Insights from Wearable Computing on Research for Mobile User Experience

Kent Lyons
Intel Research
2200 Mission College Blvd.
Santa Clara, CA 95052 USA
kent.lyons@intel.com

Abstract
In this paper we discuss issues related to the evaluation of mobile computing user experience. Drawing inspiration from the evaluation of wearable computing, we present two case studies using empirical lab methods for evaluating key aspects of a mobile experience.

Keywords
Methodology, mobile computing, wearable computing

ACM Classification Keywords
H5.m. User Interfaces: Evaluation/methodology

Introduction
Mobile computing has many attributes that make mobile interactions very compelling; however, these same attributes create a very challenging environment in which to conduct rigorous research. Mobile computing traditionally has relatively impoverished I/O devices but presents a rich opportunity for novel I/O and interaction technologies. There are extremes in usage patterns with the potential for individual interactions to last from a sub-second burst to multiple hours. There is also the potential for developing very intimate bonds with mobile devices such that the perceived lifetime of an interaction may be meaningful over many years. Mobile technologies are used in isolation and in conjunction with other technologies, and both by an individual as well as in social settings.

In order to effectively conduct research in this domain, we as researchers must understand the potential impact of these extreme conditions. Researchers must understand and predict the current and future technological capabilities and understand which are innate and which are changing. Likewise, it is import to understand how mobility and issues of time scale, among other factors, might impact the user experience.

As a result, a key challenge for mobile user experience research is: what should be studied and how? In our work, we have drawn significant inspiration from wearable computing. While the academic prototypes of

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the past decade are unlikely to become mainstream mobile platforms, they do provide a mechanism to explore the edges of mobile computing and to understand some of the fundamental characteristics that impact mobile user experience.

The author spent many years using a wearable computer in his daily life and interacting with others doing the same. In formative work, we produced a case study designed to gain insight into wearables [6]. This data was collected by instrumenting the computer to log data (screenshots) and was a lightweight version of a previous system we built for mobile evaluation [5].

Through those experiences with the everyday use of wearables it became obvious that there are many aspects of human psychology, of mobility and of the devices themselves that are critical to wearables, but more broadly, we believe, to mobile computing.

For example, some wearable computer users are able to effectively use their computers as a tool to "augment" a face to face conversation with another person [6]. This exemplifies a broader ability for wearables to be used anywhere, anytime (e.g. actively used while running down a flight of stairs, or while walking through a doorway). These examples provide evidence that the I/O devices of the wearable provide some interesting affordances (different than other mobile and non-mobile interaction technologies). Similarly, there were some aspects about the wearable that enable very fast interactions, but also the ability to effectively utilize information captured many years before on the same device. These insights lead to a broad set of questions related to how and why wearables can be used in these ways.

In an effort to begin to understand some of these phenomena, we have conducted a series of empirical studies designed to gain insight into some of these important factors. Overall this is rather representative of our current approach for investigating mobile computing research: find a set of technologies or situation that either works well (or poorly) in a mobile computing context, hypothesize the critical factors leading to that state, and (try to) empirically investigate those phenomenon in the lab. This strategy has worked well for some research questions, but is unsatisfactory for others.

Case Study: Mobile Text Entry

The study of mobile text entry is rather well suited for studying empirically in the lab. The critical issues here are to understand the relative differences between different text entry methods. Standard techniques and methods for conducting this type of research have been developed and for the most part adopted. This facilitates the comparison of entry methods between different studies. For the most part these studies either provide insights into novice typing rates, or with longitudinal evaluations, maximum obtainable rates. These evaluations have shown, for instance that the Twiddler chording keyboard works very effectively for expert users, while mini-qwerty keyboards offer much faster novice performance and a much quicker learning curve [2,7]. One potential issue with these laboratory studies is that they are rather lacking in external validity and do not take into account the effects of typing (or learning) in more realistic settings. As a result, they often represent best case scenarios. These data are useful, but it is also not completely satisfying.

To this end, we extended the evaluations to include at least one key aspect of more realistic mobile settings, the impact of visual attention. In the laboratory we used our expert mobile text entry typists and experimentally manipulated visual feedback. These studies showed one of the key differences between the Twiddler and mini-QWERTY keyboards. The Twiddler condition was just as fast and as accurate with or without visual feedback. Mini-qwerty typists on the other hand suffer from a considerable increase in error rate that does not recover significantly, even with additional practice [3].

Together, this sequence of evaluations show that some aspects of mobile user experience can be studied effectively in the lab, and furthermore, even some key issues of mobility can be considered even in a traditional static laboratory setting.

Case Study: Access Time

A second factor arising from direct experience with wearable computing was the indication that very short durations of time could have very important impacts on user experience. The Twiddler studies indicate that the ability to rapidly enter text is a key advantage, and is likely a contributing factor in a wearable user's ability to effectively use the device in many mobile settings where the real world took priority over the virtual.

Anecdotally, we suspected access time, the time to get out a device and get it ready to use, was also a critical factor and a key differentiator between the idealized usage of a wearable and a more traditional mobile device. Here, we again used a laboratory study to gain insight into this potential user experience factor.

In our Quickdraw work [1], we explored the time required to gain access to a mobile device placed on different parts of the body: in a user's pocket, worn on a holster, or mounted to the wrist similar to the wristwatch. The results showed, not surprisingly, that the watch offered the fastest access by a wide margin. More surprisingly, the holster had the worst performance (pointing out another issue anecdotally argued for by wearable users that the design of the clothing is at least as important as the design of the technology). It also showed that in the pocket condition the actually spent a large part of the access time inside the pocket, presumably with the user fumbling around trying to retrieve it. Building off the keyboard work, we decided to add a lab based mobility condition to this study, hypothesizing that mobility would have a strong detrimental effect. Surprisingly, it did not. Our experimental design did not provide insights into why it did not, but clearly this indicates another challenge for mobile researchers and the design of these experiments. Is it important to include a mobile condition in your study design? Adding additional factors to an experimental design is quite costly along many dimensions, but additional mobile factors may or may not significantly alter your findings.

Another more fundamental issue with this work is motivating the premise that seconds do matter to the experience of a mobile computing user. One can try to persuade others that this is an important factor; however, there is little direct empirical data showing the importance of saving those seconds. Furthermore, it is not entirely clear how one would go about collecting such data. There is also a similar argument to be made about other aspects of mobile computing. Intuitively in many situations, one handed use is better

than two handed use (for instance the Twiddler vs the mini-qwerty, or the research conducted by Karlson *et al.* [4]). And maybe, hands free is even better than one handed. However, there is not a body of literature to directly motivate such arguments, nor is it clear how to proceed in collecting empirical data to make such arguments. Furthermore, traditional lab based (or even studies in the field) are probably ill suited given the fleeting nature of many interactions. It is an open question as to how to assess the potential impact of technologies designed to leverage the affordances of mobile computing.

Conclusions

These examples provide some evidence that lab based studies can be effectively used for understanding some key aspects of mobile computing. While they may lack in external validity, many of the effects we are studying can still be identified with careful research.
Furthermore, since the field is still young it is relatively easy to make use of these types of evaluations. As we move into areas with effects that are more subtle, it will be more challenging to apply these methods. While they will likely continue to be extremely valuable, there is much room for methodological improvements.

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