Are Split Tablet Keyboards Better? A Study of Soft Keyboard Layout and Hand Posture

Thomas Bekken Aschim[1], Julie Lidahl Gjerstad[1], Lars Vidar Lien[1], Rukaiya Tahsin[1]
and Frode Eika Sandnes[1,2] [0000-0001-7781-748X]

[1]Oslo Metropolitan University, P.O. Box 4 St. Olavs plass, 0130 Oslo, Norway
[2]Kristiania University College, Prinsens gate 7-9, Postboks 1190 Sen-trum, 0107 Oslo, Norway
`tbaschim@gmail.com, julielgjerstad@gmail.com,`
`s326313@oslomet.no, s326295@oslomet.no, frodes@oslomet.no`

Abstract. Soft Qwerty keyboards are widely used on mobile devices such as tablets and smartphones. Research into physical keyboards have found split keyboards to be ergonomically better than ordinary physical keyboards. Consequently, the idea of split keyboards has also been applied to tablet soft keyboards. A controlled experiment with *n* = 20 participants was conducted to assess if split soft keyboards pose an improvement over ordinary soft keyboard on tables with both one-handed and two-handed use. The results show that the split keyboard performs worse than ordinary keyboards in terms of text entry speed, error rate and preference.

Keywords: Split keyboard, Text entry, Qwerty, Soft keyboard, Tablet.

1 Introduction

Tablets offer users a convenient computing platform with visually and highly interactive access to information via large touch displays. Although direct manipulation through various browsing gestures is one of the huge benefits of touch interaction, the task of entering text is still highly prevalent for sending messages and filling in forms.

Although many innovative text entry methods have been proposed for touch displays the simple Qwerty virtual keyboard appears to be still the most popular as users already are familiar with physical Qwerty keyboards and many users have developed highly efficient touch-typing skills. On tables users typically enter text with one or two fingers if using one or two hands as touch-typing is difficult due to the lack of tactile feedback. Unlike touch-typing where the eight fingers only move up or down or to the side with one finger text entry the finger must move across the virtual keyboard from one key to another. Clearly, the large distance travelled by the finger slows down text entry and imposes more physical load on the user. The distance travelled is proportional to the size of the keyboard and using larger tablets thus takes longer time than using a smartphone with comparatively much smaller displays. Clearly, instead using two fingers with two hands to cover the left and the right side of the virtual keyboard speeds up text entry as each finger must travel much shorter distances.

When text is input on a mobile device such as a smartphone or tablet with one hand the other hand is usually used to hold the device. When holding the device with two hands only the thumb is free for typing. The pointing range of the thumbs are therefore limited. Consequently, split keyboards have emerged where the left and right sides of the keyboard have been moved to the left and the right side closer aligned to the position where users typically will hold the tablet. One may thus expect that two-handed text entry will lead to improved text entry rates as the keys are even closer to the two fingers reducing both the physical effort and dexterity needed to input text.

This study set out to determine if this virtual keyboard configurations indeed leads to improvements in text entry performance though a controlled experiment. The rest of this paper is organized as follows. First related work on text entry is presented followed by a presentation of the methodology. Next, the results section presents the empirical findings which are analyzed in the discussions section.

2 Related work

There is a vast body of research into text entry on touch-displays. Many of these studies evolve around letter shaped gestures [1, 2], variations on menu selection with directional gestures [3, 4] and interactive gestures [5]. Still, much research attention has also been directed at virtual or soft keyboards that are direct representations of physical keyboards. Early work on soft keyboards attempted to optimize the keyboard layouts to achieve higher text entry rates [6, 7]. However, users are usually already trained with the Qwerty layout and are therefore unlikely to adopt new keyboard layouts. Researchers have therefore attempted to optimize the keyboard layout by making small variations on the Qwerty configuration [8, 9].

Touch typing on Qwerty is a unique skill and one of few bimanual ways of operating computers. With touch typing the left and right sides of the keyboard is operated by the two hands. Several researchers have attempted to tap into users' Qwerty skills by exploiting skill transfer across hands to achieve one-handed touch typing [10] or mimic two handed Qwerty keyboard input with two joysticks [11]. The fact that touch typing is performed with two hands did lead to the idea that split keyboards, also called adjustable keyboards, would lead to improved comfort [12, 13] and there is much attention in the ergonomics literature on physical split keyboards, for example its effect on wrist posture [14, 15] and upper body posture [16].

The idea of touch typing or ten-finger typing on touch displays has also been addressed [17, 18]. However, it is a challenging problem due to the lack of tactile feedback and consequently noisy input that is hard to decode. Still, for most practical application text entry on touch devices is performed using one or two fingers. Experiments have shown that two thumb smartphone text entry is much faster than text input using just one finger or thumb [19].

Although optimized split tablet keyboards have been proposed [20], the main emphasis is on the established Qwerty layout. In a study on hand posture with tablet text entry it was found that a narrow keyboard in portrait mode yielded improved results over landscape mode [21], yet their results with 12 participants showed that the narrow

Qwerty keyboard layout resulted in higher text entry rates than the split keyboard. In a study (also including 12 participants) comparing narrow, wide and tilted split tablet keyboard used in the lap, on a desk and in bed, found that the split keyboard design received the highest comfort rating when the keyboard was used in bed [22]. Note that these studies focused on measuring ergonomic aspects of the keyboard design such as wrist extensions and wrist angles. They did not explicitly focus on text entry speeds or error rates. Nor did they explore the effects of one-handed use.

3 Method

3.1 Experimental design

A 2 × 2 within groups experimental design was chosen with hands and keyboard type as independent variables and text entry speed in words per minute (wpm) and error rate as dependent variables. The hands factor had two levels, namely one-handed interaction and two handed (bimanual) interaction. The keyboard factor had two levels, namely ordinary soft keyboard and split soft keyboard.

3.2 Participants

A total of 20 participants were recruited at the authors institution. All the participants were students of which 8 were female (40%) and 12 were male (60%). Their age ranged from 19 to 33 years of age (*M* = 24.5, *SD* = 3.75). All the participants were Norwegian speakers but having mid to high command of English (using a Likert scale from 1-5). Total of 18 participants (90%) had some or much prior experience using iPad tablets. Only 3 participants (15%) reported experience with the split iPad keyboard.

3.3 Task

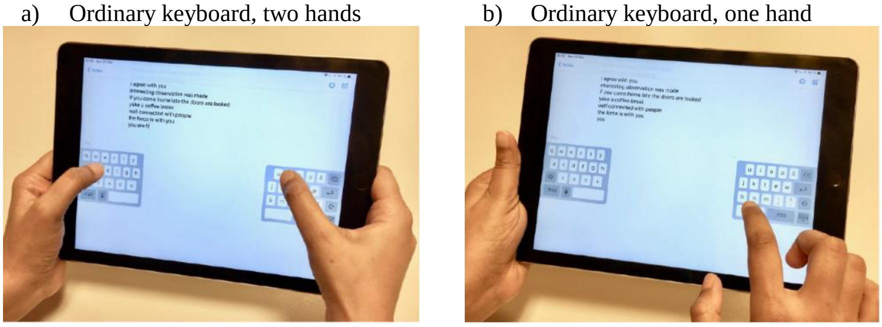
A text copying task was devised where participants copied displayed phrases using the given keyboard. MacKenzie and Soukoreff’s list of 500 simple English phrases was used [23] as a source of text to be copied. These phrases do not include capital letters, punctuations or other non-alphabetical characters.

3.4 Equipment

The experiment was conducted using an iPad Air with a 9.7-inch display in landscape mode. The virtual keyboard was configured for Norwegian as participants were expected to be familiar with this layout. Note that no Norwegian letters were used during the experiment. Word suggestions and autocomplete and error-correction was disabled during the tests. The text was written in the SimpleNote application. The phrases to be copied were displayed on a notebook computer in front of the participant.

a) Ordinary keyboard, two hands

b) Ordinary keyboard, one hand



c) Split keyboard, two hands

d) Split keyboard, one hand

Fig. 1. The hand postures used in the experiment.

3.5 Procedure

Each participant was tested individually in a meeting room in the authors university to keep the conditions as constant as possible. The four conditions of experiment were balanced by varying the presentation order according to a Latin square to compensate for learning effects. The total time taken was measured using a stopwatch. The text logs and the measured time were used to calculate the text entry speed in wpm. The iPad was held in either one or two hands. In the one-handed condition the tablet was held with one hand and text input with the index finger. In the two-handed condition the tablet was held with two hands and text input with the two thumbs. The four conditions are shown in Fig. 1. The laptop with the phrases to be copied was controlled by one of the experimenters. After completing the text entry tasks, the participants were asked to complete a simple questionnaire asking demographic information and their subjective assessment of the four input modes. Each session lasted approximately 25 minutes.

3.6 Analysis

The number of characters input was extracted from the text logs. The number of characters input and the measured time were used to calculate the text entry speed in wpm. The error rates associated with the inputted text were computed using a custom-made script. Error rates were computed using the Levenshtein distance between the inputted and the source text. Statistical analyses were conducted using JASP version 0.9.1 [24]

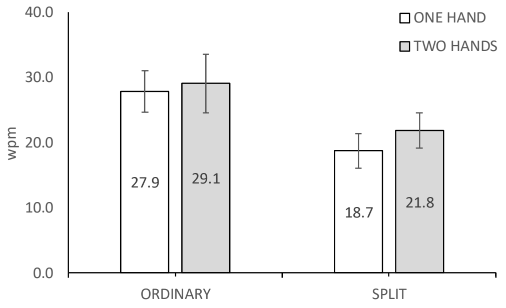


Fig. 2. Mean text entry performance in wpm. Error bars show SD.

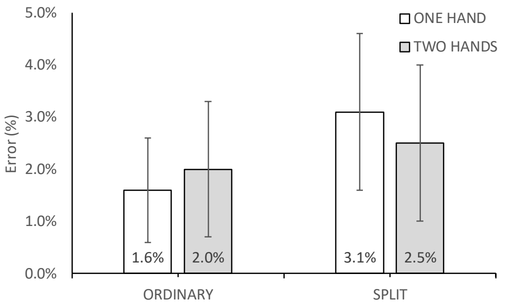


Fig. 3. Mean error rates. Error bars show SD.

4 Results

4.1 Performance

The results show that there were significant effects of both hand ($F(1, 19) = 92.164$, $p = .002$, $\omega^2 = .104$) and type of keyboard ($F(1, 19) = 217.326$, $p < .001$, $\omega^2 = .649$). Fig. 2 shows that using two hands lead to higher text entry rates than using just one hand. This observation was observed for both keyboards. The results also show that the text entry rates were higher with the ordinary keyboard compared to the split keyboard. Hence, the fastest text entry rates were achieved using the ordinary keyboard with two hands ($M = 29.1$, $SD = 4.5$). This is 33.5% faster than the text entry speed achieved with the split keyboard using two hands ($M = 21.8$, $SD = 2.7$). In fact, using the ordinary keyboard with one hand ($M = 27.9$, $SD = 3.2$) is 27.9% faster than the split keyboard with two hands. The one-handed split keyboard was the slowest condition ($M = 18.74$, $SD = 2.675$). There was also a weak but significant interaction between hand and the type of keyboard ($F(1, 19) = 9.796$, $p = .006$, $\omega^2 = .025$).

4.2 Errors

Fig. 3 shows the error rates for the four conditions. The ordinary soft keyboard yielded lower error rates than the split keyboard and the effect of keyboard type on error rate was significant ($F(1, 19) = 18.227$, $p < .001$, $\omega^2 = .140$). Interestingly, the error rates associated with the two types of hand posture were different for the two keyboards. With the ordinary keyboard one handed operation lead to fewer errors ($M = 0.016$, $SD = 0.010$) than with two hands ($M = 0.020$, $SD = 0.013$), while with the split keyboard one handed operation lead to more errors ($M = 0.031$, $SD = 0.015$) than with two handed operation ($M = 0.025$, SD = 0.015). Note that these practical differences were not statistically significant ($F(1, 19) = 0.271$, p = .608). No interactions between keyboard type and hand posture in terms of error rate were observed.

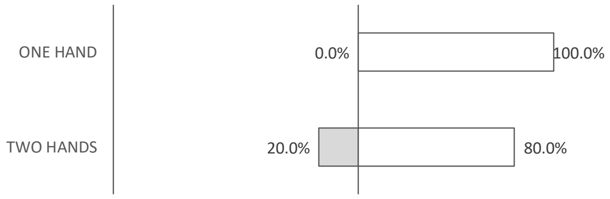


Fig. 4. Preferences for the split keyboard (grey) and the ordinary keyboard (white).

4.3 Preferences

Fig. 4 shows the participants preferences for the four conditions as a diverging stacked bar chart with preferences for the split keyboard on the left and preference for the ordinary keyboard on the right. For one handed operation all the participants preferred the traditional keyboard over the split keyboard. For two handed operation 4 of the participants (20%) preferred the split keyboard. Of these four participants only one participant indicated prior experience with the split keyboard. This means that 2 of the participants with prior experience with the split keyboard still preferred the ordinary keyboard, while 3 participants who had no prior experience with the split keyboard preferred the split keyboard when using two hands.

5 Discussion

The performance results do not match the predicted outcome as the ordinary platform outperforms the split keyboard irrespective of which hand posture is adopted. Yet the findings on text entry performance agree with the previous study of two-handed split tablet keyboards [20, 21] but not in terms of preference.

To the best of our knowledge our study is the only one also including single handed operation as a condition. As expected, the text entry performance is worse with the split layout compared to the ordinary layout. This is probably due to the fact that the index finger must travel further distances between the two keyboard halves at the left and right sides of the tablet. The participants unanimously agreed that the ordinary layout was preferable over the slit layout when operated using one hand.

It is, however, quite interesting that one-handed operation with the ordinary layout lead to a lower error rate compared to two handed input while the two-handed split keyboard lead to lower error rates than single handed operation. This phenomenon could perhaps be explained using Fitts' law which predicts the relationship between the speed, distance and target size in pointing tasks. With the split keyboard the index finger must travel further distances, possibly at higher speeds leading to missed targets, while each thumb must travel much shorter distances leading to a higher target hitting rates.

Clearly, the results obtained with split soft keyboards reported herein and in the related studies [20, 21] are negative and disagree with many of the studies of physical split keyboards [12, 13, 14, 15, 16]. One possible explanation for this is that the controlled studies with physical keyboards were conducted using ten finger touch typing while the controlled studies with soft keyboard where performed using hunt-and-peck for keys.

5.1 Limitations

The results are based on a single session. This session was and most participants first encounter with the split keyboard. It would have been relevant to have followed the participants over several sessions spread out in time to see if learning effects would lead to changes that would put the split layout in a more favorable light in terms of text entry speed and preference.

6 Conclusion

A controlled experiment comparing a soft split keyboard to an ordinary soft keyboard on a tablet computer in landscape mode were performed. The results show that the ordinary soft keyboard yielded better results in terms of text entry rates, error rates and participants preference compared to the soft split keyboard. Future work should conduct longitudinal studies of soft split keyboard designs to see if its theoretical benefits are reaped via prolonged use.

References

1. Castellucci, S.J., MacKenzie, I.S.: Graffiti vs. unistrokes: an empirical comparison. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08), 305-308. ACM, New York, NY, USA (2008)
2. Wobbrock, J.O., Myers, B.A., Kembel, J.A.: EdgeWrite: a stylus-based text entry method designed for high accuracy and stability of motion. In: Proceedings of the 16th annual ACM symposium on User interface software and technology (UIST '03), 61-70. ACM, New York, NY, USA (2003)

3. Sandnes, F.E, Tan, T.B., Johansen, A., Sulic, E., Vesterhus, E., Iversen, E.R.: Making touch-based kiosks accessible to blind users through simple gestures. Universal Access in the Information Society 11 (4), 421-431 (2012)
4. Banovic, N., Yatani, K., Truong, K.N.: Escape-Keyboard: A Sight-Free One-Handed Text Entry Method for Mobile Touch-screen Devices. Int. J. Mob. Hum. Comput. Interact. 5 (3), 42-61 (2013)
5. Ward, D.J., Blackwell, A.F., MacKay, D.J.C.: Dasher—a data entry interface using continuous gestures and language models. In: Proceedings of the 13th annual ACM symposium on User interface software and technology (UIST '00), 129-137. ACM, New York, NY, USA (2000)
6. Goldberg, D., Richardson, C.: Touch-typing with a stylus. In: Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems (CHI '93), 80-87. ACM, New York, NY, USA (1993)
7. MacKenzie, I.S., Zhang, S.X.: The design and evaluation of a high-performance soft keyboard. In: Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI '99), 25-31. ACM, New York, NY, USA (1999)
8. Bi, X., Smith, B.A., Zhai. S.: Quasi-qwerty soft keyboard optimization. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10), 283-286. ACM, New York, NY, USA (2010)
9. Zhai, S., Smith, B.A.: Alphabetically biased virtual keyboards are easier to use: layout does matter. In: CHI '01 Extended Abstracts on Human Factors in Computing Systems (CHI EA '01), 321-322. ACM, New York, NY, USA (2001)
10. Matias, E., MacKenzie, I. S., Buxton, W.: Half-QWERTY: typing with one hand using your two-handed skills. In: Conference Companion on Human Factors in Computing Systems (CHI '94), Catherine Plaisant (Ed.), 51-52. ACM, New York, NY, USA (1994)
11. Sandnes, F.E., Aubert, A.: Bimanual text entry using game controllers: relying on users' spatial familiarity with QWERTY. Interacting with Computers 19 (2), 140-150 (2007)
12. Rempel, D.: The split keyboard: An ergonomics success story. Human Factors 50(3), 385-392 (2008)
13. Çaxir, A.: Acceptance of the adjustable keyboard. Ergonomics 38(9), 1728-1744 (1995)
14. Honan, M., Serina, E., Tal, R., Rempel, D.: Wrist postures while typing on a standard and split keyboard. In: Proceedings of the Human Factors and Ergonomics Society annual meeting (Vol. 39, No. 5, pp. 366-368). Sage CA: Los Angeles, CA: SAGE Publications (1995)
15. Smith, M.J., Karsh, B.T., Conway, F.T., Cohen, W.J., James, C.A., Morgan, J.J., Sanders, K., Zehel, D.J.: Effects of a split keyboard design and wrist rest on performance, posture, and comfort. Human Factors *40*(2), 324-336 (1998)
16. Rempel, D., Nathan-Roberts, D., Chen, B. Y., Odell, D.: The effects of split keyboard geometry on upper body postures. Ergonomics 52(1), 104-111 (2009)
17. Shi, W., Yu, C., Yi, X., Li, Z., Shi. Y.: TOAST: Ten-Finger Eyes-Free Typing on Touchable Surfaces. In: Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 2(1), Article 33. ACM, New York, NY, USA (2018)
18. Zhu, S., Luo, T., Bi, X., Zhai. S.: Typing on an Invisible Keyboard. In: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18), Paper 439. ACM, New York, NY, USA (2018)
19. Azenkot, S., Zhai, S.: Touch behavior with different postures on soft smartphone keyboards. In: Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services (MobileHCI '12), 251-260. ACM, New York, NY, USA (2012)

20. Trudeau, M.B., Catalano, P.J., Jindrich, D.L., Dennerlein, J.T.: Tablet keyboard configuration affects performance, discomfort and task difficulty for thumb typing in a two-handed grip. PloS one 8(6), e67525 (2013)
21. Lin, M.I.B., Hong, R.H., Chang, J.H., Ke, X.M.: Usage position and virtual keyboard design affect upper-body kinematics, discomfort, and usability during prolonged tablet typing. PloS one 10(12), e0143585 (2015)
22. Hong, J., Heo, S., Isokoski, P., Lee, G.: SplitBoard: A simple split soft keyboard for wristwatch-sized touch screens. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (pp. 1233-1236). ACM (2015)
23. MacKenzie, I.S., Soukoreff, R.W.: Phrase sets for evaluating text entry techniques. In: CHI '03 Extended Abstracts on Human Factors in Computing Systems (CHI EA '03). ACM, New York, NY, USA, 754-755 (2003)
24. JASP Team: JASP (Version 0.9)[Computer software] (2018)