CHAPTER 20
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ARM STRENGTHENING DEVICE FOR TOTS

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INTRODUCTION

Our client is a two-year old boy who loves musical and visual feedback. He has cognitive delays, as well as poor strength, fine motor control, and coordination. His therapist requests a device that helps him improve his upper body strength and coordination. This device also needs to be durable, safe, and engaging so that he is motivated to use it. This design focuses on the creation of a school bus toy that is based on a commercial toy, with the addition of two custom handles. When the client inserts the handles all the way into tunnels that are located above the front and rear bumpers, LEDs illuminate inside the handles. This activity is similar to using an electronic shape sorter and helps with fine motor control. When he pushes the handles against the end panels inside the tunnel, the device provides musical feedback. This helps with arm strengthening, as the client has to push the handles against interior springs.

SUMMARY OF IMPACT

Our therapist commented that she had not seen a lot of toys that really engage him. However, he enjoyed using this device and it was "an adorable, therapeutic, electronic toy". She is confident that this will help him improve his strength and coordination.

TECHNICAL DESCRIPTION

The outside of the device is from the Playskool Tonka Wheel Pals Cushy Cruisin' School Bus®. The shell of the bus is made of a single mold of soft, durable polyester fiber. It is "squeezable". The bottom is made of hard plastic with an axle attached to plastic wheels. The battery chamber is milled out in the base to make enough room for a nine-volt battery, instead of the two AA batteries that normally come with the toy. The original electronics from the base the stuffing from the interior of the shell are both removed.

Fig. 20.1. Arm strengthening device with round (red) and square (green) handles.

There are two handles: one with a circular cross section, and the other with a square cross section. The circular handle is 5.40" long, has a 1" diameter, and is made from hollow acrylic tubing.

A 1.20" diameter circular red acrylic piece is fixed on the one end to prevent that end from going into the tunnel. The other end is made of concentric electrodes, which power an LED inside of the handle when it contacts the powering electrodes inside the tunnel. As a result, the handles luminesce red when pushed all the way into the tunnel. The square handle is of similar construction. It has 1" by 1" cross section and the length is 5.75". There is a green acrylic square piece on one end and concentric electrodes on the other end that connect power to internal green LEDs.

Both handles fit into corresponding acrylic tunnels, which are secured to the exterior of the bus, just above the front and rear bumpers, using a custom made acrylic flange. At the end of the tunnels inside the bus, there are electrodes that power LEDs inside the handles when they make contact.

Once the handles are inserted all the way into the tunnels, the client can push them further against spring-loaded acrylic panels. The spring action is provided by a standard toilet paper holder that is between the panels and housed in an acrylic box. As the spring-loaded panels slide along tracks, their position is detected by a pair of infrared (IR) distance sensors (Sharp GP2D120) that are mounted at the top of the acrylic box and encased in a custom-made aluminum housing to hold them in position. In this manner, the device can monitor how far the client has pushed in on the panels with the handles.

The signals from the IR sensors are input to a microcontroller. When it detects that the client has pushed the panels in a small amount, the microcontroller activates musical feedback with the programmable uMP3 module (Rogue Robotics, Toronto ON). The module has a built-in SD card slot, where the songs are loaded. The microcontroller pauses the song if the client releases the force and the panels spring back out. If the song has been playing for at least five seconds and the panels are pressed all the way in, the microcontroller triggers the module to start playing the next song on the playlist. An LM386 audio amplifier drives the speaker output. A nine-volt battery powers the circuit.

The cost of the device is approximately $300.

Fig. 20.2. Client inserting handles into the corresponding tune.

LOCKER ASSIST

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INTRODUCTION

Our client is a 13 year old middle school student who has cerebral palsy and uses a power wheelchair. She has significant problems getting books in and out of her school locker due to arm weakness, tightness and coordination. Our client has better muscle strength and control in her right arm, but she seldom uses her left arm. Thus it is hard for her to manage the heavy textbooks using one arm. Being in a wheelchair, she is positioned lower relative to the locker (she uses an upper locker of two vertically stacked lockers). Thus she is forced to lift the books almost to the height of her head. In addition, her wheelchair positions her further away from the locker, forcing her to extend her arm and torso as she reaches into the locker, which puts her in a disadvantaged mechanical position. This project focuses on a sliding shelf device that makes it easier and faster for her to remove books from her locker, as well as place books back into her locker.

SUMMARY OF IMPACT

The client stated, "I think the locker assist will make it easier for me when switching classes because I will not be as dependent on others to get books in and out of my locker. It should make it faster and less stressful for me to make the change. I think it will also help to keep my locker better organized."

TECHNICAL DESCRIPTION

The design is based on a sliding shelf that mounts to the insider of the client's locker. There is also a folding flap that assists in loading textbooks. She can easily place the book horizontally on the flap, and then rotate the flap to put the book to a vertical position on the shelf. Also simple velcro straps wrap around any textbook acting as a handle to aid her in grasping and lifting a book.

The base of the entire assembly is made out of 3/8" thick clear acrylic that is cut to fit the dimensions of

Fig. 20.3. The locker assist installed inside the client's locker.

the inside of the locker. Two 10" long, ball-bearing drawer slides are loaded on to the base using machine screws with nuts counter bored into the base. When fully extended, the drawer jutted 8" out from the locker. To counter the moment created by books on an extended drawer, stabilizing rods are installed that run from the top of the locker down to the base. These rods, screwed into the base, consist of two concentric and hollow rods that are threaded so they can be extended in length to fit tightly in the locker and exert force on the base. The mechanism is similar to a shower curtain rod that pushes against opposing walls. In this manner, the device can be easily removed from the locker and put into a new locker each school year.

A vertical piece of acrylic is mounted to the left side of the base. This provides one "bookend" for one side of the shelf. The rotating flap is also made of acrylic, cut to 4" by 9", and attached to the right side of the base using two hinges. As the flap rotates vertically, it becomes the opposite "bookend". In order to keep the bookends tight against the books so that the books stay in place, the flap can slide left and right along the base on a set of two linear rails.

While our client is capable of lifting a textbook, it is difficult for her to grasp it. A book handle is made of a loosely fitting, adjustable Velcro strap that loops around the cover of a book. This also helps to keep the book closed during transfers in and out of the locker. The cost of the device is $245.

Fig. 20.4. The client places a book on the locker assist flap, and then rotates it to a vertical position.

SEE ME MOVE AND GROOVE

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INTRODUCTION

Our client is a nine year old girl with spastic quadriplegia cerebral palsy and cortical visual impairment. While she has severe cognitive impairment, she has normal hearing and demonstrates a positive response to simultaneous audio and visual signals. She wears a brace for trunk support, and manages switch controls with her hands, though their movements still remain highly limited. Due to her visual impairment, she is unable to see peripherally and her right eye is dominant. She also does not detect all colors and therefore prefers brighter shades such as red and yellow against a dark background. She enjoys playing computer games using special software.

See Me Move is intended for home use while in a wheelchair, stander, or in bed. When the client presses a switch, the device responds with musical and/or visual feedback, as well as a shaking toy. The caregiver, parent, or therapist can select the desired feedback. The goal is to improve our client's ability to use her vision together with hearing as stimuli. The second goal is to encourage more targeted and controlled hand movements.

SUMMARY OF IMPACT

The client actively pushes her switch while in her stander and vocalizes positive feedback. Furthermore, the device allows for the client's first active participation in play from her bed. One of her nurses noted that "[this device is] pretty good for her because she's been up [in her stander] for almost an hour and a half ... and she's still interested in it ... and that's unusual." The nurse also indicated that the client will likely use the device often and it will increase her ability to rely on her vision and hearing as a stimulus, as well as create more targeted and controlled hand movements.

Fig. 20.5. The client and her therapist using the device.

Fig. 20.6. Close up of the mirror (bottom right), electroluminescent wires (top left), and shaking toy (center).

TECHNICAL DESCRIPTION

The device is mounted to the end of a microphone boom stand. A wooden base is attached and secured to the bottom of the stand to increase stabilization. The height of the stand is easily adjustable, and therefore the device can be used at locations of varying heights including the client's wheelchair, stander, and bed. The commercial switch is mounted to one of the client's existing trays. A C-shaped acrylic switch holder allows the switch to be placed face-up for normal push down activation, or upside-down for push-up activation. The device includes an acrylic mirror so that the client can see her own hands while pressing a switch, which she finds interesting because her limited field of view often makes this impossible. The mirror is mounted with a friction hinge so that it can be rotated to the proper position, or out of the way if desired.

A custom milled aluminum plate and bracket is attached at the end of the microphone boom. Three microphone goosenecks are attached to this plate to hold the three rewards: a lightshow with two different colored electroluminescent wires, a shaking toy, and a second lightshow with two more different colored wires. The use of the goosenecks allows for the custom positioning of the rewards to the client's current field of view as well as the ability of running wires through their hollow middles.

The electroluminescent (EL) wires used for the light show rest on acrylic plates that contain numerous pegs which allow the user to create any desired shape with the wire. The pegs are made of clear acrylic rods. The EL wires can be configured to light in sync with the music that the device is currently playing.

The shaking toy is constructed by taking a commercial hollowed out toy and inserting a DC motor with an attached offset weight made of bronze and acrylic.

A PIC18F4520 microcontroller controls the logic for this device. Rewards can last the length of 3, 8 or 12 seconds at which point the music pauses and the rewards stop, encouraging the client to press on her switch once again. In addition, if the client has not pressed the switch for 30 seconds, a short auditory signal is played to encourage her to press the switch. The musical feedback is from the µMP3 player (Rogue Robotics, Toronto ON), which plays music from files stored on an SD card.

Fig. 20.7. The See Me Move device.

An LM386 amplifier drives the speaker. A 12V DC from a wall transformer power both the electroluminescent wires and the DC motor inside the shaking toy.

The electronics box is custom made from acrylic, using an inter-digitated cut pattern. Peripherals connect to the box using standard audio jacks: 1/8" for the client's switch and three color coded 3/32" for the rewards. In addition, a set of push button switches atop the box provides user input for the reward, song choice, and reward duration. Also on top of the box is a set of LEDs which lets the user know the current output settings. The cost of the device is $600.

CUSTOM TRICYCLE BRAKE SYSTEM

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INTRODUCTION

Our client is a teenage girl with athetoid cerebral palsy (CP). She enjoys riding her tricycle in the neighborhood. She rides an adult tricycle, the Schwinn Meridian, and her family attached a hip brace for extra support and a pair of adaptive foot cups to keep her feet on the pedals. However, she is not able to use the conventional hand brakes because she has difficulty reaching, grasping, and engaging them. As a result, someone else must run alongside of the tricycle, holding a strap attached to the frame, and stop her by pulling on the strap. This compromises her independence.

This project design focuses on a custom braking system that allows the client to brake independently. It consists of a rotating handlebar that the client twists forward to engage the brakes, and an extended lever arm on the rear band braking system to reduce the force that she needs to apply for braking. The client can use the custom handlebar for both steering and braking, and she does not need to change her hand position to engage the brakes.

SUMMARY OF IMPACT

The custom braking system allows the client to break her tricycle independently using a rotary hand motion instead of using the conventional brake levers. She can apply the brakes without lifting her hands from the handlebar or changing her grip. Twisting forward with her hands applies the brakes and twisting backwards disengages the brakes. True to the intended design, the principles behind the custom brake system are simple and easy for the client to use. As quoted by her mother, "It will be so good for [her] to be able to ride her trike...without having someone run behind with a rope to brake for her."

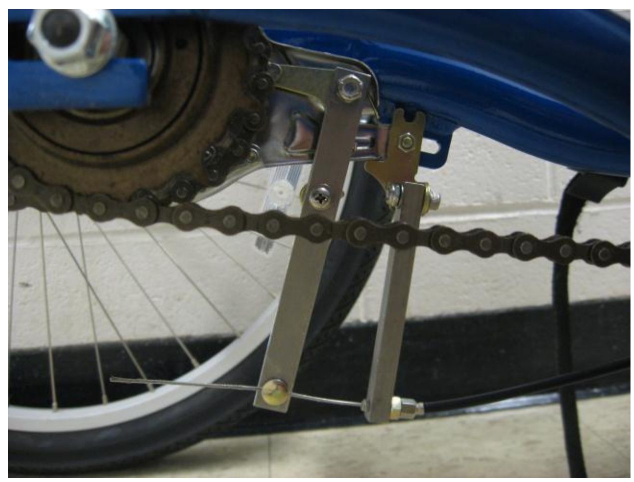

Fig. 20.8. The custom tricycle braking system (top) and close up of the extended lever arm for rear band brakes (bottom).

TECHNICAL DESCRIPTION

The Schwinn Meridian tricycle has a “cruiser” style handlebar, and our custom handlebar is clamped horizontally to it on both the left and right sides.

The custom handlebar consists of two concentric cylinder tubes, made of stainless steel. The outer cylinder is the rotating cylinder that the client holds and uses for steering and brake activation. The inner cylinder is the stationary support shaft. It mounts to the existing tricycle handlebar, and it provides an axis of rotation for the rotating cylinder.

The rotating cylinder has 1.5″ outer diameter (OD). It rides on and contacts the support shaft (1″ OD) only on its ends, which are capped with custom-made Teflon bushings. The Teflon provides a bearing surface with low friction and prevents binding between the two cylinders. Two shaft collars around the support shaft prevent lateral movements of the rotating cylinder. Halfway down the length of the rotating cylinder, two holes are drilled 45º apart to secure one end of the brake cable. The brake cable is threaded into the cylinder through one hole and threaded out of the cylinder through the second hole. The stopper on the brake cable end is larger than the drilled holes and, therefore, secures the cable to the cylinder. The holes are drilled 45º apart so that the cable running inside the cylinder does not touch and abrade the support shaft. Non-adhesive foam strips are wrapped around the cylinder as hand grips; the area surrounding the secured brake cable end is left unwrapped.

The support shaft is three feet long, which is about twice as long as the rotating cylinder. The rotating cylinder is positioned in the middle of the support shaft such that equal lengths of the support shaft are exposed on either side. A metal bracket with an adjusting barrel is attached to the front of the existing handlebar to fasten the brake cable housing to the tricycle frame and to allow the brake cable to be pulled. The custom handlebar is mounted to the existing handlebar frame using eight loop clamps that are lined with silicone to ensure a secure grip. End caps are fitted over the ends of the support shaft and existing handlebar as a safety feature. Polyester Velcro straps are wrapped around the clamps to cover sharp edges.

Fig. 20.9. Client riding the custom tricycle.

When the client twists the rotating handlebar, it pulls on the brake cable, which then pulls on a lever arm that engages the band brakes. A new lever that is 2.5 times the length of the original one provides a mechanical advantage by amplifying the applied force by 2.5 times. The extension is a bracket made of stainless steel with three holes drilled along the bracket. The top two adjacent holes are used to attach the extension to the lever to ensure a firm connection. Once attached to the lever, the extension protrudes downwards towards the ground. A brake cable anchor bolt is inserted in the third hole, closest to the ground, to fasten the end of the brake cable. Another metal bracket is placed relatively parallel to the lever extension and is secured to the tricycle frame. This bracket is thicker than the extension bracket to avoid flexure. An adjusting barrel is fitted to this bracket and keeps the cable housing in place.

Total cost of the project is approximately $300.