visual elements were developed in QML and JavaScript.

Contextual studies

In order to understand how well BendableSound supports multi-sensory stimulation in different contexts we conducted two field deployment studies. We wanted to address the following specific questions:

[1] http://tsps.cc/

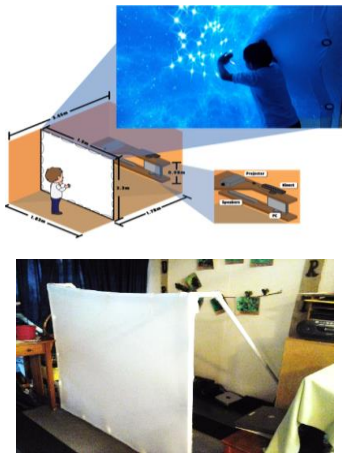

Figure 1. Set up of BendableSound in the context #1 (top); in context #2 (bottom)

Table 2. Summary of the participants involved in each context of the field deployment of BendableSound

Context	#1 Early childhood education center	#2 School-clinic of children with autism
Participants	22 children (age 2-3) 5 teachers	24 children with autism (age 3 - 11) 1 psychologist
Length	9 weeks	2 weeks
Use	Music-based activity during free-play	Improvisational music therapy session
Data collected	12 days of observation 5 focus group	6 days of observation 6 interviews

- Are children within different context (school-clinic, early education center) able to integrate the system into their everyday practices?
- Does the system address important development needs for each population?

Context #1: School-clinic of children with autism

We recruited study participants from a school-clinic of children with autism in north-western Mexico. Twenty-four children (between 3 and 11 years old) were voluntarily enrolled in the study. One psychologist was responsible for administering the therapy. We equipped one room with two video-cameras, and the BendableSound system (Figure 1 up). After all parents consented to the study on behalf of their children, we studied participant's interactions using BendableSound for the 2 weeks of the study. The children with severe autism attended to a 5-minute improvisational music therapy session, to freely interact with each of the activities available in BendableSound.

Context #2: Early education center

We recruited twenty-two toddlers (between 2 and 3 years old) and five teachers from an early education center in San Diego, California. First, the research team introduced BendableSound to the early education center principal and the lead teacher. Then, the lead teacher introduced BendableSound to the teacher aids. We installed the BendableSound system inside the classroom (Figure 1 bottom). All parents consented to the study on behalf of their children. BendableSound was installed for 9 weeks. During this time, teachers suggested that BendableSound could be used during the free-play time activities (1.5 hr. per day). During free-play, teachers offered to toddlers all the available activities that children were already able to do inside and outside the classroom, but added BendableSound. Toddlers freely choose when to use BendableSound or play with the other toys available in the classroom. On average, toddlers used BendableSound twice a week.

Data collection and analysis

In both contexts, we video recorded all sessions, and maintained field notes related to the overall experience of the use of BendableSound. We also conducted several focus groups and structured interviews to better understand the use of the system, potential opportunities and benefits for the children. Caregivers were interviewed as a "proxies" to gather participants' perceptions towards BendableSound (Table 2). Data analysis involved the use of qualitative methods to uncover emergent themes and is still ongoing.

Preliminary results

We have uncovered a number of similarities and differences between the perceived used and interaction experience with BendableSound in both of the contexts studied (Figure 2). In both deployment studies, according with data of the interviews and focus group (Table 2), teachers and children found BendableSound easy to use and useful. All the toddlers and 80% of children with autism found BendableSound enjoyable, in particular their visual and audio stimuli. Even though children lacked training in music, they enjoy to play with the sounds using BendableSound.

For toddlers (Context #2), the choice of using BendableSound was completely voluntary, most of the toddlers repeatedly played with BendableSound, but only a quarter of them played every time that it was available. All the toddlers showed excitement and we noticed how one in ten were more focused in using BendableSound than in other free-play activities. In

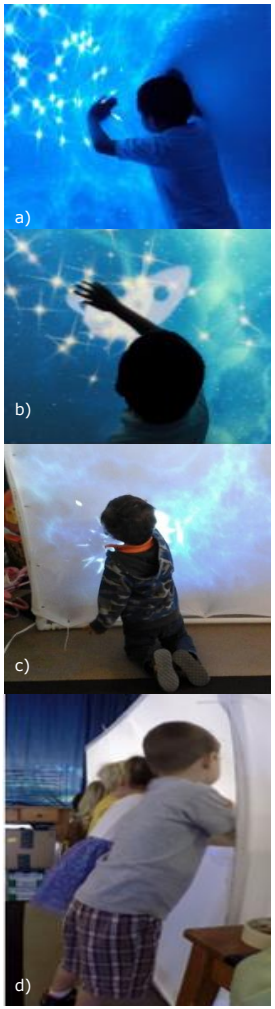

Figure 2. Context #1: Children with autism playing with BendableSound (a, b). Context #2: Toddlers playing with BendableSound (c, d).

contrast, children with autism (Context #1) used BendableSound as a scheduled therapy. Children with autism were more focused in comparison with other similar therapies available in the clinic, and 70% of the children exhibited positive emotions such as joy [1]. Even though they usually lack predisposition to spontaneously play, they were more willing to voluntary initiate interaction with music using BendableSound [1]. Our results showed that BendableSound provides an enjoyable user experience and supports free-play in both contexts.

In both contexts, a variety of interaction modalities emerged as a result of the affordances provided by BendableSound. Children enjoyed to push and swipe the space-based elements and the stars appearing on the fabric –either by using one finger, multiple fingers or their complete hand. Also, they used their whole body or specific body parts like their head or their back to discover and explore movements that they are typically not able to do with other IS. Although toddlers enjoyed using all their strength to push BendableSound, after five weeks of use teachers perceived that the toddlers started to learn how to control their strength when pushing the fabric. In contrast children with autism preferred to explore different movements and enjoyed the visualizations.

Finally, toddlers used BendableSound mostly collectively. Teachers found numerous benefits in terms of social interaction (*e.g.,* practice symbolic play, explore relationships with their peers, etc.). In contrast, children with autism used BendableSound individually, but 80% of them positively interacted with a psychologist who gave them guidance or prompts on how to use BendableSound.

Conclusions

In this paper, we present the preliminary results of two deployment studies. The first study was conducted at a school clinic of children with autism in north-western Mexico, and the second at an early education center in California. Overall, our results indicate that the easiness to interact with BendableSound, and all the stimuli available, work together to increase children's curiosity and improve their overall experience in both contexts. These results suggest that BendableSound could promote the development of social skills, self-regulation and free-play for both contexts. In future work, we plan to continue our analysis and explore the key design characteristics for a musical interface to be integrated into the two contexts discussed.

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