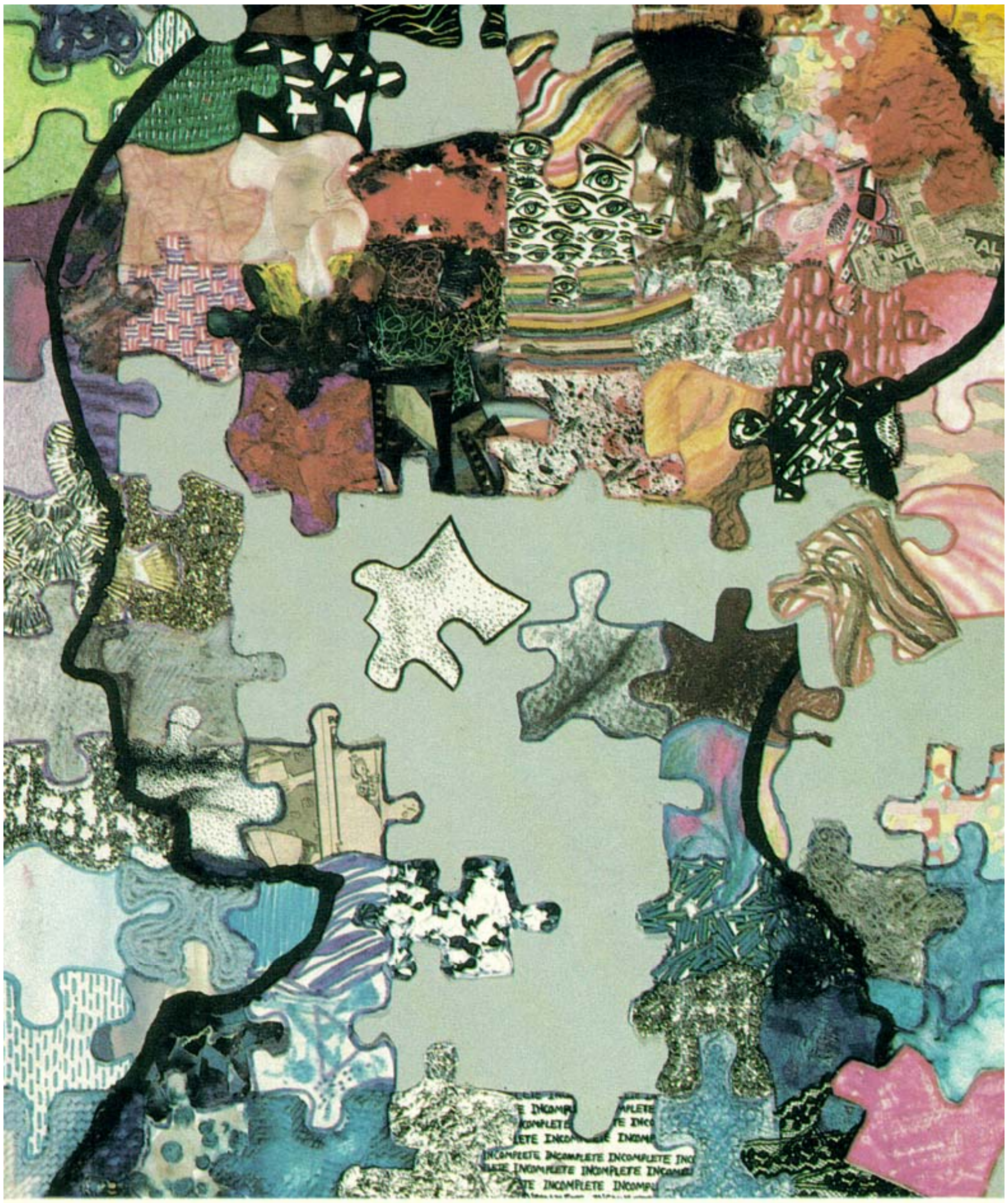
NATIONAL SCIENCE FOUNDATION 2003 ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES



Edited By

John D. Enderle and Brooke Hallowell

CHAPTER 17
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Department of Biomedical Engineering
152 Macnider, CB #7455
Chapel Hill, NC 27599

Principal Investigator:

Richard Goldberg (919) 966-5768

TALKING DOTS

Designers: Randal Cole and Arielle Drummond
Client Coordinator: Diane Brauner, Orientation and Mobility Therapist
Supervising Professor: Dr. Richard L. Goldberg
Department of Biomedical Engineering
Room 152 Macnider Hall, CB #7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Braille is an essential communication tool for people with visual impairments (VI). However, learning Braille is challenging – especially for preschool and elementary school children. Talking Dots was developed for two kindergarten girls with severe VI. The objective of Talking Dots is to develop an electronic Braille training device that improves on existing models by 1) providing exciting audio feedback and 2) reducing the need for constant instructor supervision. Secondary objectives include attempting to strengthen the user's isolated finger movements.

SUMMARY OF IMPACT

Talking Dots is not only an instructional tool for teachers, but also functions as an independent learning tool for children with VI. The audio feedback incorporates interesting animal sounds and captivating songs, which encourage the children and peak their interest. The clients' orientation and mobility therapist remarks that "teaching Braille skills (reading and writing) to students requires boring, repetitive exercises in order to develop significant tactile sensitivity, spatial memory, isolated finger strength, and numerous other basic Braille skills. The Talking Dots Braille Trainer is the first exciting, motivating game that teaches VI students (and their families) the Braille alphabet." One client's mother expressed an interest in using Talking Dots to learn Braille for herself. Initial trials have demonstrated enthusiastic use by children and adults alike.

TECHNICAL DESCRIPTION

The six pushbuttons correspond to the six dots of a Braille cell (Figure 17.1). The pushbuttons begin in the reset state, where they are pressed down and flush with the surrounding surface. When the user presses and releases the pushbuttons, they pop up 1/8 inch so that they are raised like a Braille dot. To

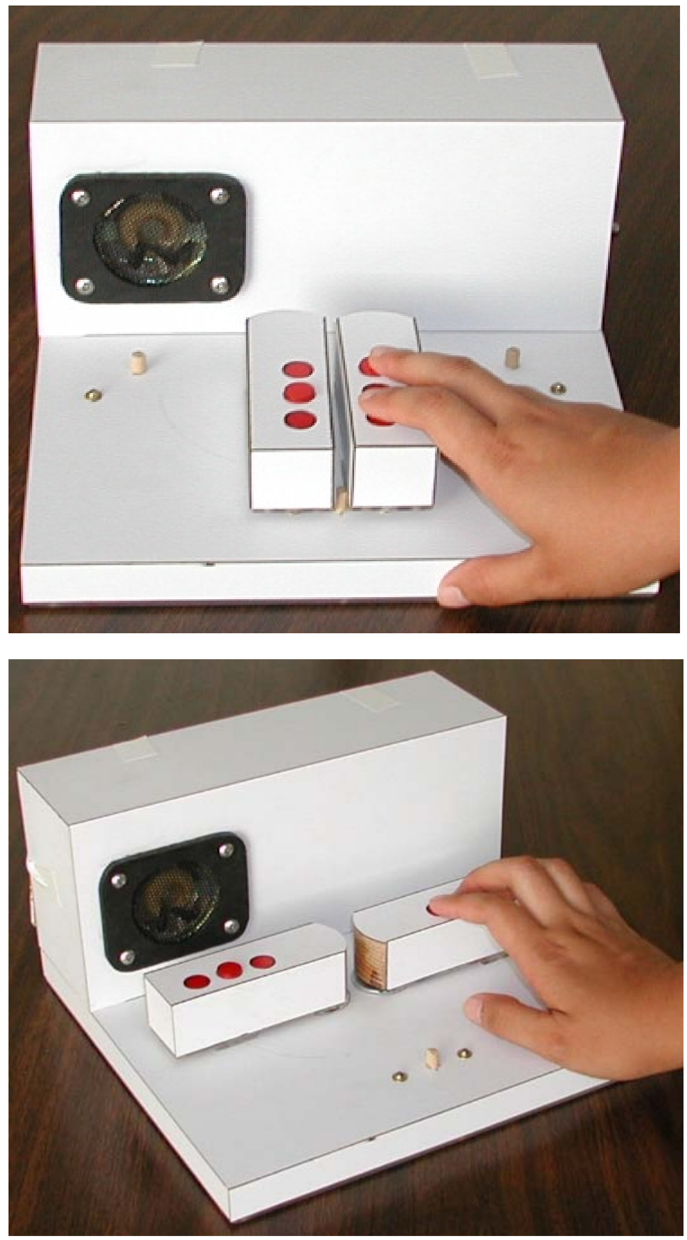


Figure 17.1. Talking Dots: (a) Vertical Cell (b) Horizontal Cell.

use the device, the student simultaneously presses a combination of the six buttons that corresponds to a

Braille character. The device determines the related letter and plays back the corresponding prerecorded message. For example, if the configuration for the letter C (dots one and four) is pressed, then the message says, "C, cat, <meow>."

The custom circuit design (Figure 17.2) is powered by a 9V DC battery source. The circuit includes a PIC 16F877 microcontroller (Microchip, Chandler, Arizona) programmed in C-language, an ISD4004 voice recorder chip (Windbond, San Jose, California), and an LM386 audio amplifier. A toggle switch allows the user to control hearing the letter and associated sound combination or just the letter independently. The volume is controlled by a potentiometer with audio tape connected through an audio amplifier to a speaker. An easy or hard toggle switch determines the degree of difficulty of the game. In the easy mode, users must press and release the combination of pushbuttons within a 500ms period; the difficult mode requires the user to press and release the buttons within 200ms. If simultaneous pressing does not occur, a message is played either indicating an incorrect entry (i.e. "represents no Braille letter") or a message for another letter that was not intended. The instructor can record new messages to change the sounds associated with each letter. A library of audio messages is provided on a CD and the teacher or parent can connect the PC speaker output directly to the device.

The six pushbuttons are mounted on two rectangular blocks that can rotate between two positions. In the vertical position, the 2 x 3 array of pushbuttons form the Braille cell. In the horizontal position, the row of six pushbuttons corresponds to the position of the keys on a typical commercial Braille keyboard. On the underside of the swing arms, the path for the wires is routed close to the pivot point of the swing arms and down through the base to the circuit box to enable the arms to swing out into the Braille writing position. This allows the arms to rotate with minimal tension on the wires.

A white laminate face is used to provide a smooth surface and easy recognition of pushbutton and switch positions for VI users. The speaker is front-mounted to give optimal sound. "Instructor only" controls are mounted on the back of the device; they include volume control, the easy or hard toggle switch, and the audio record switches. The power switch and the letter-only or letter-and-sound-combination switch are located on the side of the circuit box for easy accessibility.

The cost of this project is approximately $250.

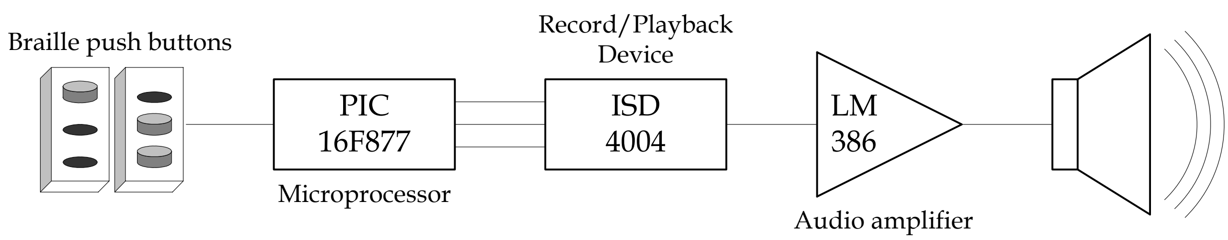


Figure 17.2. Circuit Diagram.

SENSORY PLAY GYM

Designers: Jay Fisher and Rick Uhlir-Hall
Client Coordinator: Luanne Holland, Speech and Language Pathologist, Durham Public Schools
Supervising Professor: Dr. Richard L. Goldberg
Department of Biomedical Engineering
University of North Carolina at Chapel Hill
Room 152 Macnider Hall, CB #7575
Chapel Hill, NC 27599

INTRODUCTION

The sensory play gym is designed to accommodate an eight-year-old girl with cerebral palsy, hearing impairments, and severe visual impairments. She has limited movement control of her head, hands, and feet. Her favorite position is in a side-lyer. Proper sensory development relies heavily on a child's potential to interact with various stimuli. However, it is difficult to set up switches and stimuli for the client while she is in her side-lyer. The device allows the therapist to position many sensory stimuli in locations easily accessible to the client. Once the inputs and outputs are in place, the sensory play gym allows the client to explore her environment independently while receiving vital sensory stimuli.

SUMMARY OF IMPACT

Prior to the design of the project, the client could not benefit from sensory stimuli without additional help. The play gym allows her to interact without the aid of others. Her physical therapist said, "The sensory play gym will open new doors for her. The sensory play gym will allow her to enjoy a variety of self-initiated sensory experiences that she could not be able to have otherwise. These experiences will help her to learn cause and effect, communication skills. Self-initiated movement will also facilitate improvements in active range of motion of her arms and legs. She really loves it!"

TECHNICAL DESCRIPTION

The base structure of the play gym fits around the client's side-lyer (Figure 17.3). The three detachable arches that complete the frame can be connected in different places along the rectangular base to fit the needs of the client. The input switch plugs are located at the base of the each arch. Clamps can be used to position the switch within easy reach of the child's head, hands, or feet. The output stimuli are connected to the top of each arch.

Figure 17.3. Side-lyer.

Each arch functions differently. One arch contains two input jacks directly wired to the two output plugs. Any commercial switch can plug into the input jacks and stimuli (tape player, fan, etc.) can plug into the output plugs. When the switch is pressed, it turns on the stimulus. When the user releases the switch, the stimulus turns off. A second arch contains the same direct circuitry; however, it also has a Velcro covered piece of plywood attached to the inside of the arch (Figure 17.4). The wall edge is covered with padding to prevent injury to the client. By attaching different switches, toys, and materials of various textures to the Velcro, the therapist can place stimuli at the client's fingertips. The third arch contains one input jack connected to three different output plugs via an electronic toggle circuit. Activation of the switch connected to the circuit causes the first output to turn on for 10 seconds. The next activation of the input causes the second output to turn on for 10 seconds, and likewise with the third activation. On the fourth activation of the input switch, the circuit cycles back to the first input.

The sensory play gym is constructed out of one inch diameter PVC tubing, selected for its small size and rigidity. Angled "L"-shaped pieces are used to connect the corners of the rectangular base frame. The base frame contains four different regions, each containing five holes spaced one inch apart. This allows the arches to be moved as needed. The arches are locked into place using a "T"-shaped piece at the base of the arch and two plastic coated bolts.

To protect the client, the wiring of the play gym is contained within the PVC tubing of each arch. One-eighth-inch standard audio plugs and jacks are used, making the device compatible with existing switches and toys. The toggle circuit is inside a plastic enclosure, which is attached to the PVC tubing. The diagram for the toggle circuit is shown in Fig. 17.5. A PIC16F877 microcontroller (Microchip, Chandler, Arizona) controls the circuit; it sets one the three output pins to 5V for 10 seconds whenever the client presses the input switch. The ULN2003AN drives a relay switch to turn on the appropriate stimulus.

The approximate cost of the project is $200.

Figure 17.4. Arches.

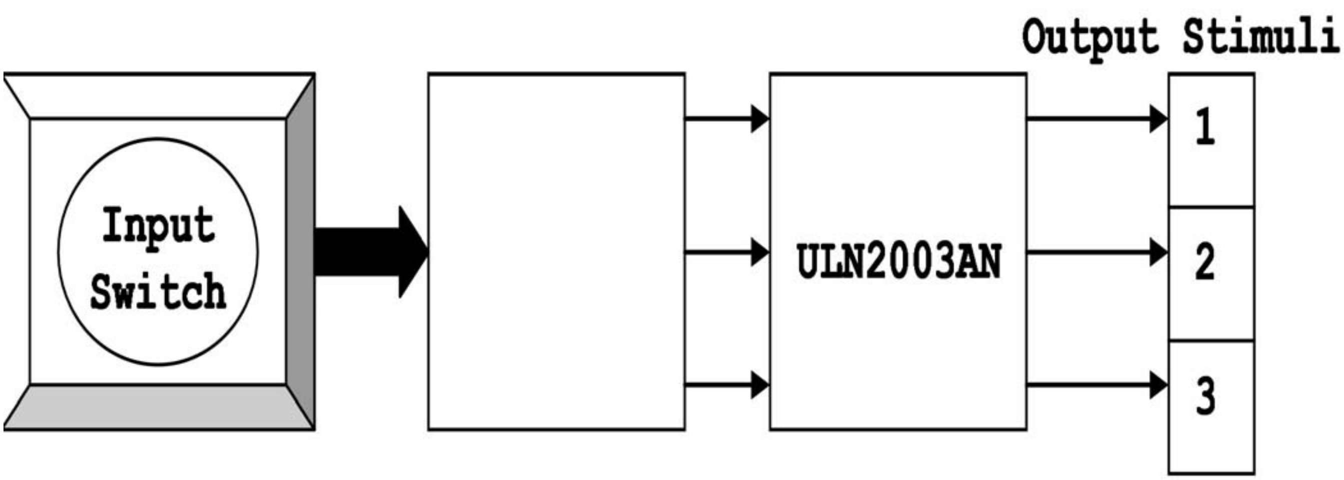


Figure 17.5. Circuit Diagram.

ORIENTATION GAME

Designers: Sirin Yaemsiri and Christa Wheeler
Client Coordinators: Susan Puckett, Governor Morehead Preschool for the Blind, and Diane Brauner, Orientation and Mobility Therapist
Supervising Professor: Dr. Richard L. Goldberg
Department of Biomedical Engineering
Room 152 Macnider Hall, CB #7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

An orientation game was developed for a 16-month-old boy with a genetic eye disorder called Leber's Congenital Amaurosis, which results in severe visual impairment (VI). As with many children with VI, he learned to walk without first learning to crawl. However, crawling is vital to developing the upper body strength and coordination required to use a cane and read Braille. Our game consists of four music cubes placed in different areas of a room. When the user turns on the game, music starts playing from one of the cubes. When the toddler hits the switch on the cube, music begins to play from a different cube. The game gives VI toddlers an incentive to crawl and explore by playing music in different areas of a room.

SUMMARY OF IMPACT

The client's teacher said that, "The orientation game is an innovative and creative way for a child who is visually impaired to develop auditory localization skills and to be motivated to move out into the environment to locate the sound. The toys are a wonderful reward for the grand effort involved in moving across space, and finding the toy that cannot be seen. This game can also easily be adapted to create more developmentally challenging activities for [the client] as he gets older."

TECHNICAL DESCRIPTION

The device (Figure 17.6) consists of a control box and four "sound cubes", which are commercial toys that were each adapted by adding a speaker and large red momentary switch. The therapist can place the sound cubes in different areas around a room. When the device is turned on, music plays from one of the sound cubes. This encourages the toddler to approach and explore the toy that is emitting the music. Once there, the toddler can hit a momentary switch button on the toy, which triggers a sound cube in another location to start playing music.

Figure 17.6. Orientation Game.

The device can operate in two modes: 1) ordered mode and 2) random mode. In the ordered mode, the child becomes familiar with the orientation of the room by hearing the sound cubes activate in a predetermined order. Once the child is familiar with the orientation of the room, the parent or therapist can switch the device to random mode so that the sound cubes activate in a random sequence. The unpredictability adds excitement to the game.

The device is powered by a 9V DC battery source. The control box includes the toggle "on or off" switch, four potentiometers with audio taper to control the volume for each sound box, a toggle "ordered or random mode" switch, and the main circuit (Figure 17.8) that determines which sound cube to activate. When the device is in ordered mode, each time the toddler hits a switch a counter in the main circuit advances one step and the sound box corresponding to that number is activated. When the device is in random mode the mod-4 counter counts continuously at 50 Hz. When the toddler hits a switch, D-flip flops latch the current count and the sound cube corresponding to that number is activated. After the D-flip flops latch the current count, 3V is sent to the corresponding M-66 melody generator chip. These melody generators have three leads: one lead is grounded, one lead receives 3V power, and the third outputs the melody. The parent or therapist can easily change the melody of each music box by switching in different M-66 chips.

Each sound cube contains a speaker and a momentary switch button.

The cost of this project is approximately $75.

Figure 17.7. Game in Use.

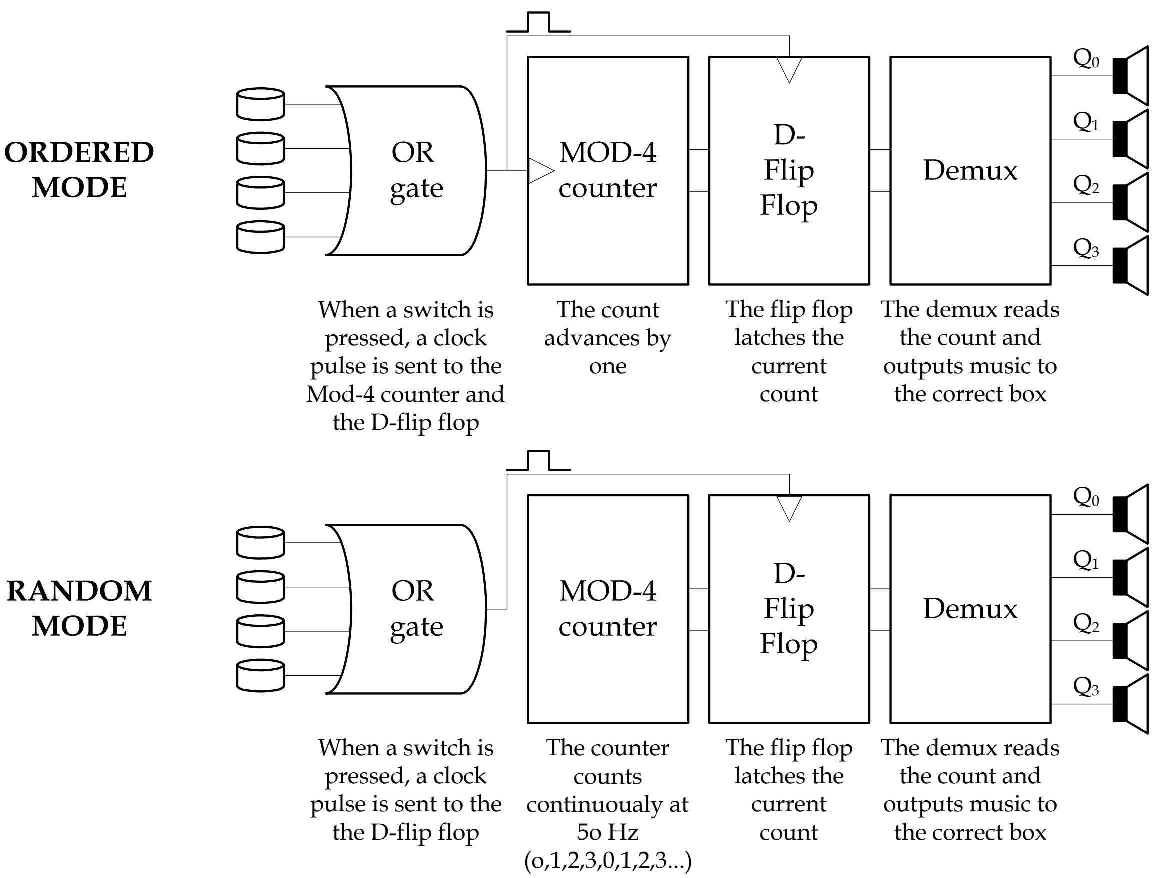


Figure 17.8. Block Diagram.