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No Smart Phone Is an Island: The Impact of Places, Situations, and Other Devices on Smart Phone Use

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ABSTRACT
We interviewed 21 people both before and after they acquired an iPhone 3G or T-Mobile G1 to assess how next-generation smart phones impact user behavior. We focused on exploring what motivates people to use their smart phones, what applications they use, what information they access or produce, when and for how long they interact with their phones, and how this usage relates to other tasks and devices. Our results suggest that the use of next-generation mobile phones depends heavily on contexts, particularly users' other devices and the places and situations users encounter. We observed that users employ their mobile phones in concert with, not independent of, their other computers. Rather than just mimicking desktop use, however, they employ their phones in different ways and for new tasks. The places and situations in which users employ their phones shape the tasks they undertake and how they make time to use their devices, fill idle time with them, or defer tasks to their other devices. We draw on our observations to offer design implications, focusing on how to support mobile phone use in the context of other devices and different places and situations.

Author Keywords
Mobile devices, smart phone, user study, contextual use, information access.

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

INTRODUCTION
Led primarily by the iPhone 3G, the latest generation of mobile phones that provide high-speed Internet access and advanced functionality is changing how people consume and act on information. Unlike mobile devices studied in most prior studies, such phones make it easy for even casual users to browse the web, handle email, and get directions anytime and anywhere. While the interfaces they provide are a significant improvement over previous phones, designing user experiences that fully leverage these "smart phones" requires a better understanding of how people actually use them. Next-generation smart phones introduce new usage patterns and opportunities that are distinct from that of traditional mobile phones and computers. This study will enable us to understand how to design for the specific characteristics and affordances of these next-generation smart phones, rather than assuming that design experience gained from prior-generation phones or even desktops or laptops will apply.

To this end, we interviewed 21 people both before and after they acquired an iPhone 3G or T-Mobile G1. Our goal was to both study how people use such devices and contrast users' behaviors before and after they acquired their smart phones. We focused on exploring what motivates people to use their phones, what applications they use, what information they access or produce, when they interact with their phones, and how mobile use patterns compare to desktop computer use patterns. We also wanted to understand how people use their phone relative to their other devices and how non-routine situations (e.g., travel) affect use.

RELATED WORK
Prior research has explored when and why people use (or want to use) mobile phones. People want to use their phones to find answers to "trivia" questions, directions, and information about places, things, and friends [13]. Without a highly-capable mobile phone, users have difficulty finding this information and primarily rely on contacting other people to get it (e.g., asking an assistant to read email) [10,12]. Devices like the iPhone and G1, however, enable users to meet their own information needs and open other mobile computing opportunities.

While next-generation mobile phones such as the iPhone and G1 are relatively new, researchers have previously studied mobile work and the use of previous generations of mobile phones. Perry et al.'s study of mobile workers [10] suggested that users often employ mobile devices when filling "dead" time between meetings, in transit, etc. While early mobile phone users would make calls and check voicemail, more recent work suggests that users with more capable phones will also check email or surf the web when filling time [9]. Even when filling time, mobile phone users must attend to their surroundings (e.g., to check for the arrival of their bus) [14], and researchers have explored the impact of such fragmented interaction [8].

Mobile phones are social devices; people primarily use mobile phones for calls that communicate information, provide awareness, and coordinate activities [12]. People also use SMS [5] and email [6,7] to build and maintain social connections asynchronously, introducing their own social uses and conventions.

The research cited above studied needs or the use of prior-generation mobile phones with weaker input capabilities, smaller screens, slower Internet access, a smaller pool of native applications, and limited location awareness. While researchers have begun to explore the design space for applications that can leverage highly-capable devices (e.g., [1]), we lack studies exploring how users actually use such devices. Our interview study of nineteen iPhone 3G and two T-Mobile G1 users explores the usage practices of users employing these next-generation smart phones and identifies design implications for mobile devices (and the other computing devices that users employ).

PARTICIPANTS

We conducted two sets of semi-structured interviews. The first set was interviews with 27 people who expressed an intent to acquire a next-generation smart phone but had not yet bought it. The second set was interviews with 21 (of the original 27) people who actually acquired one and after they had approximately two months of experience using it. The participants were all members of a corporate research lab in the United States, with a mixture of researchers (14), software engineers (5), and research managers (8) represented. Five participants were female and ages ranged from twenties to fifties (2 participants were in their 20s, 11 in their 30s, 5 in their 40s, and 9 in their 50s).

This set of users consisted mostly of those who took advantage of their lab's offer to buy iPhone 3Gs for lab members. The goal of this offer was to stimulate mobile research, both on usage practices and on new user experiences. The lab placed no requirements on what users could or should do with the phone. While the lab did pay for the cost of acquiring the phone, the users paid for the monthly service fees, so they were also personally motivated to acquire a new smart phone. Although the participants represented users who tend to lead rather than lag the adoption curve, they presented an interesting opportunity to observe usage patterns. Our hope is that early investigation of the use of these devices will provide designers and developers with timely guidance in developing experiences for them.

At the time of our initial interviews, 17 participants had basic mobile phones, 6 had 2G iPhones, 3 had Palm Treos, and 1 had a Windows Mobile PDA phone. Of these participants, only the six iPhone users and one of the Treo users had data plans. The remaining 20 users had no data plans and did not access the Internet at all on their phones. One user actually went so far as to disable a phone button that accessed the internet to avoid the extra charges involved with accessing data on the phone. The participants with basic mobile phones primarily used them as phones: only nine of them used SMS and none of them had installed any applications.

Of that initial set of users, 21 decided to acquire a next-generation smart phone. Two users acquired T-Mobile G1s running Android (1 basic phone user, 1 Treo user), while the remaining 19 users acquired 3G iPhones (11 basic phone users, 6 2G iPhone users, 2 Treo users, 1 Windows Mobile user). The iPhone and G1 provide sufficiently similar user experiences that both sets of users reported behaviors that were largely indistinguishable. Thus, we do not separate their results except where explicitly noted.

METHOD

We conducted the initial set of interviews with the 27 participants who expressed an intention to acquire a next-generation mobile phone. In these interviews, we asked participants about their current computing devices and mobile phones, the mobile phone features they used, the situations or routines where they regularly used their phones, and their expectations of using their new phones.

We interviewed each participant again (the second set of interviews) at least two months after they acquired their new smart phone. Of the 27 initial participants, 21 actually acquired a new smart phone. During this interview, we walked through aspects of the user's new phone together, including applications they installed, their web browsing history, and their email inbox. We specifically instructed participants not to check email prior to their interview so that we could actually observe how they processed new messages using their phone. We also asked more broadly about how and in what circumstances they used the phone and how using the phone affected their overall tasks and usage of other devices. Although fewer participants completed this second set of interviews, we still reached a point of convergence on recurring themes in these interviews.

Table 1. Summary of iPhone and G1 application usage data among 21 participants. "Make time" means that users typically interrupted another task to use the application; "fill time" means that users typically used the application when not engaged in any other tasks. The count for each application type sums the number of applications of that type used by each participant.

Applications	# daily users	# weekly users	# monthly users	use varies	total # users	how usage fits with other tasks
Phone	12	2	-	-	15	make & fill
Maps	-	7	1	5	13	make time
Email	9	3	-	-	12	make & fill
Web browser	8	3	-	1	12	make & fill
Camera / Photos	-	6	3	1	10	make & fill
SMS	5	3	-	-	8	make & fill
Application Types						
Info seeking (e.g., browser, Maps, stocks, Yelp, Wikipanion, Shazam)	15	18	4	15	52	make time
Info- / Entertainment (e.g., digg, browser, NY Times, games)	12	8	4	4	28	fill time
Notes / Personal / Work (e.g., clock, calendar, WritingPad)	7	10	5	5	27	make time
Social networking (e.g., Fring, Facebook, Twitter, Linkedin)	4	5	2	1	12	fill time
Media (e.g., iPod, Pandora)	3	2	2	-	7	background

We used interviews as a way of eliciting participants' usage of their mobile phones without attempting to follow them wherever they used the phone or burdening them with keeping a diary. We leveraged traces of activity left on the phone (e.g., installed applications, web browsing history) and observed users managing some email on the phone to prompt recall of their overall phone usage. Each interview lasted 45-60 minutes. We divided the interviews among the three researchers, with the same researcher conducting the before and after interview for most participants. We conducted interviews in a participant's work office (except for a telephone interview with one remote participant). We combined our notes from these two sets of interviews into a single spreadsheet and analyzed the results, looking for patterns of behavior that were common across users or subsets of users. We present our resulting observations in the next section.

RESULTS

An overarching theme that emerged during our study was that context strongly affected mobile phone use, from when users interacted with them to what they did with them and for how long. The elements of context with the biggest impact were user's other devices and the places and situations that users encountered. In this section we first provide an overview of what participants used their phones for. We then describe how these elements of context affected use.

Overview of Phone Application Use

Acquiring a next-generation smart phone had a significant impact on how participants used their mobile phones. Participants who had not previously owned a smart phone went from never reading email or browsing the web on their phone to doing so daily. While specific uses varied, most participants used email, a web browser, and applications that filled specific needs. While the flat data rate mandated by the iPhone and G1 may partially explain this dramatic change in behavior, previous research suggests that the increased capabilities and maturity of the devices is a more likely explanation [4].

Table 1 lists the number of users employing the most commonly used applications on top and the total number of applications across users for the most commonly used application types on the bottom. We only list applications where participants explicitly described their usage frequency, so the reported counts under-represent the actual usage among participants. For example, only 15 of 21 participants mentioned using the phone for making and taking calls, but we suspect that all participants used their smart phone as a phone at least occasionally.

The applications that participants most commonly reported using included the phone maps, email, web browser, camera and photos, and SMS. Though usage frequency for an application is related to utility, participants also reported deriving great utility from applications they only used in specific contexts. For example, participants used applications like Yelp, maps, weather, and the clock most heavily while traveling. Though the maps application was used by most participants, no one reported using it daily: most (7) reported weekly use and several (5) used it

occasionally or when traveling. Still, many people highlighted it as a particularly useful application.

Though many phone applications were adapted from roughly equivalent desktop applications, participants also employed new types of applications. For example, Shazam allows users to identify any song they can record. Similar functionality on a desktop computer would not make as much sense, since people are more likely to encounter unfamiliar music outside of their home or office. Other applications enabling new uses included the Apple Remote (users controlled video and music playing on computers using their phone) and SnapTell (identified and provided information on products in photos taken with the phone).

Participants also installed applications that they later abandoned or never used. When explicitly asked about those applications, they gave the following reasons:

- I have not had a use for it / it was not useful (18 applications, including public transportation, travel assistance, Weather, and Skype applications).
- The application did not work well / as expected (11 applications, including speech and sound recognition and note taking applications).
- Technical / bureaucratic problems (6 applications, including a work email client, internet radio, blogging, YouTube, SSH, and calendar applications).
- Competing applications were better (6 application types, including internet radio, file sharing, audio recorder, web browser, PIM, and note-taking applications).
- I did not like it (4 applications, including YouTube, games, and notes applications).
- Various other reasons for one or two applications each, including that the application was too time consuming to use, it had usability issues, the user became bored with it, the need was highly contextual, and that the application depended on having friends online and no friends used it.

The existence of these unused or abandoned applications has several implications. Behaviors where users installed applications without having a clear need for them, to test them out, or that were only useful in a specific context (e.g., one user installed a bus application for use on a short-term trip) were enabled by keeping the time, effort, and cost thresholds for installing applications low. This low barrier-to-entry encouraged experimentation with new applications. Another implication is that applications in some categories have a great deal of competition (e.g., file sharing and PIM applications), such that users were willing to try various applications before settling on one they liked.

We also asked iPhone users how they discovered applications. All of them reported learning of applications from the iTunes App Store (this was most common for 9 of 19 participants), people they knew (most common for 5), and online articles, typically reviews or blogs (most common for 4). These results suggest the importance of word-of-mouth in discovering applications, an importance we expect to increase as the App Store grows and browsing for content becomes more difficult. We informally noticed many lunchtime and hallway discussions about iPhone applications within this local concentration of early iPhone 3G users.

Phone Use in the Context of Other Devices

Participants described usage patterns in which they employed their smart phones to complement (rather than completely replace) their full-featured desktop and laptop computers. Prior research (e.g., [2]) similarly identified complementary uses of multiple devices; we extend that work by explicitly identifying ways in which next-generation smart phones complement users' other devices.

Device Substitution

Our participants did report that they substituted their phone for other devices in some situations (e.g., they might carry their GPS or camera less often), but overall participants employed their phones as an additional device rather than as a replacement for one or more of their existing devices (with the exception of their previous mobile phone).

Sixteen participants reported that they rarely substituted their phones for their work laptops around their office or on business trips. Only four participants brought their phones to some meetings instead of their laptops, and only one did so on a business trip. However, nine participants did substitute their phones for their laptops on personal trips. We suspect that more participants would substitute their phone for their work laptop if accessing work email on their phone was easier, but we also note that work tasks tend to require producing more content than many personal tasks, suggesting that such substitution is unlikely to occur on a large scale. Rather than substituting one for the other, users employed both devices is complementary ways, as discussed in the next section.

Task Completion Across Devices

We observed that certain tasks were commonly completed using both mobile and full-featured devices. For example, users who read feeds or news sites sometimes deferred reading linked articles to their full-featured computers. As another example, participants tended to report using a phone email application more to triage email messages that they would later read and respond to on their full-featured computer. In this way, the smart phone enabled them to make progress on tasks that they would later complete on their full-featured computer.

This difference in the way participants used email on mobile and full-featured devices revealed a practice of deferring reading of email messages, which was suggested in previous research [9]. By observing users as they triaged their email during the study, we offer a concrete description of how email management was spread across devices. Users monitored incoming email, read selected messages, and only responded to messages requiring short replies on their

phone, but deferred reading and responding to many of their messages until they reached a computer. Some participants took advantage of the ability to synchronize draft email messages across devices by starting an email message on their phone and completing it on a computer.

Somewhat surprisingly, a few participants also deferred the completion of draft messages in the other direction, from computer to mobile device. For example, one participant wanted to send an email at a particular time, so she wrote the email message on her laptop, saved it as a draft, and at the appropriate time sent it using her phone. In another case a participant occasionally thought of email messages he wanted to send while engaged in other tasks on his laptop. Rather than interrupt his current task to write the message or wait and potentially forget, he would create draft messages on his laptop with a few notes and later complete and send the messages when filling time with his phone.

Another task that users completed across devices was shopping. Four participants reported using their phones to compare prices when shopping. In a number of cases these participants discovered cheaper prices online, yet rather than purchase the products using their phone's browser, they waited until they reached a computer. To justify this deferral, these participants expressed uncertainty over whether the phone's browser could handle all the steps of the purchase process. Whether the concern is truly over the browser's capabilities or is rooted in a concern that they would miss or mis-enter important details on the smaller screen, these participants preferred to wait and use their full-featured computers to complete tasks involving money.

Phone Use in the Context of Situations and Places

Because smart phones are typically carried with the user most of the time, the opportunities for using them are different than for desktop or even laptop computers. This portability introduces a wider range of motivations for using them (e.g., location-based tasks such as seeking nearby restaurants). Furthermore, the duration of using mobile devices out in the world is governed by the need to return to other demanding tasks (e.g., driving, paying attention to companions). In the following sub-sections, we discuss motivations for phone use, allocation of time to phone tasks amidst other tasks, and how traveling significantly changes usage patterns.

Motivations to Initiate Interaction with the Smart Phone

Participants used their phones for different reasons at different times, but we broadly observed five main motivators for initiating any particular interaction session. People typically used their phones when they wanted to: seek contextually relevant information, entertain themselves, accomplish a concrete task, maintain social ties, or maintain awareness of some information.

Seeking Contextually Relevant Information. All participants described situations where they needed information that was relevant to their current context, augmenting an observation from Sohn's earlier study of mobile devices [13] with more empirical details. In line with Sohn's categories of needs, the most commonly described use cases were looking up information about places they planned to visit soon (this often involved location-aware applications like maps or Yelp); seeking the answer to a question that came up in the course of a social interaction; and satisfying the user's curiosity about something in their current context. When a need for information arose, participants would typically put aside their other activities to try to meet that need. For example, several participants described pulling their car to the side of the road to look up directions.

A common theme among participants was surprise over how useful mobile Internet access was for finding information. Several participants echoed one's comment, "I can't imagine how I lived without it." These contextually-relevant information seeking use cases were qualitatively the most valuable for many of our participants.

Entertainment or Infotainment. After information seeking, the next most common motivation, reported by all but two participants, was to fill free moments throughout the day. People described free moments while waiting in line, waiting for someone they planned to meet, picking up children, and many other idiosyncratic scenarios (e.g., while helping their children brush their teeth, while walking to their car).

When such moments arose, participants described using their phone as a diversion to avoid boredom. They might read news, check email, surf the Internet, or generally consume information to amuse themselves (infotainment), or they might just play games (entertainment). The amount of time participants spent when entertaining themselves depended on the situation; they stopped when the free time ended (e.g., it was their turn in line, the person they were waiting for arrived). These interactions therefore ranged widely in length (one participant reported 20 minute interactions), but typically lasted just a few minutes or less. Participants noted that, after information seeking, infotainment / entertainment was the most valuable use for their phones.

Accomplish a Concrete Task. Participants described their phones as convenient devices for accomplishing concrete tasks while mobile. One participant referred to tasks involving the Internet that were not necessarily relevant in their current situation as "doing online errands." He described how he would commonly remember various online tasks while mobile. "Rather than try to remember to do it when I get back to my computer, if I happen to have a spare minute, I'll do it right then and there, so I don't forget to do something." This practice highlights another way that the phone complemented users' other computers, being available for online tasks or errands when the other devices were not. Participants described a variety of online errands,

such as online banking transactions, looking up credit card transactions, and sending email.

Other concrete tasks people did were more contextually defined. For example, one participant described recording his band practices so he could listen to them later when practicing on his own. Other examples of tasks specific to the current activity were geo-caching, taking notes or photos, displaying recipes while cooking, reading plot synopses while watching TV to catch up on missed episodes, comparing prices online while shopping, and recording bicycle routes while riding. Seven participants described using their phones in this way as a supportive tool for a primary activity. The phone augmented these tasks by providing in situ device support.

Maintain Social Ties. Being continuously connected to the Internet meant that participants could be continuously connected with friends, family, and colleagues. While previous research identified SMS and email as two mechanisms mobile phone users employed to maintain social ties [5,6,7], our participants used additional native applications like Facebook, Twitter, and AirMe.

For example, one iPhone user described looking at new emails whenever they arrived to check for Facebook notifications (since only the email, SMS, and phone applications push information to the iPhone, he used email to maintain awareness of Facebook). He commented that such email messages were not urgent, but "help him feel connected." This participant and one other reported using their phones rather than their desktop computers to maintain awareness of personal email, even when sitting at their desks. The other participant used her phone not only to "feed an addiction to email," but also to limit the amount of time she spent on personal email while at work (since responding was harder). This practice represents an alternate type of complementary use of email across devices.

Two additional participants reported checking and updating their Facebook status more often after buying their iPhones, since it was quicker and easier to do with the iPhone Facebook application than with a desktop browser. Only a few participants described periodically making time to maintain social ties with their phone; most participants instead reported social networking as something they did for entertainment to fill available time (as described above).

Maintain Awareness of Information. Some participants wanted to maintain awareness of certain dynamically updated information over a period of time (e.g., checking for email from remote collaborators, monitoring stock prices during a volatile market, monitoring new houses listed for sale in a particular neighborhood). They found their phones to be a great help for maintaining such awareness when away from their full-featured computers. Typically, the information being monitored was not contextually relevant, so their periodic updates occurred somewhat arbitrarily. Participants typically found free moments amidst their other activities to quickly consume the desired information.

While this motivator was not commonly reported, those participants who wanted to monitor information found the ability to do so while mobile invaluable. For example, one participant commented that the ability to maintain awareness of information using his phone freed him from his laptop and allowed him to spend more time playing with his children on evenings and weekends. Another noted his ability to provide a timely email response while walking in the parking lot from his car to his daughter's school.

Smart Phone Use When Filling or Making Time

Participants described both *filling time* between activities with their phone (e.g., reading the NY Times while waiting in line at a store), and *making time* during a current activity to use it (e.g., finding the closest post office while driving). These two use cases involved different applications and motivations.

Filling Time. Beyond confirming previous research identifying that users employ mobile devices to fill "dead" time [9,10,14], our study characterizes how they filled their time. Participants reported using their phones in the short intervals of spare time they encountered during the day. Prior to acquiring their phones, these waiting times would have largely been unused (or spent in thought). When filling time, participants largely engaged in low importance activities like entertaining themselves (17 participants) and explicitly maintaining social ties (6). We deduce that participants tended to make time for more important phone activities, thus leaving only low importance tasks undone when they had free time. We note that participants went to varying extremes when filling time: some reported only occasionally filling time (perhaps because they still valued using their free moments for other things), while others filled almost all free moments with phone usage.

The time participants spent using their phones when filling time depended on the contextual *counter-pressure*. Counter-pressures arise because people have a set of activities that are active or pending at the time they want to use their phone. They must therefore multitask their phone usage amidst these other activities. While the desire to use the phone puts some motivational pressure on the user, other activities exert counter-pressure, motivating the user to stop using it. Counter-pressure can be either external (e.g., a plane preparing for takeoff) or internal (e.g., guilt over using the phone rather than attending to one's children). The balance between the importance of the phone use and the counter-pressure for the current or pending activity is one factor in determining how long a usage session will last.

The counter-pressure for filling time was typically an externally dictated stopping point (e.g., the person they were waiting for arrived). The counter-pressures from such stopping points typically resulted in "hard stops" where

users had to cease using their phones quickly. However, since most phone uses while filling time were relatively unimportant, participants did not seem to mind hard stops.

Making Time. When the need or desire for information or action was particularly strong, participants would make time amidst their other activities to use their phone. Whether a user would interrupt her current activity and for how long depended on the importance of the phone task and the counter-pressure exerted by the interrupted activity. Seeking contextually relevant information and accomplishing a concrete task tended to be high importance and motivated participants to interrupt activities (e.g., several participants reporting pulling their car over to look up directions). Maintaining awareness of information was a less urgent task for participants, though they still reported occasionally making time during the day (e.g., one participant reported making small amounts of time available during his day to check email when waiting to hear from a colleague). While most participants maintained social ties when filling time, a few more addicted participants would make time.

When the importance of a phone task consistently outweighed the counter-pressure, participants would use their device until they satisfied their need. However, many counter-pressures gain strength over time (e.g., waiting friends become increasingly impatient), such that users may abandon tasks before completing them if the counter-pressure gains enough strength. For example, one participant who enjoys looking up information during discussions with friends would abandon his efforts if he could not find the desired information in a timely fashion. While tasks that caused users to make time tended to occur sporadically, we noted two cases where a few participants consistently made time to use their phones: routines and addictions.

Routines. Eight of our participants had routines where they would make time to use their phones after waking up or before going to bed. Participants described these routines as opportunities to get a sense of what they had to do on either that or the next day. Participants adopted these routines after acquiring their phones. These users explained that they would use their smart phone for such a task since it was more convenient and faster to initiate use than their computer, which was turned off or not at hand.

Information Addiction. Previous research suggests that some Internet users have information and web-based social interaction addictions they regularly feed [15]. Whether an addiction is major or minor, a smart phone makes it possible to feed it anywhere, anytime. While the majority of participants waited to read news or social network information until they had time to fill, three participants reported making time for these uses. They reported strong desires to keep up to date with those particular information sources. One of them described being surprised that he regularly checked his Digg application, despite never doing so before getting his phone. He commented that it is "slightly addictive and nice to have connectivity" wherever he goes. Continuous, quick and easy access to the Internet lowers the threshold for getting information so low that minor addictions may be easier to develop and are certainly easier to feed.

Length of Usage Sessions

Whether making or filling time, participants characterized most of their phone interactions as short, lasting for at most a few minutes. In part these short interactions derive from the fact that many activities participants engage in with their phones (checking the weather, Facebook status updates, their email inbox, etc.) do not require a significant amount of time. Counter-pressures also contribute to shortened interactions by constraining the time that users have available.

While the user's situation affected the length of a particular interaction session, the availability of users' other devices also played a significant role. When choosing among their devices for accomplishing a particular task, participants appeared to balance access and initialization times against the required work time.

Access time is the time required to physically access the device. For phones, this is the time to retrieve the phone from a pocket (for most users). For computers, this time is more variable, ranging from nearly zero (when the user is sitting at the computer) to hours or days (when the user is traveling).

Initialization time is the time required to reach a point where the user can perform a desired task. This time includes the time to boot the device (if it is not running) and to start the application or service. For phones this time is around 4-5 seconds for native applications (assuming the phone is already running, which was usually the case). Mobile web applications typically take longer (10-20 seconds) because of the time required to start the application (e.g., a web browser) and access the desired content (e.g., a web site). The initialization time for full-featured computers tends to be longer, ranging from seconds (if it is running) to minutes (if it is not).

Work time is the time required to complete the task. For both phones and computers, work times range from seconds (e.g., checking the weather) to minutes or even hours (e.g., composing an email message or a blog post). In most cases, the work time for a comparable task is shorter (often significantly shorter) with a full-featured computer than with a phone because of the more capable input and output mechanisms computers provide.

We observed that interaction sessions tended to be short on phones in part because participants attempted to optimize their interactions by choosing the device that would allow them to complete a task more quickly and easily. For example, all participants reported consuming content on their phones. Consuming information is quick with a phone because the access and initialization times are minimal, and the work time in many cases is about the same for a phone and a computer (Figure 1a). As a result, participants would consume information on their phone rather than waiting until they reached a computer. In some cases participants even reported using their phone to consume information when a computer was readily available. For example, one participant reported using his phone to check his calendar even though he was standing in front of his (running) laptop because he thought that the calendar application would start more quickly on his phone. Other participants reported checking email and browsing the web on their phone at home because they thought it would be faster (and less disruptive) than walking to another room to access or retrieve (and potentially boot) a computer.

In contrast, most participants reported that they avoided producing content on their phones. They would produce content only if they could do it quickly (e.g., short email messages, status messages, taking and sharing photographs), but in general they described producing content as too difficult and time consuming. Participants instead deferred most tasks that required producing content to their computers, where the more efficient work times compensated for the longer access and initialization times (Figure 1b). Participants did report using their phones to produce content in certain circumstances, such as when traveling, where the access times for a computer were significantly longer (e.g., when the computer was back in a hotel room).

This division of interactions into access, initialization, and work times explains other behaviors. Many participants used native applications for tasks that they could also accomplish using a web application (e.g., finding information in Wikipedia). This preference for native applications can be explained in part by recognizing that initialization times are usually shorter for native than for web applications. Work times are also often shorter for native applications because they can avoid the latency of requesting and receiving web content after user actions.

We also observed that 14 of our 19 participants with iPhones opted not to access work email from their phones when their company made that capability available, despite nearly all of them mentioning the desire for such a capability during their initial interviews. The reason was that the company instituted a security policy whereby users accessing work information on their iPhones had to configure them with an eight character alphanumeric password, forcing users to authenticate in order to use their phones. This "authentication tax", when added to the initialization time, was significant enough that most users described it as a "showstopper" and gave up on accessing work email from their phone.

Traveling Changes Everything

Participants reported that their usage patterns changed significantly when traveling, highlighting the impact of place and task on phone usage. Nine of our participants traveled about 1-2 times per month, eight traveled about 4-9 times per year, eight traveled about 1-3 times per year, and travel varied for the remaining two participants. During these travel times, participants produced more information (e.g., emailing to coordinate with friends, blogging about their trip), and they consumed different types of information (e.g., restaurant reviews, flight information). Nine participants reported bringing their phone instead of their laptop on personal trips and satisfying all their information needs with it: getting directions (maps), finding restaurants (Yelp and maps), coordinating with others (phone, SMS, email), checking in for flights (browser), sharing photos (camera), and keeping in touch with people back home (email, phone, blog).

DISCUSSION & DESIGN IMPLICATIONS

An overarching theme that emerged during our study was that context affects nearly every aspect of next-generation mobile phone use, from when participants employ them to what they do with them. In short, "no smart phone is an island," but rather they are used in the context of other devices, tasks, and places.

Though we set out to study mobile devices, we also learned how they "share the stage" with the other computers. This leads to tasks being distributed among smart phones and full-featured computers. Previously, when mobile phones had limited functionality, they performed functions that

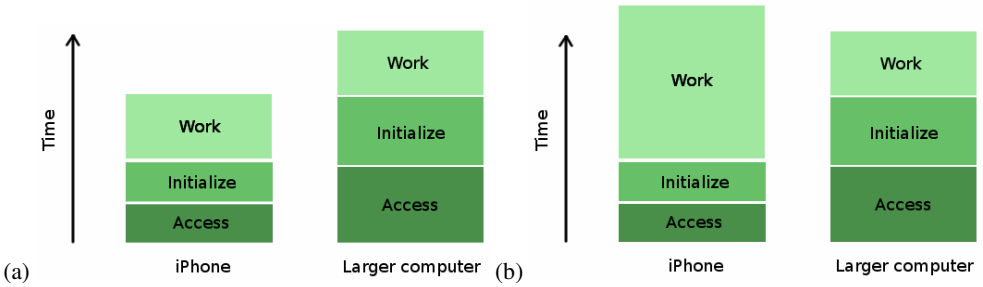

Figure 1. Phone vs. larger computer (a) consuming information, (b) producing information.

were *distinct* from computers. People used phones to make phone calls and computers for a wide range of productivity, information gathering and processing, and textual communication needs. Now that phones are becoming more capable, their capabilities overlap and users' tasks are beginning to span their phones as well as their desktops and laptops. Our observations suggest that it is not a question of mobile phones replacing full computers but of being used in concert with them. As a consequence, the design implications from our study are relevant both for mobile applications and for the desktop applications that they complement.

- *Be careful transferring user experiences from larger devices.* Our results suggest that while some usage patterns are the same across mobile and desktop devices, in other cases users employ applications in different ways. For example, users tend to monitor their inbox on mobile devices more than they read and respond to messages, suggesting an opportunity to design specialized mobile email clients.
- *Provide support for transferring tasks between devices.* Because users defer tasks from one device to another and sometimes substitute using one device for another, applications should support capturing task state, transferring it between devices, and seamlessly resuming tasks. Mobile email applications that support starting a draft message on one device and completing it on another are one example. However, we are unaware of any email application that, for example, allows users to capture the actions they *intend* to perform on received email messages on one device (e.g., reply, save, print, schedule a meeting) and then view and complete those actions on another device. Prior research has identified a similar need for transferring data across devices [2,9] and even suggested approaches toward meeting it [11]. Helping support users as they triage their email on a mobile device, so that they can follow-up with more detailed reading or other actions on their computer, suggests opportunities for coordinating the user experience among mobile and other computing devices.

We observed that mobile smart phone use must either interrupt or fit between other ongoing tasks. This usage contrasts with that of full-featured computers where users typically dedicate their attention to the computer with relatively occasional interruptions by other tasks and people. Instead, phone use is driven by other tasks: its goal is often inline with the goals of ongoing tasks (e.g., seeking contextually-relevant information), it involves making time amidst tasks or filling time between tasks, and it is kept short to minimize interruption of the surrounding context. This leads to design implications for enabling partial progress actions, abrupt task switching, and quick initialization times.

- *Provide support for partial progress on tasks.* Our participants reported that most interactions lasted at most a few minutes. Applications with tasks that may take longer should break tasks into smaller work units so users can make incremental progress when time permits. Email applications that allow users to incrementally compose messages are one example: they provide an explicit folder for draft messages and display how many partially completed messages it contains. Other applications could similarly aid users by introducing partial actions users can incrementally complete. For example, a contacts application could allow users to enter a small amount of information for a new contact and flag it as partially complete. Upon subsequent access, the application could display the number of incomplete contacts and provide shortcuts for editing them.
- *Support smooth interrupts.* Users should be able to quickly stop using an application at any point without losing their work. Native applications tend to be better at providing smooth interrupts because developers can explicitly handle these cases, but support for offline data in HTML5 means that web applications should also be able to support users who must interrupt their use.
- *Minimize initialization time.* Our participants' aversion to a security policy that adds ten seconds to initialization time suggests that developers should actively work to minimize it. While making work time more efficient (e.g., increasing the input/output capabilities of mobile devices) is obviously advantageous as well, slow initialization times tax all interactions, even those with short work times.

Finally, our results highlight the particular importance of non-routine places, as when a user travels.

- *Recognize that usage patterns change in non-routine situations.* Our results suggest that users employ their phones differently when traveling. Designers should carefully consider how our results and implications apply if their use cases suggest that their users will be in non-routine situations (such as traveling) where they are likely to act differently than the typical usage patterns we outlined. This may suggest "bundles" of applications that are relevant for the specific travel destination (such as local weather, news, public transit schedules, events). Furthermore, the mobile device might be able to recognize being in a travel context and tailor the mobile user experience toward capabilities that are used more extensively when traveling.

CONCLUSIONS

Next-generation mobile phones such as the iPhone 3G and T-Mobile G1 are changing how users consume and produce information. Our study of 21 users from a corporate research lab provides empirical observations of initial usage patterns of such phones. These observations lead to design implications not only for the mobile devices, but toward creating integrated user experiences that span the mobile and other computing devices with which users typically interact. Documenting these early user experiences is

important to guide the development of new, more effective user experiences.

As the deployment and usage of next-generation mobile devices continue to evolve, we must continue to study how usage patterns change over time. While the consumer marketplace fuels a rapid iteration of technology development and use, reflective research on emergent use practices is also an important dimension of the overall design process. Beyond focusing solely on mobile devices, we must explore how to build effective and enjoyable user experiences for the whole ecology of computing devices that are used in mobile, office, home, and other contexts.

Our observations also raise the larger issue of the impact of using smart phones to fill time, thus displacing reflective thought, stillness, or solitude. We should not assume that such displacement is positive or even neutral in the overall life experience. With the advent of next-generation mobile devices that enable users to be connected anytime, anywhere come new challenges for balancing users' need to at times avoid distractions and disturbances.

REFERENCES

1. Bellotti, V., Begole, J., Chi, E., et al. "Activity-based serendipitous recommendations with the Magitti mobile leisure guide." *Proc. of CHI 2008*. 1157-1166.
2. Dearman, D., Pierce, J. "It's on my other computer!: Computing with multiple devices." *Proc. of CHI 2008*. 767-776.
3. Dearman, D., Kellar, M., Truong, K.N. "An examination of daily information needs and sharing opportunities." *Proc. of CSCW 2008.* 679-688.
4. Gebauer, J. "User requirements of mobile technology: A summary of research results." *Information Knowledge Systems Management*, v. 7 n1,2, 2008. 101-119.
5. Grinter, R.E., Eldridge, M. "wan2tlk: Everyday text messaging" *Proc. of CHI03*. 441-448.
6. Ito, M., Okabe, D. "Technosocial situations: Emergent structurings of mobile email use", Ito, M., Okabe, D., Matsuda, M. (eds.) *Personal Portable Pedestrian: Mobile Phones in Japanese Life*, 2003, 257-273.
7. Miyata, K., Boase, J., Wellman, B. "The social effects of Keitai and personal computer e-mail in Japan." Katz, J. (ed) *Handbook of Mobile Communications Studies*, 2008.
8. Oulasvirta, A., Tamminen, S. Roto, V., Kuorelahti, J. "Interaction in 4-second bursts: The fragmented nature of attentional resources in mobile HCI." *Proc. of CHI 2005*. 919-928.
9. Oulasvirta, A., Sumari, L. "Mobile kits and laptop trays: managing multiple devices in mobile information work." *Proc. of CHI 2007*. 1127-1136.
10. Perry, M., O'hara, K., Sellen, A., Brown, B., Harper, R. "Dealing with mobility: Understanding access anytime, anywhere." *ACM TOCHI.* 8, 4, 2001, 323-347.
11. Pierce, J., Nichols, J. "An infrastructure for extending applications' user experiences across multiple personal devices." *Proc. of UIST 2008*, 101-110.
12. Sadler, K., Robertson, T., Kan, M., Hagen, P. "Balancing work, life and other concerns: A study of mobile technology use by Australian freelancers." *Proc. of NORCHI'06*. 413-416.
13. Sohn, T., Li, K.A., Griswold, W.G., Hollan, J.D. "A diary study of mobile information needs." *Proc. of CHI 2008.* 433-442.
14. Tamminen, S., Oulasvirta, A., Toiskallio, K., & Kankainen, A. "Understanding mobile contexts." *Personal and Ubiquitous Computing, 8* (2), 2004, 135-143.
15. Young, K. "Internet addiction: The emergence of a new clinical disorder." *CyberPsychology and Behavior, 1* (3), 1996, 237-244.