Text Entry Performance on an Expandable Socket Attached Smartphone in Stationary and Mobile Settings

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Abstract. This paper investigates the effects of an expandable socket attachment for mobile phone grip on stationary (while seated) and mobile (while walking on a treadmill) text entry. An exploratory study ($N = 12$) failed to identify a significant effect of the attachment on text entry speed, accuracy, and error correction effort in either settings. But participants performed relatively better with the attachment while walking. Participants also did not perceive the attachment to affect their text entry speed and accuracy. However, significantly more participants wanted to use it in mobile settings, presumably to increase the safety of their devices.

Keywords: Human factors · Smartphone · Accessories · Gadgets · Expandable socket · Attachment · Bunker ring · Grip ring · PopSocket · Text entry

1 Introduction

A recent market research revealed that low-cost smartphone accessories are becoming increasingly popular among mobile users [1]. Nowadays, mobile device users use a variety of accessories, including add-on lenses and filters, panoramic pods, selfie sticks, portable power banks, virtual reality headsets, cases and covers, and grip attachments, presumably due to their availability and affordability. Together with smartphones, these accessories are also becoming ubiquitous, demanding systematic investigations of their effects on user performance, preference, and ergonomics. While some recent works have studied several low-cost gadgets, particularly the effects of selfie sticks on physical and cognitive stress [2] and grip rings on text entry and target selection tasks [3, 4], to our knowledge the effects of expandable socket attachments for mobile phone grip on text entry performance and preference have not yet been investigated. This paper attempts fill that gap through an exploratory study.

1.1 Motivation

The motivation of this work is threefold. First, text entry researchers often conduct in-the-wild and remote user studies to explore user and usage behaviors in natural settings, where users typically use their own mobile devices. Since the effects of attachments for

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phone grip on text entry performance in unknown, many researchers struggle with the decision of whether or not to exclude the data collected on devices with these attachments. The findings of this work will enable them to make an informed decision about it. Second, this work will inform manufacturers about whether these attachments affect mobile input and interaction. This may encourage them to invest more in the design and development of more ergonomic and effective grip attachments. Finally, considering the lack of research in the area, we hope that this work will inspire further investigations involving different types of low-cost accessories.

2 Related Work

There are many grip attachments available in the market that enable users to hold their mobile devices firmly and safely. Some of these attachments also serve as stands.

Fig. 1. Two commercial grip rings. At the top, a Lynktec 360° Ring Stand [5] and at the bottom, a Bunker Ring [6] swiveled for different viewing angles.

Grip rings are ring attachments for mobile phones. With these, users slip their fingers through the ring to keep their phones firmly in hand. Users can also swivel the ring to use it as a stand (Fig. 1). An experiment studying pointing accuracy with a grip ring attached smartphone revealed that it improves pointing accuracy for smaller targets [3]. Results also revealed that attaching the ring at the middle of the phone yields a relatively better performance. A similar user study found out that grip ring does not affect mobile text entry speed or accuracy when inputting in a seated position [4].

Fig. 2. Expanded PopSocket used as a grip (left) and as a stand (right) [7].

PopSocket is an expandable socket attachment for mobile phone grip. Users pop it up as a grip and stand, then pull it back to lay flat (Fig. 2). In 2017, about 35 million PopSockets were sold across 40 countries, with an 800% annual growth rate [8].

Grip loops, in contrast, are loop attachments [9, 10] that enables thumb-free grip of mobile phones (Fig. 3). Unlike sockets and rings, loops are typically made from soft non-elastic fabric, therefore cannot be used as stands.

Fig. 3. From left, one-loop Ungrip [10], and two and three-loop Lazy-Hands [9].

2.1 Nomadic Text Entry

Many studies have investigated text entry while walking. Two earlier studies reported that tapping performance decreases for smaller targets when walking and typing [11, 12]. Another study found out that mobility impacts text entry performance in terms of text entry speed, accuracy, and mental workload [13]. A more recent study also reported similar results [14]. Some have studied the impact of using mobile phones on walking performance. They found out that both text entry and reading affect walking, resulting in a slower walking speed and deviation from a straight line [15, 16].

3 An Experiment

We conducted an exploratory study to investigate the effects of an expandable socket attachment for mobile phone grip on text entry in both stationary and mobile settings.

3.1 Apparatus

The user study used a OnePlus One smartphone, 152.9 × 75.9 × 8.9 mm, 162 g, running Android 5.1.1 (Lollipop) at 1080 × 1920 pixels (∼401 ppi density). A PopSocket [7, 8], 40.6 × 40.6 × 7.6 mm, 13.6 g, was attached at the middle of the phone. This is based on the findings of a prior study that revealed that attaching grip rings at the middle of the device yields better pointing accuracy [3].

Participants used Gboard, the default Android keyboard [17] to enter text. However, all predictive features of this keyboard were disabled, including word prediction and autocorrection, to eliminate a potential confounding factor (i.e., some may heavily rely on these predictive features, while some may not). All commonly used text entry performance metrics, including Words per Minute (WPM), Error Rate (ER), and

Keystroke per Characters (KSPC) [24] were recorded using WebTEM [18], a cross-platform Web application.

This study also used a Fitness Reality TRE5000 electric treadmill to simulate walking, which is a common practice in studies investigating mobile device usage while walking (e.g., [19–22]). It was set on 1.0 mph ($\sim$1.6 km/h) during mobile conditions. This is based on the findings of a prior study that reported that users usually maintain a walking speed between 0.9 and 1.2 mph (1.5 and 2 km/h) while using mobile phones [25].

3.2 Participants

Twelve participants took part in the study. Their average age was 21.75 years (SD = 2.6). Four of them were female and eight were male. All were frequent smartphone users. They had on average 8.16 years (SD = 2.9) of experience in mobile text entry.

Two of them were users of grip attachments—one used a Bunker Ring and another a PopSocket for about one year. Eleven of them were right-handed, one was ambidexters. The ambidexters user used the right hand to input text. They all received a small compensation (USD $10) for participating in the study.

Fig. 4. Two participants participating in the study in a seated position (left) and while walking on a treadmill (right).

3.3 Design

We used a within-subjects design for the study, where the independent variables were the grip attachment and setting and the dependent variables were the performance metrics. The conditions were counterbalanced. In summary, the design was:

12 participants ×
2 attachments (*with* and *without PopSocket*) ×
2 settings (*stationary* and *mobile*) ×
15 short English phrases [23] = 720 phrases, in total.

3.4 Procedure

First, we explained the study procedure to all participants, and collected their consents and demographics. During the study, each participant entered 15 phrases per condition. They were instructed to hold the device in portrait position with their dominant hand, and input with the thumb of the same hand. WebTEM [18] displayed one phrase at a time. Participants had to enter the displayed phrase and press the "Return" key to see the next one. They were instructed to read and memorize the phrase, then transcribe it *"as fast and accurate as possible"*. Error correction was recommended but not forced [24]. There were no practice sessions since all participants were experienced virtual Qwerty users. An experimenter manually kept record of how participants used the PopSocket.

Appropriate safety measures were taken during mobile conditions to prevent trips and falls. All participants were asked to attach the treadmill safety key to their clothing and wear a bike helmet to prevent injuries in case of an unexpected trip or fall (Fig. 4). There were also mandatory breaks between the conditions to make sure participants did not get tired of using the treadmill.

Upon the completion of all conditions, participants were asked to complete a short questionnaire, where they could rate and comment on the conditions on a seven-point Likert scale.

4 Results

Manual logging revealed that 58% ($N = 7$) participant held the PopSocket between their index and middle fingers, while the remaining 42% ($N = 5$) held it between the middle and the ring fingers.

We used a repeated-measures ANOVA to analyze all quantitative data.

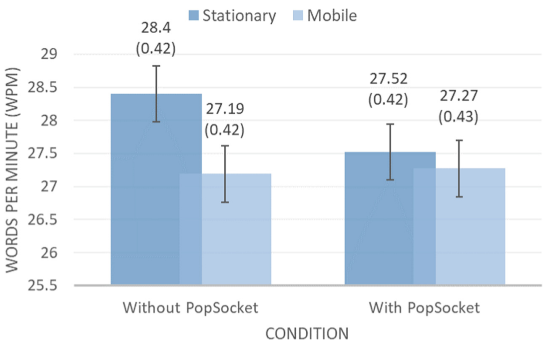

Fig. 5. Average entry speed for all conditions. The values inside the brackets and the error bars represent standard errors. Note the scale on the vertical axis.

4.1 Words per Minute

An ANOVA failed to identify a significant effect of attachment ($F_{1,11} = 0.47$, $p > .05$) or setting ($F_{1,11} = 1.42$, $p > .05$) on entry speed. There was also no significant effect of attachment × setting ($F_{1,11} = 1.27$, $p > .05$). Figure 5 displays average text entry speed for all conditions.

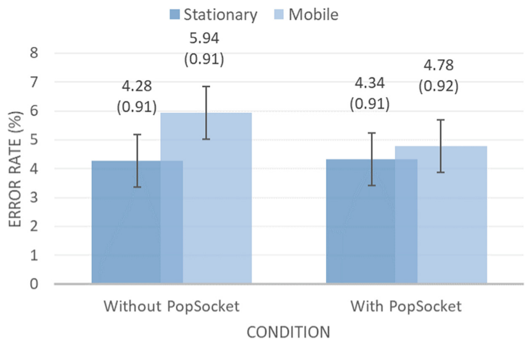

Fig. 6. Average error rate for all conditions. The values inside the brackets and the error bars represent standard errors.

4.2 Error Rate

An ANOVA failed to identify a significant effect of attachment ($F_{1,11} = 0.37$, $p > .05$) or setting ($F_{1,11} = 1.26$, $p > .05$) on entry speed. It also failed to identify a significant effect of attachment × setting ($F_{1,11} = 0.45$, $p > .05$). Figure 6 illustrates average error rate for all conditions.

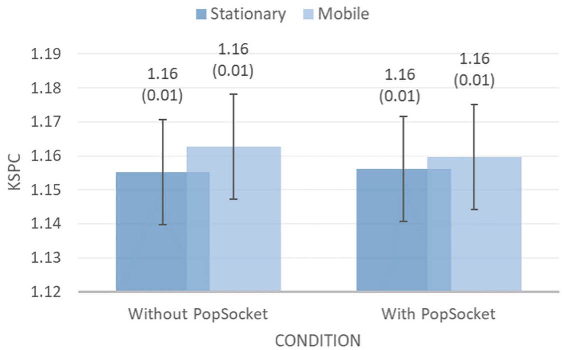

Fig. 7. Average KSPC for all conditions. The values inside the brackets and the error bars represent standard errors. Note the scale on the vertical axis.

4.3 Keystrokes per Character (KSPC)

An ANOVA failed to identify a significant effect of attachment ($F_{1,11} = 0.00$, $p > .05$) or setting ($F_{1,11} = 0.05$, $p > .05$) on entry speed. There was also no significant effect of attachment × setting ($F_{1,11} = 0.01$, $p > .05$). Figure 7 displays average keystrokes per character for all conditions.

5 User Feedback

During the study, participants responded to questions about speed and accuracy for all conditions on a 7-point Likert scale. We used a Wilcoxon Signed-Rank Test to analyze all responses.

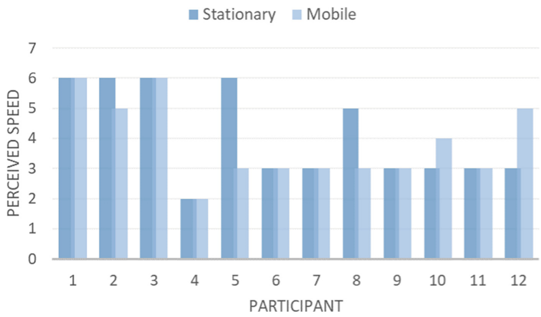

Fig. 8. User responses to whether PopSocket compromised text entry speed on a 7-Point Liker scale, where “1” to “7” represent “Definitely Disagree” to “Definitely Agree”.

5.1 Perceived Entry Speed

A Wilcoxon Signed-Rank Test failed to identify a significant effect of setting on perceived speed with PopSocket attached smartphones ($z = -0.68$, $p > .05$). About 58% ($N = 7$) participants felt that the attachment did not compromise text entry speed, while the remaining 42% felt that it did ($N = 5$). See Fig. 8 and Table 1.

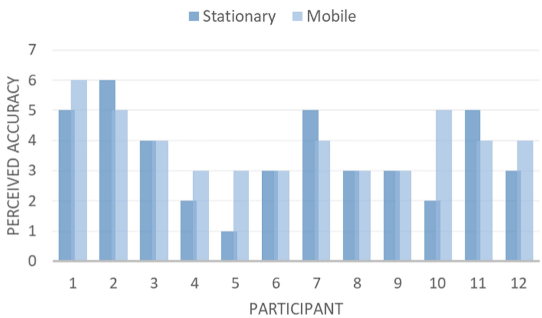

Fig. 9. User responses to whether PopSocket compromised text entry accuracy on a 7-Point Liker scale, where “1” to “7” represent “Definitely Disagree” to “Definitely Agree”.

5.2 Perceived Accuracy

A Wilcoxon Signed-Rank Test failed to identify a significant effect of setting on perceived text entry accuracy with PopSocket attached smartphones ($z = -1.1$, $p > .05$). About 58% ($N = 7$) and 42% ($N = 5$) felt that the attachment did not affect text entry accuracy during the stationary and mobile settings, respectively, while about 33% ($N = 4$) and 25% ($N = 3$) felt it did. The remaining were neutral. See Fig. 9 and Table 1.

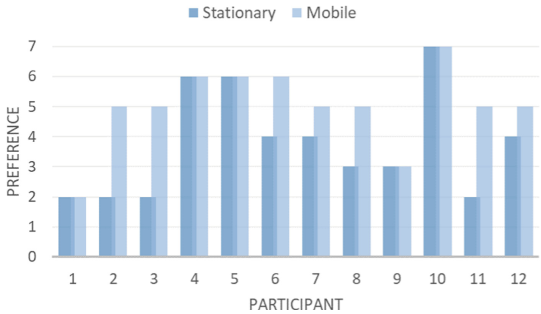

Fig. 10. User responses to whether they would use PopSocket on a 7-Point Liker scale, where "1" to "7" represent "Extremely Unlikely" to "Extremely Unlikely".

5.3 Preference/Willingness to Use

A Wilcoxon Signed-Rank Test identified a significant effect of setting on preference of using PopSocket ($z = -2.39$, $p < .05$). About 83% ($N = 10$) participants wanted to keep using it in mobile settings, while only 25% ($N = 3$) wanted to use it while stationary. See Fig. 10 and Table 1.

The questionnaire also asked participants about whether they would prefer using a different type of grip attachment, to which 17% ($N = 2$) responded that they would, 33% ($N = 4$) responded that they would not, while the remaining 50% ($N = 6$) were neutral about it.

Table 1. Percentage of users agreed, disagreed, or were neutral about the effects of the attachment on text entry speed and accuracy, and their willingness to use it. "Station." represents "Stationary" and "*" represents statistically significant result. The numbers do not always add up to 100% since they are rounded to the nearest integers.

User responses	Speed		Accuracy		User responses	
	Stationary	Mobile	Stationary	Mobile	Stationary	Mobile
Agree	42%	33%	33%	25%	25%	**83%***
Neutral	0%	8%	8%	33%	25%	0%
Disagree	**58%**	**58%**	**58%**	**42%**	**50%**	17%

6 Discussion

The study did not identify a significant effect of the attachment on text entry speed and accuracy in either stationary or mobile settings. However, the reduction in speed from stationary to mobile was relatively stronger without PopSocket (4% vs. 1%), see Fig. 5. The increment in error rate from stationary to mobile was also much stronger without the attachment (28% vs. 9%), see Fig. 6. This demands replication of this study with a larger sample size to investigate whether these effects reach statistical significance.

Entry speed was marginally higher in the stationary setting ($\sim$28 wpm), compared to that in the mobile setting ($\sim$27 wpm). Similarly, error rate was marginally lower in the stationary setting ($\sim$4%), compared to that in the mobile setting ($\sim$5%). However, these differences were not statistically significant. These contradict findings reported in prior studies, discussed in Sect. 2. The fact that a treadmill was used to simulate walking may have contributed towards this since it did not require participants to constantly check and update themselves on a changing ambient environment [14]. Relevantly, an earlier user study investigating reading comprehension and text search tasks while seated and while walking on a treadmill also failed to find a significant effect of setting on performance [22]. Error correction efforts were comparable between the four conditions ($\sim$1.2 kspc).

Subjective analysis revealed that most participants did not feel that the attachment influenced their text entry speed or accuracy. Nevertheless, significantly more participants wanted to keep using it while walking. This is more for the safety of their mobile devices (i.e., they do not want to drop their devices) rather than its impact on performance. This suggests that mobile users are willing to purchase and use accessories that increase device safety.

7 Conclusion

This paper explored the effects of an expandable socket attachment for mobile phone grip on text entry performance in both stationary and mobile settings, i.e., while seated and while walking on a treadmill, respectively. An exploratory study failed to identify a significant effect of the attachment on text entry speed, accuracy, and error correction effort in either settings. However, on average the reduction in speed and accuracy from stationary to mobile was stronger without the attachment. Further investigation is needed to observe whether these effects reach statistical significance with a larger sample size. Participants did not perceive the attachment to affect their text entry speed and accuracy. However, significantly more participants wanted to use it in mobile settings, presumably to increase the safety of their devices. We hope this work inspires researchers to empirically investigate various low-cost mobile phone accessories.

8 Future Work

This work failed to provide a clear answer to the question whether text entry researchers must exclude in-the-wild data collected on mobile devices with various attachments for grip. In the future, we will replicate the study with a larger sample size to answer this question. Further, we will explore the effects of different socket shapes and sizes, attachment locations, different hand postures, and phone orientations. We will also extend our research to other mobile phone attachments.

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