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Evaluating Single Handed Data Entry on QWERTY Layouts

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No! the abstract is not an introduction

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ABSTRACT

As technology advances, the original design of the QWERTY layout has not evolved and does not operate well in conjunction with a mouse and navigation keys. The shifted QWERTY keyboard is a new layout intended to optimize the way we operate a computer in the modern age of computing. The shifted QWERTY layout is performed on a standard QWERTY layout with modified keys that allow users to use keys that may be hard to reach like navigation keys and symbols. In our experiments, it is shown that although people who used the shifted QWERTY layout had the average input speed * of 68.28 seconds when compared to the traditional QWERTY's 35.10 seconds per trial, the shifted QWERTY was favoured by the participants stating that they much preferred the ergonomics of the layout. The Shifted QWERTY's error rate was also higher than the traditional QWERTY's error by 26%. However, this layout can be useful with enough practice to those who prefer important keys to be in close proximity in order to maximize efficiency and speed.

Keywords

Keyboard layout, text-based input, desktop text entry, single hand entry, QWERTY layout

INTRODUCTION

The QWERTY keyboard has become the de facto standard since 1971 for people to perform data entry and has become indispensable as we rely on it to perform tasks ranging from programming to surfing the web [3]. The nature of keyboard data entry has evolved much over the years from its inception as a typewriter to an input method for personal computers with graphical interfaces.

Changes to its layout have been made over the years to adapt as technology and usage of the keyboard change as seen in its progression from an alphanumeric only layout to a layout more suited for use with a computer with features like navigation and control keys. There have also been many attempts over the years to design an efficient and ergonomic alternative to QWERTY. Layouts like Dvorak and Colemak and many others have attempted to improve efficiency by placing frequently used keys on the home row and those that are not in the rows above or below to avoid the constant need to jump from the home row to rows under or above as described by West [4]. Although they were not successful due to its high price of adoption, they still have merit and provide insight when considering keyboard efficiency.

An issue often overlooked with modern keyboard layouts is the imbalance on the right side of the keyboard where it houses most of its symbols and modifier keys. When used in conjunction with a mouse, this becomes apparent when performing tasks such as text editing as most of the special characters and symbols are inaccessible with our left hand. This forces the user to either constantly move their right hand from the mouse to the keyboard or to completely abandon the home row and use their left hand to make inputs [1]. This incessant movement is extremely fatiguing and hinders both performance and efficiency. This problem stems from the fact that the original QWERTY layout was not designed to be used with a graphical interface and was intended to be used strictly for two-handed data entry on a typewriter. Similarly, the standard ANSI/ISO 104 key QWERTY layout we use today was meant to be used with a command-line terminal where both hands are to be placed on the home row at all times as it was made popular during the 1980s. With both variations, users at the time would not have a problem reaching keys that would be problematic today. As keyboards in the modern era are being used less for actual typing and more for shortcuts and navigation of content of applications with one hand on the mouse, our current layout becomes increasingly unpleasant to use [1].

The Shifted Layout Concept

A potential solution is the use of a layout that provides the user with the option of shifting hard to reach keys like numbers, symbols, and the numpad to the left of the keyboard as seen in Figure 1. Our design efforts focus on allowing the user to access all the functionality of the right side of the keyboard on the left side, to allow for one hand typing without the need of taking a hand off the mouse. The design does not involve making any physical changes to the keys in a traditional QWERTY keyboard layout, which enables the user to leverage their familiarity with QWERTY when using this keyboard layout design.

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* The units of typing speed are "words per minute"

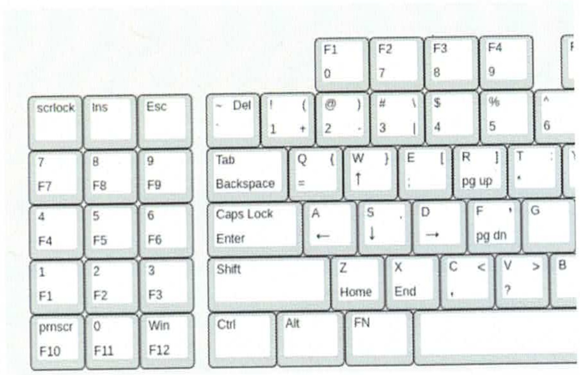

Figure 1. A prototype of the "shifted" layout with improved one hand input capabilities.

The altered keys in this layout consist of extra bottom and top legends on top of the preexisting keys. When modifier keys are pressed and held down, it toggles a mode that gives users the option to access additional symbols and functionality with their left hand to accommodate a mouse.

The shifted layout could be useful when performing data input that involves the mouse, such as editing lines of code. When using your mouse to select a phrase, it allows the user to press a shortcut to navigate the page with the navigation keys or insert symbols. It also improves functionality when not using a mouse as shifting the keyboard to the left consolidates functionality into a smaller area that keeps the users' hands in the home row and keeps movement to a minimum.

RELATED WORK

There has been previous work done in transforming the QWERTY keyboard related to the current investigation. Green et al. [2] described a specialized keyboard called the "stick keyboard" shown in Figure 2 that maps four rows of a standard QWERTY keyboard onto the home row. The results of Green and colleagues' study suggest that with user knowledge of the QWERTY keyboard layout and limited required space, the stick keyboard could produce reasonable typing speeds.

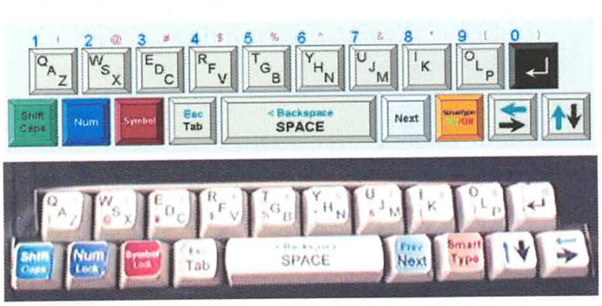

Figure 2. A diagram and hardware prototype of the stick keyboard. [2]

Another related transformation to the traditional QWERTY keyboard is the iQwerty or the interlaced QWERTY keyboard layout by Zhai and Kristensson [5] as shown in Figure 3. The iQwerty layout breaks each row of keys on the traditional QWERTY keyboard into two interlaced rows.

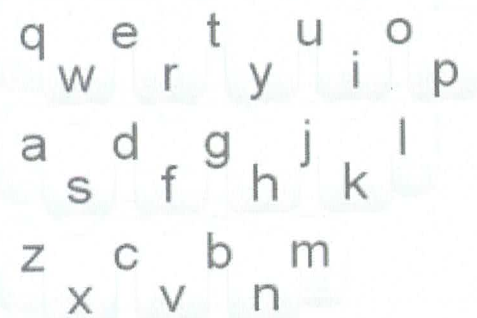

Figure 3. The Interlaced QWERTY keyboard layout [5]

Zhai and Kristensson's study suggests that there is a positive correlation between the users' knowledge of the QWERTY keyboard and the experience of the users' initial visual search.

Although the layout being discussed does not require any physical change to the keyboard (stick keyboard) or any interlacing of rows (iQwerty) it shares a common design motivation to use the users knowledge of the QWERTY.

In the following section, we describe an experiment to evaluate the speed and efficiency of the proposed keyboard layout compared to the traditional QWERTY keyboard layout.

METHOD

A user study was conducted to determine whether the shifted QWERTY keyboard layout input method was faster and more efficient than the traditional QWERTY keyboard layout input method.

Participants

Six participants were recruited for this user study. The main population from which the participants were recruited were people who are familiar with coding using the C++ language as it incorporates many of the symbols that are difficult to reach. This was done to remove the impact created by any potential outlier participants who do not have any knowledge in the specific coding language. The age of the participants fell between the range of 17 - 25.

Apparatus

The hardware used ~~to perform the series of tests for the user study~~ was the participant's home computer. To transform a traditional QWERTY keyboard into our shifted layout, an AutoHotKey script was executed to remap keys so that additional or completely different functionality was possible. An image of the shifted QWERTY layout was also provided to the users to assist them with learning the layout.

→ Literature Review for atleast 3 papers was required.

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Provide the URL in footnotes.

The software used to perform the user study was Professor Mackenzie's Typing Test Experiment as seen in Figure 4. The software recorded the task completion time and accuracy. The software also prompted a line of text from a list of phrases that the participants entered.

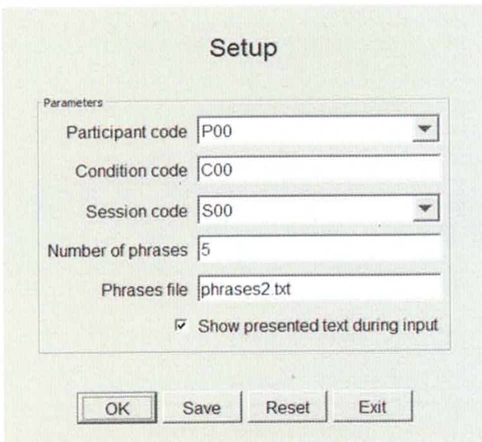

Figure 4. The Setup interface of the Typing Test Experiment software

To record the entire experiment, users were required to display a keyboard overlay and record their screen to ensure the validity of the recorded statistics and to make sure that the participants utilised the keyboard as intended.

Procedure

The participants performed a series of trials, two trials per input method per session, with no more than one session taking place per day. The trials asked the user to duplicate the blocks of code that were provided using the two input methods. Each session, participants were provided with two distinct blocks of code, wherein each block repeated twice, once using the shifted QWERTY layout, and then using the traditional QWERTY layout. The participants were also given a tutorial video on how to access the Typing Test Experiment and upload the phrase files with the blocks of code within the experimental software. The tutorial video also demonstrated how to remap the keys of their home keyboard by activating the remapping AutoHotKey script to mimic the shifted QWERTY layout.

This user study was performed longitudinally over the span of 6 sessions in order to attain information on whether the cost of learning the shifted QWERTY layout justified the benefit of learning it. This process also aided in understanding whether a crossover point occured wherein the shifted QWERTY layout was more efficient than the traditional QWERTY layout.

After the sessions took place, participants were asked fill out a questionnaire, with some of the questions being the following:

1. Did you feel the shifted layout was more efficient than the traditional qwerty layout? If so, how much more efficient and in what way?

2. Did you feel your input speed would be faster with the shifted layout given the chance to learn and use it for an extended period of time?.

3. Would you be willing to switch to the shifted layout given the chance? Did you feel it was easy to pick up and learn the layout?.

Design

This user study employed a 2 x 6 longitudinal within-subjects design where each participant was tested on both input methods. The independent variables and their levels were as follows:

- Input methods (Modified QWERTY layout, traditional QWERTY layout)
- Sessions (1, 2, 3, 4, 5, 6) ?

speed?

The dependent variables focused on task completion time and error rate.

Throughout the duration of the user study, each participant completed six sessions with each session having the user perform four trials in total. Two trails using the shifted QWERTY layout and two trials using the traditional QWERTY layout. The total number of trials of the experiment were 6 participants x 2 input methods x 6 Sessions x 4 Trials which yielded a total of 288 trials.

RESULTS AND DISCUSSION

There were 288 trials in total, wherein each participant performed two trials for each of the two input methods, traditional QWERTY and shifted QWERTY. In general, participants completed the tasks faster using the traditional QWERTY keyboard layout when compared to the shifted QWERTY layout. In terms of error rate,in general participants had lower error rates when they inputted the block of code using the traditional QWERTY layout. This data was expected as the participants had previous learning with the traditional QWERTY layout, and participants were using the shifted QWERTY layout for the first time.

Task Completion Time

The first dependent variable was task completion time measured by the number of seconds the participant took to input the given block of code.

The mean task completion time was 49.02 seconds over the 288 trials in the experiment. As Figure 6 portrays, the traditional QWERTY task completion time was 35.10 seconds for six sessions. The shifted QWERTY layout was 94.5% longer than the traditional QWERTY layout with a mean task completion time of 68.28 seconds for six italics

sessions. The standard deviation was 2.56 and 8.68 for the traditional and shifted respectively. The results were statistically significant ($F_{1,5} = 93.52$, $p < 0.05$).

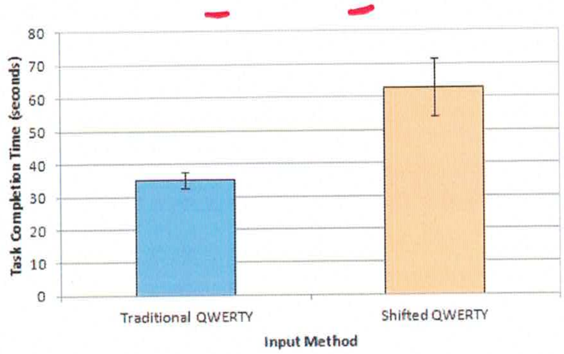

Figure 6: Mean task completion time (seconds) by input layout after six sessions. Error bars represent ±1 *SD*.

The comparison between the task completion times of both input methods broken down by sessions is presented in Figure 7. Out of the six sessions, session one presents the task completion time for the shifted QWERTY layout to be the longest with a mean task completion time of 78.32 seconds. the traditional. As each session progresses the task completion time for the shifted QWERTY layout starts to reduce, with session 3 having the lowest mean task completion time of 55.47 seconds. On the other hand, as the traditional QWERTY layout is the keyboard layout used on most computers, the participants were already familiar with this layout. Hence, the task completion time for the traditional QWERTY layout stays relatively similar, with the highest mean task completion time of 37.96 during session 3 and the lowest mean task completion time being 32.36 seconds during session 5.

A tad small

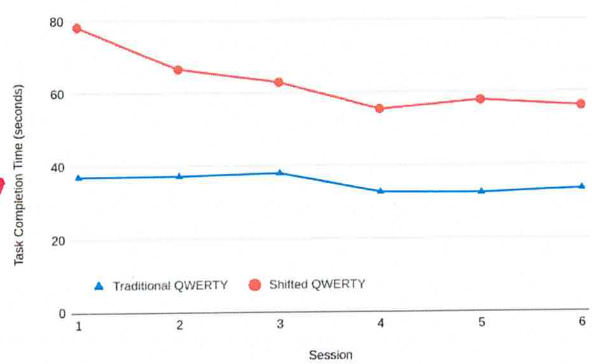

Figure 7: The mean task completion time (seconds) for traditional and shifted QWERTY over six sessions.

Over the course of six sessions, the task completion time dropped by 24 seconds.This shows that there is much more room for improvement in the future for the shifted QWERTY layout as the participants start to get more familiar with the layout and placement of the modifier keys with each trial. By projecting the data collected during the six sessions for both input methods, by session 13 a crossover point is projected, with the shifted QWERTY layout having a mean task completion time of 23.72 seconds while the traditional QWERTY layout has a mean task completion time of 24.79 seconds as seen in Figure 8.

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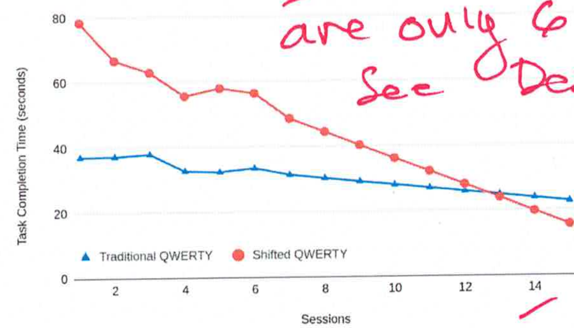

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Figure 8 : Projected mean task completion time (seconds) for both traditional and shifted QWERTY after 15 sessions.

Error Rate

The second dependent variable was error rate, which was measured as a percentage based on how many of the characters the participant inputted incorrectly or missed to input altogether. The mean for the error rate for traditional QWERTY was 1.6% while the mean error rate for Shifted QWERTY was 2.2% as seen in Figure 9. However, the results were not statistically significant ($F_{1,5} = 3.34$, $p > 0.05$)

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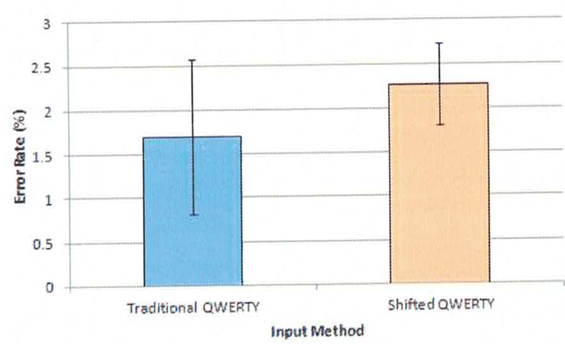

Figure 9: Mean error rate (%) by input method after six sessions. Error bars represent ±1 *SD*.

Generally the traditional QWERTYlayout has a much lower error rate than the shifted QWERTY layout. An input method with a lower error rate is generally preferred, however, by session 3, the error rate of the shifted QWERTY layout started to decrease, with the lowest mean error rate occurring during session 5, wherein it intersected with the error rate of the traditional QWERTY layout at a mean error rate of 1.51%. The traditional QWERTY layout had a higher mean error rate than the shifted QWERTY layout in session 6 with an

align

error rate of 2.66%. The error rate could indicate that participants may have gotten used to the shifted QWERTY layout or could have experienced fatigue. The average error rates in Figure 10 indicate that the traditional layout is ideal in terms of accuracy. However, it does not take into account that users were still learning the shifted QWERTY layout and room for improvement could be possible in future sessions.

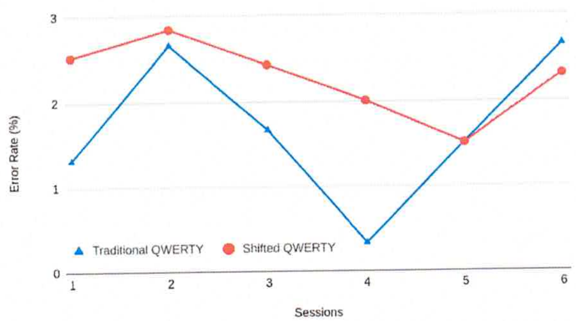

Figure 10: Mean error rate (%) for both traditional and shifted QWERTY after six sessions.

Participant Feedback

From the questionnaire that was provided after the experiment, it was determined that participants were for the most part in favour of the shifted QWERTY keyboard layout. All but two of the participants had any negative sentiment about the keyboard in terms of efficiency, task completion time and learning speed. Those in favour cited how seamless and easy it was to reach the navigation keys that they tended to avoid before. A participant stated:

"Before I used this new layout, I have never really used the page up/page down keys or the home/end keys before. Now that I've introduced them into my workflow, I find myself working much faster. Browsing the web is also much more convenient as I no longer need to move my right hand from mouse to keyboard to use certain keys. Keys are also closer together making it easier to use and more ergonomic. When doing the test trials, I did not have to search for keys in the shifted layout as they were all going to be near my left hand."

The two participants who did not like this layout did not have a traditional QWERTY layout and were using a laptop keyboard to perform this procedure. They cited hand fatigue from pressing modifier keys that were either smaller than standard size or in non standard positions. Another complaint was how hard it was to reach the F-key shortcuts as their laptop keyboard did not have a "function lock" functionality which forced them to hold down the "fn" key along with the other modifiers. Unfortunately, we did not consider this scenario in our design process.

From ratings on a Likert scale (rating from 1 to 5), the average rating for efficiency was 3.5, speed was 4.5 and learning was 4.1. This was a fairly positive response from our participants overall.

CONCLUSION

From the results from our experiment, it is clear that the shifted QWERTY layout has potential, given enough learning time. The participants achieved a mean task completion time of 68 seconds and an error rate of 2.2% after 12 trials and ~1 hour of practice of using the shifted QWERTY layout. These statistics are projected to be superior than the traditional QWERTY keyboard layout. Given enough learning time, the shifted QWERTY layout presents that it is potentially a viable alternative to the traditional QWERTY layout.

These results show that improving efficiency and speed of a keyboard does not require the need of a radical change with a completely different layout. Simple optimizations have demonstrated that the QWERTY layout is still viable and it is possible to improve performance through slight modifications.

This study also showed that participants felt more comfortable with the shifted QWERTY layout and stated that they preferred it over the traditional QWERTY layout during the later sessions of the experiment.

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1 → Video demonstration isn't clear
→ Title says Single handed. Video shows multiple hand usage.
2 → Good idea. Execution could have been better.

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