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Assisting Two Children with Multiple Disabilities and Minimal Motor Skills Control Environmental Stimuli with Thumb Poke Through a Trackball

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Background: Microswitches are the most commonly used input device for people with multiple disabilities to control environmental stimulation. However, little is known about adopting the commercial trackball with a revised trackball driver as a more feasible input device. **Aims:** To assess whether two children with profound multiple disabilities and minimal motor skills would be able to control environmental stimulation using thumb poke ability through cordless trackballs installed with a newly developed mouse driver (i.e. a new mouse driver replacing a standard mouse driver, turning a trackball mouse into a precise thumb poke detector). **Method:** An ABAB design and a 2-month post-intervention check were adopted to perform the study. **Results:** Data showed that the two children improved significantly in their target response (thumb poke) to activate the control system to produce environmental stimuli during the B (intervention) phases. This performance was maintained at the post-intervention check. **Conclusions:** The use of thumb poke in connection with a trackball allowed the children with multiple disabilities and minimal motor skills to increase their level of response and stimulation control.

Keywords: Thumb poke, detector, trackball, multiple disabilities.

Introduction

Microswitches are technical tools designed to help persons with multiple disabilities control their immediate environment with simple responses: it can be of many different kinds (e.g. pressure, wobble, pull, pedal, and leaf microswitches) to suit the physical conditions and behavioural characteristics of the users (Crawford and Schuster, 1993; Gutowski, 1996; Lancioni, Singh, O'Reilly, Sigafoos, Didden et al., 2009; Lancioni et al., 2007; Lancioni, Singh, O'Reilly, Sigafoos, Oliva et al., 2009; Leatherby, Gast, Wolery and Collins, 1992; Saunders et al., 2001). To introduce a person with multiple disabilities to a microswitch-aided

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program, one has to select a plausible response and a microswitch suitable to that response (Glickman, Deitz, Anson and Stewart, 1996; Lancioni, O'Reilly and Basili, 2001). Evaluators determine the best type of switch based on individual characteristics and considerations of position, mounting, and placement requirements. Various responses have been suggested in literature as highly plausible and convenient, for example, hand-pushing, head-turning, hand movements, and vocalization (Kinsley and Langone, 1995; Lancioni, O'Reilly, Oliva and Coppa, 2001; Sullivan, Laverick and Lewis, 1995). Microswitches matching such responses have been developed and results have generally been fairly encouraging (Gutowski, 1996; Lancioni et al., 2005; Lancioni et al., 2006; Lancioni, Singh, O'Reilly, Sigafoos, Oliva et al., 2009; Lancioni et al., 2004). Although satisfactory outcomes have often been reported, these responses and microswitches may not be suitable for children with multiple disabilities who have minimal motor control (i.e. children who have extensive paralysis of their body and can effectively control only very limited movements). For these children, it is necessary to identify some minor movements to use as target responses and set up microswitches that can detect such responses.

The computer mouse has gained wide acceptance as an input device that could be used in a "natural way" to indicate position on a display screen. Based on ergonomics, the mouse has been designed to allow most individuals to operate it easily. Individuals can interact with a computer by moving, pressing and releasing the button of a mouse. Even 3-year-old children can use a mouse (Strommen, Revelle, Medoff and Razavi, 1996). Some studies have indicated that children with developmental disabilities can learn pointing (Durfee and Billingsley, 1999; Missiuna, 1994; Shimizu and McDonough, 2006).

A trackball is a type of mouse consisting of a ball held by a socket containing sensors to detect rotation of the ball about two axes. The user rolls the ball with the thumb, the fingers, or the palm of the hand to move a cursor. It is the preferred pointing device for numerous computer users, particularly for people with some form of motor impairment. Trackballs are generally either thumb-operated, with the ball moved by the thumb and the buttons clicked by the fingers, or finger-operated, with the ball moved by the middle fingers and the buttons by the thumb and little finger. For people with low strength, poor coordination, wrist pain, or a limited range of motion, rolling a trackball can be easier than shuttling a mouse across the surface of a desk. From this point of view, the trackball is a sensitive detector, designed to detect thumb/finger poke on the ball, and transfer the wheel rolling into the movement of the computer cursor. Therefore a trackball can be used as a special switch, because its control surface is easier to manipulate than a standard mouse and it can accurately detect any thumb/finger movements. It has the basic on/off (roll/stop) function like a switch, and it can detect small rotations of the ball about two axes.

In addition, as a commercial product, a trackball also has the advantages of low cost, good technical support, can be easily procured, and can be updated with the newest technology (i.e. 2.4G wireless or Bluetooth trackball). Therefore, in addition to the exclusive use of specialized switches, people with disabilities would also gain from being trained to use very common, cheap and powerful commercial trackballs. Although a standard trackball has all the advantages mentioned above, it is difficult to apply to other applications, especially those concerning persons with disabilities.

Normally, when a trackball is connected to a computer by hand, the Windows operating system (OS) will identify this device and install its driver automatically, then define its function as moving the cursor. Therefore it is not easy to change its function into other applications (i.e. thumb/finger poke detector) to meet the needs of the people with disabilities.

Redesigning mouse drivers can redefine mouse functions, turning it into a much more powerful tool, but this is rarely proposed by researchers because of the complexity of the technology required. Only a few recent researches (Shih, Chang and Shih, 2009; Shih, Chung, Chiang and Shih, 2010; Shih, Hsu and Shih, 2009; Shih, Huang, Liao, Shih and Chiang, 2009; Shih and Shih, 2009a, b, c, d; Shih, Shih, Lin and Chiang, 2009) adopted software technology to redesign the mouse driver, and turned the mouse into a useful tool for many applications dedicated to persons with disabilities, providing them with additional choices in assistive technology.

Shih and Shih (2009d) applied Shih's revised mouse driver (i.e. a new mouse driver replaces standard mouse driver, and turns a mouse into a precise two-dimensional motion detector) to assess whether two persons with profound multiple disabilities would be able to control environmental stimulation using hand swing and a standard mouse with a newly developed mouse driver. Data showed that, with the assistance of Shih's revised mouse driver, both participants significantly increased their target response (hand swing) to activate the control system to produce environmental stimulation and maintained this performance.

Therefore it can also be realized through revising Shih's mouse driver to change a trackball into a precise thumb poke detector, especially suitable for persons with multiple disabilities and minimal motor skill.

This study was directed at two children with profound multiple disabilities and minimal motor skill whose most plausible response seemed to be thumb poke. In our case, the target response consisted of a sequence of thumb pokes. The possibility of making this response instrumental in controlling environmental stimuli was through a wireless trackball placed under their hands. Both trackballs installed Shih's revised mouse driver developed for this target response. The function of this revised driver would transfer thumb poke into a sequence of poke data instead of standard cursor movement. Through the above configuration, a standard trackball can be used as a precise detector to detect any tiny thumb poke. Trackball device does not need additional design or modification, and offers many choices based on its various formations. For example, a wireless trackball can be turned into a wireless thumb poke detector.

Method

Participants

The participants Lai and Wong were 12 and 10 years of age respectively. Lai was rated in the severe intellectual disability range. He was in a wheelchair due to spasticity, scoliosis, and foot abnormalities, and had hardly any initiative in performing foot or leg movements. He had limited physical control, but his left thumb had poke ability. He had no apparent interaction with objects and seemed very withdrawn.

Wong had congenital cerebropathy due to perinatal hypoxia. She presented spastic tetraparesis with modest head control and lack of trunk control, undetermined residual vision, and absence of speech. She was considered to be in the profound range of intellectual disability. She had poor finger function, but could still control her wrist. Her right thumb had poke ability. She would react to familiar sounds and songs, loud noises, and praise by alerting

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(turning/widening her eyes) or smiling. Their parents have given formal consent for their involvement in this experiment.

Target response, trackball setting, control system, and stimuli

The configuration of this experiment is shown in Figure 1. The target response consisted, as mentioned above, of a sequence of thumb pokes. Two Logitech wireless trackballs, installed with Shih's revised mouse driver to detect the target response, were placed under Lai's left hand (rotated clockwise 180° to help him hold it), and Wong's right hand. Shih's revised driver rotated Lai's trackball coordination by 180° clockwise, cancelled button functions of both trackballs, and transmitted the thumb poke signal to a control system.

The thumb poke signal, transmitted via wireless to the control system, is a sequence of thumb pokes. The control system is an Eee Box mini computer (ASUS, 2009), which is a mini host, with built-in Microsoft Windows XP Home Edition. It was connected to a TV through cables to play participants' favourite videos and music. Because of its low power consumption (saving up to 90% in energy consumption), small size and low price, it is practical to develop it as the control system for the disabled.

A critical value is necessary to be set for the participants' thumb poke amount, because any slight but undesired poke could be detected by the precise trackball. The control system would check the poke amount, and served to start a 6-second stimulation period contingent on the response (except in baseline phases) and to record the response, once the poke amount exceeded the critical value. The critical value could be adjusted according to the participants' personal conditions. The stimulation period involved the activation of one favourite stimulus (i.e. stimuli that had produced smiling or voice reactions). The favourite stimuli involved various types of cartoon videos and music, offered by their parents.

Experimental conditions

Lai and Wong initially received an ABAB sequence, in which A represented baseline and B intervention phases (Richards, Taylor, Ramasamy and Richards, 1999). A post-intervention check was conducted 2 months after the second B phase. Three to five sessions a day occurred within those study periods. Sessions lasted 10 minutes and were conducted at home. Responses were recorded automatically through the Eee Box control system.

Baseline phases. The baseline phases included 15 and 12 sessions respectively. The wireless trackball and the Eee Box control system were available, but the control system did not produce any stimulation. At the start of the sessions, both participants received verbal promptings to respond (i.e. verbal promptings from a therapist who asked them to poke the trackball). Promptings would be repeated during the sessions after periods of about 1 minute of non-response.

Intervention phases. The intervention phases included 45 and 60 sessions respectively. Procedural conditions were the same as during baseline except the control system produced 6 seconds of his/her favourite stimulation. A new activation, occurring while the previous one was still being followed by the favourite stimuli (i.e. within the 6-second interval in which the stimuli were on), was not recorded and did not cause an additional stimulus presentation.

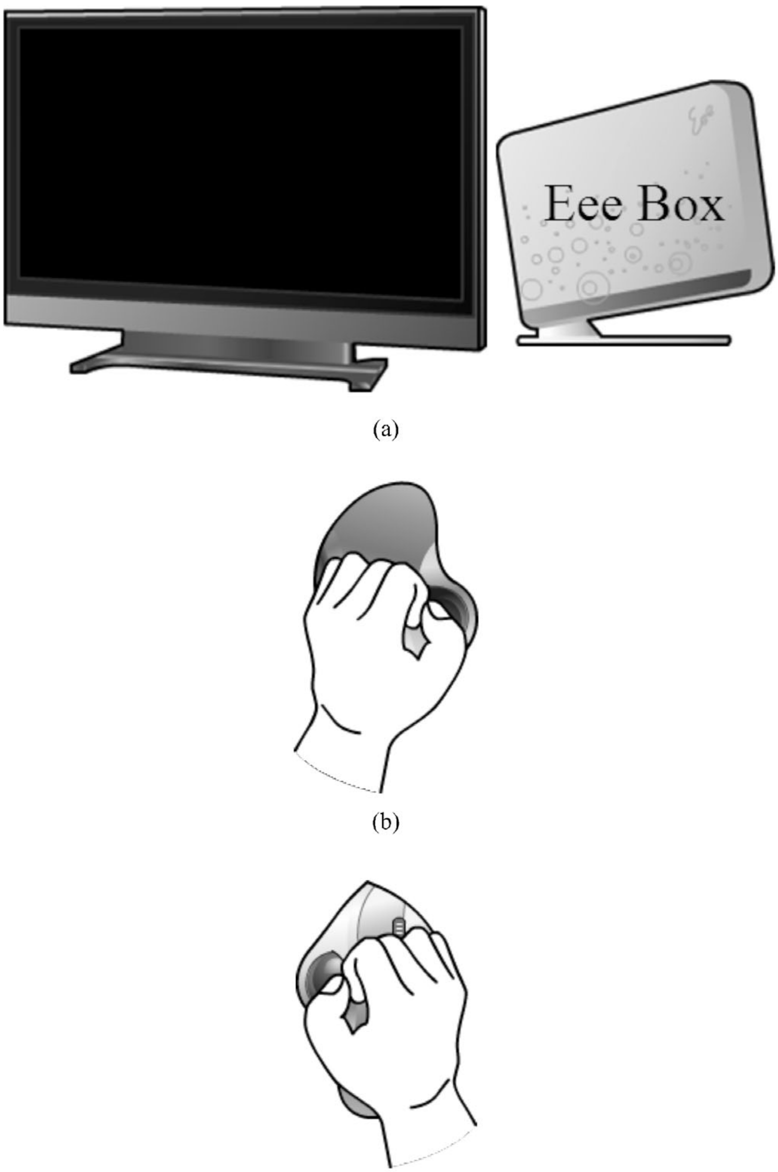

Figure 1. The configuration of this study, including a control system and two trackballs installed with Shih's revised mouse driver. The control system is connected to TV through cables, and both send the thumb poke signals through wireless to the control system. (a) The control system – an Eee Box mini computer connected to TV through cables. (b) Lai's trackball. It is rotated 180°clockwise and installed with Shih's revised mouse driver sending left thumb poke signals through wireless to the control system. (c) Wong's trackball. It is installed with Shih's revised mouse driver sending right thumb poke signals through wireless to the control system.

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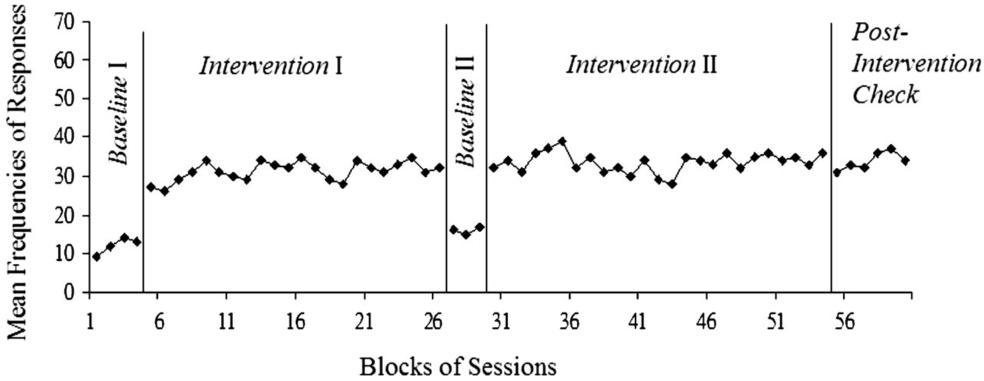

Figure 2. Lai's data. Data points represent mean frequencies of Lai's target responses per session (independent of prompting) over blocks of three sessions. Only the final points of a phase can represent a block of two sessions.

Post-intervention check. During the period separating the end of the second intervention phase and the post-intervention check, both participants continued to receive sessions comparable to those occurring during the intervention. Eighteen sessions (carried out 2 months after the end of the second intervention phase) were used for the post-intervention check.

Results

Lai's data are shown in Figure 2. During the first baseline phase (15 sessions), Lai had a mean of about 12 independent responses per session. During the first intervention phase (45 sessions), the mean increased to about 31 responses per session. This mean frequency dropped to 16 during the second baseline phase (12 sessions) to be fully restored and eventually increased during the second intervention phase (60 sessions). The intervention frequencies were largely maintained at the post-intervention check (18 sessions). The differences between the baseline responding frequencies and the intervention and post-intervention frequencies were significant ($p < .01$) on the Kolmogorov-Smirnov test (Siegel and Castellan, 1988).

Wong's data are shown in Figure 3. During the first baseline phase, Wong had a mean of about 15 independent responses per session. During the first intervention phase, the mean increased to about 40 responses per session. This mean frequency dropped to 19 during the second baseline phase to be fully restored and eventually increased during the second intervention phase. The intervention frequencies were largely maintained at the post-intervention check. The differences between the baseline responding frequencies and the intervention and post-intervention frequencies were significant ($p < .01$) on the Kolmogorov-Smirnov test (Siegel and Castellan, 1988).

Discussion

This experiment has demonstrated that both children had a large increase in the target response (thumb poke) to activate the control system and produce environmental stimulation. The use of thumb poke in connection with a standard trackball allowed the children with multiple disabilities and minimal motor skills to increase their response level and stimulation control.

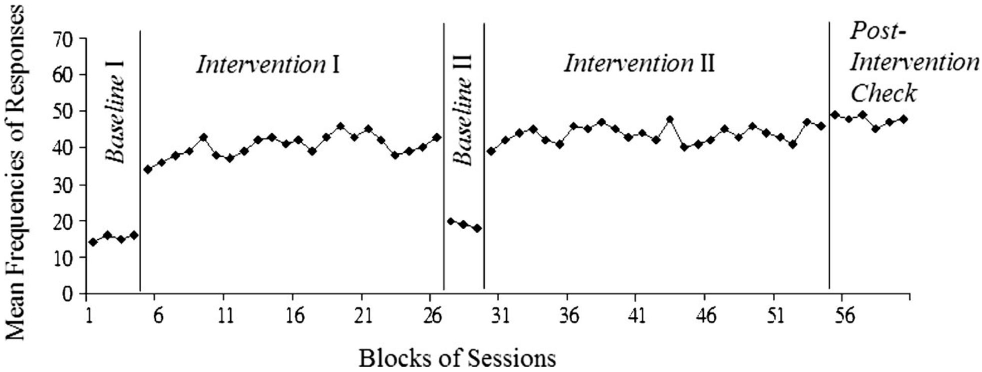

Figure 3. Wong's data. Data points represent mean frequencies of Wong's target responses per session (independent of prompting) over blocks of three sessions. Only the final points of a phase can represent a block of two sessions.

This achievement can be considered relevant as it represents new environmental engagement and an exercise of self-determination. These aspects, combined with the new opportunity of stimulation control, can be very important for improving quality of life (Felce and Perry, 1995; Wehmeyer and Schwartz, 1998). A better quality of life represents a top priority for any program aimed at helping people with profound multiple disabilities (Lancioni, O'Reilly, Oliva et al., 2001; Schalock et al., 2002).

Redesigning the commercial devices into assistive devices has the advantages of low cost, being easy to procure and to be updated to meet the needs of the people with disabilities. Another advantage of using standard commercial products is that they are easily updated with the newest technology. Results of this experiment also indicated that, with the assistance of Shih's revised mouse driver, the standard trackball can be used as a high performance and high resolution thumb/finger poke detector. Except for the trackball adopted in this study, the functions of the standard mouse can also be adjusted through driver technology to extend its applications (Shih and Shih, 2009d; Shih, Shih et al., 2009). This study only addressed two children with profound multiple disabilities and minimal motor skills whose most reliable response was to poke their thumbs in order to control environmental stimulation through standard trackballs. Other persons with profound multiple disabilities, like those with only hand swing ability, are not mentioned.

Further studies are necessary to focus on turning other commercial products into assistive devices through software technology for persons with multiple disabilities. Hopefully, standard product implementations can provide disabled users with additional choices in assistive technology and make it more affordable in educational and home contexts.

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