Computer Input Devices and the Elderly: A Musculoskeletal Disorder Focus

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Abstract. The aging process carries important implications for the design of human-computer interfaces. Decreases in vision, motor control and muscle force combined with a higher vulnerability to musculoskeletal disorders and to degenerative diseases should be taken in consideration when designing and selecting computer input devices for the elderly. This study reviews the recent research literature on computer input devices and their adequacy to the elderly user. Significant findings from evaluative studies are summarized, and recommendations are provided.

Keywords: Computer input devices · Aging · Older · Elderly · MSDs

1 Introduction and Significance

The fast aging of many western and eastern societies and their increasing reliance on information technology create a compelling need to reconsider older users' interactions with computers. Computers are critical for productive and independent living (Charness 2001). Older adults are increasingly using computers (Ball and Hourcade 2011), but they often face challenges and lag behind younger users (Ji et al. 2010; Czaja and Lee 2003). Barriers include lack of familiarity, feelings of inadequacy, declining visual and motor skills (Carpenter and Buday 2007; Mann et al. 2005). Computers allow the elderly to stay employed, informed, intellectually active, and socially integrated (Taveira and Choi 2009).

Older adults often use computer input devices in different ways when compared to younger ones. These differences in usage style can be attributed to aging effects as well as to limited familiarity with computers. Hsiao and Cho (2012) studied healthy young and older adults performing a series of mouse tasks. A three dimensional motion capture system and electromyographic analysis were used to obtain kinematic and kinetic data. Compared with young adults, the older users had greater amplitude of muscle activity in forearm, and greater cranial-cervical angle and neck flexion (forward head posture). Consequently, the older adults might be at greater risk of developing musculoskeletal disorders (Hsiao and Cho 2012).

Many older adults suffer from vision reducing eye disease (Leonard et al. 2005), and less efficient visual processing. Age-related changes affecting computer usage include reduced muscle strength and range of motion (ROM), difficulty executing fine

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movements, as well as increased incidence of arthritis and neurological disorders (Jochems et al. 2013). Size constraints in handheld devices further aggravate these issues (Díaz-Bossini and Moreno 2014; Zhou, Rau and Salvendy 2012).

The purpose of this review is to synthesize the available research on computer input devices from a perspective of older users, with an emphasis on mitigation and accommodation to musculoskeletal disorders (MSDs).

2 Methods

Using a systematic approach to literature searching, the authors first defined an initial set of keywords to guide the identification of relevant studies. Two librarians were engaged in the process of identifying and searching appropriate databases. The search was conducted primarily using electronic sources, supplemented by books and other printed materials retrieved from a network of libraries. Studies published in English were drawn from peer-reviewed journals, conference proceedings, edited books, and a variety of web-based sources.

3 Discussion of Results

Input devices sense physical properties of the user (e.g., motions, touch, voice, etc.) and convert them into predefined signals to the computer. Input devices must comply with the users' anatomic, biomechanical, perceptual, and cognitive needs and capabilities. Epidemiological studies have associated long hours of computer use with elevated rates of MSDs in the arms and neck (Gerr, Marcus, and Monteilh 2004). Furthermore, since the prevalence of several MSDs increases with age (Woolf and Pfegler 2003), additional caution in the design and selection of input devices for this population is justified. Older adults are in general slower in movement and make more submovements (Hertzum and Hornbaek 2010; Nichols, Rogers, and Fisk 2006) when operating input devices.

3.1 Keyboards

Although the association between typing and MSDs is somewhat mixed (Gerr et al. 2004), the conventional QWERTY keyboard design affects upper limbs postures (Rempel et al. 2007; Swanson et al. 1997). Typing postures are also influenced by the nature of tasks performed and the workstation configuration.

Older adults are slower typists, particularly novices, but not necessarily less accurate (Bosman and Charness 1996). Users with rheumatoid arthritis, a common illness among older adults, tend to apply high force keystrokes. They move their hands to strike keys and tend to maintain their wrists and fingers in a fixed position. These keyboarding styles appear to reduce typing productivity and have the potential to put stress on joints already affected by the disorder (Baker, Gustafson and Rogers 2010).

Mann et al. (2005) found that "larger keys" was the most common improvement request among older users. Scarce evidence exists on the benefits of alternative keyboard designs on MSD prevention, although there is some evidence that users suffering from hand-wrist pain may experience improvement in soreness and function with a split keyboard geometry (Tittiranonda et al. 1999). For handheld computers older adults prefer a physical keyboard to on-screen ones (Zhou, Rau and Salvendy 2012).

3.2 Pointing Devices

Pointing devices allow the user to control cursor positioning and to select, activate, and drag items on display. Web interaction, for example, involves frequent pointing and selecting tasks, commonly surpassing keyboard use. The pointing device design and its operational characteristics, along with the workstation configuration, and the nature, duration and pace of the tasks, affect body postures. General concerns relating to the usage of pointing devices by the elderly include prolonged static postures of the back and shoulders, frequent wrist motions and excessive forearm pronation and wrist deviation.

Mouse. The mouse is the most commonly used non-keyboard input device with desktop computers (Atkinson, Woods, Haslam, and Buckle 2004). Intensive mouse use has been associated with increased risk of upper extremity MSDs, including carpal tunnel syndrome (Keir, Bach, and Rempel 1999). Various aspects of mouse control such as moving, clicking, fine-positioning, and dragging may be difficult for older people due to declining motor control and coordination. Increased susceptibility toward disabling conditions, such as arthritis, compounds the problem. Sandfeld and Jensen (2005) indicated that the combination of small target sizes and high mouse gain reduced performance severely, as measured by working speed and hit rate, and this was especially pronounced in the elderly group. In addition, muscle activation levels were found to be generally higher among older users. Mouse usage speed was found to be negatively affected by age, as well as by age-related impairments (Baker and Rogers 2010)

Touchpad. A touch pad is a flat panel that senses the position of a finger or stylus, and is commonly found as an integrated pointing device on portable computers such as laptops, notebooks, and PDAs. For older adults using portable computers, the small pad dimension poses some challenges due to the size mismatch with the screen. Elderly users may also experience difficulty with the complex motor skills involved in tapping the touch pad (Wood, Willoughby, Rushing, Bechtel, and Gilbert 2005). Armbrüster et al. (2007) showed that older users were significantly slower than younger ones when executing touchpad tasks. Hertzum and Hornbaek (2010) comparing young (12–14 years), adult (25–33 years), and elderly (61–69 years) participants' performance in pointing tasks with mouse and touchpad concluded that all three age groups were slower and made more errors with the touchpad than the mouse, but the touchpad slowed down elderly participants more than young participants, who in turn were slowed down more than adult participants.

Trackball. Users with low strength, poor coordination, wrist pain, or limited ROM, may prefer a trackball to a mouse (Wobbrock and Myers 2006). Trackballs need little space in which to operate, unlike mice, which have large desktop footprints. Trackballs can be embedded in consoles or keyboards, making them suitable for public terminals since they cannot be easily removed (Wobbrock and Myers 2006). Chaparro et al. (1999a) concluded that the trackball might be better for the elderly when performing prolonged and repetitive actions. Chaparro et al. (1999b) suggested that the mouse may be a better device than the thumb-controlled trackball, but that a finger-ball design may offer benefits to the elderly.

Touchscreens. Touch screens allow direct user input on a display. Input signals are generated as the user moves a finger or stylus over a transparent touch-sensitive surface placed over the display. Older adults generally have positive opinions about touchscreens (Mitzner et al. 2010, Chung et al. 2010), but are less likely to use them (Fisk et al. 2012). A performance study by Findlater et al. (2013) found that older adults were significantly slower than younger adults in general with the touchscreen reduced performance gap relative to the desktop and mouse. Indeed, the touchscreen resulted in a significant movement time reduction of 35% over the mouse for older adults, compared to only 16% for younger adults. Error rates also decreased for the touchscreen. Finally, Chang, Tsai, Chang, and Chang (2014) found that performance on touch panel operations was much worse among elderly users as compared to that of young users. The authors also indicated that touchscreen size had a significant effect on operating performance, with elderly users having difficulty performing drag and scale tasks on smaller screens.

Trackpoint. A trackpoint, a small isometric joystick placed between the letter keys G, H and B on the computer's keyboard, is a common input device in laptop and notebook computers. It senses force from the fingertip, which results in a cursor movement specified by a non-linear transfer function. Research has shown that for older adults the trackpoint seems to be quite challenging to master and rather difficult to operate (Armbruster, Sutter, and Ziefle 2007).

3.3 Hands-Free Input

Voice. Voice input may be helpful to older users in a number of situations, either as the sole input mode or jointly with other control means. Speech based input may be appropriate, when the user's hands or eyes are busy, when interacting with handheld computers with limited keyboards or (touch) screens, and for users with perceptual or motor impairments (Cohen and Oviatt 1995). Jastrzembski et al. (2005) reported that speech recognition was preferred over light pens although with longer response times. No age effects within device type were found (i.e., voice versus light pens). In conjunction with other input modes voice can reduce errors, facilitate corrections, and increase flexibility of handheld devices (Cohen and Oviatt 1995). Speech recognition may enable older adults to interact effectively with a number of computerized appliances, and eliminate, reduce, or supplement the use of keyboards or other physical

input devices. Voice input seems to be appropriate when quick user input is required for descriptive information, and when minimal training is possible. However, vocal fatigue may be a concern (Welham and Maclagan 2003).

Eye Tracking. Eye-tracking devices employ a camera or an imaging system to visually track some feature of the eye and determine the location of the user's gaze. Eye-tracking devices allow the user to look and point simultaneously, with item selection achieved typically by eye blinking. These devices free the hands to perform other tasks, nearly eliminate device acquisition time, and minimize target selection time. This technology might benefit older users with limited manual dexterity. Significant constraints to its wide application include cost, need to maintain steady head postures, frequency of calibrations, portability, and difficulty to operate. Other relevant problems include unintended item selection and poor accuracy, which limits applications involving small targets (Oyekoya and Stentiford 2004). Morris, Saponas and Tan (2010) indicate that eye tracking technology, which can be incorporated in handheld devices, holds significant potential not only for motor-impaired users, but also for collecting information about a user's attention. Significant challenges remain to distinguish between gazes signifying attention to a target from the ones intended as deliberate inputs.

Gestural Input. Gesture controlled user interface (GCUI) affords realistic opportunities for specific application areas, and especially for users who are uncomfortable with more commonly used input devices (Bhuiyan and Picking 2009). Using Natural User Interfaces, more specifically using gestures or movements on a multi-touch device, can be a good alternative to overcome these difficulties (Loureiro and Rodrigues 2011). Gestural input can address difficulties found in the keyboard and mouse and improve accessibility (Loureiro and Rodrigues 2011; Bhuiyan and Picking 2009). Stößel, Wandke, and Blessing (2010) investigated whether finger gesture input is a suitable input method, especially for older users (60+) with respect to age-related changes in sensory, cognitive and motor abilities. They found that older users are a little slower, but not necessarily less accurate than younger users, even on smaller screen sizes, and across different levels of gesture complexity. This indicates that gesture-based interaction could be a suitable input method for older adults.

4 Conclusions

Increasing numbers of older adults are engaged with computers, but these users still trail the rate of participation of younger individuals and they often meet with difficulties in their interactions with this technology. The smaller and less efficient usage of computers by the elderly can be potentially attributed to the inadequate design and/or selection of input devices. Aging is commonly associated with a number of decrements in perceptual, biomechanical and physiological capacities, which can affect human-computer interaction. Reductions in vision, fine motor control and strength coupled with an increased susceptibility to musculoskeletal disorders and overall incidence of degenerative disorders must be considered when designing and selecting input devices for the older user. Evidence suggests that conventional keyboards with

larger keys are preferred. Older users may find computer mice challenging to operate, and lower mouse sensitivity (speed) and larger icons (targets) are recommended. Trackballs may offer an alternative for the elderly performing continued and repetitive pointing tasks. In laptops touchpads may reduce performance among the elderly, but are still preferable to the trackpoint, which is not recommended. Voice input has the potential to improve computer interaction among older users, either as a sole or a supplemental mode. Other forms of input such as gaze and gestures hold great promise but limited evidence exists as to their adequacy to the elderly user.

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