An Interactive Play Mat for Deaf-blind Infants

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ABSTRACT
There is a great need for the development of interactive toys for deaf-blind infants (1-3 year olds) to motivate their exploration of their environment, and develop their motor and cognitive skills. We describe relevant design criteria, gleaned from the literature and a discussion with professionals who work with deaf-blind children. We then present a toy consisting of a play mat with three activity areas: one for remembering and repeating vibration patterns and two for matching textures. Vibrators which turn on as the infant moves in the direction of an activity area, measured by pressure sensors, are used to encourage the infant to explore in that direction.

Categories and Subject Descriptors
K.4.2 [**Computing Milieu**]: Social Issues – *Assistive technologies for persons with disabilities, Handicapped persons/special needs.*

General Terms
Design, Human Factors.

Keywords
Deaf-blind; Assistive Technology; Cognitive Development.

1. INTRODUCTION
The combined loss of sight and hearing is significantly greater than either single loss alone (Gleason, 2008). Typically, when one loses vision, compensation methods heavily rely on the use of hearing and vice versa. These options are not available to individuals who are deaf-blind. In addition, vision and hearing are considered the two "distance" senses: objects and people do not have to be within reach to be observed.

The development stage typically spanning infancy is important for the development of motor coordination as well as laying the groundwork for cognitive development. During this period, children learn by actively exploring their environment (Johnson et al., 2000). Self-initiated activity during this time is also an important driving force in a child's growth from less to more mature modes of behavior. The role of *external stimuli* in motivating this development through exploration is *crucial* in this stage (McInnes and Treferry, 1982). An infant with normal vision and hearing naturally explores by responding to sights and sounds in the environment that they may experience at a distance and move toward.

However, in absence of vision and hearing, motivation to explore is minimal. It is for this reason that a deaf-blind infant's communication, social development and cognitive activity are usually delayed and, unfortunately, the infant is typically treated as mentally retarded. Thus, there is a great need to provide a different method of stimulating these potentially intelligent infants (Szeto and Christensen, 1988) to avoid these unnecessary development delays. The purpose of our work is to develop a play toy for a deaf-blind infant to develop their cognitive skills.

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2. PREVIOUS WORK
There have been relatively few devices designed for individuals who are deaf-blind, let alone for infants specifically. Several devices, such as the Tactaid II, have been designed to convert speech to vibrations through the use of a microphone and vibrators. These can also be used to pick up environmental noise (e.g., footsteps, doorbells) to make individuals more aware of their surrondings (Szeto and Christensen, 1988). Mechanically created structures, such as Nielson's Little Room, Dunnett's BeActiveBoxes, as well as improvised spaces, have been used to give an infant the opportunity to learn about space and reach for objects. One interesting component, initially designed for the Little Room, is for the child to lie on their back on a resonance board which works like a drum to give auditory and vibratory feedback from the child's movement and interaction with objects (Johnson et al., 2000).

3. DESIGN CONSIDERATIONS
The design considerations for the play toy were determined from reading the literature on deaf-blind infants and discussing the design with Peggy Sinclair-Morris and Julie Durando who work with deaf-blind children. Several ideas that motivated the design were: (1) the need for the toy to move the deaf-blind child from the reactive-passive state to an interactive state, (2) the need to give results of that interaction, so that they can make the connection that they did something (Gleason, 2008), (3) the desire to have tasks that developed the infant cognitively, (4) the need to clearly define the space for the child to play and explore and (5) the need to present objects in the same position to help develop the concept of object permanence (Johnson et al., 2000). Cost and safety were additional concerns.

In addition, very few children are totally deaf and totally blind; most have some usable vision and/or hearing. Vision can be

stimulated using bright and/or reflecting toys and hearing by creating sounds.

4. DESIGN

4.1 Overall Design

A play mat design was chosen so as to clearly define the space for the child to play and explore (Figure 1). It also contains three activity areas, which were fixed in position to help establish object permanence.

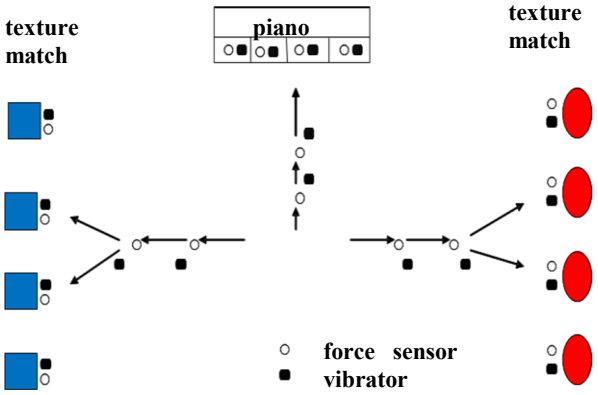

Figure 1: Overall play mat design with three activity areas: one for remembering and repeating a vibration pattern (piano) and two for matching textures. Vibrators which turn on as the infant moves in the direction of an activity area, measured by pressure sensors, are to encourage the infant to explore in that direction.

The idea is that the infant is to be placed in the middle of the mat. As an infant moves in a direction, whether randomly or purposefully, a pressure sensor will sense the movement and will cause a vibrator to vibrate further along in the direction of the closest activity. For this, a force sensing resistor (Interlink Electronics, Figure 2) will be mounted beneath an approximately 2"x4" yellow plate resting on a "button" which focuses the force onto the force sensing resistor. The vibrator (pancake type, Figure 2) will also be mounted beneath a 2"x4" reflective plate which it will vibrate. Analog electronics will be used to sense the force and trigger the subsequent vibrator. However, the sensors and vibrators in the activity areas will be controlled by an Arduino microcontroller.

Figure 2: Force Sensing Resistor and Pancake Motor

4.2 Piano

The piano is to consist of a modified version of a Little Tykes "piano" for which a piezoelectric vibrator (Figure 3) and force sensing resistor are mounted on each key. The first key will be the initial key: when the child touches this key a sequence of different frequencies of vibrations, produced by the piezoelectric buzzer, will occur. The infant will then have to mimic the vibration pattern by pressing the remaining three keys, each of which is associated with one frequency of vibration. If they are correct, all the keys will produce a smooth vibration (high frequency tone) and otherwise they will produce a harsh vibration. The sequences will start with one note and build over time as the child interacts with the device during a play session.

Figure 3: Little Tykes Baby Tap-a-Tune which is to be modified by placing a piezoelectric vibrator on top of each key. Additionally, a force sensing resistor (Interlink Electronics) will be mounted between the piezoelectric disk and the top of the key

4.3 Texture Match

The texture matching activity areas will each consist of 2 pairs of matching textures mounted, using magnets, to colored geometric shapes raised above the play mat. Magnets are used so that the parent or intervener can change the location of the matching textures, with dipswitches on the microcontroller housing used to reprogram the matches. The matching game will work by the infant making contact with a texture on an initial block for a certain amount of time. At first, when the infant contacts the block with a matching texture, a smooth vibration will be presented on that texture immediately. However, as the game is played an increasing number of times, the infant will be required to contact the match for a certain amount of time before the vibration is presented. This is meant to ensure that the "reward" does not occur by random touching.

5. FUTURE WORK

After completion of the play mat and subject to IRB approval, the playmat will be tested with deaf-blind infants through the Virginia Project for Children and Young Adults with Deaf-Blindness. We expect that from observing their interaction with the play mat, some modifications may be needed before an appropriate design is finalized.

6. ACKNOWLEDGMENTS

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