CSC 428 / CSC 2514h – Human-Computer Interaction

Assignment 2: Controlled Experiment

Smartwatch Keyboard

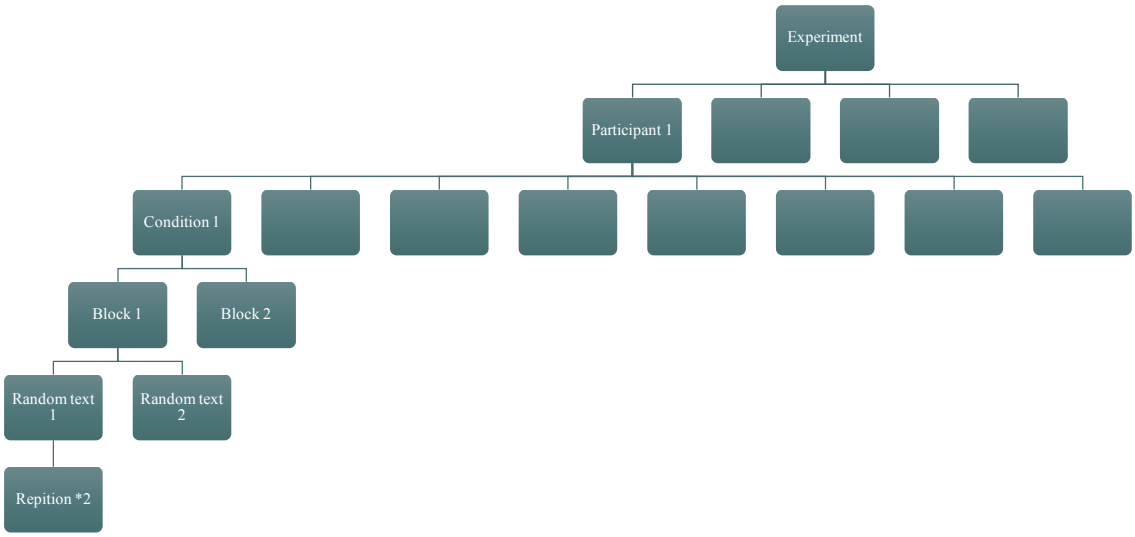
Yufeng Li

Introduction/Motivation

Smartwatches have become a trend and both Google and Apple are designing OS for them. As an OS, it's very common to process inputs from all required sources, one of them is text inputs. Though it's a uncommon need to type on a smartwatch, I devise 2 different text entry techniques to the operating system. The miniature keyboard is a traditional keyboard where users enter numbers by tapping on the keys of a miniature keyboard. The zooming keyboard is a new keyboard design where users can first tap to zoom into a section of the keyboard, and then tap on the desired character. I will conduct experiments with 4 different participants and analyze the data being gatthered to conclude which is a better technique to input text on a smartwatch.

Methodology

The task for every participant is to finish trials I prepared for the experiment. I will set up the keyboard on a phone with touch screen. If the participant need help to place the phone on his/hers wrist, I will help to do so. The process of gathering data is automated, I, the investigator, will only focus on conduct the experiment and change conditions. The experiment will be within-subjects which means every participant will face all conditions. My choices of independent variables are **text input types** and **movement status**. They each have 2 different possible values which are alphabetical text(less than 5 words) or numeric&symbolic text(15 characters since they are hard to distinguish on smartwatch), and in a moving status or in a still status respectively. The reason why I choose them is because ①Alphabetical characters looks very different from others while symbolic&numeric characters are not. This stronger contrast can make users better distinguish characters on a small screen. ②Since it's a watch, there will be scenarios where people need to type when they are not standing still or sitting. Moving screens can be very blurry for users to see. By adding 2 different keyboards, I have 8 different conditions. Since I have only 4 participants, I will use randomization to present conditions to them since there are far more conditions than participants. I will use the following structure to present trails:



Hypothesis

- There is no difference in mean time to complete typing using normal miniature keyboard vs. zooming keyboard.
- There is no difference in mean accuracy to complete typing using normal miniature keyboard vs. zooming keyboard.

Results and Analysis

I. Hypothesis 1

Mean of total completion time

Miniature	14.65487
Zooming	24.89655
Alphabetic	21.89623
Symbolic	15.96809
Still	19.33028
Moving	18.84615
Overall	19.11

Figure 1

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
KeyboardType	1	5156	5156	55.322	3.13e-12	***
Movement	1	0	0	0.001	0.971	
KeyboardType:Movement	1	45	45	0.478	0.490	

Figure 2: ANOVA of KeyboardType & Movement

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
KeyboardType	1	5156	5156	68.16	2.19e-14	***
InputType	1	1889	1889	24.98	1.28e-06	***
KeyboardType:InputType	1	1597	1597	21.11	7.74e-06	***

Figure 3: ANOVA of KeyboardType & InputType

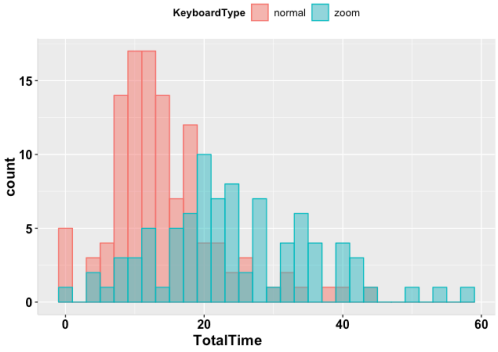


Figure 4

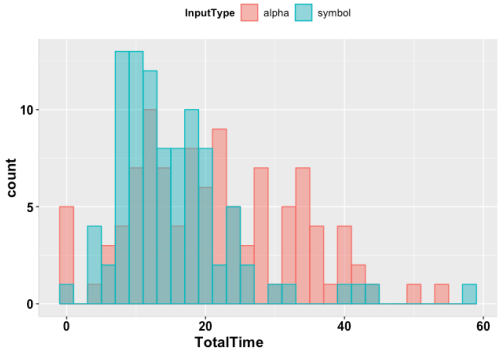


Figure 5

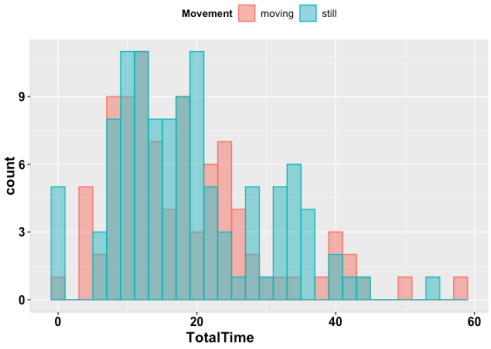


Figure 6

The grand mean for typing completion time was 19.11s. Normal miniature keyboard was the faster keyboard at 14.65487s, while zooming keyboard was the slower one at 24.89655s. This tendency can be also seen in Figure 4. The main effect of keyboard on typing completion time was statistically significant($F=55.322$ $p<0.001$ &$F=68.16$ $p<0.001$). However, the movement effect was almost none. When type in still position, the mean completion time was 19.33028s while in moving status it was a bit faster at 18.84615s. Shown in Figure 6, their completion time shares a similar tendency. The main effect of movement on typing completion time was statistically insignificant($F=0.001$ $p>0.5$). There was no interaction between keyboard type and movement status($F=0.478$ $p>0.5$). The input type effect was very significant. When typing alphabetical text the mean completion time was 21.89623s while symbolic is faster at 15.96809s. Shown in Figure 5, symbolic&numeric text had a faster typing time than that of alphabetical text. The main effect of input type on typing completion time was statistically significant($F=24.98$ $p<0.001$). There was huge interaction between keyboard type and movement status($F=21.11$ $p<0.001$). Overall, the miniature keyboard finish typing faster than the zooming keyboard and input type is a very important factor which symbolic&numeric text will complete typing faster.

II. Hypothesis 2

Mean of accuracy(%)

Miniature	38.46018
Zooming	76.88506
Alphabetic	56.46226
Symbolic	53.7234
Still	65.13761
Moving	43.24176
Overall	55.175

Figure 7

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
KeyboardType	1	72576	72576	194.14	< 2e-16	***
Movement	1	19680	19680	52.65	9.09e-12	***
KeyboardType:Movement	1	1140	1140	3.05	0.0823	.

Figure 8: ANOVA test of KeyboardType&Movement on accuracy

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
KeyboardType	1	72576	72576	156.764	<2e-16	***
InputType	1	644	644	1.391	0.2396	
KeyboardType:InputType	1	2706	2706	5.845	0.0165	*

Figure 9: ANOVA test of KeyboardType&InputType on accuracy

Figure 10

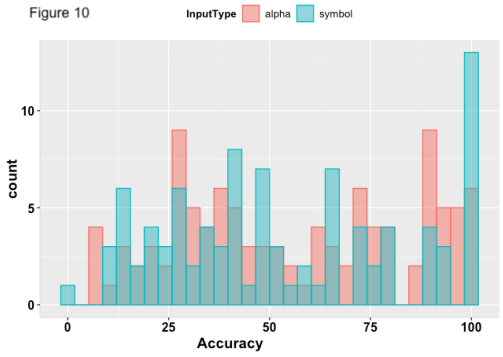


Figure 11

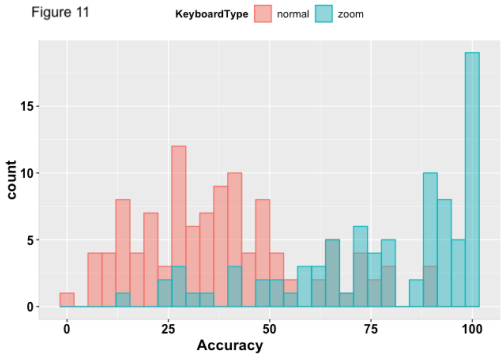
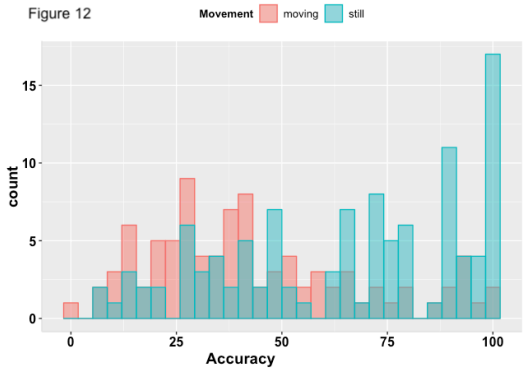


Figure 12



The grand mean for accuracy was 55.175%. Zooming keyboard was the more accurate keyboard at 76.88506, while normal miniature keyboard was the worse one at 38.46%. This tendency can be also seen in Figure 11. The main effect of keyboard on typing completion time was statistically significant($F=194$ $p<0.001$ &$F=156.764$ $p<0.001$). However, the input type effect was almost none. When type alphabetical text, the mean accuracy 56.46% while typing symbolic&numeric text, it was a less accurate at 53.72%. Shown in Figure 10, their completion time shares a similar tendency. The main effect of input type on typing completion time was statistically insignificant($F=1.391$ $p>0.1$). There was more than a little interaction between keyboard type and movement status($F=5.845$ $p<0.1$). The movement status was very significant. When typing still the mean accuracy was 65.14% while moving is less accurate at 43.25%. Shown in Figure 12, typing still was a more accurate typing position. The main effect of movement status on accuracy was statistically significant($F=52.65$ $p<0.001$). However, there was little interaction between keyboard type and movement status($F=3.05$ $p<0.1$). Overall, the zooming keyboard was more accurate at typing than miniature keyboard. The movement status affects the accuracy for certain, however, it has little to do with the keyboard types. The input type still has effects on the accuracy, however, they performs almost same in terms of accuracy.

III. Within-subjects design? Between-subjects design?

I noticed that no matter how I randomized the conditions, the participants will eventually perform faster and better under the last 2 or 3 conditions. Thus the learning speed is a compounding factor to influence experiments. Between-subjects design can rule out this effect because the participant don't enough time to get use to the keyboard provided that each experiment has only 8 trials in my experiment design. Since I only have 8 conditions, it is reasonable to find 8 participants. However, if I have more conditions, this will result in more participants needed.

Conclusion

Overall, miniature keyboard has strength in speed but sacrifices accuracy, and zooming keyboard has strength in accuracy but sacrifices speed. Based on my analysis, I think it would be better if the

miniature keyboard will be using to type symbolic&numeric text and the zooming keyboard will be using to type alphabetic text. Thus it can speed up the symbolic&numeric text typing speed at the cost of little accuracy loss.

Appendix:

Data collected(only 10 lines selected):

X	Userid	KeyboardType	InputType	Movement	TotalTime	LongestPause	Accuracy
1	0	p2	normal	symbol	moving	9	5	14
2	1	p1	zoom	alpha	moving	27	3	94
3	2	p3	normal	alpha	still	17	2	72
4	3	p2	zoom	alpha	still	23	2	90
5	4	p1	normal	symbol	moving	20	7	67
6	5	p3	normal	symbol	still	17	6	67
7	6	p3	normal	alpha	still	15	2	76
8	7	p4	zoom	alpha	moving	28	2	56
9	8	p1	normal	alpha	still	0	2	74
10	9	p3	zoom	alpha	moving	28	3	79

Output by R script:

```
> summary(aov(TotalTime ~ KeyboardType * InputType, data = my_data))
                       Df Sum Sq Mean Sq F value   Pr(>F)
KeyboardType            1   5156    5156   68.16 2.19e-14 ***
InputType               1   1889    1889   24.98 1.28e-06 ***
KeyboardType:InputType  1   1597    1597   21.11 7.74e-06 ***
Residuals             196  14826      76
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(aov(TotalTime ~ KeyboardType * Movement, data = my_data))
                      Df Sum Sq Mean Sq F value   Pr(>F)
KeyboardType           1   5156    5156  55.322 3.13e-12 ***
Movement               1      0       0   0.001    0.971
KeyboardType:Movement  1     45      45   0.478    0.490
Residuals            196  18267      93
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(aov(Accuracy ~ KeyboardType * InputType, data = my_data))
                       Df Sum Sq Mean Sq F value Pr(>F)
KeyboardType            1  72576   72576 156.764 <2e-16 ***
InputType               1    644     644   1.391 0.2396
KeyboardType:InputType  1   2706    2706   5.845 0.0165 *
Residuals             196  90741     463
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(aov(Accuracy ~ KeyboardType * Movement, data = my_data))
                      Df Sum Sq Mean Sq F value   Pr(>F)
KeyboardType           1  72576   72576  194.14  < 2e-16 ***
Movement               1  19680   19680   52.65 9.09e-12 ***
KeyboardType:Movement  1   1140    1140    3.05   0.0823 .
Residuals            196  73270     374
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

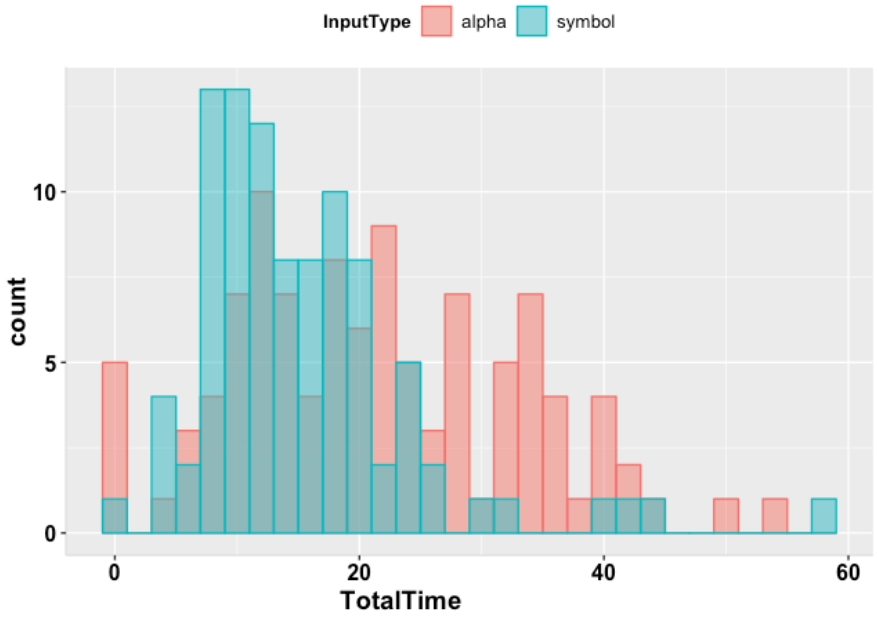
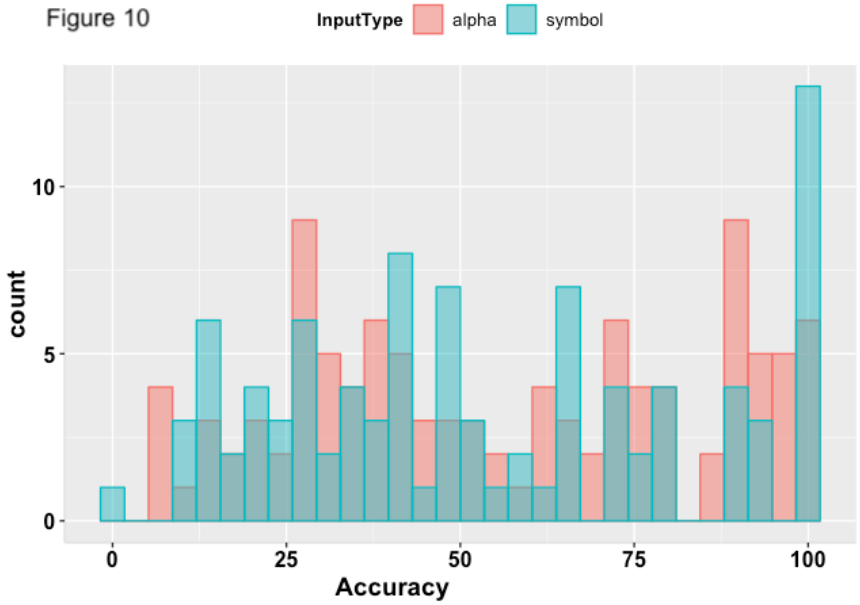
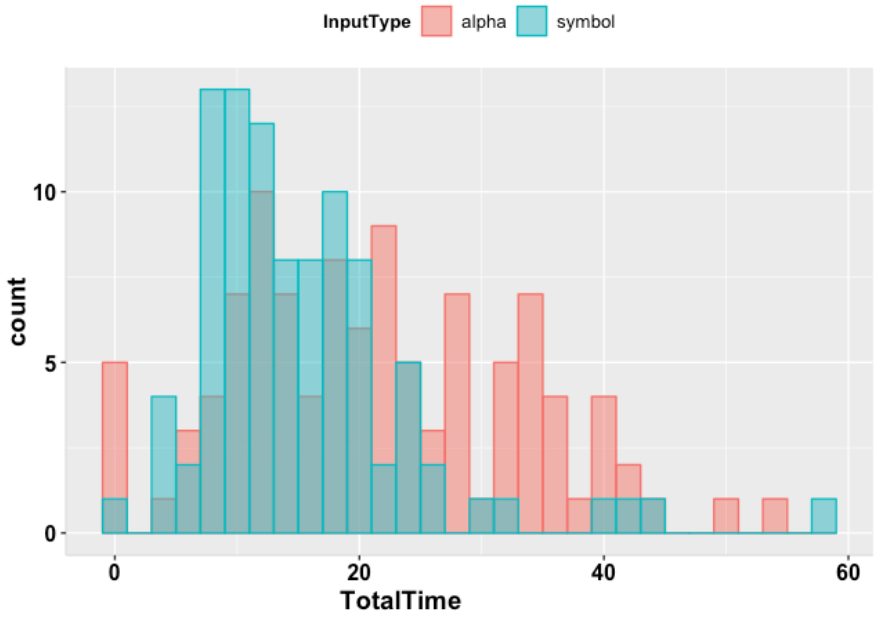
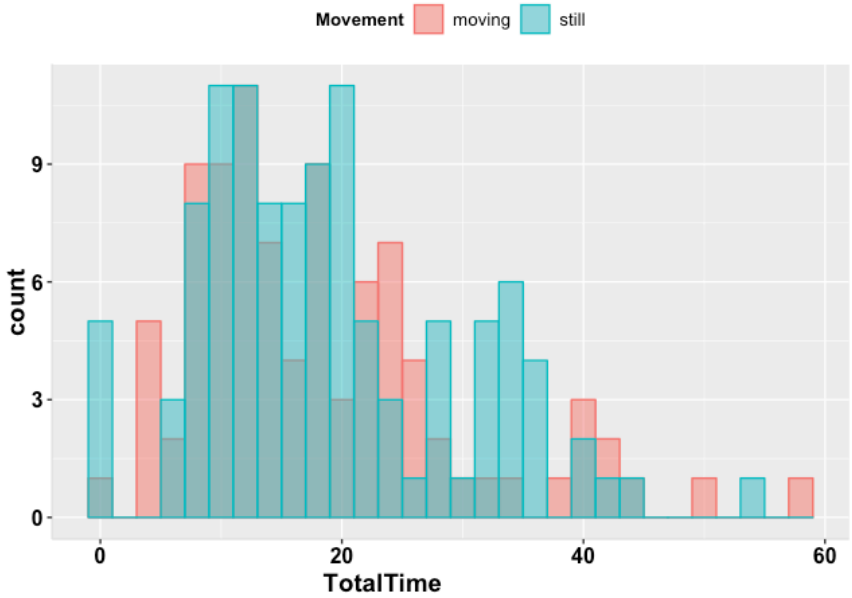

InputType
alpha
symbol
count
10
5
0
0
20
40
60
TotalTime

Figure 10


InputType
alpha
symbol
count
10
5
0
0
25
50
75
100
Accuracy


InputType
alpha
symbol
count
10
5
0
0
20
40
60
TotalTime


Movement
moving
still
count
9
6
3
0
0
20
40
60
TotalTime

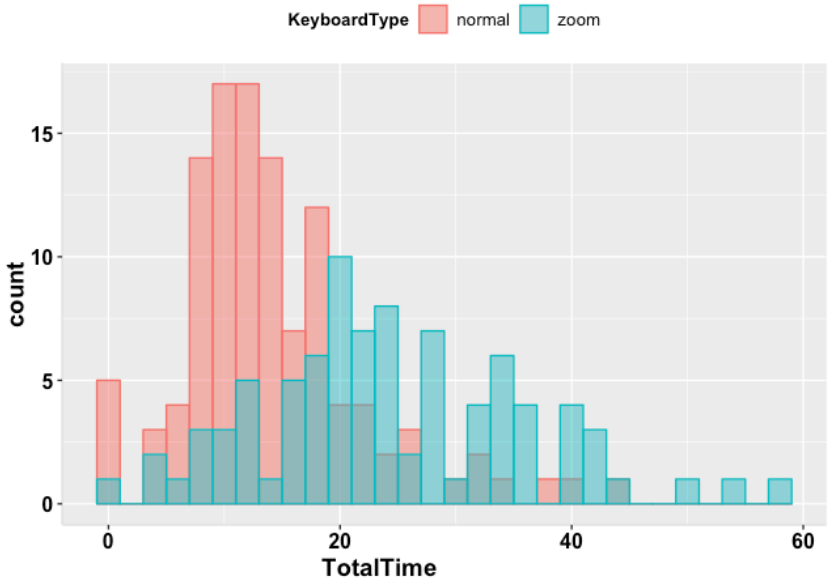


Figure 12

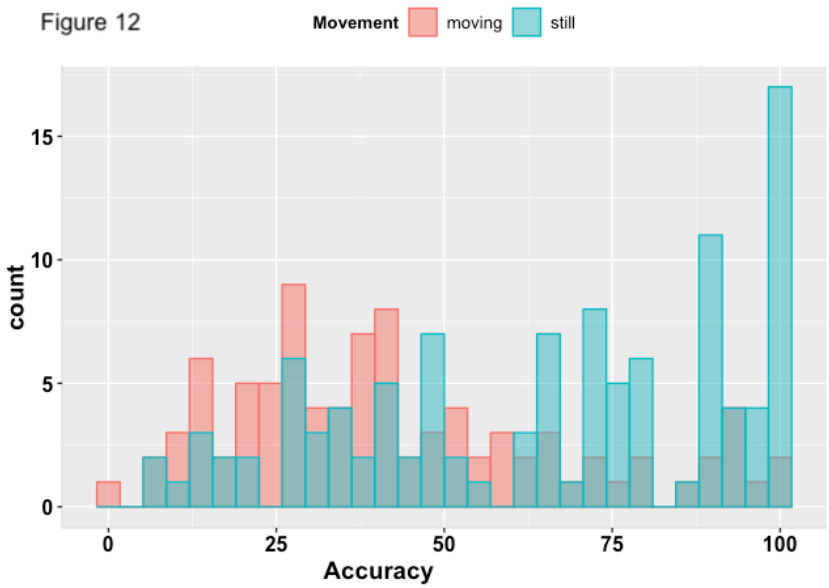
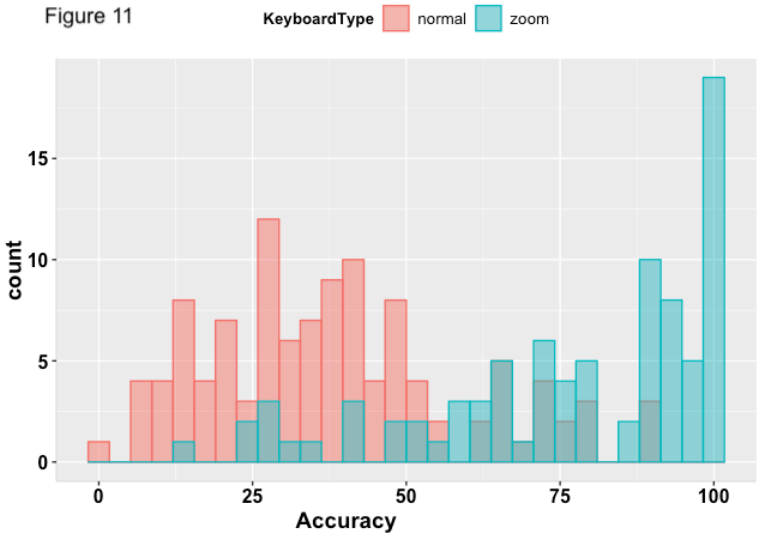


Figure 11



consent forms:

STUDY PROTOCOL TEMPLATE

Project Title: Studies on smartwatch keyboard(miniature style vs. zooming style)

Investigators: Yufeng Li derekli1995@outlook.com

Background and purpose of Research: The purpose of our study is to understand smartwatch users to help us derive requirements for the design of novel interactive computational media that are intended to be useful to people type on smartwatches. A brief description of our design concept is: Typing different text given different conditions: moving or not & input text type & different keyboards

Participant selection and eligibility: Participants will be chosen from students. They will be identified via p1,p2,p3,p4 and selected according to investigators friend. In general, they will be characterized by UofT students.

Procedure: We will brief participants about the purpose of the study, explain the attached consent form to them, and ensure that they consent to participate and sign the consent form. We will then engage the participants in silent observation. We will also with their permission make observations as follows: investigator can help participant to adjust the position of the phone on wrist to simulate smartwatch.

Voluntary Participation & Early Withdrawal: The participation in this study is entirely voluntary, and participants are free to cease participation at any time, for any reason, without the need to give any explanation. At their request, we will delete any of their data and it will not be used in our analysis or any subsequent reports or presentations.

Relationships: Our relationship to the participants may be described as follows: friend

Risk and benefit: There are no anticipated risks associated with participation in this study, beyond those associated with everyday use of computer (e.g. participants may feel that they have wasted their time). The only benefit will be to contribute to the education of the investigators.

Compensation: Participants will receive no compensation.

Information sought: The information to be sought is described in the attached to the phone.

Privacy and confidentiality: Information will be kept confidential by the investigators. Names or other identifying or identified information will not be kept with the data. The only other use will be to include excerpts or copies in the assignment submitted, but names and other identifying or identified information will not be submitted.

CONSENT FORM TEMPLATE

Consent Form: Studies on smartwatch keyboard

I hereby consent to participate in a study conducted by Yufeng Li for an assignment in University of Toronto Computer Science 428, Human-Computer Interaction.

I agree to participate in this study the purpose of which is studies on smartwatch keyboard(miniature style vs. zooming style)

I understand that

- the procedures to be used are silent observations.
- I will receive no compensation for my participation.
- I am free to withdraw before or any time during the study without the need to give any explanation.
- all materials and results will be kept confidential, and, in particular, that my name and any identifying or identified information will not be associated with the data.

Baosen Lin		18/10/24
Participant's Printed Name	Participant's Signature	Date

Yufeng Li	
Experimenter Name	Experimenter's Signature

CONSENT FORM TEMPLATE

Consent Form: Studies on smartwatch keyboard

I hereby consent to participate in a study conducted by Yufeng Li for an assignment in University of Toronto Computer Science 428, Human-Computer Interaction.

I agree to participate in this study the purpose of which is studies on smartwatch keyboard(miniature style vs. zooming style)

I understand that

- the procedures to be used are silent observations.
- I will receive no compensation for my participation.
- I am free to withdraw before or any time during the study without the need to give any explanation.
- all materials and results will be kept confidential, and, in particular, that my name and any identifying or identified information will not be associated with the data.

Yue Li		18/10/24
Participant's Printed Name	Participant's Signature	Date

Yufeng Li	
Experimenter Name	Experimenter's Signature

CONSENT FORM TEMPLATE

Consent Form: Studies on smartwatch keyboard

I hereby consent to participate in a study conducted by Yufeng Li for an assignment in University of Toronto Computer Science 428, Human-Computer Interaction.

I agree to participate in this study the purpose of which is studies on smartwatch keyboard(miniature style vs. zooming style)

I understand that

- the procedures to be used are silent observations.
- I will receive no compensation for my participation.
- I am free to withdraw before or any time during the study without the need to give any explanation.
- all materials and results will be kept confidential, and, in particular, that my name and any identifying or identified information will not be associated with the data.

Jiaxi Wang		18/10/26
Participant's Printed Name	Participant's Signature	Date

Yufeng Li	
Experimenter Name	Experimenter's Signature

CONSENT FORM TEMPLATE

Consent Form: Studies on smartwatch keyboard

I hereby consent to participate in a study conducted by Yufeng Li for an assignment in University of Toronto Computer Science 428, Human-Computer Interaction.

I agree to participate in this study the purpose of which is studies on smartwatch keyboard(miniature style vs. zooming style)

I understand that

- the procedures to be used are silent observations.
- I will receive no compensation for my participation.
- I am free to withdraw before or any time during the study without the need to give any explanation.
- all materials and results will be kept confidential, and, in particular, that my name and any identifying or identified information will not be associated with the data.

Yizhou Zeng		18/10/24
Participant's Printed Name	Participant's Signature	Date

Yufeng Li	
Experimenter Name	Experimenter's Signature