Improving One-Handed Textual Entry on Mobile Devices

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With highly developed information technology, people have become accustomed to using virtual keyboards on mobile devices to type and text in various social and work situations. In many scenarios, people need to type with only one hand and use the other hand to do other things. Our research focuses on improving people's typing experience using mobile devices with only one hand. Nonetheless, one-handed interaction with mobile devices is influenced by multiple factors, including variations in keyboard functionality. Notably, mobile device keyboards still lack comprehensive support for one-handed typing, potentially leading to accidental touch, missed touch and other behaviors that can hinder typing efficiency. In this study, our goal is to better understand the user experience of typing with only one hand, and to explore ways to improve the effectiveness and efficiency of typing on mobile devices with one hand. In this first assignment, We employed a questionnaire-based survey and refined the questionnaire based on observations of pilot participants as they completed it. Subsequently, we distributed the enhanced questionnaire to a group of 27 individuals for completion and subsequently conducted a comprehensive analysis of the collected questionnaire data. Additionally, We also narrowed down our original focus into a feasible and specific problem by discussing the survey result. We believe our work not only aims to identify pain points of people using one-handed typing but also serves as a foundation for future contextual inquiry research.

CCS Concepts: • **Human-centered computing** → **Interaction techniques**.

Additional Key Words and Phrases: text entry, one-handed, typing, mobile phones, textual entry

1 INTRODUCTION

The history of one-handed typing is closely tied to the design of keyboard layouts. The QWERTY keyboard we are familiar with and the oldest was designed with one-handed typing in mind. In the QWERTY layout, more English words can be spelled using only the left hand than using only the right hand. Specifically, more than 3,000 English words can be typed with only the left hand, while only more than 300 words can be typed with only the right hand. The three most common letters in English, 'E', 'T', and 'A', can all be typed with the left hand. [2] While this is detrimental to right-handed people, it also lends credence to the effectiveness of one-handed typing. In 1936, Dvorak improved the QWERTY keyboard and created the Dvorak Keyboard (also called American Simplified Keyboard, or simply Simplified Keyboard), and Dvorak was specially designed for the efficiency of one-handed typing. [3] In 1960, Dvorak designed separate left- and right-handed Dvorak layouts for one-handed typing. The two keyboards are generally mirror images of each other, except for some differences in some uncommon keys, which are suitable for left-handed people and right-handed people. In the design, he tried to minimize the need to move the hand from side to side (lateral movement), as well as reduce the movement of the fingers. In the past twenty years, there has been new development in the keyboard for one-handed typing. Edgar Matias et al [6]invented the Mirrored Keyboard. The idea is to only use one hand (preferably the left one) and type the right-hand letters by holding a key which acts as a modifier key. The layout is mirrored, so the use of the muscle memory of the other hand is possible , which greatly reduces the amount of time needed to learn the layout, if the person previously used both hands to type. This represents people's continuous pursuit of the combination of ergonomics and typing efficiency.

After entering the 21st century, the rapid development of informatization and the increasingly popular electronic products have enabled people to use virtual keyboards on mobile devices in more scenarios than traditional physical keyboards.[8] As mobile devices are more integrated into people's life scenes, people can not only sit at a computer desk and type on a heavy keyboard, but can also conveniently type in coffee shops, classrooms, or on the bus. In different situations, people often free up the other hand to do other things and use only one hand to

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conveniently complete the typing action. This makes the demand for one-handed typing greatly increased in today's era. [7]

People's pursuit of one-handed typing efficiency piqued our interest and we set our promise as uncovering the challenges that arise with one-handed typing in order to enhance the user experience when typing with a single hand on mobile devices. After preliminary research, we discovered that besides the keyboard layout, other keyboard features like auto-complete and key sizes, as well as the device's operating system, can also affect how people experience one-handed typing. To gain deeper insights into users' experiences with one-handed operation, we meticulously devised a two-phase questionnaire approach. Initially, we crafted a survey and conducted a pilot study, enhancing the questionnaire based on feedback obtained from participants during this phase. Subsequently, we employed a snowballing distribution method to administer the refined questionnaire to a broader audience, amassing a total of 27 responses. For a comprehensive view of the questionnaire, please refer to Section 3 and the accompanying appendix.

2 RELATED WORK

One-handed textual entry on mobile phones has been studied extensively by HCI researchers. This area of study is driven by a wide variety of use cases, ranging from improving typing accessibility for those with disabilities to the increasing prevalence of texting while walking. We carry mobile phones around with us all the time, and as a result, interacting with it while on-the-go has become a daily routine [1]. According to a recent study in 2022, 26% of people always use a mobile phone while walking on the street, 43% sometimes do, 28% occasionally do, and only 3% do not [4]. While texting on-the-go, individuals must multi-task. They must not only maintain awareness of their surroundings but also be focused on interacting with the mobile device that is in motion. As a result, the combination of multitasking and interacting with a often shaken device, impairs the user's typing performance and accuracy significantly [1].
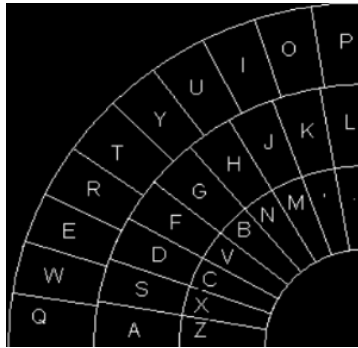

Fig. 1. CAK Keyboard Layout [9]

Past research has been done studying how different types of layouts can be used to optimize typing accuracy and speed for one-handed textual entry for mobile devices. Some of the existing one-handed keyboard layouts include curved keyboards as well as a user-adaptable standard QWERTY keyboard [9]. The CAK (Circularly Arced Keyboard), as shown in Figure 1, equally divides each key by 90 degrees into a quarter-circle layout [5]. It is intended to be operated with a single thumb and training time to become familiar with the CAK layout is minimal. The idea behind it is to allow the user's thumb to be able to reach every single key without having to reposition the phone. However, studies have shown that the improvement to speed and accuracy is not that significant on top of the added learning curve to being familiar with the layout [5].
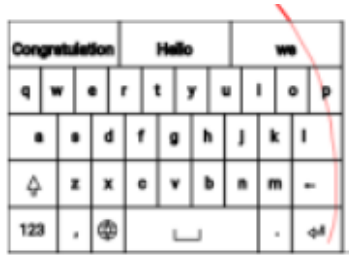
Fig. 2. User-adaptable keyboard [9]

The user-adaptable keyboard layout allows the user to resize the standard QWERTY layout to their desired size as well as shift it to the left or right side of the screen, depending on their typing hand. This layout has a much lower learning curve and is significantly better received by users [9].

There have also been existing studies and concepts that focus more on one-handed typing on physical keyboards instead of virtual keyboards on mobile devices. One of these existing technologies is the Half-QWERTY keyboard. The HALF-QWERTY keyboard has half the keys of a standard keyboard. To type the characters that are not present on the half keyboard, the user must press the spacebar and the mirror half of the keyboard will be mapped onto the keys. Studies show that there is an increased error rate as well as decreased speed [6].

Although there are already existing technologies and keyboard layouts to address the need of one-handed typing on mobile phones, most of these existing technologies have a steep learning curve and reduce the accuracy and speed of typing. In addition, most HCI research is focused on the English alphabet and does not look closely into other writing systems, such as Chinese or the Cyrillic alphabet. As a result, the effects of one-handed textual entry for the majority of the human population is severely understudied. Furthermore, there has been no research that we are aware of that studies the effects of switching keyboard languages on speed and accuracy. This is important as bilingualism among the general population is on the increase. Lastly, most HCI research is also focused on character entry and does not focus on entry of symbols such as #, %, or. Entries of these symbols typically require the user to switch to a symbol keyboard layout, which may not be standardized over all keyboards interfaces, as opposed to the standard QWERTY layout.

3 ESTABLISHING FOCUS: INITIAL SURVEY

The purpose of the survey was to determine whether one-handed text entry on a mobile device could be a valid focus and if so, further narrow it down by examining its potential difficulties and issues. Otherwise, we hoped to perhaps broaden or even shift the focus by including questions about other areas within text entry on a mobile device beyond just one-handed typing.

3.1 Method

After deciding the initial focus of the survey to be one-handed text entry on mobile devices, we defined the survey protocol and designed the questionnaire.

3.1.1 Define inclusion/exclusion criteria. The inclusion and exclusion criteria for participants was intentionally lenient, since this was only the initial stage of user-centered design and we aimed to understand the context of use for as many stakeholders as possible. Thus, we defined the protocol to include all participants over the age of 18 and have previously used a smartphone, and exclude those otherwise.

3.1.2 Design questions and question paths. The survey was created using Google Forms and initially consisted of the following six sections: (1) consent, (2) demographics, (3) whether the participant had previously typed on their phone with one hand, (4) one-handed mobile text entry questions, (5) general text entry questions, (6) end of survey. Section 1 first described the purpose of the study, guaranteed the participant's anonymity, and then asked one question to ensure the participant was over 18 and they have previously used a smartphone (meeting the inclusion/exclusion criteria). If the participant answered "no", the survey would immediately end; otherwise, the survey would proceed to the next section. Section 2 consisted of questions regarding participants' demographics information. This information was important as it would inform us about to which group of people we could generalize our results to, and about the certain human factors the participants may exhibit. Other than the general demographics such as age, gender, etc., we also asked questions about their smartphone usage, such as their brands. Questions like these allowed us to gain a better understanding of the features the OS may provide to the participants. Section 3 consisted of one question asking whether the participant had prior experience with typing on their phone with one hand. If so, they would proceed to section 4 (i.e., the survey proceeds as normal) which asked more questions specifically focusing on the context of use for one-handed text entry on smartphones and its potential difficulties; otherwise, they would skip section 4 and be redirected to section 5 which asked questions regarding the broader context of use for text entry on mobile devices beyond just typing with one hand. Section 6 contained a message thanking the participants for completing the survey. When creating the questions, we tried to avoid common pitfalls of survey design as much as possible. For example, to avoid forcing answers, every question either provided a "neutral" or "prefer not to answer" option, or did not require an answer (i.e. participant could choose not to answer the question and still proceed in the survey). The complete initial survey is located at Appendix B.1.

To ensure the quality of the survey before distributing to a large sample, a pilot test was conducted on the initial survey with a total of 9 participants (see Section 3.2.1 for specific tasks/procedures of the pilot study). We then addressed the issues discovered from the pilot study by collectively examining the entire survey question-by-question and after thorough discussion, making necessary changes to either the question, the options, and/or the order of questions to resolve each issue. For example, one common issue that was found in many questions and answer choices was using terminology that was unfamiliar to the participants. Thus, we rephrased the questions and answer options with layman's terms or use examples to show their meanings. Another issue was that some participants found the placement of demographics question at the beginning of the survey to be "weird", since after reading the purpose of the survey in section 1, they expected the questions to be about smartphone text entries, instead of their gender, race, etc. Thus, we moved the demographics section to be the last section of the survey to avoid any confusions. Furthermore, we addressed some newly-discovered pitfalls that we failed to take into account when designing the initial survey, such as leading questions and unbalanced answer option. We also removed some questions that were found to be repetitive or unrelated to the topic of text entry.

After addressing all the issues discovered from the pilot study, the final survey consisted of the following sections: (1) consent, (2) general smartphone usage questions, (3) one-handed mobile text entry questions, (4) general text entry questions, (5) demographics, (6) end of survey. All sections except section 2 corresponded to an existing section from the initial survey, with appropriate changes applied to them. The current section 2 consisted of the question for determining whether the participant had prior experience with one-handed typing on a smartphone (with the same section skip/redirection logic as before), and two more questions regarding smartphone usage patterns imported from other sections. Additionally, the current section 1 contained a more detailed description of the purpose of the survey, while section 6 contained an extra request to distribute the survey to more people (see Section 3.2.2 and 3.3 for more information). The complete final survey can be found in Appendix B.2.

3.1.3 Specify analysis methods. We planned to use exploratory data analysis (EDA) on the data we collect, since we mainly wanted to observe general patterns.

3.2 Tasks and Procedures

3.2.1 Pilot study. The pilot study was used to ensure the quality control of the survey. Each team member individually conducted the pilot study with 1 to 2 acquaintances (totalling 9 participants) either online or in-person. During the study, each participant was first informed that the purpose of this study was to gather data that could improve the quality of the survey, and no personal identifiable information would be recorded. We obtained the participant's consent via both verbal confirmation and selecting "yes" to the question in section 1 (consent) of the survey. They were then instructed to fill out the survey on any electronic device, while constantly narrating their thoughts and confusions out loud. Each participant's issues regarding the initial survey were recorded during the pilot session. On average, the study took approximately 10 minutes to complete. We thanked the participants after completion, and no monetary compensation was provided.

3.2.2 Final survey. After refinement of our questionnaire, we used a URL link generated by Google Forms to distribute the survey online (see Section 3.3 for sampling method). Upon clicking on the link, each person would be informed of the purpose of the survey and assured with the anonymity of their responses. Then, they would choose to either give their consent to participate and assert that they meet the inclusion/exclusion criteria by selecting "yes" to the very first question, or select "no" otherwise; the former would continue to fill out the rest of the survey (on any electronic device), whereas the latter would be exited out of the survey. We expected the final survey to take about 7 minutes to complete, taking the average time of the pilot studies and the total number of questions we had into consideration. After completion, each participant received a thank you message and a request to forward the survey to more individuals, a choice left to the discretion of the participant. After data collection period ended, we examined the responses to ensure that the data was completely anonymous and no personal identifiable information was recorded.

3.3 Participants

Age group	Number of participants
18-25	26
26-40	1
41-60	0
61-80	0
80+	0

Table 1. Age group of participants.
96.3% between ages 18-25, 3.7% between ages 26-40

A convenient sample was selected using a snowball method. Each team member sent out the final survey online as an URL link to all of their acquaintances who met the participants' inclusion criteria defined in the survey protocol (see Section 3.1.1). Those who received the survey were informed to complete it virtually at their convenience and then forward it to 2 or 3 acquaintances who may be potential stakeholders. No monetary incentives were given for the completion of the survey. Using the snowball method, we hoped to gather as many responses as possible. After three days of data collection, a total of 27 participants completed the survey (96.3% between ages 18-25; 77.8% Asian, 11.1% White and Asian, 11.1% other; 66.7% Man; 55.6% unemployed; 71.8% multilingual; 3.7% have a disability; see Table 1- 6 for complete demographics information).

Race and ethnicity	Number of participants
White	0
Latinx or Latin American	0
Black or African American	0
American Indian or Alaska Native	0
Asian	21
South Asian	1
Middle Eastern or North African	0
Native Hawaiian or Pacific Islander	0
Multiracial (specifically, White and Asian)	3
Prefer not to answer	2
Other	0

Table 2. Race and ethnicity of participants
77.8% Asian, 11.1% White and Asian, 3.7% South Asian, 7.4% prefer not to say

Gender identity	Number of participants
Woman	7
Man	18
Non-binary / Gender fluid	1
Indigenous or other cultural minority gender (e.g., two-spirit)	0
Prefer not to answer	1
Other	0

Table 3. Gender identity of participants
66.7% man, 25.9% woman, 3.7% non-binary/gender fluid, 3.7% prefer not to answer

Employment status	Number of participants
Employed full-time	9
Employed part-time	3
Self-employed	0
Unemployed (including student)	15
Retired	0
Other	0

Table 4. Employment status of participants
55.6% unemployed (including student), 33.3% employed full-time, 11.1% employed part-time

Number of languages proficient	Number of participants
1	6
2	15
3	6
4+	0

Table 5. Language proficiency of participants
55.6% proficient in 2 languages, 16.2% proficient in 1 language, 16.2% proficient in 3 languages

Disability status	Number of participants
Yes	1
No	24
I don't know	2
Prefer not to say	0

Table 6. Disability status of participants

88.9% do not have a disability, 7.4% do not know, 3.7% have a disability

3.4 Results

The survey data were exported from Google Form and the corresponding plots were made for each question (other than the demographics questions) using the Chart feature in Google Sheets. The questions and their results are listed in the order which they appeared in the survey. The results of the questions are analyzed either individually, written immediately after a figure, or in a group, written after a contiguous block of figures. See Appendix B.3 for the complete responses (anonymized and de-identified) from all participants.

3.4.1 General smartphone usage questions. (corresponding to survey's section 2)

Question 1: On average, how long do you use your smartphone per day?
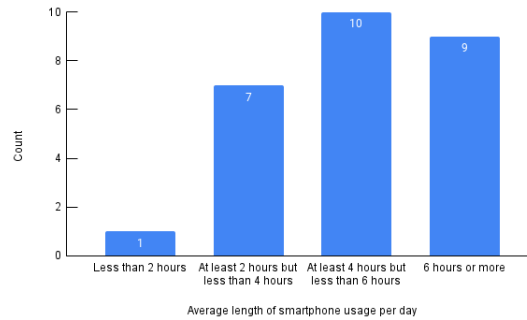

Fig. 3. Count of participants' average lengths of smartphone usage per day

Participants are roughly evenly distributed among using their smartphone for at least 2 hours but less than 4 hours (7 out of 27, 25.9%), at least 4 hours but less than 6 hours (10 out of 27, 37.0%), or 6 hours or more (9 out of 27, 33.3%) per day. Only 1 participant (3.7%) uses their phone for less than 2 hours per day.

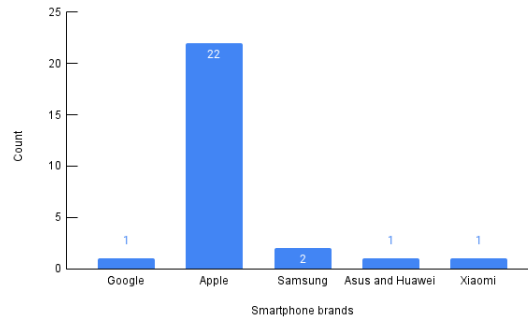Question 2: What brand is your smartphone?

Fig. 4. Count of participants' smartphone brands

An overwhelming majority of participants (22 out of 27, 81.5%) have Apple as their smartphone. The remaining participants were roughly evenly distributed among using Google, Samsung, Xiaomi, and Asus/Huawei as their smartphone. This implies that the majority of the participants would be using Apple's IOS operating system as well as its associated features and are subjected to IOS's user experience designs.

Question 3: Have you ever entered text (typed on the virtual keyboard) on your smartphone with one hand?
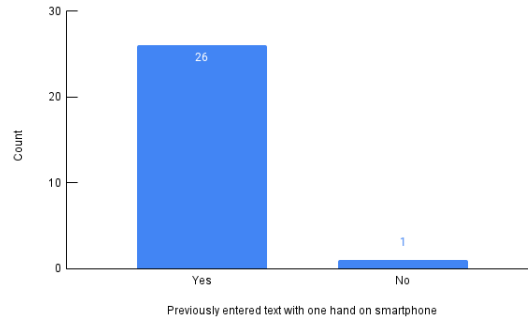

Fig. 5. Count of participants' average lengths of smartphone usage per day

Almost all participants (26 out of 27, 96.3%) have previously entered text with one hand on a smartphone. The one person who has never entered text with one hand skipped the next section of the survey, therefore questions 4 to 17 in the following section only has 26 responses.

3.4.2 One-handed mobile text entry questions. (corresponding to survey's section 3)

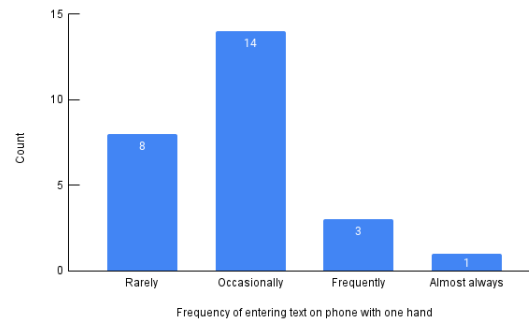Question 4: How often do you enter text on your phone with one hand?

Fig. 6. Count of different frequencies of one-handed text entry on a smartphone performed by participants

Out of the participants who have previously entered text on their smartphone with one hand, a majority of them (14 out of 26, 53.8%) occasionally do so, whereas some of them (8 out of 26, 30.8%) rarely do so. Though these adjectives are not too impactful, the results of this and the previous question still demonstrate the existence of one-handed text entry on smartphones as a valid interaction between the user and the technology.

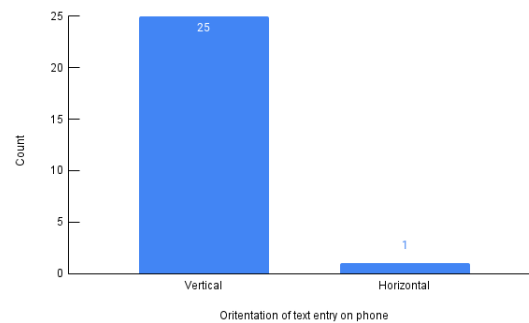Question 5: Do you usually enter text with your phone in a vertical or horizontal position?

Fig. 7. Count of different orientations of text entry on phone used by participants

Out of the participants who have previously entered text on their smartphone with one hand, almost all of them (25 out of 26, 96.2%) tend to enter text vertically.

Question 6: How comfortable are you with typing on your phone with one hand?
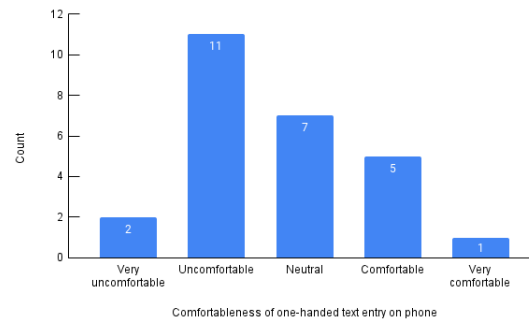

Fig. 8. Count of different levels of comfortableness experienced by participants when performing one-handed text entry

Question 7: What is the level of difficulty you find when entering text with one hand compared to entering text with both hands?
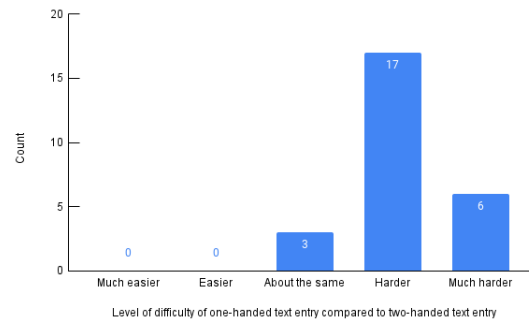

Fig. 9. Count of different levels of difficulty experienced by participants when entering text with one hand vs. two hands

Question 8: What is your typing speed when entering text with one hand compared to entering text with both hands?
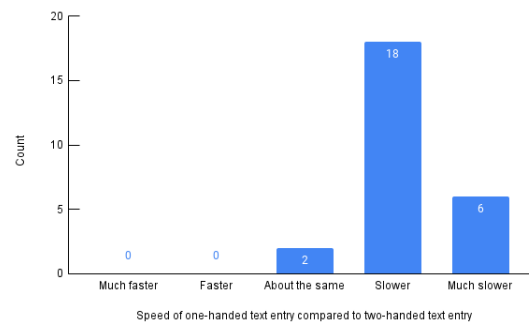

Fig. 10. Count of different typing speeds exhibited by participants when entering text with one hand vs. two hands

Questions 6, 7, and 8 attempt to measure the usability of existing smartphones' keyboards when performing one-handed text entry across three facets: comfortableness, difficulty, and efficiency. As shown in Figure 8, exactly half of participants (13 out of 26) find typing on their phone with one hand to be uncomfortable to very uncomfortable, while the other half of participants either have neutral opinions (7 out of 26, 26.9%) or find it to be comfortable to very comfortable (6 out of 26, 23.1%). Moreover, an overwhelming majority of participants find it harder (23 out of 26, 88.5%) and slower (24 out of 26, 92.3%) to enter text with one hand compared to entering text with both hands, as shown in Figure 9 and 10, respectively. None of the participants find it easier or faster to enter text with one hand compared to two hands. This indicates that there are flaws in the current smartphones' keyboards for one-handed text entries.

Question 9: How often do you make mistakes/typos when entering text with one hand compared to entering text with both hands?
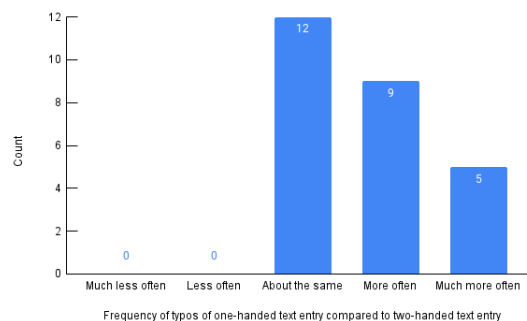

Fig. 11. Count of different frequencies of typos experienced by participants when entering text with one hand vs. two hands

Question 10: What is the level of difficulty you find when fixing mistakes/typos with one hand compared to fixing mistakes/typos with both hands?
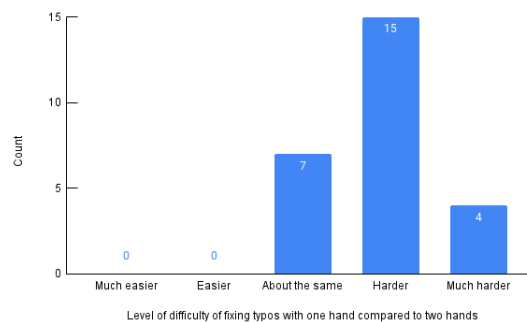

Fig. 12. Count of different levels of difficulty experienced by participants when fixing typos with one hand vs. two hands

Question 11: What is your opinion on the autocorrect feature of your phone's keyboard?
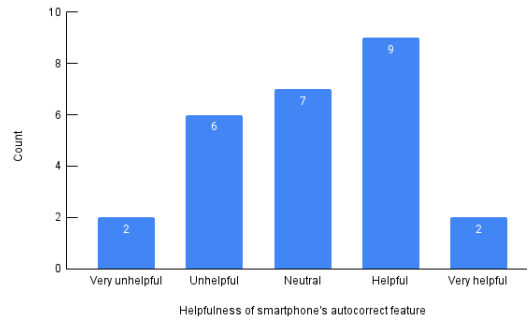

Fig. 13. Count of different opinions expressed by participants on the helpfulness of smartphone's autocorrect feature

Questions 9, 10 and 11 attempt to further explore the usability of the existing smartphone's keyboard for one-handed text entry, specifically regarding the ability to avoid and correct mistakes (typos). As shown in Figure 11, the majority of participants (14 out of 26, 53.8%) tend to make typos more often or much more often when entering text with one hand compared to with both hands, and the remaining participants (12 out of 26, 46.2%) make typos with one hand as often as with both hands. Similarly, the vast majority of participants (19 out 26, 73.1%) believe that it is more difficult to correct typos on their phone with one hand than with both hands, while the remaining (7 out of 26, 26.9%) believe that it is about the same level of difficulty, as shown in Figure 12. This indicates that the existing keyboard on a smartphone may be more error-prone and harder to correct mistakes when typing with one hand compared to with both hands.

Contrary to the prior two questions' data with uneven distributions that skew towards the right, regarding the helpfulness of the autocorrect feature, the opinions are roughly evenly split on both sides. As shown in Figure ??, 11 out of 26 participants (42.3%) think that autocorrect is either helpful or very helpful, 8 participants (30.8%) think it is unhelpful or very unhelpful, whereas the remaining 7 participants (26.9%) have neutral opinions about autocorrect. Though there are more participants with positive opinions on the autocorrect feature, it is difficult to conclude anything as this difference is marginal and the sample is quite small. Thus, it is safer to say that there appears to be mixed opinions on the autocorrect feature of a smartphone; additional questions and corresponding statistical analysis may be needed, for instance, to test which aspects of the autocorrect feature people think are helpful and which aspects are not.

Question 12: On a scale of 1 (easy to use) to 5 (hard to use), what is your opinion on your phone's keyboard layout when typing single-handed?
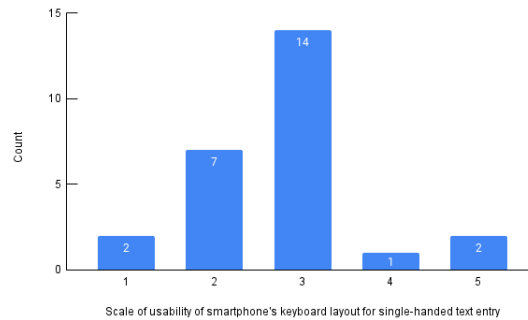

Fig. 14. Count of different levels of usability of keyboard layout experienced by participants when performing one-handed text entry

Question 13: What do you think of the size of the keys on your smartphone's (default) virtual keyboard?
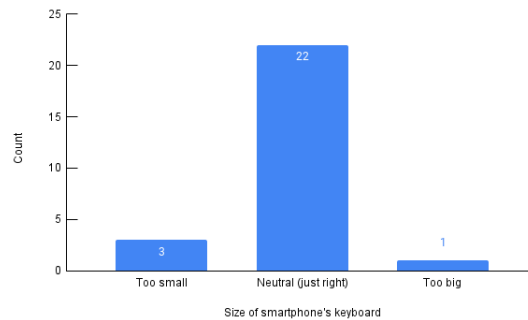

Fig. 15. Count of different opinions on the size of the keyboard expressed by participants

Questions 12 and 13 aim to test whether layout and size play a role in the usability of a smartphone's keyboard for one-handed text entry. Figure 14 shows that a majority of participants (14 out of 26, 53.8%) have neutral opinions about their current text entry keyboard layout, while the general view is that the data is somewhat skewed towards the 'easier' side, with 7 out of 26 (34.6%) participants believing the layout is easy or very easy to use. This indicates that most people are already satisfied with the existing layout of a smartphone's keyboard. Similarly, almost all participants (22 out of 26, 84.6%) think that the size of keys on their smartphone's keyboard is just about right as shown in Figure 15. Together, the data of these two questions imply that key size and general layout are likely not major factors that contribute to the difficulty of single-hand text entry on mobile devices. These results are in face of the finding that the participants make mistakes typing text more often one-handed, if not just as often as with both hands.

Question 14: What is the level of difficulty you find when switching between numbers and letters using one hand compared to that of two hands?
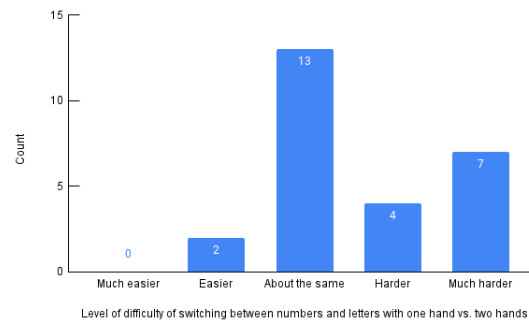

Fig. 16. Count of different levels of difficulty experienced by participants when switching between numbers and letters using one hand vs. two hands

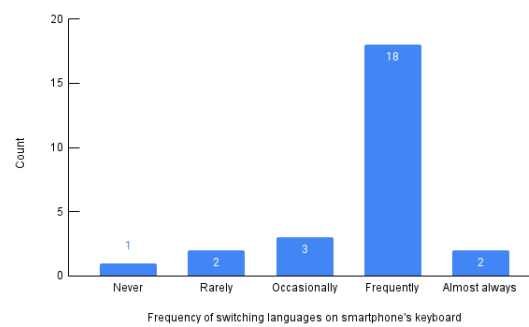Question 15: How often do you switch languages (including emojis) on your keyboard?

Fig. 17. Count of different frequencies of switching keyboard languages experienced by participants

Question 16: What is the level of difficulty you find when switching languages using one hand compared to that of two hands?
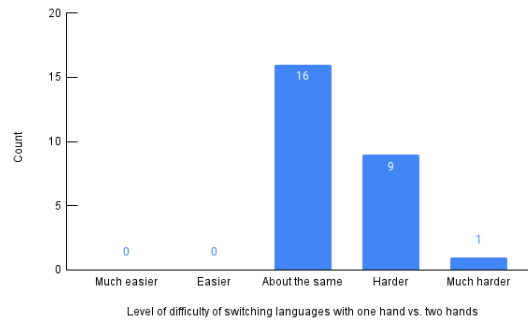

Fig. 18. Count of different levels of difficulty experienced participants when switching keyboard languages with one hand vs. two hands

Questions 14, 15, and 16 aim to test whether keyboard switching plays a role in the usability of a smartphone's keyboard for one-handed text entry. In Figure 16, 11 out of 26 participants (42.3%) think it is hard or much harder to input text when they need to switch between alphabetic and numeric keyboard with one hand. Although 13 participants (0.5%) have neutral opinions on this topic, compared to keyboard layout and key size, keyboard switching does invoke a relatively more negative feedback pertaining to text entry with one hand. A related finding is about switching between language keyboards. It is a similar operation to switching to the numeric keyboard. As is shown in Figure 17 and 18, a majority of participants switch between different languages frequently and think the difficulty to do so with one hand is about the same as with both hands. Yet from Figure 18, we can also observe that no participant thinks switching with one hand is easy; 10 out of 26 (38.5%) believe it is hard or very hard to perform such a task with just one hand. Together, the results of these 3 questions indicate that switching between numbers and letters, and switching languages could be contributing factors towards difficulty of single-hand text entry.

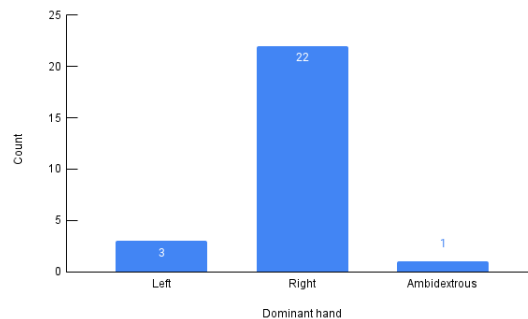Question 17: What is your dominant hand?

Fig. 19. Count of different dominant hands of participants

Of all 26 participants, 22 (84.6%) have their right hand as the dominant hand, only 3 (11.5%) participants' dominant hand is their left hand, and 1 (3.8%) participant is ambidextrous. An effective keyboard design for

single-handed text entry should take the user's dominant hand into consideration and should take the benefit of the doubt that the design for right-hand may not mirror exactly to the design for left-hand. Thus, it may be better to narrow the focus to text-entry with the right hand, and first design specifically for users whose dominant hand is the right hand. In future iterations on the design, designers may take accessibility into consideration and design for those whose dominant hand is not their right hand.

3.4.3 *General text entry questions.* (Corresponding to survey's section 4)

Question 18: How comfortable are you typing on your phone without looking at the keyboard?
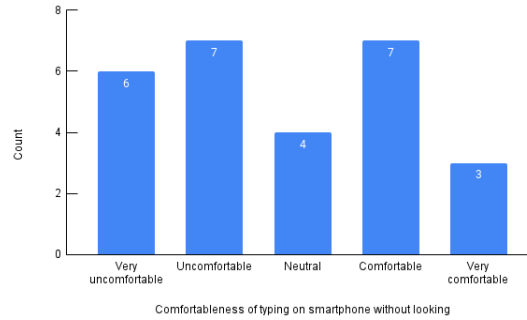
Fig. 20. Count of different level of comfortableness experienced by participants when typing on their phone's keyboard without looking

Figure 20 shows that participants varied a lot in their ability of touch typing (typing without looking at the keyboard), with 10 participants (37.0%) being comfortable or very comfortable, 13 (48.1%) being uncomfortable or very uncomfortable, and 4 (14.8%) having neutral opinions.

Question 19: What is your opinion on the autocomplete (predictive text) feature of your phone's keyboard?
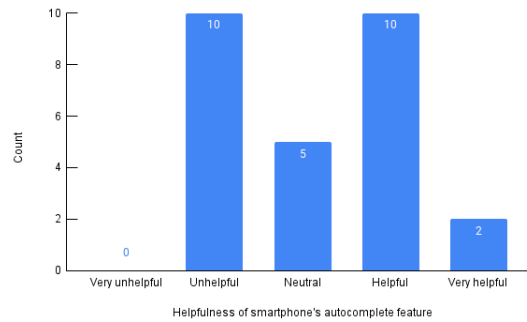
Fig. 21. Count of different opinions expressed by participants on the helpfulness of smartphone's autocomplete feature

In Figure 21, almost half of participants find the autocomplete feature to be at least helpful during textual input. However, the majority have neutral opinions at best, and find it unhelpful at worst.

Question 20: What is your opinion on customized shortcuts for typing? (e.g., type 'omw', turns into 'on my way')
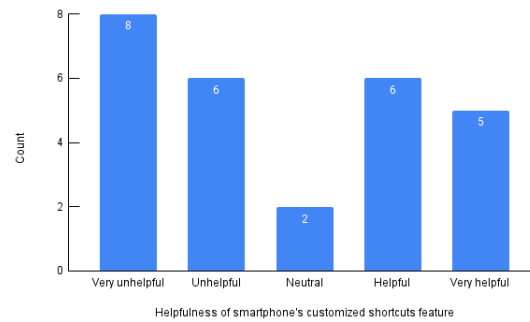
Fig. 22. Count of different opinions expressed by participants on the helpfulness of smartphone's customized keyboard shortcuts

Figure 22 shows that participants are opinionated and divisive about customized shortcuts.

Question 21: Have you ever tried other 3rd party keyboard apps on your phone?
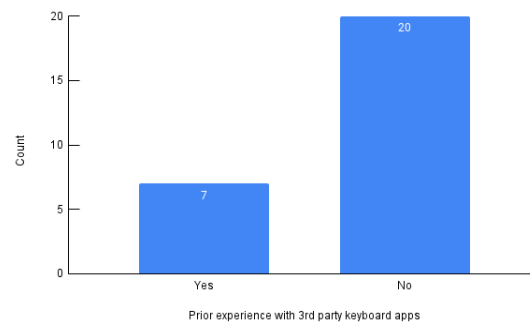
Fig. 23. Count of whether participants have used third-party keyboards

Figure 23 shows that a majority of participants have never used a third-party keyboard.

Question 22: What is the level of difficulty of entering text on a smartphone compared to that of a computer?
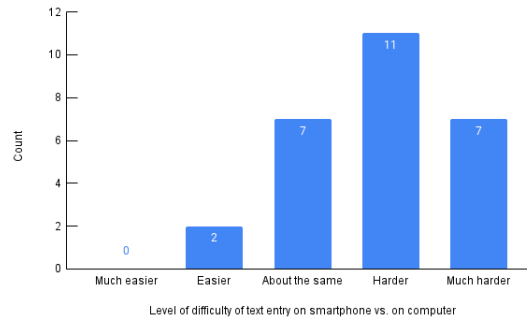
Fig. 24. Count of different levels of difficulty of text entry experienced by participants on a smartphone vs. on a computer

Figure 24 shows that the vast majority of participants (25) think that text entry on the phone is as hard or harder than that on computer, and only 2 participants think it is somewhat easier.

Question 23: What are some other text entry methods that you have tried/used on your smartphone? Select all that apply
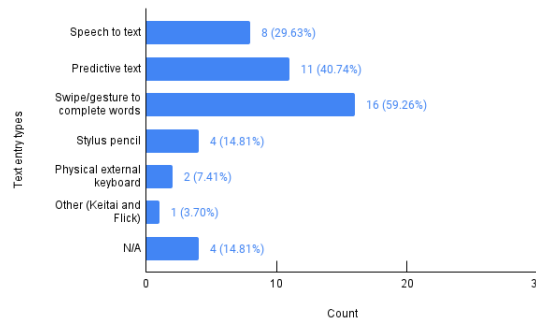
Fig. 25. Count of different text entry types used by participants

Figure 25 shows that alternative forms of text entries on mobile devices are still quite novel and unfamiliar to the participants, with swipe-input (gesture) having the most users (16 out of 27, 59.26%) in our study.

4 UNDERSTANDING CONTEXT OF USE: CONTEXTUAL INQUIRY

4.1 Method

What did the method entail?

4.2 Tasks and Procedures

How was consent for participation sought and administered? What did the task entail? Were participants given any prior instructions? What were they? How long did the task take on an average? How did you go about ensuring quality control of tasks?

4.3 Participants

Please provide demographic information of participants: number of participants, by age, by gender, by disability if relevant for the study, by experience with task, location, any other criteria for recruitment, how they were recruited, were they given any incentives, mode of study conducted (virtual or in-person). How did you decide on the number of participants for your study?

4.4 Results

Please provide detailed summary of findings. Consult your consolidated affinity diagram to help craft the story.

5 USER REQUIREMENTS AND FUNCTIONAL CONSTRAINTS

Provide a comprehensive list of objective, testable requirements that are not implying solutions. Make sure you ground your user requirements in the context of use.

6 INITIAL DESIGN AND LOW FIDELITY PROTOTYPES

6.1 Personas

6.2 Sketches

6.3 Storyboards

6.4 Paper Prototype

7 USABILITY EVALUATION

7.1 Heuristic Evaluation

7.1.1 Method. What did the method entail?

7.1.2 Tasks and Procedures. What did the task entail? Were participants given any prior instructions? What were they? How long did the task take on average? How did you go about ensuring quality control of tasks?

7.1.3 Participants. Please provide demographic information of participants: number of participants, by age, by gender, by disability if relevant for the study, by experience with task, location, any other criteria for recruitment, how they were recruited, were they given any incentives, mode of study conducted (virtual or in-person) How was consent for participation sought and administered? How did you decide on the number of participants for your study?

7.1.4 Results. Report the results of heuristic evaluation here.

7.2 Simplified User Testing

7.2.1 Method. What did the method entail?

7.2.2 Tasks and Procedures. What did the task entail? Were participants given any prior instructions? What were they? How long did the task take on average? How did you go about ensuring quality control of tasks?

7.2.3 Participants. Please provide demographic information of participants: number of participants, by age, by gender, by disability if relevant for the study, by experience with task, location, any other criteria for recruitment, how they were recruited, were they given any incentives, mode of study conducted (virtual or in-person) How was consent for participation sought and administered? How did you decide on the number of participants for your study?

7.2.4 Results. Report the results of simplified user testing here.

8 FINAL DESIGN AND FUNCTIONAL HIGH-FIDELITY PROTOTYPE

9 USER EVALUATION

Use the knowledge from the lectures and previous evaluations to populate this section and its subsections.

9.1 Method

9.2 Apparatus

9.3 Tasks and Procedures

9.4 Participants

9.5 Results

10 DISCUSSION

Before discussing the findings, it is important to note that we used a convenience sample for this survey, thus the results have low external validity. Consequently, all analysis and interpretations mentioned in Results and Discussion only apply to the specific sample of respondents of this survey. However, even without being able to generalize to a larger population, the results still do provide some initial insights into some existing issues with one-handed text entry on mobile devices.

Of the 27 participants who completed the survey, we found that one-handed text entry on smartphones is an existing interaction prevalent to users (as explained in Figure 5 and 6 in the Results section). Moreover, out of those who do type with one hand, users tend to find it less comfortable, harder, and slower to type with one hand compared to typing with both hands (as shown in Figure 8-10), implying that there are flaws in the current smartphone's keyboard for the interaction of one-handed text entry. This supports our original focus on one-handed text entry on mobile devices.

In attempting to narrow down the focus by examining specific areas for improvement on the existing smartphone keyboard, we found that users tend to make more typos and have a harder time to correct them when typing with one hand compared to with both hands (as shown in Figure 11 and 12). We also found that users find it more difficult to switch between letters and numbers, and also to switch the language of the keyboard with one hand than with both hands (as shown in Figure 16-18). These findings allow us to narrow the focus from "improving text entry on mobile devices with one hand", to "improving the ability to fix typos, switch between numbers and letters, and switch languages on a smartphone keyboard with one hand".

Furthermore, since the majority of participants use iPhone (Figure 4) and are right-handed (Figure 19), we decided to further narrow the focus to regarding just using the iPhone keyboard with the right hand. This may be beneficial to later stages in the UCD process since the iPhone has a uniform keyboard across all iPhone devices, unlike Android which has a wider variety of keyboards, thus limiting the potential confounding factors. Moreover, specifying the focus to be just the right hand also helps since the usability of a one-handed keyboard likely depends on the hand which the user uses to interact.

Thus, from the survey results, we successfully showed the validity of our focus and narrowed it down to "improving the iPhone keyboard to better support right-hand-only interaction, specifically on fixing typos, switching between letters/numbers, and switching languages."

11 CONCLUSION

Through this survey, we obtained valuable initial insights into one-handed text messaging on mobile devices, shedding light on important issues with this form of input. Among the 27 participants, we observed that one-handed typing is a common method on smartphones. However, users generally find typing with one hand less

comfortable, more challenging, and slower compared to using both hands, suggesting that current smartphone keyboards may have limitations in supporting one-handed input. This also reflects that our research focus on using one-handed input on mobile devices has practical value.

As we explored specific areas for improvement, we found that users were more likely to make typographical errors and had greater difficulty correcting them when typing with one hand. Additionally, they faced challenges in seamlessly switching between letters and numbers and changing the keyboard's language while using one hand. These findings led us to further narrow our research focus, honing in on "improving the ability to fix typos, switch between numbers and letters, and switch languages on a smartphone keyboard with one hand".

These discoveries continue to serve as a valuable reference and source of influence for future research efforts. Notably, the outcomes of this preliminary survey set the stage for subsequent contextual inquiries aimed at gaining a deeper understanding of the intricate relationship between one-handed input and the overall user experience on mobile devices. We eagerly anticipate future researchers leveraging these findings to better comprehend and cater to the needs and preferences of mobile device users, ultimately contributing to advancements in mobile keyboard design and user experience.

ACKNOWLEDGMENTS

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A   RESPONSIBLE RESEARCH: HUMAN SUBJECTS RESEARCH PROTECTIONS

(a) Sang Hyun S's PEERRS Certificate

(b) Isaac T's PEERRS Certificate

(c) Yichen Z's PEERRS Certificate

(d) Franklin K's PEERRS Certificate

(e) Zi Rui Z's PEERRS Certificate

B   SURVEY AND QUESTIONNAIRE INSTRUMENTS

B.1   Initial Questionnaire Design

How do you text on your phone?

How do you text on your phone?

You are invited to participate in a survey about how do people enter text on their phone. The survey should take about 5 minutes.

Your participation is voluntary and there are no risks
involved. Your responses will be completely anonymous. We will not be
able to link your responses to you and at no point will you be asked
for any identifying or contact information.

Thank you.

1. You must be **at least 18** years old and **use a smartphone** in order to participate in   *
   the survey. By clicking on I agree, you are confirming your agreement with these
   conditions and you are consenting to participate in this survey.

   Mark only one oval.

   ◯ I agree

   ◯ I do not agree   *Skip to section 6 (End of Survey)*

Demographics

2. What is your age?

Mark only one oval.

- ◯ 18-25
- ◯ 26-40
- ◯ 41-60
- ◯ 61-80
- ◯ 80+

3. What is your employment status?

Mark only one oval.

- ◯ Employed full-time
- ◯ Employed part-time
- ◯ Self-employed
- ◯ Unemployed
- ◯ Retired
- ◯ Student
- ◯ Other: _____

4. How many languages are you proficient in?

Mark only one oval.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4+

5. Do you have a disability?

   Mark only one oval.

   ( ) Yes

   ( ) No

   ( ) I don't know

   ( ) I prefer not to answer

6. How often do you use a smartphone?

   Mark only one oval.

   ( ) Several times an hour

   ( ) Several times a day

   ( ) Once a day

   ( ) Several times a week

   ( ) Rarely

Mobile Text Entry with One Hand

7. Have you ever entered text (typed on the virtual keyboard) on your smartphone *
   with one hand?

   Mark only one oval.

   ( ) Yes

   ( ) No   *Skip to question 24*

Mobile Text Entry with One Hand Continued

8. How often do you find yourself needing to enter text on your phone with one hand?

   Mark only one oval.

   ◯ Several times an hour

   ◯ Several times a day

   ◯ Once a day

   ◯ Several times a week

   ◯ Rarely

9. In what situations do you find yourself entering text on your phone with one hand? Select all that apply.

   Check all that apply.

   ☐ On transportation
   ☐ Walking
   ☐ Eating

   ☐ Other: _____

10. How comfortable are you with holding your phone with one hand?

Very Uncomfortable

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Very Comfortable

11. Do you usually enter text with your phone in a vertical or horizontal position?

Mark only one oval.

⬭ Vertical

⬭ Horizontal

12. What is the level of difficulty you find when entering text with one hand compared to entering text with both hands?

Mark only one oval.

Much Easier

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Much Harder

13. What is your typing speed when entering text with one hand compared to entering text with both hands?

Mark only one oval.

Much Faster

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Much Slower

14. How often do you make mistakes when entering text with one hand compared to entering text with both hands?

Mark only one oval.

Much Less Often

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much More Often

15. What is the level of difficulty you find when fixing mistakes/typos with one hand compared to fixing mistakes/typos with both hands?

Mark only one oval.

Much Easier

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Much Harder

16. What is your opinion on the autocorrect feature of your phone's keyboard?

Mark only one oval.

◯ Very helpful

◯ Helpful

◯ Neither helpful nor not helpful

◯ Not helpful

◯ Very not helpful

17. What is your opinion on the usability of your phone's 'qwerty' keyboard when typing single-handed?

Mark only one oval.

- ⚪ Very usable
- ⚪ Usable
- ⚪ Neither usable nor not usable
- ⚪ Not usable
- ⚪ Very not usable

18. What do you think of the size of the keys on your smartphone's virtual keyboard?

Mark only one oval.

- ⚪ Too big
- ⚪ Too small
- ⚪ Neutral (just right)

19. How often do you find yourself switching between numbers and letters?

Mark only one oval.

- ⚪ Almost always
- ⚪ Frequently
- ⚪ Occasionally
- ⚪ Rarely
- ⚪ Never

20. What is the level of difficulty you find when switching between numbers and letters using one hand compared to that of two hands?

Mark only one oval.

Much Easier

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Much Harder

21. How often do you switch languages on your keyboard?

Mark only one oval.

◯ Almost always

◯ Frequently

◯ Occasionally

◯ Rarely

◯ Never

22. What is the level of difficulty you find when switching languages using one hand compared to that of two hands?

Mark only one oval.

Much Easier

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much Harder

23. What is your dominant hand?

Mark only one oval.

⬭ Left

⬭ Right

⬭ Ambidextrous

Other Mobile Text Entries

24. How comfortable are you typing on your phone without looking at the keyboard?

Mark only one oval.

Very Uncomfortable

1 ○

2 ○

3 ○

4 ○

5 ○

Very Comfortable

25. How often do you use autocomplete (predictive text) when typing?

Mark only one oval.

○ Almost always

○ Frequently

○ Occasionally

○ Rarely

○ Never

26. What is your opinion on the autocomplete feature of your phone's keyboard?

Mark only one oval.

○ Very Helpful

○ Helpful

○ Neither helpful nor not helpful

○ Not helpful

○ Very not helpful

○ N/A

27. How often do you use customized shortcuts in your smartphone to increase typing efficiency?

Mark only one oval.

○ Almost always

○ Frequently

○ Occasionally

○ Rarely

○ Never

○ N/A

28. How often do you use customized gestures to increase your typing efficiency?

Mark only one oval.

○ Almost always

○ Frequently

○ Occasionally

○ Rarely

○ Never

29. Have you ever tried other 3rd party keyboard apps to improve typing experience?

Mark only one oval.

○ Yes

○ No

30. What is the level of difficulty of entering text on a smartphone compared to that of a computer?

Mark only one oval.

Much Easier

1 ○

2 ○

3 ○

4 ○

5 ○

Much Harder

31. What are some other text entry methods that you have tried/used on your smartphone? Select all that apply.

Check all that apply.

☐ Speech to text
☐ Predictive text
☐ Swipe/gesture to complete words
☐ Stylus pencil
☐ Physical external keyboard
☐ Other: _____

End of Survey

Thank you for completing the survey!

B.2   Final Questionnaire Design

How do you text on your phone?

How do you text on your phone?
You are invited to participate in a survey about how do people enter text on their phone. This survey will be used to gain a better understanding of the difficulties of texting with one hand. The survey should take about 7 minutes.

Your participation is voluntary and there are no risks involved. Your responses will be completely anonymous. We will not be able to link your response to you and at no point will you be asked for any identifying or contact information.

Thank you.

1. You must be **at least 18** years old and **have used a smartphone before** in order   *
   to participate in the survey. By clicking on I agree, you are confirming your agreement with these conditions and you are consenting to participate in this survey.

   Mark only one oval.

   ◯ I agree

   ◯ I do not agree   *Skip to section 6 (End of Survey)*

General

2. On average, how long do you use your smartphone per day?

   Mark only one oval.

   ◯ Less than 2 hours

   ◯ At least 2 hours but less than 4 hours

   ◯ At least 4 hours but less than 6 hours

   ◯ 6 hours or more

3. What brand is your smartphone?

Mark only one oval.

- ( ) Apple
- ( ) Google
- ( ) Leveno
- ( ) Motorola
- ( ) Samsung
- ( ) Xiaomi
- ( ) Other: _____

4. Have you ever entered text (typed on the virtual keyboard) on your smartphone with one hand?   *

Mark only one oval.

- ( ) Yes
- ( ) No   *Skip to question 19*

Mobile Text Entry with One Hand

5. How often do you enter text on your phone with one hand?

Mark only one oval.

- ( ) Almost always
- ( ) Frequently
- ( ) Occasionally
- ( ) Rarely

6. How comfortable are you with typing on your phone with one hand?

Mark only one oval.

Very Uncomfortable

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Very Comfortable

7. Do you usually enter text with your phone in a vertical or horizontal position?

Mark only one oval.

◯ Vertical

◯ Horizontal

8. What is the level of difficulty you find when entering text with one hand compared to entering text with both hands?

Much Easier

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much Harder

9. What is your typing speed when entering text with one hand compared to entering text with both hands?

Mark only one oval.

Much Faster

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Much Slower

10. How often do you make mistakes when entering text with one hand compared to entering text with both hands?

Mark only one oval.

Much Less Often

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much More Often

11. What is the level of difficulty you find when fixing mistakes/typos with one hand compared to fixing mistakes/typos with both hands?

Much Easier

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much Harder

12. What is your opinion on the autocorrect feature of your phone's keyboard?

Mark only one oval.

Very Unhelpful

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Very Helpful

13. What is your opinion on your phone's keyboard layout when typing single-handed?

Mark only one oval.

Hard to use

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Easy to use

14. What do you think of the size of the keys on your smartphone's (default) virtual keyboard?

Mark only one oval.

⬭ Too big

⬭ Too small

⬭ Neutral (just right)

15. What is the level of difficulty you find when switching between numbers and letters using one hand compared to that of two hands?

Mark only one oval.

Much Easier

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much Harder

16. How often do you switch languages (including emojis) on your keyboard?

Mark only one oval.

◯ Almost always

◯ Frequently

◯ Occasionally

◯ Rarely

◯ Never

17. What is the level of difficulty you find when switching languages using one hand compared to that of two hands?

Mark only one oval.

Much Easier

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Much Harder

18. What is your dominant hand?

Mark only one oval.

◯ Left

◯ Right

◯ Ambidextrous

Other Mobile Text Entries

19. How comfortable are you typing on your phone without looking at the keyboard?

Mark only one oval.

Very Uncomfortable

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Very Comfortable

20. What is your opinion on the autocomplete (predictive text) feature of your phone's keyboard?

Mark only one oval.

Very Unhelpful

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Very Helpful

21. What is your opinion on customized shortcuts for typing? (e.g., type 'omw', turns into 'on my way')

Very Unhelpful

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Very Helpful

22. Have you ever tried other 3rd party keyboard apps on your phone?

◯ Yes

◯ No

23. What is the level of difficulty of entering text on a smartphone compared to that of a computer?

Mark only one oval.

Much Easier

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Much Harder

24. What are some other text entry methods that you have tried/used on your smartphone? Select all that apply.

Check all that apply.

☐ Speech to text
☐ Predictive text
☐ Swipe/gesture to complete words
☐ Stylus pencil
☐ Physical external keyboard
☐ Other: _____

Demographics

25. What is your age?

Mark only one oval.

- ◯ 18-25
- ◯ 26-40
- ◯ 41-60
- ◯ 61-80
- ◯ 80+

26. What is your race/ethnicity? Please select all that apply

Check all that apply.

- ☐ White
- ☐ Latinx or Latin American
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ South Asian
- ☐ Middle Eastern or North African
- ☐ Native Hawaiian or Pacific Islander
- ☐ Prefer not to answer
- ☐ Other: _____

27. What is your gender identity?

Mark only one oval.

- ◯ Man
- ◯ Woman
- ◯ Non-binary / Gender fluid
- ◯ Indigenous or other cultural minority gender (e.g., two-spirit)
- ◯ Prefer not answer
- ◯ Other: _____

28. What is your employment status?

Mark only one oval.

- Employed full-time
- Employed part-time
- Self-employed
- Unemployed
- Retired
- Other: _____

29. How many languages are you proficient in (reading/writing)?

Mark only one oval.

- 1
- 2
- 3
- 4+

30. Do you have a disability?

Mark only one oval.

- Yes
- No
- I don't know
- Prefer not to answer

End of Survey

Thank you very much for completing the survey!

If possible, would you please forward this survey to people you know who are over 18 and have used a smartphone? Thank you!

Google Forms

B.3   Anonymized and De-identified Questionnaire Data

Timestamp	You must be *at least 18* y	On average, how long do	What brand is your smart
9/21/2023 21:05:50	I agree	At least 2 hours but less t	Google
9/21/2023 21:13:47	I agree	6 hours or more	Apple
9/21/2023 21:34:28	I agree	6 hours or more	Apple
9/21/2023 21:47:28	I agree	6 hours or more	Apple
9/21/2023 21:50:32	I agree	6 hours or more	Apple
9/21/2023 21:59:08	I agree	6 hours or more	Apple
9/21/2023 22:23:04	I agree	At least 4 hours but less t	Apple
9/21/2023 22:33:48	I agree	At least 2 hours but less t	Samsung
9/21/2023 23:02:12	I agree	6 hours or more	Apple
9/22/2023 5:08:09	I agree	At least 2 hours but less t	Asus, Huawei
9/22/2023 10:08:02	I agree	At least 4 hours but less t	Apple
9/22/2023 10:16:26	I agree	At least 4 hours but less t	Apple
9/22/2023 15:49:47	I agree	6 hours or more	Apple
9/22/2023 17:31:01	I agree	At least 4 hours but less t	Apple
9/22/2023 20:17:18	I agree	Less than 2 hours	Apple
9/22/2023 20:41:03	I agree	At least 2 hours but less t	Apple
9/22/2023 20:56:49	I agree	At least 4 hours but less t	Apple
9/22/2023 21:12:25	I agree	At least 4 hours but less t	Apple
9/23/2023 0:18:10	I agree	At least 4 hours but less t	Samsung
9/23/2023 14:27:11	I agree	6 hours or more	Apple
9/23/2023 16:35:59	I agree	At least 4 hours but less t	Apple
9/23/2023 23:11:08	I agree	At least 2 hours but less t	Apple
9/23/2023 23:22:58	I agree	At least 2 hours but less t	Apple
9/23/2023 23:52:13	I agree	At least 4 hours but less t	Apple
9/23/2023 23:59:24	I agree	At least 2 hours but less t	Apple
9/24/2023 10:56:31	I agree	At least 4 hours but less t	Apple
9/24/2023 15:12:36	I agree	6 hours or more	Xiaomi

Have you ever entered te	How often do you enter te	How comfortable are you	Do you usually enter text
Yes	Occasionally	3	Vertical
Yes	Frequently	5	Vertical
Yes	Rarely	2	Vertical
Yes	Occasionally	2	Vertical
Yes	Occasionally	1	Vertical
Yes	Occasionally	2	Vertical
Yes	Occasionally	2	Vertical
Yes	Rarely	2	Vertical
Yes	Occasionally	3	Vertical
Yes	Frequently	2	Vertical
Yes	Occasionally	2	Vertical
Yes	Rarely	2	Vertical
Yes	Rarely	1	Vertical
No			
Yes	Occasionally	3	Vertical
Yes	Occasionally	3	Vertical
Yes	Almost always	3	Vertical
Yes	Frequently	4	Vertical
Yes	Occasionally	2	Vertical
Yes	Occasionally	4	Vertical
Yes	Rarely	4	Vertical
Yes	Occasionally	3	Vertical
Yes	Occasionally	4	Vertical
Yes	Rarely	4	Vertical
Yes	Rarely	2	Vertical
Yes	Rarely	2	Horizontal
Yes	Occasionally	3	Vertical

What is the level of difficu	What is your typing speed	How often do you make m	What is the level of difficu
4	4	3	4
3	4	4	5
4	4	3	3
4	4	4	4
4	5	5	3
4	3	5	4
5	4	4	3
4	4	4	4
5	4	3	4
5	5	5	5
4	4	3	4
5	4	3	5
5	5	3	3
4	4	3	3
4	5	3	4
5	5	4	4
4	4	4	5
4	5	4	3
4	4	3	4
4	4	4	4
3	4	4	4
4	4	5	4
3	4	3	4
4	4	3	4
4	3	3	4
4	4	5	3

What is your opinion on th	What is your opinion on y	What do you think of the s	What is the level of difficu
4	5	Neutral (just right)	4
2	3	Neutral (just right)	4
3	3	Neutral (just right)	5
2	2	Too big	5
4	3	Too small	3
3	2	Neutral (just right)	2
4	2	Neutral (just right)	4
3	3	Neutral (just right)	5
3	1	Too small	3
2	1	Neutral (just right)	3
4	3	Neutral (just right)	5
5	3	Neutral (just right)	3
4	2	Neutral (just right)	3
2	3	Neutral (just right)	3
2	4	Neutral (just right)	5
4	3	Neutral (just right)	3
4	3	Neutral (just right)	5
4	3	Neutral (just right)	3
3	3	Neutral (just right)	3
2	2	Too small	3
4	3	Neutral (just right)	3
1	3	Neutral (just right)	2
1	3	Neutral (just right)	3
3	5	Neutral (just right)	5
3	2	Neutral (just right)	3
5	2	Neutral (just right)	4

How often do you switch l	What is the level of difficu	What is your dominant ha	How comfortable are you
Frequently	3	Right	4
Occasionally	4	Right	5
Frequently	4	Right	1
Frequently	4	Right	2
Frequently	3	Left	1
Frequently	3	Right	1
Frequently	4	Right	5
Frequently	4	Right	2
Frequently	4	Right	2
Almost always	3	Right	1
Frequently	4	Right	4
Frequently	3	Right	2
Frequently	4	Right	4
			2
Rarely	3	Right	3
Frequently	5	Right	3
Occasionally	3	Left	4
Never	3	Right	5
Frequently	3	Right	4
Frequently	3	Ambidextrous	3
Occasionally	3	Left	1
Frequently	3	Right	2
Rarely	3	Right	2
Frequently	3	Right	4
Frequently	3	Right	3
Almost always	3	Right	4
Frequently	4	Right	1

What is your opinion on th	What is your opinion on c	Have you ever tried other	What is the level of difficu
4	4	Yes	3
2	1	No	3
3	3	No	3
2	4	No	5
2	1	No	5
2	2	Yes	5
4	2	No	4
2	5	Yes	5
2	1	No	3
3	5	Yes	4
4	1	No	4
3	1	No	2
4	4	No	4
3	2	Yes	4
2	4	No	4
2	1	No	5
4	1	No	2
5	2	No	3
4	5	No	4
4	2	No	3
2	3	Yes	5
4	4	No	4
3	2	No	4
4	4	No	3
2	5	No	4
4	5	No	5
5	1	Yes	4

What are some other text	What is your age?	What is your race/ethnicity	What is your gender ident
Predictive text, Swipe/ges	18-25	South Asian	Man
Speech to text, Predictive	18-25	White, Asian	Man
Swipe/gesture to complet	18-25	Asian	Man
Predictive text	18-25	Asian	Man
Speech to text	18-25	Asian	Man
Predictive text	18-25	Asian	Woman
	18-25	White, Asian	Man
Swipe/gesture to complet	18-25	Asian	Non-binary / Gender fluid
Swipe/gesture to complet	18-25		Man
Speech to text, Swipe/ges	26-40	Asian	Man
Swipe/gesture to complet	18-25	Asian	Woman
Speech to text, Predictive	18-25	Asian	Woman
Speech to text, Predictive	18-25	Asian	Woman
Swipe/gesture to complet	18-25	Asian	Man
Speech to text, Predictive	18-25	Asian	Man
Predictive text, Swipe/ges	18-25	Asian	Man
Speech to text, Predictive	18-25	Asian	Man
Swipe/gesture to complet	18-25	Asian	Man
	18-25	Asian	Man
Predictive text, Swipe/ges	18-25	Asian	Woman
Swipe/gesture to complet	18-25	Asian	Man
N/A	18-25	Asian	Man
	18-25	Asian	Man
Predictive text, Stylus per	18-25	White, Asian	Man
Speech to text, Swipe/ges	18-25	Asian	Woman
Swipe/gesture to complet	18-25	Asian	Woman
Swipe/gesture to complet	18-25	Prefer not to answer	Prefer not answer

What is your employment	How many languages are	Do you have a disability?	
Unemployed	2	No	
Unemployed	1	No	
Employed full-time	2	No	
Unemployed	2	No	
Unemployed	2	No	
Unemployed	3	I don't know	
Student	2	No	
Unemployed	3	Yes	
Student	1	No	
student	3	I don't know	
Unemployed	3	No	
Unemployed	3	No	
Employed part-time	2	No	
Student	2	No	
Employed full-time	1	No	
Student	2	No	
Employed full-time	1	No	
Employed full-time	1	No	
Employed part-time	3	No	
Unemployed	2	No	
Employed full-time	1	No	
Unemployed	2	No	
Employed part-time	2	No	
Employed full-time	2	No	
Employed full-time	2	No	
Employed full-time	2	No	
Employed full-time	2	No	