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Effects of cursor freeze time on the performance of older adult users on mouse-related tasks

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ABSTRACT

This study determines the optimum range of cursor freeze time (CFT) for basic target acquisition tasks. The effect of five levels of CFT was measured on double-clicking, clicking, and drag-and-drop operations, along with the inconvenience perceived by users at these levels. Older adult users find these standard mouse operations challenging because of slipping and accidental cursor movement. In this study, 24 older adult participants (13 males and 11 females) performed the abovementioned tasks repeatedly across five levels of CFT (0, 200, 400, 600, and 800 ms) and rated their perceived inconvenience at each level. CFT was found to have a significant effect on the three basic target acquisition tasks as well as the inconvenience perceived by participants. Performance on the drag-and-drop task was negatively influenced when the CFT was increased from 600 to 800 ms. The analysis suggests that a CFT of 200–400 ms is the optimum range for improved performance on the tasks.

1. Introduction

People over 65 years of age represented 14.5% of the U.S. population in 2014, and are estimated to increase to 21.7% by 2040. A large number of these people will use computers to undertake many tasks in their daily lives (Ortman et al., 2014). Studies have shown that using a computer with a standard mouse can cause difficulties for novice computer users and many older adult users (Wood et al., 2005). However, it is uncontroversial that pointing devices contribute to the ease of use of computers, where the mouse plays an important role as the primary source of interaction (Jung, 2014; Jensen et al., 2002; Müller et al., 2010). Some studies have found that in using pointing devices, older adults face more difficulties in clicking, double-clicking, and drag-and-drop operations than younger users (Lee et al., 2012; Findlater et al., 2013). In particular, double-clicking is among the most difficult tasks for older adult users, who have to resort to inconvenient and unwieldy solutions, such as making use of the right mouse button click to select from a list of options to avoid double-clicking (Czaja and Lee, 2002; Smith et al., 1999; Hollinworth and Hwang, 2011).

Older adult users with motor impairments face difficulties in keeping a mouse static while clicking, because of which the cursor slips off the target (Keates and Trewin, 2005). This has also been observed with healthy older adults when selecting a target (Keates et al., 2005; Chen et al., 2010; Schmid et al., 2015; Pérez et al., 2016). However, the focus in this context been on target selection using a mouse cursor and potential improvements in clicking actions (Keates et al., 2005; Paradise et al., 2005; Tang and Lee, 2007). Few studies have examined difficulties faced by older adult users with clicking, double-clicking, and drag-and-drop tasks (Fisk et al., 2009). Smith et al. (1999) found that older adult users faced more difficulties in clicking and double-clicking because the cursor tended to slip off the target. Paradise et al. (2005) showed that cursor slipping was the main cause of double-clicking errors. Keates and Trewin (2005), and Keates et al. (2005) observed that older adult users were most likely to execute unintentional button presses before pointing to the intended target for clicking or double-clicking.

A great deal of research (e.g., Cockburn and Firth, 2004; McGuffin and Balakrishnan, 2005) has been conducted with the aim of improving mouse task performance using Fitts' Law to enhance cursor positioning and selection time by expanding the target as the cursor moves closer to it. There may be a benefit in expanding targets and reducing net selection time that, nonetheless, is small in practice (Lam, 2008). Other techniques have been proposed to enhance pointing performance using a larger target size while reducing target distance. For example, area cursors and sticky icons developed by Worden et al. (1997) use an enlarged

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cursor and gain-diminished targets. Grossman and Balakrishnan (2005) evaluated the area cursor (bubble cursor) for older people. With this technique, task performance improved when the target was surrounded by empty space; however, performance degraded in cases involving small and dense targets. Mott and Wobbrock (2014) introduced the Bubble lens as an alternative technique that automatically magnifies adjacent targets when a user attempts to acquire small and dense targets. The Bubble lens improves the performance of the Bubble cursor and has garnered positive user feedback, but has not been tested with older adults.

Trewin et al. (2006) developed a slip assistance technique (Steady Clicks) to reduce clicking errors. They found that clicking errors occur when the cursor slips off a target before the mouse button is released. They proposed that these errors can be reduced by temporarily freezing the cursor at the button-down event. Accidental clicks occur when the cursor is en-route to the target or the user unintentionally presses the button. These errors can be reduced by preventing clicks made while the cursor is moving at a high speed and ignoring coincidental button presses. This technique has proved to be helpful for older adults for clicking; however, without double-clicking and drag-and-drop support, this technique is of limited use. Moreover, there is no clear explanation of how such freezing intervals are assigned to the mouse cursor.

Wobbrock et al. (2009), and Wobbrock and Gajos (2008) introduced the goal-crossing technique as a new target acquisition paradigm. With this technique, users do not point to a restricted area, but pass over a target line. They suggested that older people prefer the goal-crossing style of interaction, but error rates were higher for this alternative. The angle mouse is an additional pointing-assistance technique that aims to improve target acquisition by modifying the mouse control display gain based on the deviation of angles sampled during cursor movement (Wobbrock et al., 2009). This technique is beneficial for pointing tasks but brings about no improvement in clicking (Pérez et al., 2016).

Salivia and Hourcade (2013) designed a technique (PointAssist) for target selection and click success rates by automatically detecting the type of motion that occurs when users face difficulty in pointing at a target and slip off the target. PointAssist adjusts the speed of the mouse cursor to reduce the number of slips off the target, and offers proxy targets to reduce the distance that the cursor must travel as well as the movement time by bringing the target closer to the cursor once a pointing movement has taken place. In practice, this technique did not considerably improve the time taken for other mouse tasks; however, target accuracy improved for some participants (Hourcade et al., 2008).

Pointing techniques that only adjust the speed or location of the cursor, track mouse movement, and lower mouse gain in case of pointing difficulty do not accommodate clicking-related tasks. Although these techniques are beneficial for enabling mouse interaction, especially for older people, most of them do not address basic target acquisition tasks (i.e., clicking, double-clicking, and drag and drop) that are mutually interdependent. For example, Steady Clicks improves clicking but its impact on dragging is potentially disruptive. Thus, while a technique that can improve the performance of a single task has potential for application, its lack of support for related tasks is a major limitation. Likewise, clicking, double-clicking, and drag and drop are the three generic tasks that are mainly performed with the left mouse button. Therefore, a technique that can enhance the performance of a single task should be carefully managed to ensure that it does not affect the performance of another, adjacent task.

In general, every mouse action consists of one or two clicking events, where errors are mainly associated with the clicking task. Clicking errors are possible when a user intending to press the left mouse button unintentionally moves his/her hand. As a result, the cursor may float away from the intended target of clicking. This is a more commonly observed problem in double-clicking action, when the same target needs to be clicked twice, when the cursor moves away from the target for the second click. Drag and drop involves a single click by pressing and holding the left mouse button, where the cursor must travel with the given item (folder or icon) from one place to another (dragging). A drag-and-drop error can occur when a user fails to focus on the intended task during the button-down event. This is common in older people because they tend to experience greater levels of exertion and discomfort in their hands, which affects their focus (Chaparro et al., 1999).

Unintentional cursor movement during target selection is not the only difficulty often faced when clicking or double-clicking. Studies have shown that novice and older adult users encounter double-clicking errors due to the speed at which the action needs to be performed (Laursen et al., 2001; Hurst et al., 2008). However, a double-clicking action can successfully be executed when the two consecutive clicks are executed within 500 ms of each other—the default value set by Microsoft Developer Network (MSDN) on the Windows platform (Hollinworth and Hwang, 2011). If double-clicking is delayed, Windows recognizes it as two separate button clicks, which is a common issue for novice computer users, older adults, or those with poor motor skills (Trewin, 1996).

It appears that the default interval for double-clicking is too short and needs adjustment. If the cursor is fixed during the mouse button-down event for a suitable interval, slipping and unintentional cursor movement can be reduced. This can increase the time available for clicking as well as double-clicking actions. For example, if the cursor is fixed for 1000 ms (1 s), it remains static on the intended point of click for 1 s. This is cursor fixation, and can be imposed once the left mouse button is pressed. We call it cursor freeze time (CFT) here. Yet, there is no clear evidence on how the addition of this specified interval can affect performance on double-clicking, clicking, and drag-and-drop tasks. Therefore, the objective of this study is to devise a technique to improve the performance of older adult users on these three generic mouse tasks that are mutually interdependent and are performed using only the left mouse button. To this end, we developed a computer program in Microsoft Visual C++ for simulating the Windows graphical user interface, on which we set five levels of CFTs at 200-ms intervals from 0 to 800 ms. We examined the effect of these levels on three basic target acquisition tasks (double-clicking, clicking, and drag and drop) as well as perceived inconvenience to users at each level of the CFT. The purpose was to determine the optimum range of CFT for improved performance on mouse tasks.

2. Method

2.1. Participants

An experiment was conducted with 24 older adult participants (13 males and 11 females; age range 69–79 years; mean age = 71.7) to investigate the effects of CFT on the performance of double-clicking, clicking, and drag-and-drop tasks and the perceived inconvenience to the participants. Data was collected for the number of attempts for double-clicking, clicking, and drag-and-drop tasks and perceived inconvenience at time intervals of 0, 200, 400, 600, and 800 ms of CFT.

Before the experiment, a practice session was arranged and each participant was given 5 min for pre-training. They provided their informed consent before participating in the main experiment. All participants were novice computer users, and had no musculoskeletal disorders or any other injuries in their hands and arms. However, people who are 65 years of age or older tend to have poor motor control skills in general when using computers with a