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Assisting people with multiple disabilities improve their computer pointing efficiency with thumb poke through a standard trackball

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ABSTRACT

This study evaluated whether two people with multiple disabilities who could not easily use a computer through a standard input device (i.e., mouse or trackball) would be able to improve their pointing performance using thumb poke with a standard trackball through a Dynamic Trackball-Pointing Assistive Program (DTPAP) and a newly developed trackball driver (i.e., a new trackball driver replaces the standard trackball driver, and changes a trackball into a precise thumb poke detector, and intercepts trackball action). Initially, both participants were given baseline sessions, then intervention started with the first participant. When his performance was consolidated, new baseline and intervention occurred with the second participant. Finally, both participants were exposed to the maintenance phase. Data indicated that both participants improved their pointing performance significantly with the use of DTPAP and remained highly successful through the maintenance phase. Implications of the findings are discussed.

1. Introduction

For people with disabilities, computer technologies play a very important role in broadening their lives, increasing their independence, accessing mainstream society, and increasing their capacity to engage fully in daily activities and academic or vocational options (Bradley & Poppen, 2003; Brodwin, Star, & Cardoso, 2004; Houlihan et al., 2003; Wong, Chan, Li-Tsang, & Lam, 2009). Therefore, computer technologies have a tremendous potential to create a venue of equalization between people with and without disabilities, and have been widely used in education, academic study, daily life, communication training, entertainment, and pre-job training. The benefits are clearer when persons with disabilities are given the opportunity to improve their level of competency and to improve their operation ability (Brodwin et al., 2004; Davies, Stock, & Wehmeyer, 2002a; Davies, Stock, & Wehmeyer, 2002b; Mann, Belchior, Tomita, & Kemp, 2005; Ritchie & Blanck, 2003).Most people with disabilities will find that it is difficult or impossible for them to operate computers with a standard mouse or similar pointing devices (Brodwin et al., 2004; Rao, Seliktar, & Rahman, 2000; Shih & Shih, 2009b). Most commercial computer-input devices (i.e., mouse, trackball and keyboard) are targeted at the mainstream population, without taking into account that these devices might be used by people with disabilities who generally encounter mouse operation problems and providing the type of accommodation that meets the needs or desires of people with disabilities (Abascal & Nicolle, 2005; Brodwin et al., 2004; Rao et al., 2000; Wong et al., 2009).

Therefore, Shih and Shih (2009a, 2009c) adopted software technology by redesigning the mouse driver, and presented a multi-mouse configuration interface to enable disabled people to complete mouse operation by utilizing the remaining

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ability in each limb to operate several standard input devices (i.e., mice or trackballs). For example (Shih & Shih, 2009a, 2009c): (a) the right hand could use a mouse (rotated clockwise 90° to help him hold it) to control the cursor's left-to-right movement. This redesigned mouse driver rotated the mouse coordination 90° clockwise, and cancelled the up, down, and button functions (i.e., the function of this mouse was only to transfer his right hand swing into right-to-left movement of the cursor, and the up-to-down movement and button functions did not work), (b) while the left hand could control the up and down movement (this driver cancelled the left-to-right movement and button functions), and (c) the mouse button was pressed by the toe of the left foot. This mouse driver retained only its button function, and the right button function was set the same as the left button, in order to increase the pressure surface (i.e., pressing the left or right button both produced the left button function). Therefore, with the assistance of multi-mouse configuration, people with disabilities who cannot easily or possibly use a computer through standard input devices can use very common, cheap, and powerful commercial input devices as people without disabilities can, instead of using specialized-design alternative computer-input devices which are suitable for them. This thus provides them with additional choices in computer assistive technology.

Pointing, which is achieved by moving the cursor over certain targets (areas, icons, etc.) and clicking, is adopted by most computer programs and CAI software as the most common basic mouse operation (Donker & Reitsma, 2007a, 2007b; Shimizu & McDonough, 2006). Common pointing problems for persons with disabilities include inability to select small targets, difficulty moving a pointing device in a straight line, or difficulty controlling the pointer's buttons. Such users can benefit from being provided useful functions in pointing, such as automatic target center cursor positioning, to position the target quickly, easily, and accurately (Grossman & Balakrishnan, 2005; Park, Han, & Yang, 2006).

Many researchers have studied assistive programs to improve the pointing ability (target positioning/acquiring), in order to facilitate the computer operation quality, for people with disabilities (Ahlstrom, 2005; Ahlstrom, Hitz, & Leitner, 2006; Akamatsu & MacKenzie, 2002; Casiez, Vogel, & Balakrishnan, 2008; Cockburn & Brewster, 2005; Cockburn & Firth, 2003; Dennerlein & Yang, 2001; Grossman & Balakrishnan, 2005; Park et al., 2006). These studies have characterized pointing performance in terms of movement trajectories, accuracy, clicking behaviors and speed.

Recent studies (Shih, Cheng, Li, Shih, & Chiang, 2010; Shih, Chung, Chiang, & Shih, 2010; Shih, Hsu, & Shih, 2009; Shih, Huang, Liao, Shih, & Chiang, 2010; Shih, Li, Shih, Lin, & Lo, 2010; Shih, Shih, & Chiu, 2010) adopted software technology to redesign the mouse driver in order to improve computer operation performance: (a) Automatic Pointing Assistive Program (APAP), where the user can click the mouse button when the cursor is near the target (inside the activation area), instead of moving the cursor over the target, to improve the users' pointing efficiency (Shih, Hsu, et al., 2009). (b) Extended Automatic Pointing Assistive Program (EAPAP), which solves the limitations of APAP when targets are too close to each other (Shih, Li, et al., 2010). The activation areas in EAPAP are not bound to their corresponding targets, but are placed properly on the screen, and use icon and text prompts to indicate their corresponding targets. (c) Dual Cursor Automatic Pointing Assistive Program (DCAPAP), where the dual cursors (a virtual cursor and a system cursor) are adopted to offer users an operating environment with Mouseover effects which is closer to the real conditions (Shih, Chung, et al., 2010). (d) Extended Dual Cursor Automatic Pointing Assistive Program (EDCAPAP), which solves the limitations of DCAPAP when targets are too close to each other (Shih, Shih, et al., 2010). (e) Multiple Cursor Automatic Pointing Assistive Program (MCAPAP), where driver technology is adopted to enable co-located users, having their own virtual cursors with APAP function, to collaborate through a single computer (Shih, Cheng, et al., 2010). (f) Automatic Drag-and-Drop Assistive Program (ADnDAP), where the complex dragging process, which is difficult or impossible for persons with disabilities to operate, is replaced by a simple clicking operation with APAP function (Shih, Huang, et al., 2010).

These software-based (redesigned mouse driver) approaches are powerful because they can reset mouse functions to enable a standard mouse to adapt to needs of people with disabilities. They are compatible with all currently available software; thus existing software can be utilized to improve the operating efficiency of people with disabilities without being modified or rewritten.

However, the researches mentioned above are focused on persons with disabilities who can operate a mouse to move a computer cursor, but have low operation efficiency. It is not suitable for people who cannot easily or possibly use a computer through a standard mouse. Therefore, it is necessary to identify a plausible and specific response (such as hand pushing/movements, head-turning, and thumb poke) to use in a computer operation interface, and set up switches/detectors that can identify such responses.

A mouse wheel is generally finger-operated, which is easily operated to control a scrolling or zooming function (Brodwin et al., 2004; Shih, Chang, & Shih, 2009; Shih, Shih, Lin, & Chiang, 2009). With the basic on/off (rolling/stop) function as a switch, a mouse wheel can be used as a thumb/finger poke detector because it can detect any tiny rotation of the wheel by the thumb/fingers. Therefore, Shih, Shih, et al. (2009) applied mouse driver technology to changing a mouse wheel into a precise thumb/finger poke detector to match the unique characteristics of people with multiple disabilities and minimal motor skills, and assessed whether they would be able to control environmental stimulation using thumb/finger poke with a standard mouse wheel (Shih, Shih, et al., 2009). Based on this research, Shih, Chang, et al. (2009) proposed a new operation method, Dynamic Pointing Assistive Program (DPAP), where the user can rotate a mouse wheel by poking it with their thumb/finger. The poke action will be intercepted, and the cursor will automatically jump to a series of pre-defined target positions in order, according to the wheel rotation amount and direction (Shih, Chang, et al., 2009).

In addition, the mouse is also an excellent detector of hand movement, sensing motion in two-directions (horizontal and vertical), and translating this to cursor movement on a computer screen. Possessing the on/off (moving/stop) basic function of a switch, it can be also used to detect movement speed and acceleration in two-directions. Shih and Shih (2009d)