

Mouse-Typing on Alternate Keyboards

1 INTRODUCTION

1.1 The Problem

Your company produces phone/fax machines, all which use a hardware phone pad. People can use the phone pad to enter alphabetic characters, which is used to create an on-line directory containing people's names, phone numbers, and notes on them. Users can then scroll through the directory and direct dial a person. Through caller id, the details of the caller are automatically displayed whenever the phone rings. Customers usually rave about these features.

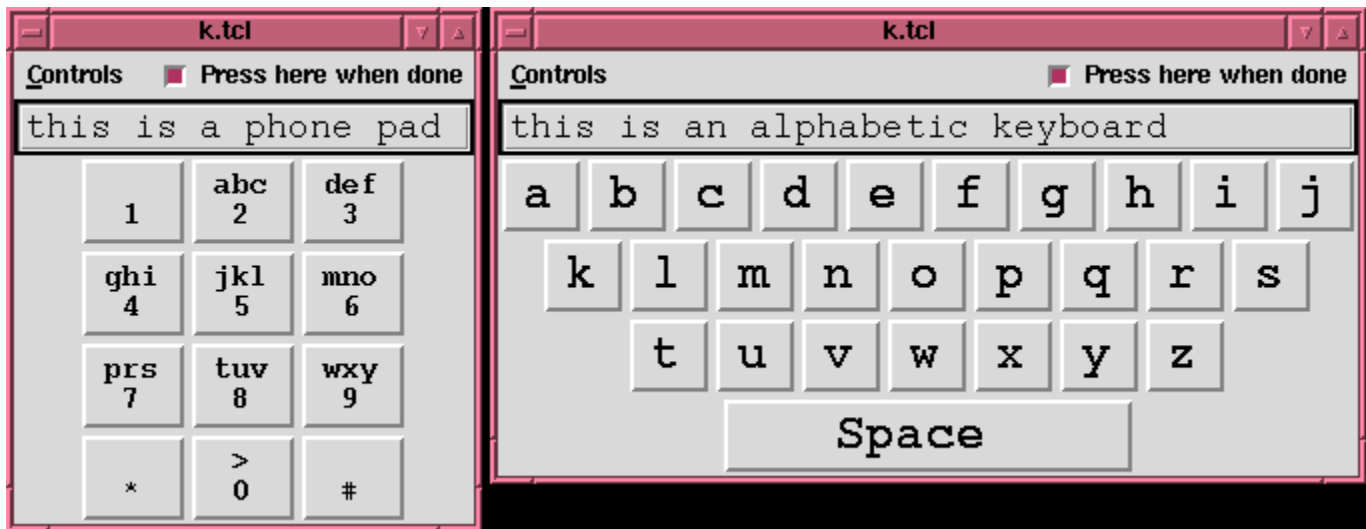
You have been placed in charge of producing a new version of your company's phone/fax machine. This version will have a small screen, a mouse, and no hardware keyboard and/or keypad. An alternate design using a pen is also being considered. Typing of numbers and text will be done by displaying a simulated keyboard on the screen, and by selecting keys with the mouse (called mouse-typing) or with the pen (called pen-typing).

The problem is deciding what keyboard design to use. On one hand, you can simulate the conventional phone pad already used on your fax machines and all telephones (below left). People type letters by multiple clicks of keys, and by using the '>' to move ahead a letter. For example, typing 'hi' involves pressing '4' twice (for h), the '>' (for moving forward a character), and pressing '4' three times (for i). Alternatively, you can simulate an alphabetic keyboard (below right). However, your marketing department has convinced your boss that standard qwerty keyboards should not be used, as they believe many users of this product are not experienced typists and that all people will be fairly fast on one of the other layouts.

The choice of alphabetic or phone keyboard is not clear, for there are several tradeoffs.

- The full-sized alphabetic keyboard requires a larger screen, which is more costly to produce and will require a bulkier product
- pen-based interfaces are far more costly than mouse-based interfaces
- People's mouse-typing / pen-typing speed and their error rates on these different keyboards are not known.
- Some of the product users are experienced typists. It's not clear what the typing tradeoffs would be moving from a standard qwerty to the alphabetic or phone pad.

You have decided to run an experiment comparing typing speed and error rate on these keyboards, and will use the results to make recommendations about which layout should be used in the product. Some background to existing keyboard layouts and computing without keyboards is given in the Appendix.



2. DESCRIPTION OF THE EXPERIMENT

2.1 Hypothesis. You will be collecting data and comparing through statistics the mouse-typing speeds on the alphabetic and phone layouts. Several null hypothesis are listed below, each a bit more complex than the previous and each requiring different statistical analysis methods.

Null Hypothesis (simplest): There is no difference between people's mouse-typing speed when using an alphabetic and a phone pad layout on a simulated keyboard. People are expected to have several years of experience typing with standard Qwerty keyboards and with a mouse.

Null Hypotheses (more complex): There is no difference between people's mouse-typing speed when using an alphabetic and a phone pad layout on a simulated keyboard. People's skill-level in traditional typing has no effect on their proficiency with mouse-typing with either of the layouts, where people are categorized as poor typists (< 20 words per minute), medium typists (21-40 words per minute), and expert typists (41-60 words per minute).

Null Hypotheses (most complex): There is no difference between people's mouse-typing and pen-typing speeds when using an alphabetic and a phone pad layout on a simulated keyboard. People's skill-level in traditional typing has no effect on their proficiency with mouse-typing with either of the layouts, where people are categorized as poor typists (< 20 words per minute), medium typists (21-40 words per minute), and expert typists (41-60 words per minute).

2.2 Subjects. Subjects are members of your group, all University of Calgary students. You may use other subjects as well, but make sure they have equivalent computing and typing experience. Subjects are expected to have several years of typing experience, although a broad range of typing speeds are expected.

2.3 Materials. Appendix 0 describes how to get, test and use the custom software that presents a soft keyboard showing only the letter keys and a space bar on a screen. Other appendices provide instructions for downloading software, instructions to subjects, text for copy typing, consent forms, questionnaires, and individual work sheets.

2.4 Method. Each subject goes through the following steps, detailed further in Appendix 1.

a) *Prolog:*

- They are asked to sign a consent form (Appendix 3).
- The experiment is described to them (Appendix 1).
- They answer a pre-test questionnaire (Appendix 4).
- They are given additional instructions as they perform the task (Appendix 1).

b) *Trial 1-2: Typing speed with physical keyboard*

- Subjects are given two English paragraphs to copy type using the physical keyboard (Appendix 2).
- When subjects are ready, the experimenter presses the *Press here to begin* button, and the subject types the paragraph.
- Immediately after the subject finishes the task, the experimenter presses the *Press here when done* button.
- The process repeats itself with a new paragraph.

c) *Trials 3-8: Typing speed with the two keyboards*

- The experimenter selects one of the keyboards (order to be determined by your TA) and describes it to the subject.
- The subject is given an English sentence to mouse type (Appendix 2). After reading it, the subject presses the *Press here to begin* button and enters the sentence. When complete, the subject presses the *Press here when done* button.
- The process is repeated on the same keyboard layout with two more sentences.
- After the keyboard is tested, ask subjects what they thought about the layout.
- The process is repeated with the other keyboard layout.

d) *Post-session*

- Ask subjects what they thought about all keyboards, and have them state which one they preferred (Appendix 4).
- Ask them for any other comments.
- Debrief them. Explain your motivation if they wish (for example, expectations about keyboard layouts)

3. RESULTS

Each subject will be identified by a unique number. You should collect your numeric and qualitative results on the worksheets as given in Appendix 5. Your numeric data should be recorded in EXACTLY the format described on the worksheet. For hypothesis 1, you would calculate a t-test contrasting the typing rates on the two layouts. An example set of data and the results of a T-test are in Appendix 6. As well, you could plot a scattergram that contrasts subjects' typing speed on the conventional typing test (the X-axis) with their typing speed on each of the other "soft" keyboards (the Y-axis). For each scattergram, draw a straight line that best "fits" the result. (I will be doing this through statistics as well, through something known as a regression analysis.)

Your write up usually includes a table of summary statistics and descriptions of the t-test result.

4. WHAT TO DO WITH ALL THIS

An experimental report typically follows the style specified in the accompanying document "[How to structure reports on experiments in human-computer interaction](#)". This assignment specification already gives material for the introduction, description of the experiment, and expectations in the results section. It would also include a related work section, and it would be up to you to investigate other keyboard studies.

It is up to you to interpret what the results mean. You should discuss this with your group, and *think* about it. Think about the impact your findings would have to the application constraints described in this scenario, the general use of soft keyboards, the implications to other practitioners, your critical reflections, and a research agenda of future study and issues. Use both the qualitative and quantitative findings of your study, as well as prior research on keyboards.

Your conclusion should make a recommendation and should justify your results.

Include your rough data and worksheets in an appendix. This should include the work sheets where you recorded pre- and post-experiment answers to questions, subject's comments, etc. You would not normally include this in a paper, but you should always maintain this as an archive that you can use if you have to refer back to your data and its analysis.

5. BACKGROUND

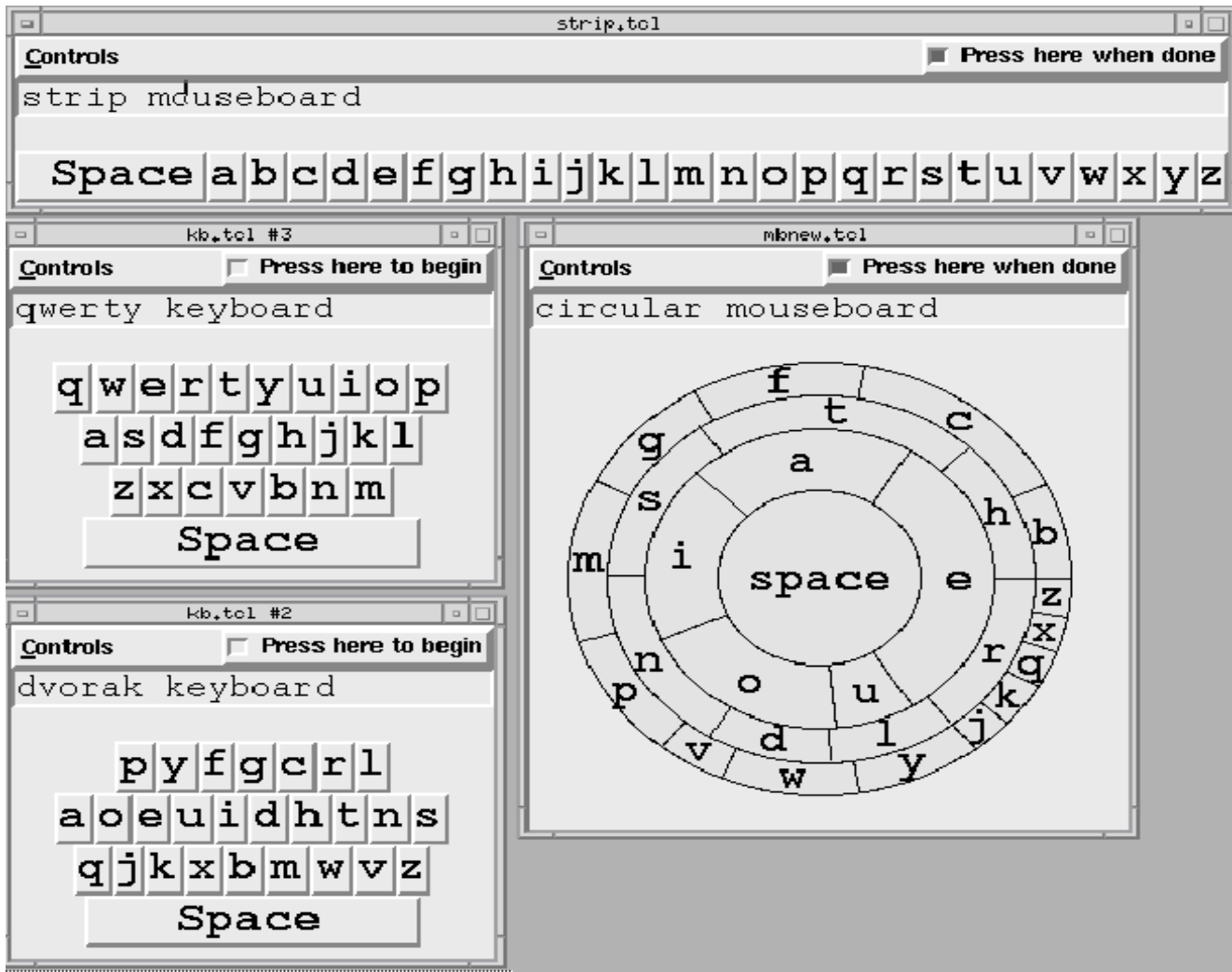
5.1 Keyboard layouts

Early typewriter mechanisms were quite crude. Typebars (the levers that actually struck the paper) tended to jam, particularly when two nearby keys were hit in rapid succession. The first typewriters had keyboards that were laid out alphabetically, and fast typists would routinely run into jamming problems.

The Qwerty layout (below middle-left), named for the first six keys in the top-left row, was developed in the late 1870's to minimize the jamming problem. It increased the spacing between common pairs of letters so that sequentially-struck keys would not jam. It was also developed for two-finger typing; touch typing was unknown until the early 1900s. The Qwerty layout is found on virtually all of today's computers.

Today, typewriter mechanics and jamming are no longer a concern, and several alternate layouts to Qwerty exist. Alphabetic keyboards (above right) that lay out the keys in alphabetic order have recently appeared on several devices, such as pocket computers, calculators and children's toys. The idea is that non-typists can find keys more quickly because they know the alphabet. Surprisingly, most studies have found that typing speeds on alphabetic keyboards are lower than that of the Qwerty, even for non-typists.

The Dvorak keyboard (below, bottom-left), developed in the 1930s, was based upon time and motion studies of touch-typing of English text. Its design simplifies a typist's finger motion, increases the amount of time spend on the home (middle) row, and balances the amount of work done by all fingers. Frequently used letters are placed on opposite halves of the keyboard to maximize two-handed typing sequences (which is faster than one-handed typing of characters in sequence). Studies contrasting Dvorak and Qwerty typing confirm that Dvorak is indeed faster after training; however, there is some disagreement on the amount of improvement.



5.2 Computers without keyboards

We are beginning to see more and more computers without keyboards. Examples are:

- computers in public places (e.g. information kiosks)
- computer games (e.g., video parlors)
- pocket computers (advanced calculators and schedulers)
- pen-based computers (Macintosh Newton)

In spite of the prevalence of graphical interfaces, many situations still require text input (as in the fax machine product above). The most promising way to do this without a keyboard is by character recognition, where you use an electronic pen to print letters. The computer either recognizes the letter shapes or the order of strokes that make up the letter, and replaces it with a typeset version of its guess. The catch is that computers using character recognizers are still fairly rare, are notoriously inaccurate (especially with messy writers), and require users to train themselves or the character recognizers. Also, handwriting tends to be slower than typing, especially for lengthy passages.

Another option to text input is *mouse-typing*, where a person does the equivalent of one-finger typing of keys on a screen instead of touch-typing a physical keyboard. Because mouse-typing uses only one hand, we can consider radically different keyboards. For example, we previously tested a circular mouseboard (see figure above, middle-

right) that places letters in a circle, with most frequent letters having the larger keys and being closer to the center (the idea was that it should be easier to select frequent keys). We also tested an alphabetic strip keyboard (above, top) that presented the keys in alphabetic order across a single row.

It isn't immediately obvious which of the qwerty, dvorak, alphabetic, circular, phone, or strip layouts work best for mouse-typing or pen-typing. Consider the following points:

- Most typists are already trained to the qwerty keyboard, but the layout is designed around mechanical considerations.
- The dvorak keyboard specifically maximizes human performance. Yet it is unfamiliar, and untrained people are forced into a hunt and peck strategy through a seemingly random arrangement of letters.
- With an alphabetic and strip keyboard, people may be able to find keys quicker, since they know the alphabet. However, the layout does not make any attempt to put frequently-typed letters together.
- All performance evaluation of previous keyboards are based on two-handed typing. People's mouse typing and pen-typing speeds, which are equivalent to one-finger typing, may be quite different.
- The phone pad is familiar, but typing on it is not. Also, several key strokes are required for each character.
- There are space and layout considerations as well; certain keyboards demand more space on the display.

Our previous studies have shown that people consistently mouse-type faster on the Qwerty than on the other keyboards (in spite of what marketing says!). However, we still don't know how well people perform on the phone pad, and the alphabetic keyboard. Which do you think is best?

Appendix 0. Preparing the Software

Step 1. Install Tcl/Tk

Download [Tcl/TK](#) v8.04, the programming language necessary to run the software, on a Windows machine. It is a self installing script that will bring up a dialog box. Run the installer, and press the obvious default buttons.

Step 2. Testing the software

1. Download and save [kb.tcl](#) from this link.
2. Run it by double clicking the kb.tcl file. You will see a window with a querty keyboard in it.
3. Select the Controls Menu (upper left) and try changing it to an alphabetic or a phone keyboard.
4. Note that the program will produce a file called test1.txt containing the data after you run it.
5. Click the "Press here to begin button"
6. Start typing (anything you want for now). When you are done, click the "Press here when done' button.
7. Repeat steps 3-6 with a different keyboard.
8. Select Quit from the Controls menu.
9. There should now be a file called test1.txt in the same folder where you saved kb.tcl. This contains the data:
 - o Trial number e.g., Trial : 1
 - o Keyboard type e.g., -type : Qwerty
 - o Time in seconds e.g., -time : 5
 - o Text typed e.g., -text : my name is fred

Appendix 1: Instructions to Subjects

A.1 Description of the Experiment

The following description should be read to each subject at the beginning of the experiment. Italicized text are instructions to the experimenter. Replace the term 'mouse typing' with 'pen typing' if you are using a pen-based system.

Before you begin, you should have a worksheet available for the subject. You should also have the interface up and running, with the Qwerty layout selected. No other windows should be visible. Also, assign subjects a subject number. Assume this one is Subject B.

Introduce yourself. Give them the consent form to sign, on their worksheet. If it is not signed, do not proceed.

- My name is _____, and I will be giving you instructions on what to do and will answer your questions.

You're helping us by trying out a new product in the early development stages. We have several different versions of this product, and we're looking to see which version is the easiest to use. If you have trouble with some of the tasks, it's the product's fault, not yours. Don't feel bad; that's exactly what we are looking for. Remember, we are testing the product versions, not you.

Tell the participant that it's OK to quit at any time.

- Although I don't know of any reason for this to happen, if you should become uncomfortable or find this test objectionable in any way, you are free to quit at any time.

Tell them about the experiment, and record the subject id.

- Our team is working on a computer that does not have a keyboard. Because text entry may be occasionally required, we plan to put a simulated keyboard on the screen, such as the one you see in front of you, through which people can "mouse type". *Show them the screen.* The keyboard includes only lower case letters and a space bar. There are no numbers or backspace key. Anything you type appears on this one line entry.

You "mouse-type" by selecting a key on the screen. For example, I will type your subject identification, which is "subject b". Notice that I have to press this button on the upper corner before it will let me type.

Press the "Press here to begin" button and mouse-type "subject three four".

- When I am done, I press this button to tell the system I have finished.

Press the "Press here when done" button.

Point to the screen

- The purpose of this experiment is to study people's ability to "mouse-type" using a variety of different keyboard layouts. The keyboard layouts we will use are as follows. This layout is called a Qwerty keyboard, and is the same layout usually found on typewriters and computers.

Select the Phone Pad layout.

- This layout is called a phone pad keyboard. Notice that the letters are arranged as they are on your telephone. I'll type the word 'test' on it to show you how it works.
Start typing. You type a letter by pressing and cycling through each letter on a key until the correct letter appears. To accept the next character, you have to press the '>' key. To type a space, you have to press the '>' twice.
Leave a space and show that the letters s and z require 4, not 3 button presses. Also notice that the 'prs' button includes the letter 'q', while the 'wxy' button includes the letter 'z'.

Select the Alphabetic layout.

- This layout is called an alphabetic keyboard. Notice that the letters are arranged in alphabetic order. I'll type the word test on it to show you how it works.

Note: Don't tell subjects about the possible advantages or disadvantages of each method!

Administer the pre-test questionnaire on the worksheet. Write down the answers as they are supplied!.

- Before we begin the typing task, I would like you to answer a few questions found on this form.

A.2 Specific task instructions

Don't forget to record any comments on the worksheet.

- For all typing tasks, I am going to ask you to type as fast as you can. However, I want you to avoid typing errors. If you do make an occasional mistake, just keep on going... there is no backspace key!. If you make many errors, then you are probably trying too hard and you should slow down a bit.

Task 1: Measure their touch typing ability. Set it up to the qwerty keyboard

- We will begin by measuring your actual typing speed using the physical keyboard.

Give them the paragraph.

- Please read the following paragraph aloud. When you are ready to begin, I will press this button and tell you to begin typing. When you are done, tell me and I will press the button again. Any questions?

Do it!

- Now lets do it again with the next paragraph. *Ask them to read it aloud, and repeat the previous step.*

Task 2, 3 and 4: Measure their mouse typing ability with various keyboards. Note that the order you run these experiments in will be assigned by your TA! For illustration, assume the order is Phone and Alphabetic. Change the layout to the Phone keyboard.

- Now we will see how fast you can mouse-type on the phone keyboard. As before, you should type as fast as you can while still avoiding typing errors. This time, you will be pressing the button at the beginning and end. Read the first sentence aloud, and start whenever you are ready. This sentence is for practice.

Note: Subjects may forget to press the button starting and ending the experiment. Remind them!

Give them the 2nd sentence

- Now do the same with this sentence. We will be recording your typing time and erros, so go as quickly as you can and try to keep your typing errors down.
Read the sentence aloud and start whenever you are ready.

Give them the 3rd sentence

- Now here is the last sentence with this keyboard. Read it aloud and start when ready.

Let them type it.

- Good. What do you think about mouse-typing with this layout?

Record their comments on the worksheet

Switch keyboards, and repeat the above procedure for the alphabetic keyboard. Use the same sentences in the same order of presentation.

- I'll switch to the next keyboard.....

Adminster post-test questionairre on the worksheet

- Now that you have used all keyboards, can you rank order them from best to worst? Do you have any other comments to make?

Record the results. You may want to ask other questions on oddities that you may have observed.

At this point, the experiment is complete. You can answer any questions that the subject may have. Thank them. Finally, record your own observations of what you saw that were not captured by subject's comments.

Appendix 2: Text for copy typing

Remind subjects to ignore capital letters , carriage returns, and punctuation. If they make a mistake, they should just keep on going. Use the first two paragraphs for copy typing on the physical keyboard. Use the three sentences for mouse-typing. The subject will type all three sentences in succession with a particular keyboard layout. The same succession is followed for all layouts.

Paragraph 1 (212 letters)

- there were two cupcakes in his lunch bag and there was also a chocolate bar with almonds in it but all i had in my lunch bag was an old peanut butter sandwich and an old health cookie that did not taste very good

Paragraph 2 (212 letters)

- i went to school with gum in my mouth and now there is gum in my hair and when i got out of bed this morning i tripped on the skateboard and by mistake i dropped my sweater in the sink while the water was running

Sentence 1 (46 letters)

- come back next week and we will play some more

Sentence 2 (46 letters)

- after school my mom took us out to go shopping

Sentence 3 (46 letters)

- on the way down the stairs i saw an orange cat

Appendix 3: Consent Form

1. Consent Form

Research Project Title: Mouse-typing on alternate keyboards

Investigator(s): <List of investigators should go here>

Sponsor : None

Subject ID: _____

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The purpose of this study is to test how well people type without a keyboard on different keyboard layouts. We will use the results of this study to determine which layout is most appropriate for a product we are currently developing. You have been asked to help us as you are typical of the types of people who may use the end-product.

You will be shown a set of on-screen keyboards, and will be given instructions on how to use them. We will then ask you to copy-type some text using these keyboards. We will watch and take notes on what you do. We will also ask you a few questions before, during, and after each task. The system will record what you typed and how long it took you to type it.

If you agree to participate, we expect this to take between 20-40 minutes of your time. There are no further obligations expected. You should not experience any discomforts or any risks to your well-being. To protect your confidentiality, all collected data will be identified only by an anonymous subject name, e.g., Subject B, and will be stored on a password-protected computer. However, portions of the actual data collected may be presented to other researchers in either its raw or processed form.

If you wish, you can receive a copy of any publications produced about this data by contacting the investigator. These should be available with 3-6 months after your participation.

Finally, there is no financial remuneration associated with this study. We recognize that you are volunteering valuable time, and we thank you for it.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, please contact:

If you have any questions or issues concerning this project that are not related to the specifics of the research, you may contact <Your name here>. If you are not satisfied by our response, you may also contact the Research Services Office at 220-3782 and ask for Mrs. Patricia Evans.

Participant's Signature _____ Date _____

Investigator and/or Delegate's Signature _____ Date _____

Witness' Signature _____ Date _____

A copy of this consent form has been given to you to keep for your records and reference.

Appendix 4: Questionnaires

1. Pre-test Questionnaire.

Place a checkmark next to the most suitable choice

A) Are you comfortable typing with a Qwerty (standard) keyboard?

Yes

No

B) Do you:

touch type

two-finger type

one-finger type?

C) Have you ever typed alphabetic text on an

alphabetic keyboard

a phone pad?

If so, how often and how recent? _____

D) Do you usually use a mouse when you use a computer?

yes

rarely

never used a mouse before

E) Have you used the optical mouse on Sun workstations? (*show them the mouse if they are not sure*)

I use it regularly

I have used it less than 5 times

I have never used it

F) Is there anything we should know about that may hinder your ability to mouse-type, for example, vision problems or physical disabilities? (Don't answer this if you don't want to.)

2. During-test Questionnaire.

Which keyboard was used first? _____

Subjects comments after using the first keyboard:

Subjects comments after using the second keyboard:

3. Post Test Questionnaire:

Which Keyboard did you prefer? _____

Do you have any comments about either keyboard?

Investigator's comments:

Appendix 5: Work Sheet

Subject number: _____

Circle the order that this experiment was done

1. Touch typing, then phone pad , then alphabetic
2. Touch typing, then alphabetic, then phone pad ,

Trial	Text type/letters	Total time	Characters/minute calculation: <i>Characters in sentence * 60 / Time to type sentence</i>	# of typing errors
Touch-typing 1	paragraph 1 212 letters	.	.	.
Touch-typing 2	paragraph 2 212 letters	.	.	.
Phone pad 1	sentence 1 46 letters	.	.	.
Phone pad 2	sentence 2 46 letters	.	.	.
Phone pad 3	sentence 3 46 letters	.	.	.
Alphabetic 1	sentence 1 46 letters	.	.	.
Alphabetic 2	sentence 2 46 letters	.	.	.
Alphabetic 3	sentence 3 46 letters	.	.	.

Summary data for all subjects

Subject number	Keyboard order (A or P) for the <u>first</u> keyboard used	Time in Chars/minute for the <u>second</u> touch-typing trial	Average time of trials 2&3 in chars/minute for the <u>first</u> mouseboard used	Average #errors of trials 2&3 for the <u>first</u> mouseboard used
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.
.
<i>example:</i> B05-01-3	<i>alphabetic done first</i> A	80.33	55.4	7

Each subject should also have qualitative results in a separate file, e.g., SubjectB.notes, which must include:

- Subject number as above
- subject's preferences of keyboards
- questionnaire results
- subject's comments
- experimenter notes