Evaluation of a Model of Human-Computer Interaction and the Incidence of Repetitive Strain Injuries

Overview

The issue of Repetitive Strain Injury (RSI) in the workplace and in educational institutions is one of the most preventable injuries that occur. With over 8.4 million new worker compensation RSI claims made in 1999, it is now one of the largest problems occurring in the US and other technological nations (Simon & Aleskovsky, 2000). The estimated costs of this plague are now at the 100 billion US dollar mark per year in terms of compensation and lost wages. The rate of incidence of RSI has climbed from 18 percent of all occupational illnesses in 1981 to, almost 70 percent today (Costello, 2001). One of the main reasons that this problem is so pervasive and expensive is the time it takes to cause a permanent injury. In as little as one year, pain and discomfort can lead to permanent injury that is very difficult to repair, and which can result in a life-changing disability. The government and industry are now examining software solutions to augment hardware, ergonomic and educational improvements to organizations (Howard, 1997). In Keir, Bach, and Rempel (1999), where the role of the mouse as a factor in causing RSI was studied, it was found that even short term use of the mouse created biological conditions suitable to contracting RSI. With the increase in use of the Internet as a primary vehicle for information retrieval and research in the work place, methods are needed to reduce the amount of mouse activity. The TextMouse Web Executive was created as a tool to enable browsing of the Internet via the keyboard with only limited use of the mouse. It is our hypothesis that the TextMouse Web Executive will reduce the frequency of RSI complaints in comparison to other methods for browsing the Internet. Our present findings show that there is no significant difference in the self-reported levels of discomfort using either the mouse or the keyboard in an Internet browsing task. However, there is a trend toward a decrease in the reported level of discomfort using a keyboard versus the mouse in browsing the Internet that show up as the time is spent browsing the Internet increases.

Introduction

Repetitive Strain Injury

Repetitive Strain Injury (RSI) is a cumulative trauma disorder that describes over twenty different kinds of soft-tissue injuries ranging from tennis elbow to writer's cramp. It starts with what is a normal everyday occurrence in the body and can result from spending long hours performing a repetitive action. Heintzelman and Pfeiffer (1997) report that using a computer for more than two hours a day can lead to RSI. Muscles, tendons, ligaments and other connective tissues are stretched and moved. The movement of the muscles and tissues produces approximately twelve or so neurotoxins and inflammatory metabolics. Under normal conditions, when your body rests and stretches, your body washes away these toxins. However, when you maintain constant use of these tissues, day after day, the toxins build up and chemically fuse tendons and other tissues together. The fusion of the tissues causes discomfort, pain and the disability, and has been shown to limit movement and range of motion by up to 50 percent (Simon & Aleskovsky, 2000).

When you look at the job of the average "desk jockey" what do you see? Typically, you'll see improper positioning of the body in relation to the equipment, long hours of repetitive key strokes, long periods of sitting, lack of frequent breaks, high stress, poor nutrition, weight gain and lack of regular exercise, all risk factors for RSI (Simon & Aleskovsky, 2000). Estimates suggest that as many as 50% of all women who perform keyboard work as their primary job suffer from RSI (Heintzelman & Pfeiffer, 1997). Some of the signs and symptoms of RSI are: "funny" feelings in the arms and hands, discomfort, pain or tingling in extremities, impairment, weakness, clumsiness and chronic pain (Heintzelman & Pfeiffer, 1997). Eventually, if left untreated, normal work may no longer be possible due to pain and disability.

Use of the mouse has been found to be one of the leading causes of RSI in professionals whom use computers. Any solution found to help reduce the frequency of mouse usage, would be of benefit to the work place community as a whole (Johnson et al., 1993). The use of the Internet is now considered to be one of the many tools that office workers use in their daily job routine. The TextMouse Web Executive was designed to minimize the amount of mouse usage in everyday job tasks that require the use of the Internet.

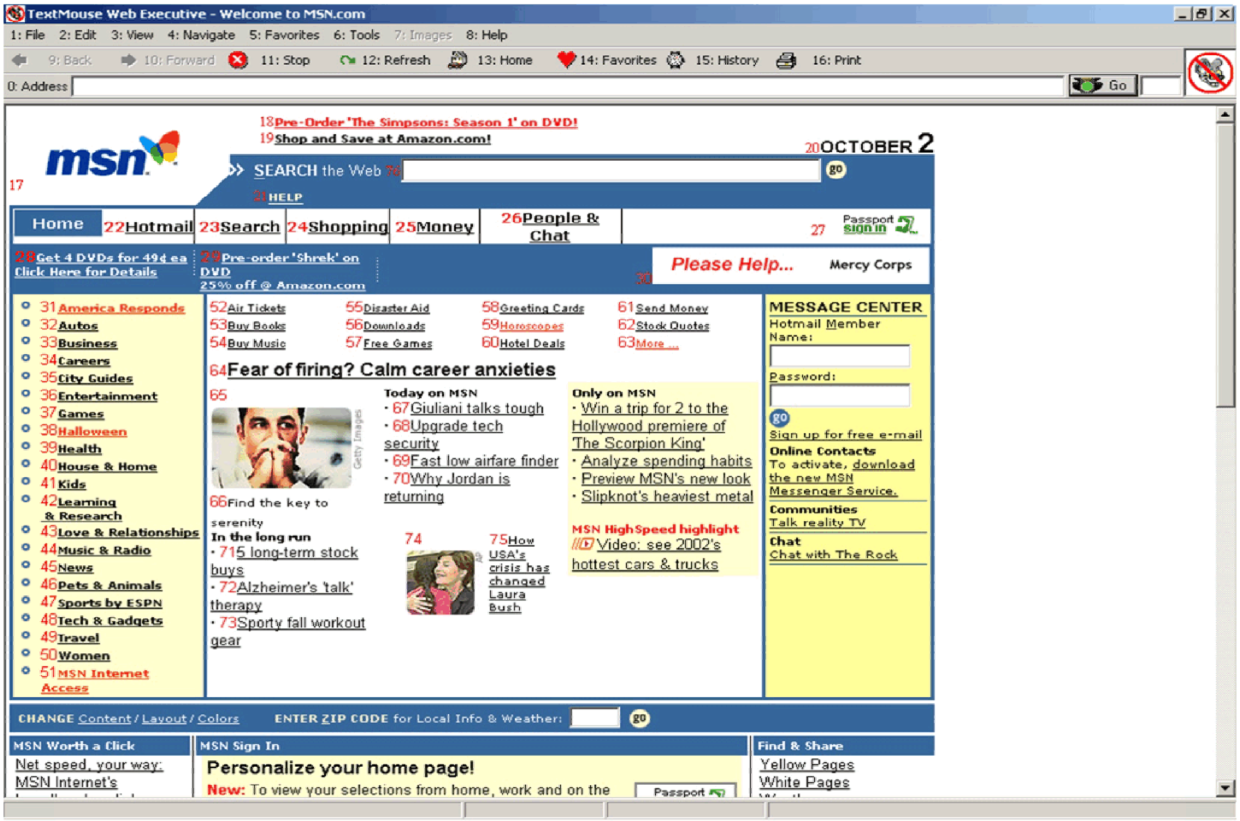
The TextMouse Web Executive was written using Microsoft's Visual Basic 6.0. The software works by associating alphanumeric and numeric labels with the links on a web site. The labels are inserted in the Menu, Bars, Taskbars, Address Box, and the HTML code used to describe buttons, textboxes and clickable links. Each label is placed before the link with which it is associated, and is highlighted to contrast with the surrounding text. The color that is used by the numbered links can be changed via a palette located on the Tools Menu. To initiate navigation to a new web site the URL for the web site is entered in the Address Box. After pressing the 'Enter' button, the web browser navigates to the new site and the selected page is loaded. After the page is completely loaded, all the links are assigned an alphanumeric / numeric label, and the Go Box is enabled to receive input from the keyboard. Then, any label that is entered from the keyboard will cause the browser to navigate to the corresponding link on the web site. The mouse can also be used, in usual manner to click on a link. Since all Menu and Toolbar functions are also labeled, it allows the user to access these functions using the keyboard in the same manner in which they navigate from web site to web site. It should be mentioned that as of the writing of this paper, common Microsoft interface shortcuts have not been implemented, ie. 'ALT F' to access the file menu.

Methods

Participants

The profile of the participants in this study are summarized in Table 1. The study consisted of 18 participants, 12 males and 6 females. The participants where recruited from notices on posters, word of mouth and news-group posting. Of the 18 participants, 6 had a diagnosed history of RSI and 2 participants stated anecdotal symptoms of RSI. Of the 18 participants, 3 scored within the 'very mild' disability range on the DASH questionnaire, 4 scored within the 'mild' disability range, and 11 participants scored in the 'no problem' range. Some of the participants had previously undergone corrective surgery for RSI and had stated some recovery, and as a result, groups were divided by DASH score rather than just case history. Thus, participants who scored above the 'No

Figure 1. Screen shot of TextMouse Web Executive



Problem' range were placed in the RSI group, and those within the 'No Problem' range were placed in the control group. So, participants in the control group either have no case history of RSI or present no symptoms of RSI. The participants spent an average of 27.17 hours (SD: 14.44) per week using a computer and an average of 9.11 hours (SD: 8.68) browsing the Internet. 67% of the participants in the study were Computer Science students or IT professionals.

Table 1. Description of Participants

	Number of Participants	History of RSI	No History	Very Mild Dash Score	Mild Dash Score	No RSI by DASH	Average Computer Usage/wk	Average Web Usage/wk
Male	12	1	3	1	1	10	26.67	9.92
Female	6	5	3	2	3	1	28.17	7.3
Total	18	6	6	3	4	11	27.17	9.11

This table describes the number of participants by gender, if they have a history of RSI, what they are rated as by the DASH, and the average hours per week of computer and Internet usage.

Equipment

All tasks were performed on an IBM – PC compatible, consisting of a PIII 866 MHz Intel processor CPU and 256 MB of PC 133 RAM, running the Microsoft 2000 Professional Edition operating system. A 17" SVGA monitor was used with a resolution of 1024 X 768, and 32 bit color. The mouse was an ergonomic Microsoft 3-button scrolling mouse. The keyboard was a Microsoft 98 compatible Fujitsu keyboard with a QWERTY layout and a numerical keypad. The chair that was an ergonomically designed chair that allowed for adjustable back support, adjustable leg height, and adjustable arm height. The desk was a standard 6 foot by 3 foot desk that is not adjustable, and the top of the desk was at a height of 2.5 feet. The top of the monitor was level with the eyes. The connection to the Internet is a T1connection running over a 10/100 megabit Ethernet, Novell network. The stopwatch is a standard stopwatch that can count in the tenths of a second. The web browser used in the tasks for both the mouse and the keyboard was the TextMouse Web Executive. It is a Visual Basic web browser based upon the VB 6.0 architecture. It inserted html into web pages to allow for traversal throughout the web browser and over the Internet via the keyboard. TextMouse places all of the numbered links contiguously along the bottom left hand side of an image map.

Procedure

Participants were seated at the desk. They were requested to complete a *Disabilities of the Arm, Shoulder and Hand* (DASH) questionnaire, a preliminary demographic questionnaire, and a pre-experiment discomfort questionnaire. After completion of the questionnaires, the participants were placed in front of the computer and given time to make any adjustments necessary to make themselves comfortable. Each experiment began with a 3 minute training period where the participants were shown how to operate the TextMouse Web Executive. The training time was short due to the similar look and operation of the TextMouse to other current web browsers. Following this instruction, the participants were taken through a scripted sequence of predetermined tasks, provided by the facilitator, to familiarize them with the tasks. During the first round of the experiment the facilitator read the script to the participant, and a second copy of the script was placed in a comfortable location for reference. Upon the completion of the first round, the participants completed a follow-up questionnaire to determine the level of discomfort and fatigue and provide other insights. The participant was then given a choice to either continue on to the second round or make an appointment for at least 48 hours later. The choice was based upon their perceived amount of discomfort and fatigue. If there was discomfort and fatigue, the participant was encouraged to delay the second round for at least 48 hours, and was then taken directly to a physiotherapist for treatment. If the participant decided to immediately carry on with the second round, then a pre-experiment questionnaire was completed to provide a baseline for discomfort and fatigue for the back-to-back sessions. The participants were not encouraged to perform back-to-back sessions, however, several participants stated that they would not return for the second round and wanted to complete the experiment.

Figure 2. Sample script of the Task List the participants went through

1) *Select history and then google and then close the history*
2) *Locate the average family income for Canada at the Stats Canada web site*
3) *Select Favorites on top menu and then add to favorite list*
4) *Place cursor in Address box and type in www.Altavista.com*
5) *Search for essay on Romeo and Juliet*
6) *Select all the text and paste on notepad*
7) *Select Stats Canada page from the favorites list and then select View then Source*
8) *Close the Favorite list*
9) *Using the history list select the google search engine*
10) Locate the Edmunds autos site

Tasks

Each round of the experiment is broken down into various tasks designed to encompass many of the common activities encountered while browsing the Internet. These tasks were combined into a single script and are randomly placed throughout the script.

Timing the participants

The participants were told they were being timed and they were to proceed as quickly and accurately as possible through the sequence of tasks. The time recorded each round was the total time spent to complete all tasks. It is assumed that most participants will desire to perform the tasks in the most efficient manner possible. Visual reminders of the pace and time to perform tasks is the only prompting that the participants receive. The web sites visited were not cached into memory so that the experience more closely mimics browsing the Internet. The main purpose of timing the participants was not to obtain a time, but to artificially increase the stress on the participant, perhaps leading to a stronger grip on the mouse, an increase build up of Carpal Tunnel Pressure, and neck and arm strain. A build up of Carpel Tunnel Pressure aggravates the wrist and fingers as though the participants were 'mousing' for a much longer period of time (Keir, Bach, & Rempel, 1999).

Selecting and menu traversal

This section of the tasks deals with how compatible the TextMouse Web Executive is with other web browsers. In order to be an effective substitute for conventional web browsers, the TextMouse must be capable of performing many of the more commonly used functions expected by users. A set of predetermined tasks were presented to each participant requiring them to use many of the functions typically used in a work setting. The following six tasks were performed by each participant:

- navigating backwards and forwards through the web site history
- saving a web site to favorites list on the menu bar
- saving a web site to the hard disk
- printing out a web page
- copying text and pasting it to another application
- stopping the web browser from loading a new page

Navigating to new web sites

This set of tasks looks at web site navigation and searching for web sites using common search engines. The following two tasks require those using the mouse switch to the keyboard for text entry.

- use a search engine to locate topical web sites
- manual text entry of new web site URL

Selecting links in web pages

These three tasks determine how well the TextMouse handles various web sites and moving around within a web site.

- click on web site menus
- click on the links in a web site
- form entry on a web site

Design

This experiment is a within subjects design with a factor of self reported levels of fatigue and discomfort by device type i.e.(keyboard or mouse). Each participant was scheduled for two, one hour sessions. Each participant performed the tasks on only one device type per session. The average duration of device usage for each session was 8:26 for round 1 and 7: 28 for round 2.

- *Usability Design*

  The usability of the TextMouse Web Executive was a concern of the clinical trial. The design of the tasks are such that they test many of the most commonly used options and functions found in current web browsers. The user group that this software is targeted at needs a tool with which to search the Internet, but reduces the amount of mouse usage. Therefore, the software must be able to meet the requirements of the majority of users and provide the functionality required, if it is to be an effective replacement for tools that are currently available in the work place.

  Our experiment does not test the use of other web browsers such as Microsoft's Internet Explorer. Other studies have looked at the usage of the mouse in more commonly used software and the impact or RSI (Keir et al. (1999), Fogleman and Brogmus (1995), Franco et al. (1992), Franzblau et al. (1993) and Karlqvist et al. (1994)). Several questions inquire about other web browsers used by the participants. The participants were asked to subjectively rank the TextMouse Web Executive against other browsers that they currently use.

- *Fatigue and Discomfort Design*

The experiment was designed to test our hypothesis that a reduction in the frequency of RSI insults will occur with the use of the TextMouse Web Executive using the keyboard verses the TextMouse Web Executive using the mouse. To this extent, the tasks focused on tasks that normally require mouse usage, accuracy of movement, and repetitive mouse movement as a means to increase the carpal tunnel pressure. A timing factor in our experiment was used to increase the participant's tension, and perhaps, increase the carpal tunnel pressure due to a stronger grip on the mouse. We assumed that those who have a case history of RSI would most likely develop an incidence of RSI due to the build-up of carpal tunnel pressure (Keir, Bach, & Rempel, 1999). It should be noted that the tasks are similar to those that the average person would perform in typical work setting.

- *Questionnaire Design*

  - Dash Questionnaire

The participants were given a standardized test (DASH) to determine the presence of RSI, either diagnosed or otherwise. The DASH is designed to measure the physical disability of a heterogeneous population. The target audiences of the DASH are those individuals who place low, moderate, or high demands on their upper limbs as a result of their work or play. As a result the DASH was designed to measure a wide range of symptoms and disabilities in the upper limbs across diverse populations. The DASH questionnaire will help to establish the control group and the RSI group (McConnell, Beaton, & Bombardier, 1999). Participants who score as having RSI, by the DASH, were placed into the RSI group. This may mean that some individuals who do not have a diagnosed history of RSI were placed into the RSI group, and some who have a diagnosed history of the RSI may be placed in the Control group. The rational for this decision is that some of the participants have had corrective surgery or treatment, and as a result, have found relief from the signs and symptoms of RSI.

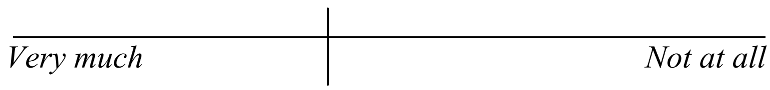
  - Pre-experiment Questionnaire

This questionnaire was designed to obtain information from the participants regarding their current level of stress and discomfort, where the discomfort is, its quality, and whether the participants are currently experiencing a headache. The questionnaire was given to the participants before each trial to establish a base score from which we can compare the results of discomfort, stress and headache scores after the trial is completed. The participants were scored on a 10 point scale. The participants must dissect a horizontal line (10 point scale) with a vertical line indicating their subjective opinion about the question. Opposite ends of the scale are labeled to give the participant references as to where they might like to put their line. The results are reported as exactly what was measured and there is no application of conservative measures to temper our results (ie. 1.3 plus/minus 0.5 as a way of making the results more conservative due to possible participant error in line placement between similar questions on different questionnaires).

Figure 3. Sample of a question with a scale and labels and an interpretation

For example,

Do you like ice cream?



This example would indicate that you like ice cream a little. The score would be 3.4 out of possible 10 for this sample. A score of 5.0 would mean that you neither like or dislike ice cream, if that is possible.

- <u>Demographic Questionnaire</u>

This questionnaire examined various attributes of the individual participants. It covered issues such as: age group, gender, occupation, diagnosed history of RSI, any treatments if needed, types of computer peripherals used, any problems with using those peripherals, average number of hours using the computer per week, average number of hours browsing the Internet per week, and what types of software they are familiar with. This questionnaire provided information about how we may group various participants according to the information that they provided in the questionnaire. These may include grouping the individuals according to case history of RSI, gender, or any other variable found in the demographics.

- <u>Follow-up Questionnaire</u>

This questionnaire looked at how the participants feel after a trial has been completed. This provides us with a means of measuring the actual amount of discomfort, stress, and headache that we caused as a result of the trail. We hypothesized that the scores on this questionnaire were higher than those on the pre-experiment questionnaire. To determine the amount of change experienced by the participant in each trail, the pre-experiment questionnaire scores were subtracted from the corresponding follow-up questionnaire scores. The same scale and style of questions are used in this questionnaire as are used in the pre-experiment questionnaire (refer to Figure 3 for an example). In addition to the questions that are duplicated from the pre-experiment questionnaire, we ask other questions that deal with subjective likes, dislikes, and difficulties encountered in using the TextMouse as perceived by each participant. The additional areas covered by the follow-up questionnaire include: level of difficulty experienced in navigating the Internet using the TextMouse Web Executive by device type, how easy the interface was to learn, placement of the labels on the web page, what web browsers the participant is currently using, how the TextMouse compares to other web browsers used, features/aspects of the TextMouse that they liked, disliked, and felt could be changed.

Results

Discomfort

The initial level of discomfort and fatigued described by the participants, as reported in a pre-experiment questionnaire, was an interesting find. We had hypothesized that the initial level of discomfort and fatigue would be 0.0 on a 10 point scale. However, we found that the average level of discomfort was 2.3 out of 10 with a standard deviation of 2.4 for round 1 and a mean of 2.5 and standard deviation of 2.25 for round 2. There is a significant correlation between reported level of stress and reported level of perceived discomfort prior to beginning the experiment ($r = .65$, $p < .05$). Some other reasons for the surprisingly high starting discomfort report may be due to participants coming to the experiment after a physical workout, or after being at work for part of the day.

The level of discomfort that each participant felt after completing a round was examined. Our results show that the mean level of discomfort after the first round (Mean = 2.900, SD = 1.989) was reportedly lower that the second round (Mean = 2.561, SD = 2.271).

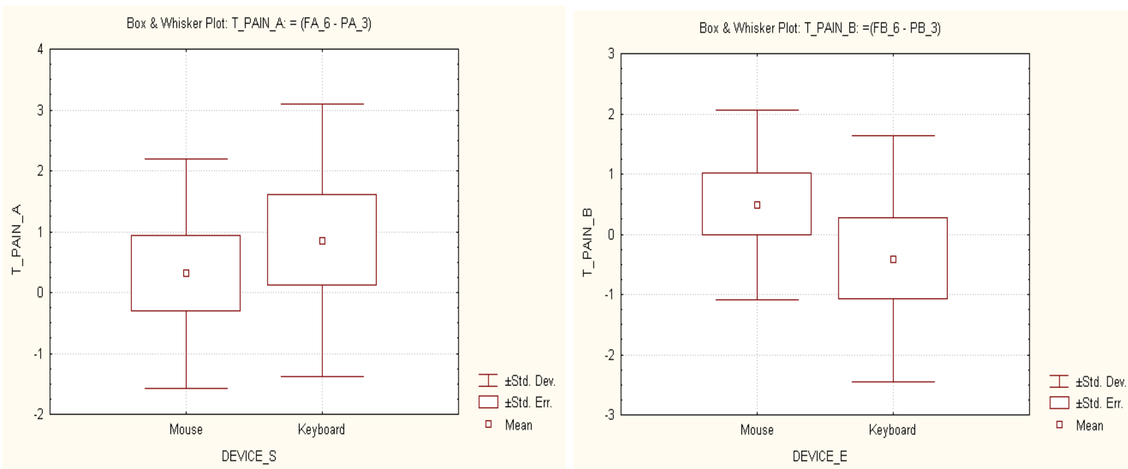
Table 2 Description of Pre-experiment and Follow-up discomfort means

	Pre-Experiment Mean	Follow-Up Mean
Round 1	2.317	2.900
Round 2	2.522	2.561
Total	2.419	2.731

Next, we subtracted the level of discomfort found in the follow-up questionnaire from the discomfort reported in the pre-experiment questionnaire. Our hypothesis was that the level of discomfort following each round would be higher than the level of discomfort before the round. Our results did not show any significant difference in the self-reported levels of discomfort and fatigue using the mouse, versus the keyboard, to browse the Internet. However, we were able to uncover some interesting trends that will require more analysis and research in the future. The average level of discomfort reported across both devices was 0.583 out of 10 (SD = 2.032, Range = 7) for the first round and 0.0389 (SD = 1.829, Range = 8.9) for the second round. When this is broken down between mouse and keyboard effects for the total discomfort of the first task, there is no significant difference between the means (Mouse = 0.311, Keyboard = 0.8556, ($F = .3099$, $p < 0.585$)). The second round, again there were no significant differences, however, examining the means we found that the keyboard seemed to reduce the level of reported discomfort rather than increase it, as did the mouse (Mouse = 0.4889, Keyboard = - 0.4111 ($F(1,16) = 1.10$; $p<0.3108$)). As shown in Figure 4, the longer the participants used the mouse, the more discomfort they reported, where as, the longer the participants used the keyboard, a reduction in the amount of discomfort reported was found. When the participants were asked where, if any, the discomfort occurred, the participants reported that discomfort occurred 53 % of the time in the wrist, 25% in the arm, 22% in the shoulder, 11% reported problems with the fingers, and 44% stated that the discomfort occurred in multiple areas. When we looked at who was reporting less discomfort after the round than before the round, 28% of the participants reported a decrease in the level of discomfort after the first round, and of those, 60% of found relief with the Keyboard. When we looked at the second trial, 44% of the participants reported a decrease in the level of discomfort, with 75% of those reporting relief with the keyboard.

Figure 4 Bar chart of total discomfort experienced by the participant by device

Round 1 Round 2



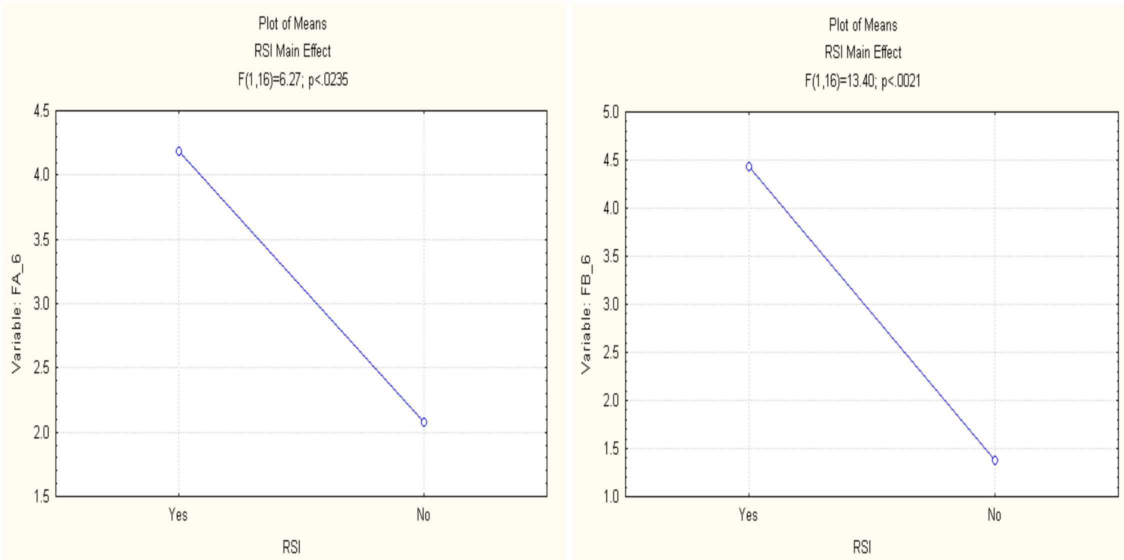
These charts show the round 1 & 2 levels of discomfort by device. As discussed above round 2 shows us a hint of what we expected to happen with prolonged use of the mouse. The result of a reduction in discomfort reported with the use of the keyboard over round 2 was an unexpected, although we did predicted a lower keyboard discomfort value than mouse value after round 2.

One of the possible reasons for this trend is shown in Figure 4, is the high rate of participants who choose to perform both rounds back-to-back rather than wait for the second session, 48 hours later. For the study as a whole, 16 out of the 18 participants opted to perform back-to-back rounds. One of the major concerns that we had in designing this test, is individuals with a case history of RSI, would incur too much discomfort as a result of a drawn out round. Therefore, we decreased the number of tasks the participants had to perform in order to reduce the amount of discomfort experienced by the participants. The number of tasks required to cause discomfort, was pre-tested with an individual with RSI, and was found to cause minor discomfort. However, there seems to be a need to require the participants to go through more trials to elicit the effect that we are looking for.

As would be expected, those individuals whose score on the DASH indicated they had RSI, reported a significantly higher level of discomfort than those indicated as not having RSI ($f\,(1,16) = 6.269$, $p < 0.0235$).

Figure 5 Graph of Significant Difference

Round 1 Round 2



These graphs demonstrate the significant difference found in the self-report of discomfort between those participants who have RSI, as scored by the DASH, and those who do not.

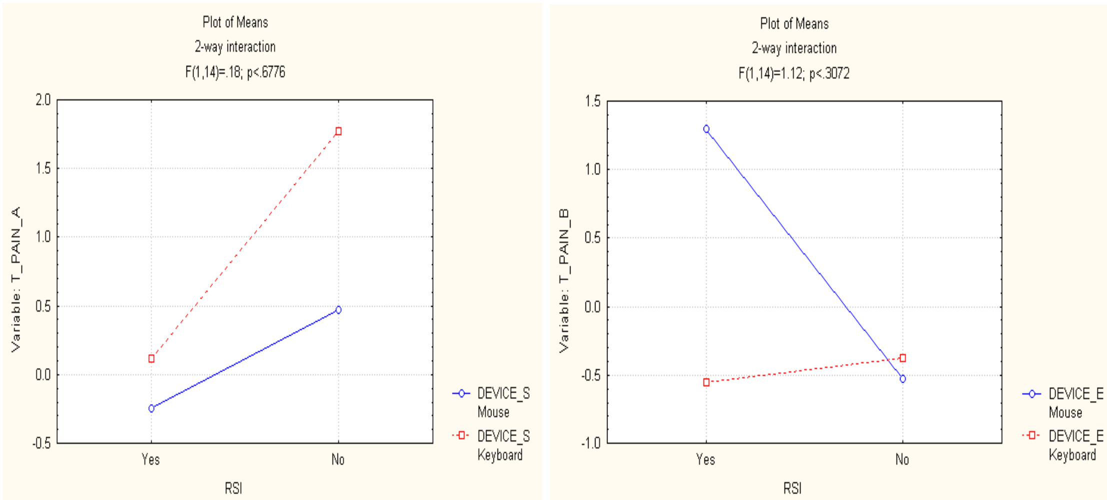
Looking the interaction between those that have RSI, the device used, and the reported level of discomfort that the experiment caused, we find these results. For round 1, we found that the keyboard causes a small amount of discomfort and that the mouse actually relieved some of the discomfort. However, with prolonged use, the difference found between the mouse and the keyboard for round 2 is more pronounced for those who have RSI. This is the effect that we hypothesized would be evident, barring the lack of a significant difference. For both rounds there is no significant difference between the RSI, device used, and reported level of discomfort (round 1, $F(1,14) = 0.18$, $p < 0.6776$; round 2, $F(1,14) = 1.12$, $p < 0.3072$). However, we feel that this is the start of a trend and with more back-to-back trials, we hypothesize that we were able to see a significant difference between the amount of discomfort caused by the mouse versus the keyboard for those individuals suffering from RSI. When we look at Figure 6, we notice that for those participants who do not suffer from RSI, their level of reported keyboard discomfort is higher for the keyboard than for the mouse. One reason may be that the desk is not adjustable, and for some participants they were unable to adjust the position of the keyboard. This may be because their height made the ergonomic chair uncomfortable when their feet were off the ground. A possible remedy to this situation may be to add the use of a footstool in future experiments to alleviate this problem.

Other Information Gathered

In terms of any possible gender effects, at this point in time with the study, the effects that were found are not valid as 5 of the 6 females scored as having RSI by the

Figure 6 Graph of interaction between Device, RSI category and Discomfort reported

Round 1 Round 2



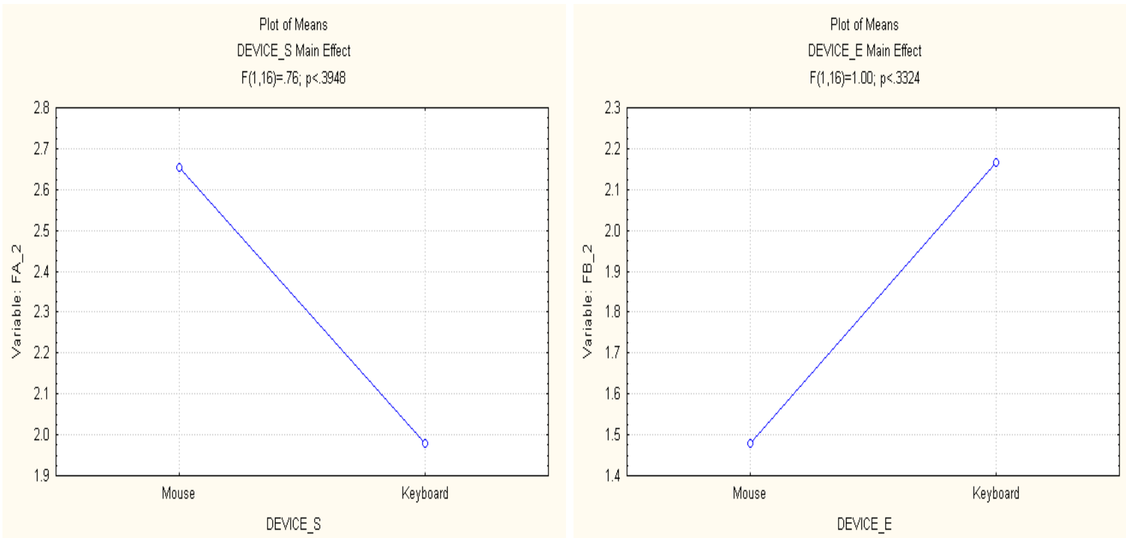
These graphs demonstrate the level of discomfort that RSI users experience when using the keyboard and the mouse in an Internet browsing task. The longer the RSI participants browse the Internet, the greater the disparity in the reported level of discomfort by device.

DASH, versus 2 out of the 12 men. Also, 5 of the 7 participants who had a diagnosed history of RSI were female, leading the statistics so show a gender bias toward women. More men with RSI need to be included in the study to balance the current effect found before any valid conclusions can be made about any role that gender may play in this experiment.

Participants found that the TextMouse interface was fairly easy to learn with an average score of 2.317 (SD = 1.633) out of a possible 10. There was no significant difference between the mouse (Mean = 2.655) and the keyboard (Mean = 1.9778) in terms of ease of interface use. For the second round, again we find a slight decrease in how easy the interface was to learn using the mouse compared to the first rounds (mouse Mean = 1.447; keyboard Mean = 2.167) compared to round 1. This decrease in the mouse time, is attributed to learning the task rather than an increase in the ability to use the TextMouse Web Browser. However, the keyboard interface seemed to pose a slight problem with learning in the second round when participants started out using the mouse in the first round. For the most part, participants had trouble waiting for the alphanumeric links to load and ended up pressing the wrong numbers resulting in incorrect web pages being loaded. No significant results were found regarding the keyboard or mouse in terms of ease of interface use. Some of the other areas of the interface that were found to be problematic by the participants, when asked for areas of improvement, had to do with the History / Favorites list that was displayed. The links inside these areas changed as the web pages loaded, and people often typed in the wrong number when trying to perform the tasks quickly rather than waiting for the page to finish loading. As seen in Figure 7, those who used the mouse in round 1 also noted more difficulty learning to use the keyboard interface. One possible reason for this is when the participants started out using the mouse, the TextMouse could be treated just like any other graphical web browser, however, once the participants switched to the keyboard, they needed to wait for the labeled links to load, while when previously using the mouse, they did not have to wait. This is one area that will need more examination in future experiments.

Figure 7 Graphs of Ease of Learning TextMouse by device type

Round 1 Round 2

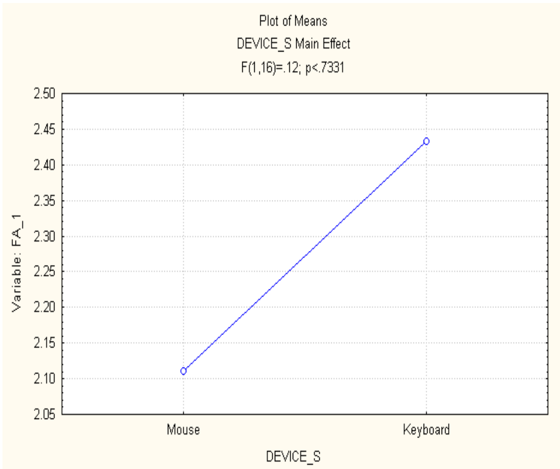


These graphs show how easy it was to use the interface of the TextMouse. You will notice that the keyboard in round 2 was more difficult to use than the mouse. This may be because of the impatience of the participants who were used to using a mouse in the previous round.

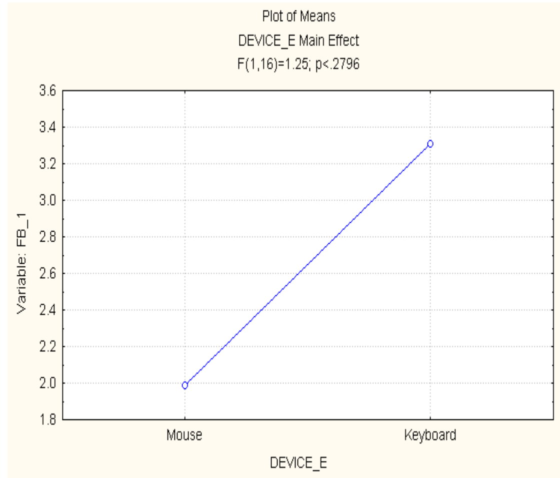
The level of difficulty in navigating the Internet using the TextMouse with a mouse was rated with a mean of 2.111 and keyboard at 2.433 out of 10 for the first set of rounds. For the second set of rounds the mouse was rated at 1.989 and keyboard at 3.3111. Again most of the agitation came when people began trying to navigate to links that had not yet been displayed when using the keyboard. As Figure 8 shows, participants in both rounds complained about the difficulty navigating. Some of the complaints came from not having all of the features implemented in the TextMouse that are implemented in most other web browsers. Most of the participants stated that they were not yet familiar with our labeling system to the point where they could just enter the numbers of the menu and toolbar to navigate. This slowed them down leading to some frustration on the part of the participants. There was also the fact that when the participants use the mouse they were able to close the history/ favorites frame while on a search engine page, where with the keyboard they were forced to either wait till the search was complete or escape from the textbox on the search engine and then close the frame and then reenter the textbox. This also led to a lot of numerical searches on the Internet due to trying to close the frame using the search engine textbox.

Figure 8 Graph of Level of Difficulty Navigating the TextMouse Web Executive

Round 1



Round 2



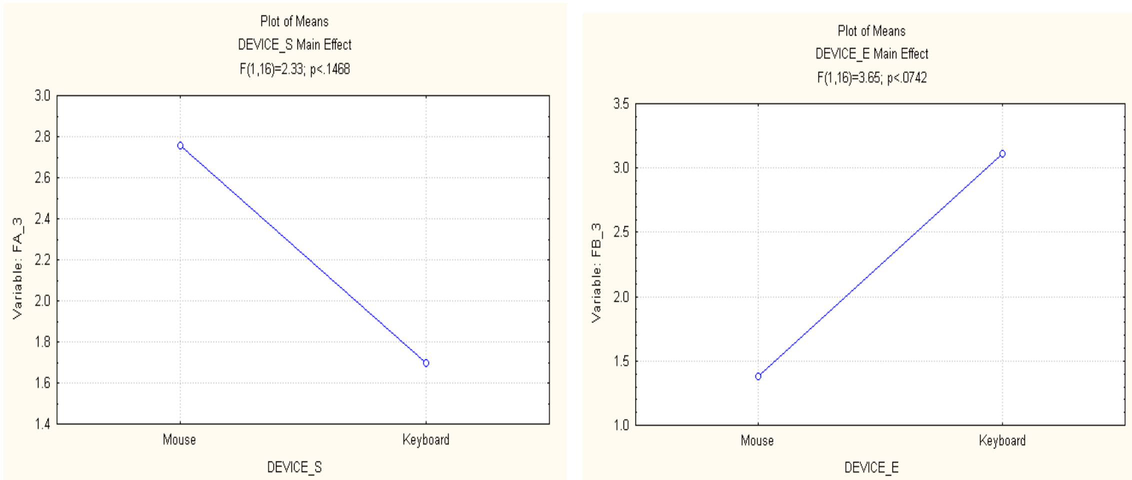
Both of these graphs show that the keyboard was more difficult to navigate the TextMouse Software. This was impart due to not having the keyboard labels memorized. There were also some features that were not yet implemented in the TextMouse Web Executive that some of the participants were looking for such as Microsoft shortcut keys.

Participants found that the placement of the alpha numeric links to be appropriate with a mean of 2.228 (SD = 1.525) during round 1. Comparisons of means during the first round between keyboard and mouse found that the numbered links were very appropriate when first learning the tasks and the TextMouse interface (Mouse Mean = 2.7556; Keyboard Mean = 1.7000). When the mouse and keyboard comparisons were made mouse (Mean = 1.378) and keyboard (Mean =3.111) for the second round, there is a definite trend towards the keyboard links being “Inappropriate” when navigating using the keyboard versus using the mouse where the links are not noticed or needed as much ($F = 3.65$, $p < .0742$). One of the reasons we see an interaction as seen in Figure 9 is that for those that used the mouse first, they found the labels to be of no use, where those that used the keyboard first found that they were quite appropriately placed and easy to find. For round 2, those that used the mouse first now used the keyboard, and as stated above, many of those who started with the mouse and moved to the keyboard were frustrated by how long it took to load the labels for the links. However, it must also be pointed out that when one reverses the numbering system that at the appropriateness of how the labels were placed is still at least 7 out of 10, with 10 being most appropriate.

The TextMouse Web Executive rated as slightly better than other web browsers that the participants used. The mean of 4.378 (SD = 2.1512) was recorded for the participants. A score of 0.0 was rated as the better than other comparable web browsers, 10 rated as the worse, and 5.0 rated as “Indifferent”. However, for the round 1, the individuals using the keyboard (Mean = 3.4667) and the Mouse (Mean = 5.2289), there is a definite trend towards preferring this browser to other browsers ($F = 3.75$; $p < .0706$).

Figure 9 Graph of Appropriate Positioning of Labels by Device Usage.

Round 1 Round 2

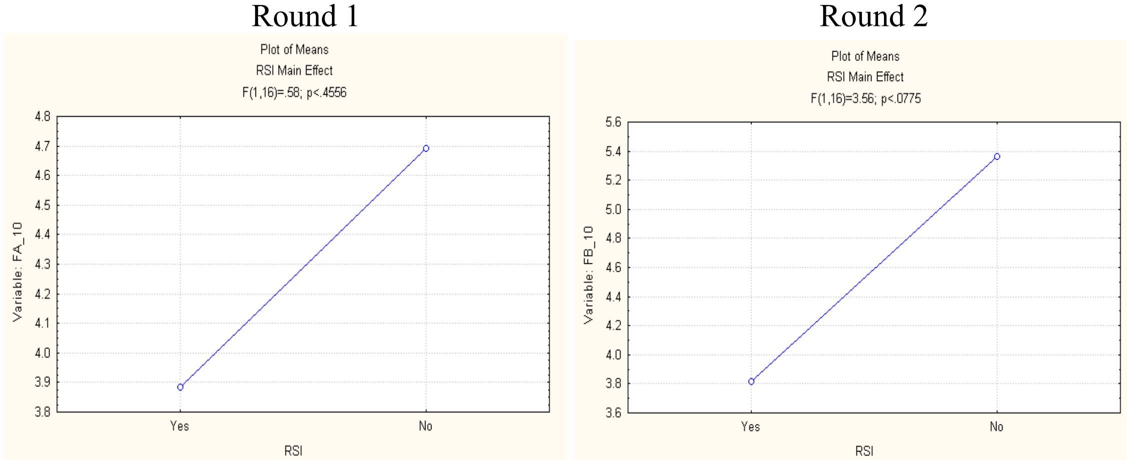


As noted above there is almost a significant difference between the appropriateness of label position on the web page and the device used for round 2.

By the second round the opinions had changed (Mouse Mean = 4.2667, Keyboard Mean = 5.2556 (F = 1.35; p < .261)). When we look at RSI and the participant's like or dislike of the TextMouse, compared to the web browsers that they currently use, we find the results as in Figure 10. For round 1 we find those that have RSI tend towards liking the TextMouse (Mean = 3.886) as apposed to those who do not have RSI (Mean = 4.691). For the second round we find similar results (have RSI (Mean = 3.8142), No RSI (Mean = 5.3636)).

Figure 10 Comparison of TextMouse To Participant's Current Web Browser.

Round 1 Round 2



These graphs show that those who have RSI show a bias towards favoring the TextMouse Web Executive compared to the web browser that they are currently using.

Conclusions

Although we were unable to prove our hypothesis, we were able to glean new information about our experimental design and some other research questions that need to be asked. We did find that participants reported a lower level of discomfort using the keyboard versus the mouse, when the trials were performed back-to-back. This seems so suggest that future experiments would require either more tasks or longer tasks in order to elicit any significant results in terms of discomfort experienced as a result of device use. We also found that some participants had difficulty moving from a mouse interface to a keyboard interface. The extra time taken to load the new links onto the web page, seemed to frustrate some of the participants, causing and increase in erroneous web pages being loaded when the participants moved from a mouse to a keyboard.

We also discovered that most participants had an unexpected level of initial discomfort reported which is related to the amount of pre-experiment stress that is experienced by the participants. One of the interesting notes is that on average most participants experienced only a minimal increase in the amount of discomfort reported over the trial.

The results that we reported were not tempered in any way by adding in a measure of conservative estimation (1.3 plus/minus 0.5). In order to make the findings more appealing to others, conservative figures may need to be implemented in the future experiments. One other option is to change the rating scale to a numeric scale rather than a subjective scale.

Some of the things that will need to be implemented in the next experiment are the use of Microsoft short cut keys, such as “ALT F”, how the TextMouse handles Textboxes, the History / Favorites Section needs work with scroll bars on bottom of frame, and a better history interface (history with back and forward buttons and possibility of URL completion history). These features will eliminate some of the complaints that some of the participants had about the TextMouse Program. Next in terms of changes to the experimental design, we will need to add more trials in order to elicit any possible significant effects between the mouse and keyboard for RSI. We will need to add in more checks for not only where people are complaining of discomfort but also which hand/arm/shoulder is being affected and used for the experiment. We will also need to see where on the keyboard they are typing and with what hand they are typing. Although the experiment is counterbalanced, use of the keypad or the numbers on the top of the keyboard will make a difference to the how much use a hand/arm/shoulder is going to get during the experiment and as a result, how much and where the participant will complain of discomfort.

Some of the future areas that will need looking at are the use of alternative methods of navigation. We are looking at the possibility of developing a voice recognition element to the TextMouse that will allow for voice navigation of the Internet. We will also look at the interaction between the keyboard and other devices (such as trackballs, keypads, etc.) in terms of RSI and the amount discomfort caused. There are also some software features that we are looking at implementing to make the TextMouse more applicable to other areas of disabilities. We are looking at the addition of mouse highlighting the nearest possible link, with a line drawn to that link so as to allow the highlighting of the link with as little mouse movement as possible. This should allow people with fine motor control problems the ability to use a mouse to browse the Internet. We are also looking at allowing the TextMouse to change background colors of the web pages displayed to aid those with scotopic sensitivity. We are also looking into the ability of the TextMouse to use voice to read the web page design, layout and content to those who are blind. All of these additions are looking towards allowing a broader scope of disabilities access to the Internet through use of the TextMouse Web Browser.

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Appendix

A) Listing of all comments recorded from the experiment.
B) Pre-experiment questionnaire
C) Demographic Questionnaire
D) Follow-up Questionnaire
E) TextMouse Task List
F) Dash Questionnaire

Appendix A Comments Made by Participants

Key: D plus any letter refers to the Demographic Questionnaire and the number of the question.
FA refers to the Follow-up Questionnaire for Trial 1
FB refers to the Follow-up Questionnaire for Trial 2
PA refers to the Pre-experiment Questionnaire for Trial 1
PB refers to the Pre-experiment Questionnaire for Trial 2
Participants are numbered according to their study id number so that this information can be referenced if more analysis is needed.

1.CS Major

a. D10 – MS Office, w98,NT, XP, MSIE
b. FA9 – IE, other suck
c. FA11 – none
d. FA12 – the numbering schema needs more work
e. FB9 – Yes IE, nothing better
f. FB11 – being able to just enter the # to navigate
g. FB12 – can't keep up with the experienced user

2 Programmer

a. D7 – gets painful sometimes
b. D10 - Office, Windows, Lotus Notes, Erwin, Oracle, Main Frame, Netscape
c. FA8 – Pain
d. FA9 – Netscape
e. FA11 – with the exception of the periodic table the numbers were easy to read.
f. FA12 – knowing when to press enter once or twice ie history & favorites button
g. FB7 – Shoulder, Wrist, fingers
h. PA4 – Shoulder, Arm, Wrist, fingers
i. PA5 - general discomfort
j. PB4 – shoulder, Wrist, finger

3. CS Major

a. D10 – Win 98, Netscape, IE, Mozilla, Linux Konqueror
b. FA8 – Sharpness
c. FA9 – Yes, ie, netscape, mozilla
d. Fa11 – numbering for everything
e. FA12 – loosing focus
f. FA13 – handling selections
g. FB8 – Warmness
h. FB12 – loosing focus
i. FB13 – handling selection tables
j. PA5 – tightness – I just worked out
k. PB5 – sharpness

4 Psych Major

a. D10 – Netscape, Windows 98
b. FA9 – Netscape
c. PA5 – weakness in left (arm)
d. PB5 – weakness

5 CS student

a. D10 – Office, Netscape, Linux, XP
b. FA8 – None to low
c. FA9 – Explorer, Netscape, Mozilla
d. FA11 – I liked the numbers of the links
e. FA12 – I don't like the history
f. FA13 – Go box might have to be improved for people with existing disabilities.
g. FB8 – None ->Mild
h. FB11 – Good numbering system
i. FB12 – Little learning curve, easy enough to overcome
j. FB13 – Numbering could be more distinguishable
k. PA5 – Dull Pain, tightness
l. PB4 – Shoulder, Wrist
m. PB5 – none to mild

6 Comp Sci Major – sometimes my hand aches when I use a mouse

a. D10 - Ms office, IE 6, Ms Win 98, VS 6.0
b. FA8 – tightness
c. FA9 – IE 6
d. FB8 – tightness
e. PA 4 – shoulder, wrist, arm
f. PA5 – tightness
g. Had some problems with the Internet loading images to the web browser, stalled all the time. Tool over 1 hour to perform the experiment

7 Self Employed

a. D10 – MS Office, Win 98
b. FA8 – Tightness
c. FA9 – IE
d. FA11 – Enjoyed using keyboard, made selection of desired search simple / no mistaken clicks
e. FA12 – none at present time
f. FA13 – Can't think of any at this time
g. FB8 – Tightness
h. FA9 – Yes, IE
i. FA11 – Found little difference with existing browsers
j. PB5 – tightness / stiffness

8 Bio Major

h. D10 – Ms Office, IE, Win 98, Internet Messenger, Telnet
i. FA8 – a little weakness
j. FA9 – IE, Netscape
k. FB8 – a little stiffness
l. FB11 – Sometimes the numbered links are handy
m. FB12 – a little awkward at first, a little slower as well
n. FB13 – numbers by the close, minimize/ etc. buttons

9.Theology Student

a. D4 – Tendonitis – shoulder
b. D5 – Surgery, physiotherapy leading to recovery
c. D10 – Ms Office
d. FA8 – a bit of fatigue
e. FA9 – no

f. FA12 – none came to mind, moving between mouse + keyboard
g. FB8 – less than with mouse
h. FB11 – hands stay on the keyboard rather than move back + forth to mouse. Red numbers are easy to see
i. FB12 – occasionally having to wait for numbers
j. PB5 – slight fatigue

10 Psych student

b. D4 – 8 Years
c. D10 – Win 98, IE, Office 2000
d. FA8 – tightness
e. FA9 – IE
f. FA11 – I frequently experience arm pain using mouse, so I like TextMouse Web
g. FA12 – Sometimes the numbers are hard to see because of the background color is similar to use color
h. FB8 – tightness
i. FB12 – If I can use either input device freely, the numbers on the page would still helpful, but this time I have to use only mouse, so the numbers seems to busy.
j. PA5 – tightness
k. PB5 – tightness

11 College Teacher, Dean of Students

a. D7 – Mild difficulty with standard keyboard and mouse; easier to use a "natural" keyboard (ms)
b. D10 – MS office, win 98, ME, Corel Draw, IE, Photoshop, PageMaker, Ulead Video studio, Media Player, QuickTime
c. FA8 – mild ache; tightness
d. FA9 – IE
e. FA11 – Keyboard shortcuts! Yes!!
f. FB8 – tight; mild ache; knot under shoulder blade tension up right side of neck * discomfort in left arm/wrist
g. FB11 – Liked keyboard options
h. PB5 – mild ache; tightness

12 Business Analyst

a. D7 – When Fingers and arm is swollen then have problem -> once every 3 months or more as weather changes.
b. D10 – Netscape, Microsoft Office(Word, Excel), Bloodshed, Quicken, PowerPoint
c. FA8 – Stiffness and swelling of wrist and fingers
d. FA9 – Netscape
e. FA11 – Similar to others I have used. No major learning curve
f. FA13 – change the color of the pages. White to a green background. Why – scotopic sensitivity syndrome
g. FB8 – slight swelling in wrist and fingers
h. FB9 – IE
i. FB11 – placement numbers are nice less wrist movement. Ability to change color of number and various ones to select from.
j. FB13 – change background color, scotopic sensitivity syndrome
k. PA5 – Swelling in wrist and fingers. Shoulder minor pain.
l. PB5 – Stiffness and swelling in wrist and fingers

13 Student, Sys Admin

a. D10 – Linux
b. FA8 – funky feeling in index knuckle
c. FA9 – Real ones such as lynx, Netscape, Opera, links
d. FA11 – gopher in top right hand side
e. FA12 – no right click pop up menus
    i. Button layout disallows easy navigation
    ii. Go button (what does it do?)
    iii. Not every link on every site had numbers assigned, left a little confusion
    iv. History button opened a nice list of past sites, no drop down bar for past history or auto url completion
    v. Difficult to choose choices from history / favorites
    vi. Numbering scheme very poor.
f. FA13 – have an animated gopher to show browser working
g. FB8 - muscles tight a little around middle knuckle
h. FB12 – numbering scheming for links needs to be improved
    i. A pain to try to find what numbers among a bunch of links
    ii. Placement on numbers by links can cause a user to guess which number is correct
    iii. Number colors for menu bars need to stand out more
    iv. Cannot complete more than one operation when changing pages
i. PA5 – tingling after body building workout yet loose.
    i. A little warm pain in right forearm

15 Computer Science

a. D10 – MS Visual Studio, Adobe Photoshop, ME Office, IE, Win 98, Flash
b. FA9 – IE
c. FA11 – if no mouse works very well, quick
d. FA13 – if in a text-box, ignore character input

17 Computer Science

a. D10 – Microsoft products, linux, IE, Lotus Suite
b. FA8 – Weakness in wrist, right handed when using mouse, Wrist feels light tight.
c. FA9 – Yes, IE, Netscape
d. FA11 – I liked the numbered links on the web page.
e. FA12 – The menu bars could be a lot bigger. I do not see little text as good. It did not grab my attention when searching for things.
f. FA13 – New Mouse, A trackball mouse would be great for TextMouse Web Executive. The scrolling mouse was to difficult to use because limited positioning of web browser.
g. FB8 – None
h. FB11 – Now, after using the keyboard I do not like the numbered links.
i. FB13 – The scrolling in the Westjet Boxes was difficult to navigate , Reason because I kept on thinking to hit backspace. Which returned me to WestJet homepage. Also error that I didn't really password popped up.
j. PA5 – Thumb on left hand is muscle is tight.
k. PB4 – Wrist , fingers
l. PB5 – Right wrist – weakness Left thumb – weakness – weakness / tightness

19 CS student

a. D7 – When typing a lot there is pain in wrist.
b. D10 – MS Office, IE 5.5, Win 2K
c. FA8 – mind discomfort, pain, right wrist.
d. FA9 – Yes, IE 5.5

e. FA11 – number the links was a good idea
f. FA12 – Favorites/history list number should remain static after the page is loaded.
    i. Numbers should load with the page, not after the page is completely loaded.
g. PA5 – mild discomfort in right wrist, mild pain

21 Comp Sci Major

a. D10 – Office, linux, ssh, photoshop, win 98, notepad
b. FA9 – I.E.5, Netscape4.7x
c. FA11 – loads fast, more simple interface, more viewing room,
    i. Like ability to access links via keyboard
    ii. Did not like how inserting links sometimes messed up formatting …. Especially on linked images that were only a part of larger image.
d. FA13 – support for DHTML, flash, Embedded link #'s into images
e. FB 13 – on select text input, select text in textbox

22 System analyst, software engineer

a. D5 – Massage, Stretching, ice, anti-inflammatory medication
b. D7 – Forearm pain from mouse use
c. D10 – MS Office, Netscape, windows 95
d. FA8 – tightness, weakness
e. FA9 – Netscape, IE
f. FA11 – Fairly complete in its links, numbers are ordered on page
g. FA12 – Not fully windows compliant eg. Alt F does nothing, Url locator doesn't remember yahoo.com etc, no scroll bar access via keyboard in history frame, Typed in "R" in a list box (for Regina) then had to erase the R
h. FB8 – tightness, weakness
i. PA5 – tightness, weakness
j. PB5 – tightness, weakness

Appendix B

Study ID#________________

TextMouse Pre-experiment Questionnaire

The following questionnaire will ask you several questions about how you are feeling at this present time. Please place a vertical line that intersects the line presented, following the question to indicate your answer.

For example,

Do you like ice cream?

____________|______________________

Very much | Not at all

This example would indicate that you like ice cream a little.

1)) Please indicate the amount of pain you are presently experiencing in your head:

____

None Severe Pain

2) Please indicate the level of stress you are presently experiencing for having participated in this experiment:

____

None Very Stressed

3) Please indicate the level of discomfort in your wrist, arm or shoulder if any presently feel

____

Extreme Discomfort None

4) If you answered anything other than None in Question 3 Please indicate where

__ Shoulder __ Arm __Wrist __ fingers

5) Please describe the quality of this discomfort (ie Pins and Needles, tightness, weakness, etc) if any.

Appendix C

Study ID#________________

Demographic Questionnaire

1) Please indicate the appropriate age group
__ 18-22 __ 23-29 __ 30-39 __ 40-49 __ 50-65 __ 66 +

2) Please indicate your Gender __ Male __ Female

3) Please indicate your Occupation (if a student please state your major).

4) Do you have a diagnosed history of Repetitive Strain Injury (i.e. Carpal Tunnel Syndrome, Tennis Elbow)? __ Yes __ No

If Yes, approximately how long have you had this condition and type?
_____ Days _____Months _____ Years

5) If you have a diagnosed history of RSI, are you currently under a treatment regime?
__Yes __ No
If Yes, please describe your treatment?

6) Please indicate the types of computer input devices that you use, if any?
___ Keyboard ___ Mouse ___ Trackball ___ Other
Please describe Other ….

7) Do you have any problems operating any of the computer input devices indicated in question 6?
__ Yes __ No

If Yes, please describe the problem.

8) Please estimate the average number of hours per week that you use a computer._____ Hours

9) Please estimate the average number of hours per week that you browse the Internet._____ Hour

10)Please list the software packages you are most familiar with and use regularly. (ie Microsoft Office, Netscape, Linux, Windows 98, etc)

Appendix D

Study ID#________________

TextMouse Followup Questionnaire

The following questionnaire will ask you several questions about how you are feeling at this present time. Please place a vertical line that intersects the line presented, following the question to indicate your answer.
For example,

Do you like ice cream?

Very much | Not at all

This example would indicate that you like ice cream a little.

In the following questionnaire please answer either 'a' or 'b' depending on which one applies to you during this testing session.

1) a) Please indicate the level of difficulty you had navigating the TextMouse Web Executive with a mouse:

None Difficult

b) Please indicate the level of difficulty you had navigating the TextMouse Web Executive with a keyboard:

None Difficult

2) You found that the TextMouse Web Executive interface was:

Easy to Learn Hard to Learn

3) The placement of the numbered links on the web pages were:

Appropriate Inappropriate

4) Please indicate the amount of pain you are presently experiencing in your head:

None Severe Pain

5) Please indicate the level of stress you are presently experiencing for having participated in the experiment:

____

None Very Stressed

6) Please indicate the level of discomfort in your wrist, arm or shoulder if any presently feel

____

Extreme Discomfort None

7) If you answered anything other than None in Question 6 Please indicate where

__ Shoulder __ Arm __Wrist __ fingers

8) Please describe the quality of this discomfort (ie Pins and Needles, tightness, weakness, etc) if any.

9) Do you presently use other web browsers on a regular basis? Which ones?

10) If you answered yes to question 9, how does the TextMouse Web Executive compare?

____

Better Indifferent Worse

11) Please describe any aspects / features of the TextMouse Web Executive that you liked.

12) Please describe any aspects / features of the TextMouse Web Executive that you disliked.

13) Please describe any aspects / features of the TextMouse Web Executive that you would like to see added in order to improve it.

Appendix E

TextMouse Task List

11) Locate the atomic weight of the 23rd element on the periodic table using www.Google.com as the search engine and the Los Alamos Lab (non-flash)
12) Using the back button move back to the google search engine
13) Locate a Regina Florist
14) Select the address box and type in www.yahoo.com
15) Select the yahoo auction and find the price of the first apple computer notebook G3
16) Using the back button move back to the yahoo home page and locate the top story on the news
17) Select the home button
18) Locate the percentage assigned to the cs170 midterm for this semester
19) Select history and then google and then close the history
20) Locate the average family income for Canada at the Stats Canada web site
21) Select Favorites on top menu and then add to favorite list
22) Place cursor in Address box and type in www.Altavista.com
23) Search for essay on Romeo and Juliet
24) Select all the text and paste on notepad
25) Select Stats Canada page from the favorites list and then select View then Source
26) Close the Favorite list
27) Using the history list select the google search engine
28) Locate the Edmunds autos site
29) Select the new auto site but before the web site loads stop the load and move to the advise selection further down the page and then select Leasing Basics
30) Select the print icon, make sure that the printer is set to department printer, select pages and print the first page only.
31) Select the home button
32) On the Computer Science home page select Department Research
33) Select the major research areas button
34) Locate Dr. Hamilton and click on his web page link
35) Select his research interests
36) Select View and then minimize
37) Move down and select the Mouse button at the bottom of the screen to reopen the browser
38) Select the home icon
39) Select the recruiting button on the computer science web site
40) Select file and save as menu item
41) Save the document in the My Documents folder that pops up
42) Select the back button
43) In the address box enter www.westjet.com
44) Then select the Flight schedule
45) Select a flight departing from Regina with a destination of Vancouver for week of Feb 14.
46) Select Home