A PLUSH SWITCH FOR ACCESSING TABLET-BASED APPLICATIONS FOR CHILDREN WITH MILD TO SEVERE MOTOR LIMITATIONS

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ABSTRACT

Therapeutic play helps promote cognitive, social, and physical skill development in children. Recent articles report how tablet computers are used to provide an inexpensive therapeutic device to engage children with visual, cognitive, and learning disabilities through various therapy and rehabilitation Apps. Although this current market is growing, what has been overlooked is the large populace of children, especially younger children, with limited fine motor skills, such as those with neurological movement disorders that include cerebral palsy, traumatic brain injury, spina bifida, and muscular dystrophy. These children are kept from interacting with touch-based tablet computers due to difficulties in 'touching' a specific small region with appropriate intensity and timing (i.e. effecting press and swipe gestures). As a solution to this issue, we discuss a unique device that converts any possible pressure applied from the body into tablet-based gestures designed to fully engage children. The design of the device is to facilitate the delivery of effective in-home therapy opportunities for children lacking fine motor skills.

BACKGROUND

Due to the pervasiveness of tablet devices and their ease-of-use, the emergence of tablet-based applications (Apps) for providing rehabilitation and therapeutic interventions for children with disabilities is fast growing. With advances in Augmentative and Alternative (AAC) communication Apps for children who have difficulty speaking (Allison, 2012) to cognitive memory Apps for children living with a traumatic brain injury (DePompei, 2008), resulting clinical studies indicate that the use of Apps can provide effective therapeutic solutions for children with disabilities. The resulting dilemma though is that with the introduction of the tablet device itself, there is an entire population of children with disabilities that become excluded. Unfortunately, these touch-based tools pose difficulties to children that have limitations in affecting the common pinch and swipe gestures required for touch-based interaction. The fact that over 200,000 children with disabilities being served in the public school system have an orthopedic impairment, including multiple disabilities (U.S. Department of Education, 2011) validates that there is a large demographic of children that are being overlooked by the introduction of the tablet device into mainstream society. This is especially true for younger children in which therapeutic interventions typically incorporate play within the therapy scenario to assist children in achieving their developmental milestones.

Children with/without disabilities all have developmental milestones to achieve. For children with motor disabilities, physical, occupational, and speech-language therapy services are prescribed to support functional adaptation or compensation to the disability in the context of their developmental progress. These pediatric physical therapy scenarios typically incorporate play within the therapy scenario to provide an engaging and motivational intervention that may enhance the child's participation. No one will argue about how important play is during childhood. The role of play in the development of children has been extensively studied, and a large body of work exists to discuss the importance and nature of play. Piaget's book "Play, dreams, and imitation in childhood" is one of the earlier references showing the importance of play in the learning of cognitive, social, and physical skills (Piaget, 1951). In the therapy framework, play is considered to be the primary activity of the child, a prerequisite to achieving competency in daily activities of living (Ellis, 1973). Two characteristics considered the most essential to the design of play are that it be intrinsically motivated and that it be pleasurable (Reilly, 1974). In fact, free-play, which is spontaneous, intrinsically motivated, and self-regulated by the child, is shown to provide a direct forum for children to develop competencies by exploring their own capacities, to understand cause-and-effect relationships, and fosters creativity, among other things. It also allows a child to develop skills for coping with anxiety and frustration (Cotton, 1984). Unfortunately, due to a number of factors, most children with disabilities are deprived of opportunities for play outside of the clinical setting (Missiuna, 1991). As such, in order to provide access to play opportunities for children with disabilities, in this paper, we discuss a mobile switch interface device for enabling access to tablet-based Apps that is inclusive and engaging to all children.

METHOD

Although the current assistive technology market has provided speech, hearing, and visual aids using tablet devices, the market has overlooked the large populace that has difficulties using the touchscreen interface. For such children with motor impairments, general access to computing platforms is currently accomplished using a physical device, such as a switch. Switch types of devices range from hand switches, head switches, foot switches, mouth switches, and even switches that can detect muscle

movement. To enable use of software applications with these switches, an application must enable scanning, a technique that enables movement through a pre-set list of elements that can be selected. Step scanning (or single-switch scanning) allows transitioning through the elements in a pre-set order whereas two-switch scanning enables a range of scanning options that include row and column navigation. The speed and pattern of scanning, as well as the way items are selected, must be individualized to the physical, visual and cognitive capabilities of the user. Although there are a variety of switches that can translate consistent and voluntary movement from any body part, the switch, itself, cannot be directly plugged into a computer or tablet device. In order to use a switch, a switch interface must be used to connect the switch to the computer. Although there are a number of switch interface devices that exist for traditional computing platforms, there are few interface devices available for tablet devices.

Tablet devices are known to provide an interactive experience that has revolutionized learning for children. While these tablet devices are intuitive to utilize and easy for many children, those with motor limitations tend to have difficulties due to the fine motor skills required for interaction. Based on the emerging appeal of tablets, there has been a slow influx of switch-accessible Apps being created, but only on the iOS (iPad) platform and most are focused on augmentative and alternative communication (AAC) Apps (Farrell, 2013). For example, of the 475,000 Apps listed as native to iPad in October 2013, less than 0.02% of them were switch-accessible.

Thus, in order to provide children, especially younger children, with disabilities an engaging interface to tablet-based applications, we have developed a plush switch device based on the TabAccess design (Park, 2013; Howard, 2013). This accessible device is designed to engage children that have difficulties affecting the common pinch and swipe gestures required for touch-based interaction.

The motivation for designing the original TabAccess prototype began by examining the results of a study, which reviewed a number of different joysticks and switches for use by children with motor impairments (McCann, 1966). The basic purpose of the study was to develop electronic devices to extend the capability of a child with Cerebral Palsy when all other avenues leading to physical independence had been exhausted. Common considerations found with these devices were 1) most devices had four selection options - typically up, down, left, and right, 2) certain physical requirements had to be met in order for a particular input device to be operational, and 3) in order to be useful, the device had to have reliable behavior and a high degree of accuracy. Motivated by this study, TabAccess was designed based on the functionality of the slammer switch (a single-switch input device), which was the easiest to use, into an n-selection wireless input device. We integrated the device, which provides wireless access via Bluetooth to the tablet and connection of up to six plug-and-play switch input devices, into a plush sensor housing that provides a kid-friendly design made to increase durability and interactivity for kids with limited fine motor control. Pressure-based sensors embedded within the plush switch can be grouped together in various configurations, either acting together as one switch or acting independently for increasing functionality. For translation of gross motor gestures, we have also developed a methodology to convert raw sensor data retrieved from multiple sensors into touch-based gestures that interact with various therapy and educational Apps. This provides the ability to generate a number of unique commands using the wireless device, which enables automated conversion of inputs into gestures. The functionality of the device has been evaluated in a number of sessions with children with disabilities (Figure 1) (Howard, 2014) and has been shown to provide an interactive experience for engagement.

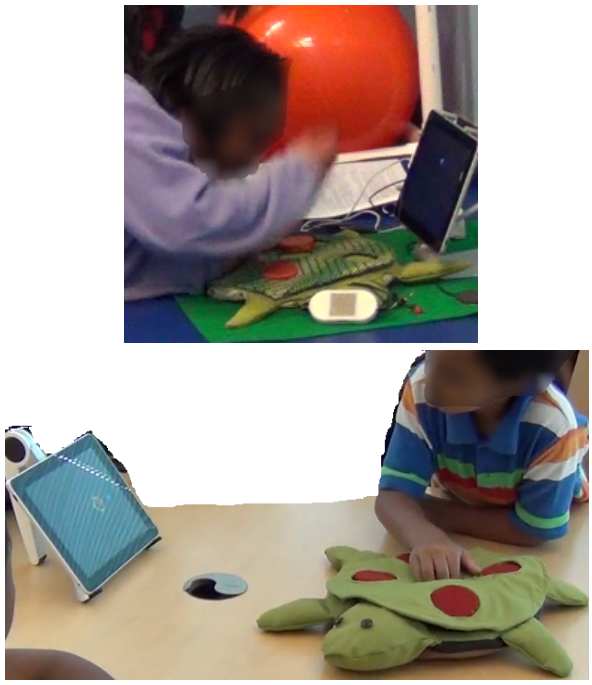

Figure 1. Early subject trials of the plush switch used in sessions with children with disabilities

RESULTS

The device was evaluated for engaging children with disabilities in interactive tablet-based Apps. Eleven children participated in the interactive sessions, ranging in age from 8 to 14 years old (Males: 9; Females: 3; mean(age): 10.1; stdv(age): 2.0). All parents signed parental consent forms (with verbal assents provided by the children). Children had, on average, some experience using switches and tablet devices (Table 1). Disabilities of the children ranged from those with Cerebral Palsy, Spina Bifida, TBI, Spinal Muscular Atrophy, and Autism (Table 2). To provide a

forum for free-play, we evaluated with Apps that required understanding of cause-and-effect relationships. Nine of the children interacted with an App on the Android platform, whereas three of the children engaged with a cause-and-effect App on the iPad. For those children who had sufficient upper-arm mobility for providing touch-based gestures, we compared reaction time and accuracy between using our device versus using touch (Table 3).

Table 1: Statistical Measures on Experience (options ranged from A lot = 4; Some = 3; A little = 2; None = 1)

	Average	Stdv
How much experience do you have using a tablet such as an iPad?	3.3	0.8
How much experience do you have using a switch or button to control a computer?	3.4	0.7

Table 2: Demographic Profile of Children

Gender	Primary Diagnosis	Age
Male	Cerebral Palsy	8
Male	TBI	8
Male	Autism	8
Male	Cerebral Palsy	8
Male	Autism	9
Male	Spinal Muscular Atrophy	10
Male	Cerebral Palsy	10
Male	Autism	11
Female	Cerebral Palsy	11
Male	Spina Bifida	12
Female	Cerebral Palsy	12
Female	Cerebral Palsy	14

Table 3: Performance Comparison: Touch versus Switch

	Time (Seconds)	Accuracy (Percent: correct hits/total hits)
Touch	28.2	57%
Switch	27.4	64%

DISCUSSION AND FUTURE WORK

In this paper, we discuss a plush switch that enables access to tablet-based applications for children with upper-body motor limitations. The pilot study with children provides some evidence that the functionality of the device provides improved performance over touch-based interaction. Although the mean accuracy associated with the switch device was greater than that for touch, we need additional evidence for validating its full benefit. As such, future assessment will include correlation of performance with specific motor skill level, such as classified by the Gross Motor Function Classification Systems (Wood, 2000). Another study limitation to resolve is identification of cognitive skill level by administering cognitive tests such as the Pictorial Test of Intelligence, which can be used with children with motor disabilities (French, 2001). We believe that by incorporating these two metrics as dependent variables, we can further identify the inclusion criteria associated with achieving full-benefit with device usage. These additional metrics will enable us to further quantify the efficacy of the switch to enable access to tablet-based applications for children with mild to severe motor limitations.

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