Smart Phone Use by Non-Mobile Business Users

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ABSTRACT

The rapid increase in smart phone capabilities has introduced new opportunities for mobile information access and computing. However, smart phone use may still be constrained by both device affordances and work environments. To understand how current business users employ smart phones and to identify opportunities for improving business smart phone use, we conducted two studies of actual and perceived performance of standard work tasks. Our studies involved 243 smart phone users from a large corporation. We intentionally chose users who primarily work with desktops and laptops, as these "non-mobile" users represent the largest population of business users. Our results go beyond the general intuition that smart phones are better for consuming than producing information: we provide concrete measurements that show how fast reading is on phones and how much slower and more effortful text entry is on phones than on computers. We also demonstrate that security mechanisms are a significant barrier to wider business smart phone use. We offer design suggestions to overcome these barriers.

Author Keywords

Mobile devices, smart phones, user study, security.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Human Factors

INTRODUCTION

Smart phones have undergone rapid and significant innovation in recent years. The latest generation of phones supports complex multi-touch input, gesture-based interaction, advanced soft keyboards, enhanced connectivity, and a great number of dedicated special-purpose applications. This rapid innovation raises a number of research issues. One critical question concerns the future of such devices in the workplace. For the majority of business users, who are *not* primarily mobile but work mostly in a fixed location, how and why do smart phones support work? Identifying factors that impact these usage patterns can shed light on potential ways in which smart phones can enhance users' productivity.

Prior work has focused on the small set of business users who are primarily mobile (working from multiple locations throughout the day) and who rely heavily on their smart phones [15,18]. We instead focus on the much larger group of business users for whom smart phone use is entirely optional. It is unclear how and why these users employ smart phones for business, nor do we fully understand how their smart phone usage relates to their usage of traditional desktop or laptop computers. On the one hand, it may be that smart phones are increasingly replacing traditional computers for work tasks, a view spread by some of the popular press [14,22,23]. This view is supported by studies showing how smart phones are increasingly able to support and even co-opt traditionally desktop-based tasks such as web browsing and emailing (e.g., [6]).

On the other hand, there remain many barriers to smart phone usage. Smart phone screens are much smaller than desktop or laptop screens, which can make it more difficult to quickly understand large amounts of information [23]. Another common complaint is that typing is onerous on phones, even with hard keyboards and word completion algorithms. These difficulties could explain people's reluctance to respond to emails or compose documents on their phones [6,10]. Typing difficulties might also affect phone usage in the workplace in other ways. For example, many corporations require complex alphanumeric device passwords to protect proprietary information. Anecdotally, entering passwords may be particularly difficult on smart phones, potentially leading users to avoid business use of their smart phones altogether [10].

To date, there has been little formal assessment of potential barriers preventing effective use of smart phones for business. We therefore need systematic studies to better understand usage of the current generation of smart phones. Such understanding will move us beyond anecdote to more effectively guide future research and the development of mobile technologies. In this paper, we begin to build this understanding by exploring objective and subjective task performance on current smart phones.

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First, we need to better understand *objective* performance differences between smart phones and traditional computers for basic tasks such as reading, typing, and password entry. When is smart phone use comparable to, and when does it differ widely from computer use? Conducting this analysis will allow us to more closely examine purported difficulties with using smart phones.

Second, it is important to understand users' *subjective* beliefs about their own task performance on smart phones. This will help us understand how people's perceptions may influence their phone usage independently from their objective performance. Prior studies suggest that people do not use their phones to edit documents or compose emails because they *believe* that these activities are onerous and time consuming [9,10]. By contrast, they may read information on their phones because they believe that reading is efficient and easy. We therefore need to test people's estimations of the effort and time required for these tasks to determine whether perceptions can explain usage patterns. We also need to explore the possibility that usage may be affected by people's perceptions of the importance and difficulty of various tasks.

To this end, we conducted two studies of smart phone business use. Using a mixed-methods approach, we measured actual and perceived performance of basic reading and typing tasks. Through semi-structured interviews and surveys, we also asked people to make direct comparisons between their smart phone and traditional computer use to uncover their current practices and any barriers they encounter when using smart phones.

We make two overall contributions. First, we present new data that show how task performance significantly differs across phones and computers in several key areas. Second, we characterize the barriers that prevented our participants from fully leveraging their smart phones in the workplace. As a result we are able to identify areas for future research on new mobile technologies to address these barriers.

We note that our studies focus on North American corporate users of the current generation of smart phones. While some survey respondents were from Europe and Asia, the majority of the survey respondents, and all of the participants for the performance and perception assessments, were from the United States. Our goal was to provide a "snapshot" of current business use of smart phones and offer guidance for the future development of smart phone technologies for this population. However, smart phones are just as important for the broader population and some of the basic task results, such as reading and typing performance, may well be the same across populations. Nevertheless, it is beyond the scope of this paper to specifically address the broader population.

RELATED WORK

Prior research suggests that people's usage of smart phones differs from their usage of traditional computers both in terms of what phones are used for and when they are accessed. Studies have shown that phones engender fragmented attention and are overwhelmingly used for short sessions, which may prevent the execution of complex tasks [15]. Karlson and colleagues [6] also hinted at an imbalance between information-viewing and information-producing tasks on phones after observing that people tended to read most email messages they received but only generated occasional and short replies. Similarly, Matthews and colleagues [10] found that context, namely other devices, tasks, and places, also constrained people's use of their smart phones. Consistent with earlier work [16,17,18], they observed that people often used their phones to "fill time" in the absence of counter-pressures such as pending activities or the presence of others. These findings provide insight into current smart phone practices but also raise the additional questions of whether smart phones are inherently only suitable for certain tasks or whether selective usage patterns evolved from prior behavior and perceptions.

Related work has explored the *complementary* use of smart phones and computers. This research indicates that people often employ their phones and computers together, though not without difficulty [6,16]. Dearman and Pierce [2] showed that activities often spanned multiple devices, but that managing information across devices remained a challenge (see also [19]). More recently, researchers observed that people often began tasks on their phones but deferred them for completion on their computers [7]. Together these studies suggest that phone use often complements computer use, but that phones are not yet able to match computers in supporting many everyday tasks.

Finally, some researchers have looked explicitly at the use of phones for work, but they focused largely on how phones may affect work-life balance. Mazmanian and colleagues [11,12] were among the first to report the compulsive email-checking practices of Blackberry users in corporations. Other researchers have also found that mobile technologies blur the boundaries between work and personal life [1,13,19]. Though informative, these studies did not probe deeply into the types of work undertaken, and they examined prior-generation phones with lower capabilities than current-generation smart phones.

In summary, prior research has identified a number of significant challenges to widespread use of phones for standard tasks, many of which apply to business contexts. We extend this previous research by explicitly examining task performance and task perception on smart phones in order to understand more deeply *why* people are behaving as reported in the literature, and to see whether those prior patterns of behavior are reflected in user reports of business smart phone use. We demonstrate that performance is surprisingly close between smart phones and traditional computers for some tasks but measurably far in others. We discuss the design implications of our results with particular regard to text entry, and we argue that addressing existing barriers might enable new and more productive uses of current and future mobile devices.

METHOD

We conducted two studies with smart phone users in a large software and services corporation. Our first study consisted of 32 in-person interviews and individual observations of both actual and perceived task performance on smart phones and computers. Our second study was a large-scale web survey of 214 smart phone users, which investigated whether similar practices and motivations held across a large pool of users. We report each study in turn, followed by a general discussion of the results.

STUDY 1

Participants

We conducted semi-structured interviews and made performance and perception measurements with 32 smart phone users. Two participants did not complete the study as instructed – one did not have a functioning network connection and the other was unwilling to type the emails in the study. Due to the lack of data for those participants, we removed them from the analysis of the study.

Of the remaining 30 participants, 6 were Android OS users, 9 were Blackberry users, 14 were iPhone users, and 1 was a Palm Pre user. Five participants were female. The average age of participants was 39 years (ranging from 28 to 62 years). Two of the 30 participants were not willing to type the short email after completing the long email on their phones. For these two participants, we substituted the mean time from all other participants for the missing data points.

Interview Questions

We asked participants about their current smart phones, their typical use of their phones, and their ability to access work data and applications on their phones. We asked how long they had owned their phones, how their usage compared with their computer, why they had bought the phone, and their perceptions of its main advantages and disadvantages compared with their computer.

Observations

Objective Data

During the observation stage, participants performed two types of tasks: reading and typing. Participants performed both tasks using their own phones and primary work computers. We timed how long participants took to type and read a "short" email (35 words consisting of 217 characters including spaces and line breaks, which did not require scrolling) and a "long" email (108 words consisting of 552 characters including spaces and line breaks). To ensure that the tasks were reasonably realistic, we used email messages from the Enron corpus [3].

Typing: Participants typed the short email twice, once on their phone and once on their computer, and they typed the long email twice, again on their phone and on their computer. We counterbalanced task order for length of email and device. We had users send the emails to a functioning email account after typing them so that we could count the number of errors they made.

Reading: Participants read one short email and one long email on their phone, and they read a different pair of short and long emails on their computer. The short emails were matched for length and complexity, as were the long emails. To verify that participants had read each email, we asked them a short comprehension question afterwards. All participants provided reasonable answers to the questions.

Passwords: Finally, we asked participants to type an eight-character, mixed case, alphanumeric password on their phone and on their computer. This task was representative of the corporation's smart phone password security requirement. We recorded the number of tries and total time taken to log in successfully.

Subjective Data

Before completing the tasks, we showed participants a set of short and long emails and asked them to estimate the *time* (in seconds) and *effort* it would take them to read or type each email on their phone or computer. Effort was indicated using the Mental Effort Scale, or Subjective Mental Effort Questionnaire [21], which is a single scale with nine labels from "Not at all hard to do" to "Tremendously hard to do". Participants were also asked to estimate time and effort to enter a given eight-character, mixed case, alphanumeric password on each device.

Analysis

In our analysis, we investigated the effects on performance and perception of the following within-subject factors: Device (Computer or Phone), Task Type (Reading or Typing), Stimuli (Email or Password), and Email Length (Short or Long). We used repeated measure variance analysis for statistical significance tests. We included testing order and additional between-subject factors (such as phone model and phone keyboard type) in the tests, affecting the degrees of freedom reported below. In no case was testing order or its interaction with other factors found to be significant, eliminating concerns of transfer effects between conditions. Sphericity adjustment, such as Greenhouse-Geisser corrections, was also checked, but no significant effect was found to impact our conclusions. We therefore report only the original number of degrees of freedom in the F tests.

STUDY 1 RESULTS

Actual Performance of Reading and Typing

We present our results for reading and typing in terms of *speed*, rather than task completion time, to allow for meaningful comparisons across tasks of varying lengths. We calculated reading and typing speed by dividing completion time by the number of characters read or typed, and then converted each result to the standard unit of words per minute (wpm) using the convention of counting every five characters, including spaces, as one word [4].

As expected, both reading and typing speeds were slower on the phone than on the computer (see Figure 1 on following page). However, this difference was more pronounced for typing tasks than for reading tasks.

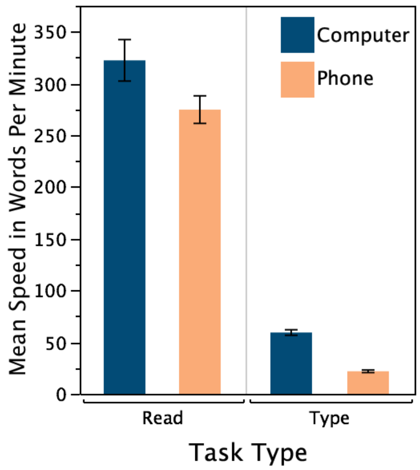


Figure 1. Mean speed of Reading and Typing Emails (combined Short and Long) on the Computer and Phone.

Reading

Reading speed was slower on the phone (*M*=274.65 wpm, *SD*=103.09) than on the computer (*M*=322.28 wpm, *SD*=155.27). This difference was statistically significant ($F_{1,26}$=6.4, *p*=.017). However, the computer to phone ratio (defined as *computer typing speed/phone typing speed*) was only 1.17, and participants' comments suggested that they perceived this difference to be negligible. More than one participant said they were willing to "read anything" on their phones, while others explained that reading on phones was "like reading on the computer as far as I'm concerned".

At the same time, there was evidence that typical reading practices differed among users between the phone and the computer. A few participants mentioned reading novels on their phones, while others reported skimming emails or reading "some portion of everything". We return to this point later in the discussion.

Typing

We asked participants to correct all errors they noticed in their typing, and they followed these instructions to the degree that the remaining errors (on average .001% or 0.475 characters evenly spread across the conditions) were negligible. The speed reported below is therefore the *effective* speed including error correction.

Typing speed was significantly and substantially slower on the phone (*M*=21.79 wpm, *SD*=9.76) than on the computer (*M*=59.27 wpm, *SD*=20.71; $F_{1,26}$=185.5, *p*<.0001). Here the computer to phone ratio, 2.72, was much larger than for reading. However, phone-typing speed was still surprisingly high when compared to the previously reported speed of 20.36 wpm achieved by experts on T9 keyboards [5]. Though participants were fairly adept at typing on their phones, they expressed reluctance about doing so and mentioned typing emails only when the situation was deemed urgent: "I can type faster on a [computer] keyboard than I can on here, so I will only do short replies. I don't really have the patience to put together a long, well thought out response." Others made sure to include "sent from my iPhone" disclaimers to explain typos or brief telegraphic messages. Yet others would respond to urgent emails by calling the sender: "If it's a critical issue, rather than type it all out on the phone, I'll call you".

In addition, typing style and the underlying typing technology of phones did not significantly affect typing speeds. Despite anecdotal beliefs that hard keyboards are better for typing than soft keyboards, we found no statistically significant difference in typing speeds between hard (*M*=24.67 wpm, *SD*=12.52) and soft (*M*=20.35 wpm, *SD*=7.83) keyboards ($F_{1,22}$=2.16, *p*=.1) in this experimental setting. When we divided participants into groups based on their keyboard type and typing style (whether they used one or two fingers), no significant effect could be found in pairwise Bonferroni comparisons (with *p* = 0.57, 0.85, and 1.0 between one finger typing on a soft keyboard, two finger typing on a soft keyboard, and two finger typing on a hard keyboard respectively).

Finally, participants pointed out specific challenges of typing on their phones, many pertaining to auto-completion and auto-correction software. The majority of their comments made reference to specific words that had been incorrectly "corrected". It therefore appears that even a low incidence of errors was negatively perceived because of the potential cost of these mistakes.

Passwords

Typing speed for passwords was markedly slower, both on the phone (*M*=6.00 wpm, *SD*=2.56) and on the computer (*M*=17.29 wpm, *SD*=7.27), than standard email typing, which averaged 21.23 wpm and 55.59 wpm for the short email on the phone and computer respectively. This difference was significant ($F_{1,26}$=138.7, *p*<.0001). In addition, there was a significant interaction effect between the task and device ($F_{1,26}$=78.7, *p*<.0001). Though participants typed passwords more slowly than they typed short emails on the phone, this difference was even greater on the computer (see Figure 2).

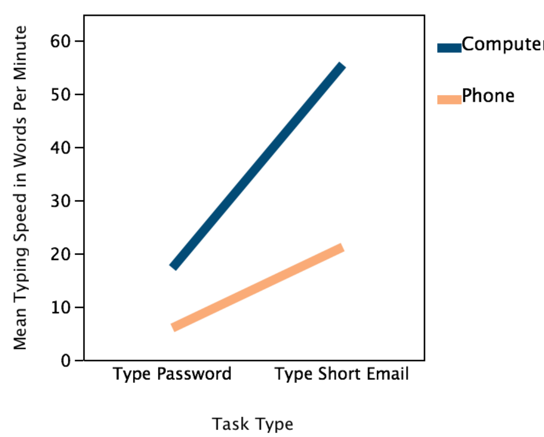


Figure 2. Mean speed of Typing Short Emails versus Typing Passwords on the Computer and Phone.

Consistent with previous anecdotal work, participants found the slow typing speed of passwords particularly problematic on their phones. This was partly because it prevented them from using their phones to quickly check email or perform other lightweight tasks. Participants observed that the difficulty of password entry "limits your ability to do anything else with the phone" and "the spontaneity of having the phone is somewhat lost". In some cases this led participants to remove work access from their personal phones, sometimes repeatedly: "I just find it so obnoxious to have to log in to my phone every time I want to use my phone and not just when I want to access [work] services that I've just always uninstalled it." Other participants avoided setting up work access on their phones altogether.

Perceived Performance of Reading and Typing

Our analysis of perceived performance is based on participants' *estimations* of the time and effort required to complete each task. To investigate how estimations compared to actual behavior, we also tested these measures against actual performance.

Overestimations and Underestimations of Time

To determine how accurately participants estimated the time they spent completing tasks on their devices, we performed an analysis of the log ratio of estimated time over actual time (see Figure 3). We transformed the data in this way to achieve a normal distribution and symmetrical scaling between over- and under-estimations. Thus a positive log ratio would indicate an overestimate while a negative log ratio would indicate an underestimate. The greater the distance from 0, the further the estimate was off.

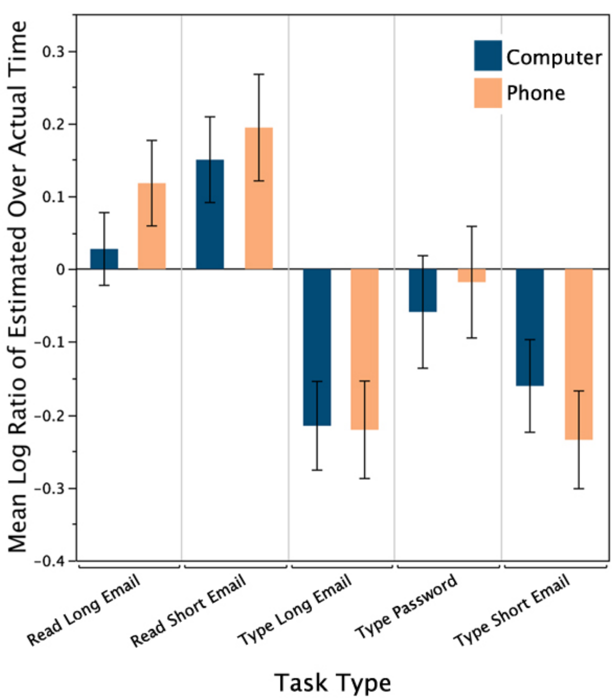


Figure 3. The log ratio of expected time over actual time for Typing and Reading tasks on the Computer and Phone.

We observed a significant difference between Typing (M=-0.2, SD=0.35) and Reading (M=0.12, SD=0.33; $F_{1,26}$=42.3, p<.0001) as well as a significant Device × Task Type interaction effect ($F_{1,26}$=5.98, p< .021). As shown in Figure 3, participants tended to overestimate the amount of time needed for reading but underestimated the amount of time needed for typing. This was true of both the phone and computer.

These observations suggest an interesting paradox in light of participants' comments that they "read more than I write for sure", and "find it hard anyway to reply and sort of deal with email…I can read it and see if there's anything important but I don't really use it in an outgoing manner". Even though participants significantly overestimate the time taken to read and underestimate the time required to type, they are willing to engage in significantly more reading than typing.

Overall Effort

Participants estimated the effort needed to complete each task using the Mental Effort Scale [21], which ranged from 0 to 150, prior to actually performing the tasks. As expected, participants considered typing (M=22.76, SD=29.33) to be significantly more effortful than reading (M=4.38, SD=7.40; $F_{1,26}$=32.0, p<.0001) and long emails (M=16.62, SD=26.63) were significantly more effortful than short emails (M=10.53, SD=18.91; $F_{1,26}$=14.44, p<.001). Performing these tasks on the phone (M=26.38, SD=29.08) was also considered to be more effortful than performing the same tasks on the computer (M=5.61, SD=10.89; $F_{1,26}$=69.73, p<0.0001).

We also observed a significant Device × Task Type interaction effect ($F_{1,26}$=19.53, p<.0001) as well as a significant Device × Email Length interaction effect ($F_{1,26}$=35.72, p<.0001). The difference in estimated effort between phone and computer was much greater for typing than reading, and much greater for long than short emails (see Figure 4).

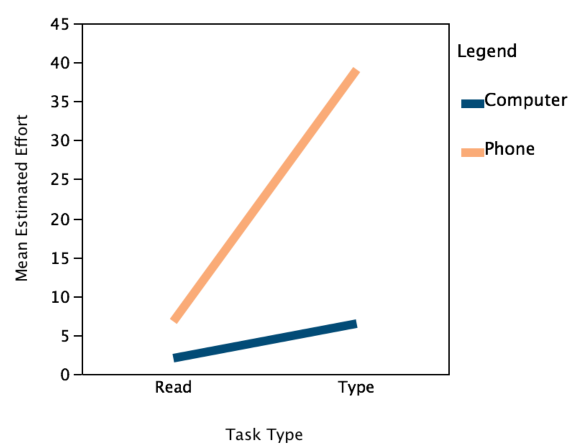


Figure 4. Mean estimated effort for Typing versus Reading Emails (combined Short and Long) on Computer and Phone.

In addition, participants considered password entry to be particularly effortful on the computer (*M*=11.10, *SD*=13.61) and even more so on the phone (*M*=40.31, *SD*=27.30). By comparison, the mean perceived effort for typing the short email was only 6.58 on the computer and 28.15 on the phone. Recall that the password task required typing only 8 characters, or up to 12 when additional keyboard mode switches were included, while the short email required typing 217 characters. These results indicate that length is clearly not the only factor that influences perceptions of effort.

Effort Intensity

To examine more deeply the disproportionately high effort associated with password entry, we calculated effort "intensity" as the amount of effort per unit of time for task completion.

We found that across devices, typing passwords (*M*=2.24, *SD*=2.38) was considered significantly more effortful than typing the short email (*M*=0.16, *SD*=0.22), even when normalized by completion time ($F_{1,26}$=13.9, *p*<.001). Though this difference was significant for both the computer and the phone, our interviews suggest that participants were particularly frustrated by password entry on their phones. The security requirement of entering a complex password was described as "obnoxious", "angering", "a royal pain", and "too much overhead".

Correlations Between Actual and Estimated Time

As shown in Figure 5 below, the correlation between estimated time and actual time, across all tasks, was surprisingly high (R^2 = 0.99). While individual estimates indicated some uncertainty from the participants, as well as variance within the group, the mean estimated time (*M*=65.93 seconds, *SD*=119.04) closely matched the mean actual time (*M*=77.54 seconds, *SD*=119.43).

Importance and Difficulty

In addition to measures of time and effort, we examined participants' ratings of the importance and difficulty of three work-related task areas, Calendar, Documents, and Email, across two modes, Editing and Viewing. Ratings were performed on a 5-point Likert scale in each case.

We found that Calendar (*M*=3.43, *SD*=1.42) and Email (*M*=3.5, *SD*=1.11) tasks were considered *more important* than Document tasks (*M*=2.42, *SD*=3.77; $F_{2,58}$=14.29, *p*<.0001), while Viewing (*M*=3.56, *SD*=1.32) was also more important than Editing (*M*=2.67, *SD*=1.31; $F_{1,29}$=60.96, *p*<.0001).

However, we observed that Calendar (*M*=3.08, *SD*=1.34) and Email (*M*=2.75, *SD*=1.37) tasks were also considered *less difficult* than Document (*M*=3.77, *SD*=1.09) tasks ($F_{2,58}$=18.4, *p*<.0001), and Viewing (*M*=2.77, *SD*=1.32) was considered less difficult than Editing (*M*=3.62, *SD*=1.22; $F_{1,29}$=33.7, *p*<.0001). Taken together, these ratings support the themes that emerged from the interviews regarding reading or viewing as more important but less difficult, while typing or editing is regarded as less important but more difficult. However, the current study does not allow us to determine precisely how importance and difficulty are related or whether importance is adversely affected by perceived difficulty.

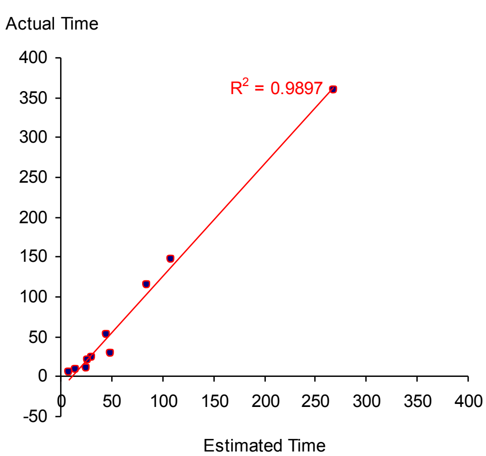


Figure 5. Mean actual and mean estimated times (in seconds) were highly correlated across all tasks.

Phone Versus Computer Preferences

We also systematically coded the interview transcripts to identify a series of common themes among participants. A major theme that emerged was that participants often *expected* their smart phones to act as a substitute for traditional computers. However this contrasted with their *reported* use, which revealed a different set of practices that appear to be specific to the mobile platform.

Participants often described using their phones when they were unable to access their traditional computers. For example, they reported using their phones "if my laptop died", "when I do not have to open my computer", "when it's a big pain in the butt to get out your laptop", or "when I don't have the computer in front of me". The greater ease of access afforded by phones was often cited as an advantage of the phone in these cases.

In contrast, when given a choice, participants exhibited a general preference for their computers, observing that "there's not a lot of reason to use that [phone] if I have something else" and that "everything's nicer on the computer". Phones were described as "big for portability but not for everyday use" and comparable to computers not because of the features they shared but because "it has all the problems inherent to a computer".

These qualitative discussions help to situate our quantitative data by reiterating participants' differing perceptions of their phones and their computers, a theme that we revisit in Study 2. Although phones offer advantages of portability and connectivity, there are still significant barriers that prevent them from completely replacing computers.

Discussion

The results from Study 1 begin to answer some of the questions we raised regarding smart phone use by non-mobile workers. Confirming anecdotal evidence in the literature, we found that participants were much more willing to read than type on their phones. This was borne out in both the actual and perceived task times. We found that reading speeds were comparable between the phone and the computer, with computer to phone reading speed ratios of only 1.15 for the short email and 1.2 for the long email. In contrast, typing speeds were 2.5 to 3 times slower on the phone than on the computer.

Interestingly, the correlation between mean perceived times and mean actual times in our study was surprisingly high, suggesting that participants in general had a fairly good idea of how long these tasks take to perform. However, our results also suggest that time alone does not determine people's willingness to perform certain tasks on their phones. We found that extra effort was associated with typing tasks overall and particularly for tasks on the phone.

While participants in general were good at estimating task completion time, we noticed an interesting trend: they were willing to read emails even though they tended to overestimate the time required to do so. In contrast they were unwilling to type emails even though they underestimated the required time. Again, this raises the question of what other factors besides time influence individual patterns of phone use.

Finally, participants regarded password entry as particularly onerous, significantly more so than typing regular text. Not only were participants much slower typing passwords on the phone, but the estimated effort of doing so was disproportionately high. There are several likely explanations for these results. Password entry methods that deliberately mask entered characters increase the difficulty of error detection and correction. Additionally, passwords that employ mixed case and alternating letters and numbers often require switching keyboard modes. We found that this extra effort led many participants to seek ways of reducing the complexity of phone passwords, including setting "simple" passwords and frontloading passwords with "all characters and then all numerals or vice versa". It is worth pointing out that these strategies were adopted even though participants were aware that they might reduce the effectiveness of the passwords. This aversion to device passwords calls into question how widespread the use of smart phones for business is really likely to be if companies require passwords as the price of access and users have the option *not* to use their phones for work.

STUDY 2

We conducted a web survey of 214 smart phone users from the same corporation. In the survey, we asked participants how they used their smart phones for work and personal purposes. We used open-ended questions to identify factors that influenced their decisions to perform work tasks on their phones or defer them until they had access to a computer. In addition, we queried respondents about: whether their phone was used for work or primarily personal use, where they used their phone, and the primary tasks they carried out on it, in each case comparing their phone preferences with their computer usage.

Participants

88% of our survey respondents were Android OS (67), Blackberry (33), and iPhone (89) users. 78% of all participants paid for phone service themselves. 54% worked primarily from a private or shared office, 33% worked primarily from home, and 12% worked primarily from a client site or other location. More respondents reported using their phones on a daily basis at work (64 in their own office, 63 outside their office) and at home (72 in their home office, 70 elsewhere in their home) than in transit (50 in private transit, 31 in public transit).

Results and Discussion

Task Frequency

A strong theme that emerged from the survey results was a discrepancy between consuming and creating content on smart phones. Consistent with the results of our first study, respondents reported generating content on their phones less frequently than they viewed content. Overall, they reported performing standard work tasks relating to email, calendar, and documents more frequently on their computers than on their smart phones. Within each application, respondents also tended to view content more frequently than they edited content when using their phones (see Table 1 for snapshot). Their explanations suggested that these habits were driven by a perception of their phones as serving a different function from their computers.

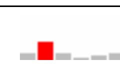
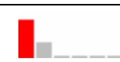
Task	Task Frequency Counts	
	Computer	Phone
View Email		
Compose Email		
View Document		
Edit Document		
View Calendar		
Edit Calendar		

Table 1. Task frequencies on phones and on computers, with Frequency (*x*) decreasing from Hourly (leftmost bar) to Never (rightmost) and Count (*y*) ranging from 0 to 106 people.

Looking more closely at the frequency data, we performed a repeated measures analysis of variance in which Device (Phone or Computer) and Task Type (Read or Write) were within-subject factors. Note that missing data from incomplete responses affected degrees of freedom in the following analysis.

We found that respondents performed reading tasks (*M*=4.64, which roughly corresponds to several times a week) significantly more frequently than they performed typing tasks (*M*=3.75, or several times a month; $F_{1,129}$=245.95, *p*<.0001). They also performed these tasks more frequently on their computers (*M*=5.13 or several times a day) than on their phones (*M*=3.25 or several times a month). This difference was significant ($F_{1,129}$=322.5, *p*<.0001).

As we anticipated there was also a significant Device × Task Type interaction ($F_{2,258}$=29.12, *p*<.0001). This interaction indicates that the difference between reading and typing frequency was far greater on participants' phones than on their computers.

Barriers on the Phone

When respondents were asked to explain *why* they rarely or never performed some tasks on their phones, the most common response, apart from lack of system support (e.g., some users could not remotely access the corporate network), revealed a preference for performing these tasks on their computers instead. Most comments described the computer as "easier" or "simpler" to use than the phone, particularly with respect to input mechanisms and the general user experience.

Respondents gave a number of reasons suggesting that they experienced increased effort and lower confidence when using smart phones for data entry. For example, the form factor was an issue for creating or editing documents because the "screen size [was] too small" and there was "no convenient input mechanism". Respondents were also less confident about making changes to calendar entries on their phones than on their computers. One respondent said he would prefer using his laptop for editing his calendar in order to "ensure no mistakes and avoid multiple updates to [my] audience". Similarly, another said that when creating or composing text, they would "need a laptop to do [it] properly". These comments replicated themes from Study 1, echoing participants who described deferring emails that needed to "look right and be properly punctuated" to the computer "just in case", and adding further support to those who worried that they could not trust their phones because they might "mistype stuff".

Together these comments provide greater insight into our findings from Study 1 and help to identify additional factors that affect phone use other than task completion time or speed. In particular, the reduced ease of use and lower confidence associated with phones may also be responsible for driving up the perceived effort of using phones for work tasks. Respondents were especially concerned about making data entry errors on their phones.

Difficulty with Passwords

We found additional corroboration of our Study 1 results when probing respondents' perceptions of passwords on their phones. Corporate security restrictions for smart phone access were again a recurring source of frustration, both in terms of accessing non-corporate applications and using the phone to support both work and personal practices. As one respondent noted, the "security requirements of entering a [corporate] password just to use the other applications on my phone is too onerous". This prevented respondents from switching fluidly between work and personal use of their phones since "the security layer would render my phone unusable as a [personal] phone".

We also asked participants to recall any situations in which they wanted to use their phones but were unable to or had difficulty completing a task. Again, passwords seemed to be a significant barrier. One respondent noted that they were "not willing to enter a huge password every time I start my phone". Similarly, another respondent was not able to quickly check his calendar because he does "not like to enter a password every time". These comments suggest that respondents deliberately weigh the tradeoff between the security cost and the benefit of using phones for short interaction sessions. Passwords on phones, much more so than on computers, obstruct the common pattern of short, intermittent use (see also [10]). Respondents did not object to password entry on computers in the same way because they found them easier to type and could amortize the cost across longer usage sessions.

The Purpose of Phones

Finally, respondents echoed findings from Study 1 regarding phones as lightweight monitoring devices. The willingness of our Study 1 participants to read information on their phones was reflected in comments made by our Study 2 respondents. Some explicitly noted that they currently use their phones as "an information consumption device" and "not [a] production device". Others explained that the main purpose of their phones was to "check and read status" or "browse lightweight information".

We identified similar themes when examining the tasks that respondents wanted to carry out in the future. Those who did not have remote access to their email and calendar data wanted lightweight, fast access. The remaining requested tasks revolved around viewing more information and communicating with colleagues by IM. Interestingly, there was little mention of supporting editing tasks. The few respondents who did ask for this type of support specifically wanted support for simple data capture, such as time card entry or receipts. This appears to be consistent with smart phone practices identified in the literature, reaffirming the belief that users do not currently view or use their phones as direct substitutes for their computers.

GENERAL DISCUSSION

Overall, our results suggest that how business users choose to employ their smart phones is influenced by the time, effort, confidence, and perceived affordances associated with their phones. We found that current smart phone support for reading tasks is comparable to that of traditional computers, but typing tasks take longer and are perceived as more effortful, with passwords proving especially difficult. This performance data is consistent with our interview and survey data, which show predominant usage of phones as reading devices with occasional (minimal) text entry. In this section we discuss the implications of these results with particular attention to text entry and security mechanisms.

First, it is clear that *relative* performance can strongly influence the usage of devices, particularly when people have access to both a smart phone and a computer. This choice of devices is likely to be relevant for business users of varying degrees of mobility. The relative performance of smart phones, as indicated by the computer to phone (CP) ratios of both actual and perceived behavior, may determine which tasks users choose to complete on their phones and which tasks they defer to their computers. We observed low CP ratios for reading tasks, which may explain people's willingness to view information on their phones. Conversely, we found high CP ratios for typing tasks, particularly in terms of associated effort, which may explain why people prefer to avoid or defer such tasks to the computer. While our findings provide a clearer picture than prior anecdotal work, the direction of influence between task importance and task difficulty is unclear. Further research is needed to disentangle the exact nature of this relationship.

In the case of password entry, both poor performance and the additional effort required to enter a password correctly seemed to go beyond what most people were willing to tolerate. Reactions to passwords were much stronger and more negative than might be expected from the need to type a piece of short text. These reactions likely stem from both input challenges, such as the need for keyboard mode switches or extra key presses, and their hindrance of the short, intermittent usage patterns common to phones. Among the primarily non-mobile users investigated in this work, the majority did not own separate business and personal smart phones, which made password requirements especially disruptive to their mobile practices.

Based on our results, we identify a number of challenges preventing effective use of smart phones in the workplace. First, the relative performance of typing-related tasks needs to improve on smart phones. We can address typing difficulties by offering better text input methods or by providing keyboards that are fast, easy to use, and highly portable. Contrary to expectations, we did not find evidence that hard keyboards improved typing. However, we did observe that at least one person was enamored by speech-to-text entry while at least two people made use of gesture-keyboards invented by HCI researchers [7,25,26]. Interestingly, in both cases participants enjoyed the overall input experience to the extent that they were willing to overlook a higher incidence of incorrect word detection. These observations suggest that there is room for novel text entry methods on smart phones, and it will be interesting to see if further development of these paradigms can eventually lower the CP ratio of typing performance.

Second, it is important to note that the benchmark for phone performance is not necessarily computer performance of similar tasks. Usage patterns of phones differ from those of traditional computers, particularly with respect to the length of the interaction. As a result, even supporting faster typing on phones may not make passwords more palatable. We therefore need security mechanisms that are acceptable to both corporations and users. Small steps that we can take to improve the acceptability of mobile password entry include: 1) Make passwords application-specific so that people can access personal applications or the web without entering complex corporate passwords; 2) Improve password interfaces by showing the last few characters of a password instead of just the last one, or by expanding a soft keyboard so that there are fewer keyboard mode switches required; and 3) Change the required structure of passwords so that there is less need to switch between keyboard modes (e.g., reduce the number of switches between upper and lower case or letters and numbers). A larger, more fundamental change would be to separate applications into distinct business and personal contexts and place security around the business context rather than around the entire device.

Third, we observed an interesting phenomenon regarding confidence and trust. People expressed concern and a lack of confidence around potential mistakes that appeared to be related to the small displays of smart phones. For example, they were afraid of failing to catch a mistake when filling out a form or editing a document. This phenomenon needs to be explored in greater detail to better understand how small smart phone displays impact perceived difficulty and users' willingness to complete various tasks.

In sum, we provide an initial examination of the factors that influence smart phone business use, and we show that the types of tasks business users choose to perform differ between smart phones and traditional computers. Our results suggest a way to prioritize the development of smart phones by focusing on opportunities where phones can effectively replace computers on a task-by-task basis. Our findings demonstrate that people regard mobile email and calendar access to be top priorities, just as they are on the desktop. More broadly, applications and services that allow people to consume new types of information on their phones are likely to be the most adopted, followed by applications that support simple text entry. Applications that require extensive text entry are the least likely to be adopted. Applying these priorities may yield higher adoption of new mobile services and help business users to more productively employ their smart phones.

CONCLUSION

In this paper, we systematically examined current smart phone use to better understand how future workers may employ these devices. Through two studies of actual and perceived performance of standard work tasks, we provided concrete data showing how fast reading is on phones and how much slower and more effortful text entry is compared to traditional computers. We also demonstrated that onerous security mechanisms pose a significant barrier to wider smart phone use in corporations. This snapshot of smart phone use helps to explain why even highly capable phones are not yet substitutable for computers, and it also identifies design considerations to potentially help business users employ their smart phones more productively. Based on our results, we suggested approaches to overcoming existing barriers and identified directions for future work.

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