

Making Local Information More Accessible: A Diary Study of Information Channel Selection of Mobile Users

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ABSTRACT

The mobile Web has been a dominant channel for mobile users to fulfill information needs. Mobile users, however, also use other information channels such as the environment and personal sources. Through a 14-week exploratory diary study with ten mobile users, we found *uncertainty with the accessibility* of target information in an information channel to be a significant barrier for mobile users in using that channel to address an information need. This barrier is especially apparent when the information to be sought is for an upcoming activity or plan. In addition, we found that local infrastructural information such as information of services, resources, and directions within a specific point of interest was often perceived inaccessible or difficult to access on the Web, resulting in mobile users often preferring to use other information channels to obtain the information. We provide an explanation of the impact of such uncertainty using the cognitive maps framework from environmental cognition, and provide design implications on how Ubicomp systems can make local infrastructural information more accessible to mobile users.

Author Keywords

Mobile, information seeking, user behavior, information channel selection, diary study, uncertainty, cognitive maps

ACM Classification Keywords

H.m. Information Systems: Miscellaneous

General Terms

Design, Experimentation, Human Factors

INTRODUCTION

Thanks to advances in mobile technology and increased access to the mobile Internet, the mobile Web has become

an important channel for mobile users to address information needs. While Sohn et al. [27] reported mobile users using the mobile Web 73% of the time to address information needs, a similar investigation by Heimonen [19] with active and experienced mobile users reports that 94% of the time active users utilize the mobile Web to address information needs. In recent years, there has been an increasing interest among the Ubiquitous Computing (Ubicomp) community in creating an intelligent and context-aware service [20] to provide information support to mobile users based on their current contextual condition. For example, when a user is detected to be proximate to a certain area, he or she could be prompted by a nearby device with information that is related to his or her current location and/or activity. While there has been a significant amount of effort devoted to creating such an environment, it is important to consider what kind of information support is valuable for such a service to provide, given that nowadays mobile users have become accustomed to using mobile phones (mobile apps, mobile browsers) for addressing their information needs.

In a recent study, Church et al. [7] suggested that mobile phones are used for searching various types of information, but also reminded us that mobile users also use other means to address information needs, depending on the type of needs that they want to address. For example, mobile users often *ask people* when the need is personal; they also often look at street signs when navigating in the environment. Much early research studying information channel and source selection suggested that factors including proximity [12,26] and information quality [21] of, and the personal comfort [12] with an information channel can all affect people's information channel selection. However, these early studies were conducted in the workplace setting, where the contexts under which information needs arise can be quite different from the contexts in the mobile environment. Thus far, it has not been clear in the mobile environment when and why a particular information channel might be considered limited and insufficient for addressing a specific type of information need(s). In this paper, we aim to gain insights into this question, and hope to identify the information support that a Ubicomp system can and should provide to assist mobile users in obtaining desired information.

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With such an aim in mind, we conducted a diary study with 10 smartphone users to investigate how they utilized different information channels to address their information needs in the mobile environment. In particular, we investigated in depth the moments at which the users found difficulty addressing information needs, and at which they were concerned about using a certain information channel to address their information needs. We sought to understand the contexts under which these moments occurred, and attempted to uncover reasons behind the difficulties and concerns mobile users had with/when using a particular information channel to address an information need.

Because the aim of the study was to understand when a specific information channel is chosen over others, our analysis focused on the information needs that are feasible to address via different channels. We specifically chose *environmental* information needs [15] as the focus, which are related to the elements and the activities occurring in the physical environment (e.g. finding local services, looking for direction, finding products in a store, etc.), and are addressable by attending to the physical environment, asking people, or using mobile phones, so that we could analyze why a user would choose one channel over the others.

Through a 14-week diary study with follow-up debriefing interviews, we identified that our participants' choices of information channels for addressing environmental information needs were largely affected by their *familiarity* with the channels. In particular, when participants were unfamiliar with a channel, their *uncertainty with the accessibility of target information* became a (large) barrier preventing them from using that information channel. This concern was especially apparent when the target information was sought for an upcoming activity or plan for which the users perceived a time constraint. Moreover, we found that local infrastructural information such as information about resources and services of a specific local point of interest (POI) was often perceived to be inaccessible or difficult to access on the Web. We discuss our findings with a theoretical framework called *cognitive map* [25] and provide design implications.

RELATED WORK

Studying Mobile Users' Information Needs

Prior to this work a number of studies have sought to understand mobile information needs and how these needs are influenced by contextual factors. Time, location, activity, and social contexts were found to have an impact on mobile users' information needs, intents behind the search, and mobile application usage [4,6,8,9,19,29]. In addition, Sohn et al. [27], Heimonen [19], and Church et al. [7] have investigated how mobile users actually address information needs. While Sohn et al. [27] reported mobile users' decisions of *when* to address information needs, Heimonen [19] and Church et al. [7] suggest that the way in

which mobile users address their information needs is affected by the topics of the information they are seeking. Chua et al. [6] showed that the perception of mobile phones and information needs affect users' mobile phone use. Amini et al. [2] found that mobile users collaboratively used multiple devices for local search. While many of these prior studies have suggested the way in which mobile users address an information need in general, we further investigated the in depth reasons behind the decisions to use or not to use a particular information channel, which allowed us to identify the impact of *uncertainty* on choosing an information channel.

Studying Information Channel and Source Selection

Researchers in information science, communication studies, and organizational studies have studied the information channel selection phenomenon for many years. The principle of least effort and cost/benefit analysis are two well-known frameworks for analyzing this phenomenon [18]. Literature has suggested that factors including task urgency [1], accessibility [12,26], information quality [21], and personal comfort [12] have an impact on the selection of information channels. However, these studies were conducted in the workspace and organization setting (e.g. in a library, company, university). In the mobile environment, the scope, activity and social contexts, and the availability of technology are different from those in the workspace setting. Thus, the question remains: to what extent do these factors impact how people select an information channel in the mobile environment?

To the best of our knowledge, this study is the first empirical and in depth investigation focusing on how mobile users address environmental information needs using different information channels. The main contributions include 1) identifying the impact of *uncertainty* on mobile users' choice of an information channel for addressing information needs, and 2) identifying the extent to which local infrastructural information, such as information of resources and services of a specific local POI, is often perceived to be inaccessible or difficult to access by mobile users while on the go. In design implications we provide suggestions as to how Ubicomp systems may address this issue.

METHODOLOGY

We conducted a 14-week diary study followed by debriefing interviews with 10 smartphone users who actively used their phone for searching information. Earlier studies have demonstrated the validity and effectiveness of using diary study for investigating mobile information needs (e.g., [6,8,9,19,22,27]).

Participants

Eleven active smartphone users were initially recruited for the study via the first author's social network (5 female, 6 male). One user dropped out from the study due to personal

reasons. His data were hence not included in the analysis. Occupations of the users included engineer, designer, graduate student, salesperson and flight attendant. Participants' ages were between 25 and 30 years old. All participants have used their smartphone over two years, and more than three times per day. All participants were native Chinese speakers, who participated in the study in three locations during the study: Michigan (4), California (3), and Taiwan (3).

Procedure

The study consisted of diary entries, an introductory interview, and a debrief interview. In the introductory interview instructions were given to the participants and demographic and smartphone use information was collected. Each participant was asked to use a specified mobile journal application called Catch Note¹ and instructed on its use to record their diary entries. Catch Note allows users to create diary entries with text, photos, and voice recording. It also provides a Web interface for users to review and edit their diary entries online. We asked participants to record a diary entry whenever they used an information channel to obtain information while they were anywhere except at home or at work. We reminded participants to pay special attention to instances of seeking information from the environment, because we assumed that such instances might be performed less consciously. To help the participants better understand how to answer the prescribed questions, we walked them through examples of using the environment, personal sources, and mobile phones to address an information need.

In each diary entry, we asked participants to take a photograph that best represented their current context using Catch Note, and to record a voice memo to describe: a) what information they were seeking, b) why they sought the information, c) where they were and their familiarity with the place, d) whether they successfully obtained the information and why, and finally e) why they chose one information channel rather than others. While the first four questions indicated the context under which an information need arose, responses to the last question displayed participants' own assessment of different information channels for addressing their information needs at that moment, which might also directly or indirectly indicate their concerns with using a particular information channel in that context.

In the debriefing interview we asked clarification questions about incomplete or ambiguous diary entries. Participants' capture of photographs and voice memos were done for two reasons. First, photo and voice capture were presumed to be less burdensome than text entry. Voice memos particularly allowed participants to explain in more detail about each information seeking instance. Second, these media types are

All	Number	Percentage
Mobile App	48	20.6%
Mobile Browser	97	41.6%
Online Map	46	19.7%
People	20	8.6%
Environment	19	8.2%
Printed Document	3	1.3%
Total	233	100.0%
Environmental		
Mobile App	28	20.3%
Mobile Browser	37	26.8%
Online Map	41	29.7%
People	13	9.4%
Environment	17	12.3%
Printed Document	2	1.4%
Total	138	100.0%

Table 1: Frequency of Information Channel Use

well suited to helping participants recall details during follow-up interviews [5]. Nevertheless, we allowed participants to provide textual input if they preferred to do so. Some participants reported that they occasionally entered a few keywords first to remind them what to report when they recorded a voice memo later.

All voice memos were transcribed and shared with participants. Because we instructed participants to report in the language they felt most comfortable with we obtained voice memos in both Chinese and English. Entries in Chinese were transcribed and translated into English by the first author, who is a native Chinese speaker. Both interviews and diary entries were coded and analyzed using an iterative process of generating, refining, and probing emergent themes. The coding themes were focused on the topics of information needs, how the needs were triggered and addressed, and most importantly, the reasons and concerns behind the decision to use and not to use a particular information channel. Through this approach, we were able to identify when, how, and why participants chose a particular information channel at certain moments.

RESULTS AND FINDINGS

Our study took place between February 11th, 2012 to May 31st, 2012, during which time participants generated 212 diary entries (min = 3, max = 43, avg = 21.2, standard deviation = 13.96). Of the 212 diary entries, the most frequently sought topics of information were: direction and location (25.0%), trivia (23.1%), points of interest (17.5%), local services information & review (15.2%), and entertainment (8.0%). Although we had a small number of participants, the distribution of topics was similar to those in previous studies [27][9]. All participants had recorded their diary entries in familiar as well as unfamiliar environments.

¹ <https://catch.com>

Channels to Obtain Environmental Information

The frequency of the use of information channels emerging from the data is shown in Table 1. Eighteen out of 212 diary reports involved using at least two information channels, resulting in 233 information channel uses in total. Participants used multiple channels when they failed to obtain information from the first channel they chose, or when they wanted to validate and to compare information obtained via multiple channels. Among the 212 entries, 123 entries were searching for environmental information, resulting in 138 information channel uses. As expected, predominantly mobile phones (including mobile browser, mobile applications, and online maps) were used for all information needs (82.3%) and for environmental information needs (77.4%). From the opposite perspective, this also indicates that there were 22.6% of entries in which participants chose not to use mobile phones to satisfy environmental information needs. These instances suggest moments when mobile phones were less preferred or considered limited.

Among the diary entries categorized as environmental information needs, participants often used online maps to search environmental information. Specifically, mobile applications (20.7%) were used to search more narrowly for restaurants, movies, entertainment options and topics on a forum. Participants reported that mobile applications provide focused and detailed information about particular places. Participants often *asked people* when the target information was related to personal experience, mostly related to directions & instructions (9 out of 13), and specific knowledge of a particular place (4 out of 13). Finally, as expected, the physical environment (e.g. signs, street, store) was primarily used for addressing environmental information needs (17 out of 19).

Reported Reasons for Choosing an Information Channel

Participants reported various reasons for choosing an information channel. For diary entries that were ambiguous or unclear, we let participants see their entries and add more explanation. The most commonly reported reason was *efficiency*. All participants reported that they had chosen an information channel because it was the fastest way. For example, P2 thought that he could quickly obtain traffic information through the Maps app, saying: *"I chose Google Map because I can quickly see the traffic condition later."* This applies to all information channels. For example, despite the wide access to mobile Web, some participants believed that it was faster for them to obtain information through the environment, saying: *"I will pass by [the library] anyway so I just came over and see [the operation hour]. Besides you have to spend a long time to look this up on their website."* (P5)

Another frequently reported reason is *habit*. Participants often reported that they chose an information channel because they were used to it. For example, several participants reported that they always used Yelp to search

restaurant-related information; many participants also reported that they had used an online map to search location and direction. P5, in particular, indicated that he was used to looking for event-related (e.g. concert, musical) information on a bulletin board in a coffee house: *"Actually, I can also see this information from other sources. Just like this one I can also see it in other places. But I'm just used to coming here and seeing it [bulletin board]."* However, he further explained that he was unsure what keywords to use to search the same information. The bulletin board was a place where he could see various flyers of events and according to him, there was no website that allowed him to see a group of events together.

Another reason related to efficiency is *it's the only way*. That is, participants sometimes thought that there was no other information channel than the one they used for addressing their information needs. For example, P5 used a mobile travel application to search for attractions he should visit in the city he was visiting. He had originally expected to see a physical map in a subway station, but when he did not see any such map, he decided to use the application to search for attractions. *"So, why did I use my phone? One reason is that I'm already in the station. Plus, I did not see any physical map or a bulletin board [in the station]."* However, P5 did not attempt to find an attendant to ask. It was likely he perceived that there was no attendant nearby, and thus thought that his phone was the only way, or, a more efficient way, to obtain the information.

Finally, *information quality* and *personal comfort* were another two reported reasons. Aspects of information quality reported by participants included accuracy, precision, and richness. For example, P10 searched on Google Maps because he wanted to know the more precise location of a place. He reported, *"I like to be specific and get the address so I didn't ask other friends."* He further added, *"Another friend told me he went to Adam's Morgan in Pittsburgh so I looked it up with my smartphone. Even though these two friends tried to tell me the location of these places, I still look up these places on my own to see the exact location."* In another example, P8 wanted detailed information about a restaurant so that she could find a good restaurant, *"...the clerk at most said something about what restaurants are open there. I can easily get that [information] by just checking the floor directory. What I want to see are real pictures and reviews."*

Personal comfort refers to participants' comfort with using an information channel. Participants mostly did not report "comfortable channels," but rather, information channels they felt uncomfortable with. The discomfort sometimes came from their perception of the social appropriateness at that moment, or was because of their unfamiliarity with the information channel. For example, P5 felt it "weird" to ask directions from a busy attendant without buying a ticket. Because of this concern, he decided to use his phone. *"I saw an attendant there, but he is not like a policeman and I*

could not go and ask. I mean, he was busy selling tickets, and there was a long line. I would not wait in the line just to ask directions and not buy a ticket. It was weird, so I just checked on my phone.” (P5)

Uncertainty with the Accessibility of Information

In the previous section, we presented various reported reasons from participants regarding why they addressed their information needs through a certain information channel. However, as mentioned earlier, we are particularly interested in the moments at which a user decided *not* to use an information channel, because by identifying these moments we may uncover the gaps between information channels and participants’ needs. As a result, we further investigated the entries in which participants reported difficulties, concerns, and hesitance in using an information channel.

What we found recurring and emerging among participants’ difficulties and concerns, is the *uncertainty* that participants felt with the accessibility of the information in an information channel. Usually this then hindered them from using that information channel to seek information. Researchers in information science have assigned *accessibility* of information various notions (e.g. [10,12]). A commonly used notion is *access difficulty*—the time and effort required, and the difficulty encountered in reaching a particular information source [1,10,12]. In our study, when participants were uncertain with the *time* that they would need to spend to obtain the target information via a particular information channel, or were uncertain about *how to access (effort)* the target information via the channel, they tended to give up trying to use it and then switch to another information channel that they were more confident using. This usually made them think that the channel they ultimately used was *the only way* to obtain the information. But what usually happened was that they simply “perceived” the information inaccessible or difficult to access, without actually comparing the competing information channels. For example, while P5 reported, “*I was wondering which entrance I should go into the station. [...] I thought I’d just ask the attendant since I don’t know any other ways to know it,*” he perceived that such information would not be accessible online, and thus he was uncertain how long it would take him to explore in the environment to find the entrance.

Similarly, when P10 was looking for directions for inside a building, he first tried to find a map because he was certain that there must be a map of the building displayed. He did not search his phone because he assumed, without actually checking it, that there would be no such map online. “*I walked toward the Music school building and [was] thinking about how to find Britton Hall. [B]ut I didn’t use smartphone since I assumed there is no such detail map in it.*”

In another example, P7 wanted to buy a ticket for a local train service for an upcoming journey. but she was uncertain about whether she could find the service schedule online. As a result, she ended up spending 25 minutes going to the station to check the schedule. “*I don’t quite remember where to buy the tickets. So just rode my scooter there and checked. Otherwise I don’t really know where to find the schedule.*”

This pattern was quite consistent when the information was related to a current or upcoming activity or plan, as the three examples above have shown. However, this pattern was even more apparent when participants perceived the information need as urgent. For example, when P7 was in a hurry to catch a train, she was uncertain whether she could get a reserved ticket from a ticket machine. She was also reluctant to use her phone to search this information since the train would be arriving soon. She eventually asked an attendant for the information. “*I chose to ask the attendant because if I had to use my phone to look up whether I could get the ticket from the machine, I had to think about what keywords I should use to filter out the irrelevant information.*” Later she said, “*I think the time was too short to use the phone. I had searched before [coming to the station] but I couldn’t find any information about it. It’s just faster to find someone and ask. He [the attendant] was just standing there. If he had not been there, I don’t think I’d have had the mood to search either. If there were no attendant, I’d just have asked someone.*”

In particular, we found that it was the infrastructural information such as information of specific content of the services, the resources of, and the directions *within* specific local POIs (e.g. stations, buildings, stores) that participants often perceived inaccessible or felt uncertain about how to access through a different information channel, as opposed to finding locations of or directions between POIs. In these cases, participants usually ended up finding a person to ask, because they assumed that the people they asked would know better about local infrastructural information than they did.

Below we discuss our findings regarding uncertainty and perceived accessibility, and provide design implications.

DISCUSSION

Uncertainty, Perceived Accessibility, and Urgency

Our findings suggest that participants’ uncertainty with the perceived accessibility of the target information in an information channel is a significant barrier for them in using that channel to seek information, especially when the target information is sought for an upcoming activity or plan, for which participants feel pressed for time.

This finding may be explained by the framework of cognitive maps [12][25] in environmental cognition. In environmental cognition, a cognitive map is usually referred to as a metaphor that people act in the environment

just as if they possessed a map in their heads. When it is said that a person is familiar with a certain area, he or she acts as if the essentials of the environment, a model or map, were already stored in his or her head, so that they can predict where things are and how to reach them in the environment [12].

In a digital environment (e.g. an information system, a website, a mobile application), a cognitive map is essentially a mental model of that environment, which stores where the information is and how to access it [28]. However, in the physical environment, even if users are uncertain about where things are exactly, their prior experience with other similar environments can still help them explore and predict what they will likely encounter in the current environment (e.g. predicting that there must be a map of the building inside a building). Users can start from a nearby area and gradually navigate to the target information. The perceived physical distance might be long, but because it is predictable, users may still be willing to continue to look for the information in the environment.

In contrast, in a digital environment, especially on mobile phones, users' access to information is often through searching with keywords to directly retrieve relevant information. This suggests that users would need to possess some knowledge of the keyword(s) to use for searching. If they lack the knowledge of which keywords to use, or even are uncertain about whether target information is accessible on the Web, they might feel unsure as to how much time it would take them to access the information, and thus might prefer to use the information channels that they are more certain with. After all, there is not necessarily a "nearby" area for them to start with. Such behavior is also illustrated in Kaplan's clarity-based decision making framework. "... people tend to avoid situations in which they might become confused, where they might not know how to behave. ... They prefer and benefit from making decisions that put them in domains in which they can use what they know..." [24].

Moreover, in terms of information seeking, Freed [13] has characterized urgency as "the expected time available to complete the task before a specific, *undesirable consequence* occurs". While participants were on the go and were searching for environmental information related to their plan, they usually had a time by which the plan should be completed. Despite the fact that the plan was not necessarily always *urgent*, being unable to anticipate how much time it would take them to obtain the necessary information, was undoubtedly, something they would like to avoid. After all, failing to get the information may result in the plan not being completed (e.g. getting on a bus or a train, buying a ticket, arriving at a destination). On the other hand, switching to an information channel they were more certain with, despite the fact that it might be less efficient, put them in their comfort zone and allowed them to anticipate when they could obtain the information.

Making Local Information More Accessible

Most of the time participants could manage to find the environmental information they wanted using different information channels. However, participants often found it challenging to find access to infrastructural information related to specific local POIs using these channels, especially through mobile phones. The challenges of using mobile phones to obtain such kinds of information were usually a result of participants being uncertain about whether the information existed online, and how to access the information (i.e., what keywords to use for search). They usually ended up spending time exploring in the environment or asking people nearby. Although we are optimistic that participants were taking advantage of various information channels to obtain information, there were times when their explorations were inefficient, and other times where they felt confused, unconfident, and even nervous about how to obtain the information through channels other than mobile phones.

We think that these are the moments where Ubicomp can and should provide information support. Specifically, we suggest Ubicomp systems focus on supplying information that is often *perceived* as inaccessible or difficult to access. In this study, we identified infrastructural information associated with a local POI as belonging to this category, especially when the information was related to the internal resources and directions *within* a place. Some web services such as Wikimapia [30] have sought to gather information on local resources. However, Wikimapia currently lacks sufficiently detailed information about internal resources and directions. This kind of information is usually available on printed documents for visitors, or presented on kiosks or maps. But it is often perceived to be difficult to search and/or to access online. We suggest Ubicomp systems which aim to provide environmental information support (e.g. [3,16,23]) ought to organize these resources to make local infrastructural information more easily accessible, comprehensible, and traceable for mobile users. For example, future systems should be developed to identify the user's current location and proactively push the infrastructural information retrieved and organized from different sources and channels to the user's phone as a notification. A more sophisticated version is a service that can predict the place to which a user is heading/going [11,14] and then pushes the notification before the user arrives.

If specific infrastructural information (e.g. content or availability of a specific service) is challenging to extract and to organize from the Web, the system can try to direct users to an appropriate information channel to obtain the information, such as pointing out where an information desk, a kiosk, or a floor plan is. Such a support would be particularly helpful if the user is new to the environment or when the environment is large and complex, for which it is also difficult for users to locate particular information sources in the environment. While indoor positioning

technology is being developed [17], the service can track the user's as well as the clerks', attendants', or even volunteers' positions, and provide their positions for the user. We believe that such an information service can resolve some of the uncertainty arising while seeking local infrastructural information. What would be important to note is that environmental information is usually sought for an upcoming activity. Thus such kind of information is best delivered to the user before the user actually needs it.

Study Limitations

The current study is subject to several limitations. First of all, our findings are based on a small sample of Chinese smartphone users between the ages 25 and 30. As a result, their information channel selection behaviors might not be representative of the general mobile user population. Second, while we expect that much of information acquisition when on the go is passive and serendipitous, our data fail to reflect such characteristics. This is because the participants were instructed to report their information seeking instances while they were aware of their information needs from a more active information seeker role, instead of an information receiver role. Third, our diary study was based on the participants' willingness to report their information-seeking instance; as a result, the participants had the control of what to report and what not to report in a diary entry. Finally, since mobile phones were used by participants to record diary entries, they might be more willing to or more likely to remember to record an entry while they were using the phone to search information, as compared to while obtaining information from the environment or personal sources. However, if any system biases were caused by one of these limitations, the biases would have little impact on the value of our findings, since our findings were drawn from an in-depth qualitative data analysis, which were focused on particularities, i.e. understanding when and why mobile users would find a certain information channel limited for addressing information needs.

CONCLUSION

Mobile technologies have made a breakthrough in how people obtain information when they are on the go. The convenience offered by mobile technologies and advanced information retrieval systems make it possible to obtain a variety of information through mobile phones almost anywhere. Yet, this convenience has not effectively prevented mobile users from feeling uncertain with accessing certain information, such as infrastructural information of local POIs, which is often perceived hard to access or inaccessible on the Web. In this paper, we provide insights into why this uncertainty might be a barrier for users to seek information, especially when the user is seeking information for an upcoming activity or plan. We suggest Ubicomp systems address this issue by making the needed yet challenging-to-access information more

organized and accessible, and by pushing it proactively to users so that they may act more confidently while on the go.

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