Barriers and bridges in the adoption of today's mobile phone contextual services

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ABSTRACT

This paper presents ethnographic observations, a diary study and a large-scale quantitative questionnaire (n=395) designed to study the reasons for adoption and refusal of context-aware mobile applications. Through a qualitative study we identify 24 user needs that these applications fulfill and 9 barriers for adoption. We found that for many of the identified needs *the end-goal is not that of receiving information*, thus complementing work on mobile information needs. Also, this work offers an actionable list of obstacles that prevent contextual services to reach a larger audience. Finally, our findings suggest the opportunity to develop novel mobile applications that fulfill needs in the *activity and personal contextual dimensions*, and that of developing an *application store for feature phones*.

Authors Keywords: Context, Diary Study, Ethnographic Study, Human Needs, Mobile

ACM Classification Keywords: H.1.2 [Models and Principles]: User/Machine Systems [Human factors]

General Terms: Experimentation, Human Factors

INTRODUCTION

Applications on mobile phones are becoming increasingly popular. Mobile applications sales are expected to reach 17.5bn US dollars by 2012, a 62% year-on-year increase [20]. Part of this success is related to the growth of *smartphone*[1] markets which totaled 314.7 million units in the first quarter of 2010, a 17% increase from the same period in 2009 [4]. Still, 90% of the global market is dominated by *feature* phones[1] and market research shows that this share is not expected to drop dramatically any time soon [20]. Feature phone users do not switch to smartphones for a variety of reasons, including the higher cost of the hardware and related dataplans. There are also *barriers for adoption*, such as the lack of usefulness for using enhanced application that these devices offer.

In this paper, we study one particular kind of application: *contextual services*[2]. These are applications that sense and model the user's context to operate. Contextual services are one of the driving forces of the success of application stores as they enable novel forms of interaction and communication that were not possible before [4].

From an academic perspective, research on mobile contextual services has been conducted for the past twenty years [12]. However, most of this work was conducted by using prototypes of innovative contextual services, which were often installed on *ad-hoc* devices for the period of the study. Therefore, research in the field would benefit from more *naturalistic* studies focusing on why people use existing contextual services. Given the rise of popularity of these applications, we are now in a position to conduct a more *ecologically valid* study on the motivations that push people to use contextual services –and the problems they might face.

Particularly, we are interested in: (1) identifying the human needs that support the adoption of contextual services (we call these *contextual needs*) and (2) understanding how these needs relate to more general human needs. For instance, some applications might be designed to send a distress beacon in case of an emergency, thus answering a *safety need*. Personal safety is generally a more fundamental need than the need supported by an application designed to make new friends by connecting with familiar strangers (*i.e.*, *love and belonging need*). In this work, we argue that reflecting on the *ordinal relationship* between the needs might help uncover opportunities for novel contextual services. Moreover, we analyze potential barriers for adoption of contextual services (3). In particular, we study users who do not like or know about the existence of current contextual services that can fulfill their needs.

To reflect on these issues we have carried out two user studies: the first is a qualitative ethnographic observational study of the contextual needs that smartphone users experience in their lives. The second study is a quantitative large-scale questionnaire where we aim at generalizing the findings of the qualitative study to a larger population.

RELATED RESEARCH

What is context? Context has been defined in many ways. In the past, there has been little agreement on what context is and how to operationalize its definition. Schilit *et al.* [18] presented one of the earliest definitions of context-aware computing and referred to context as *location, iden-*

[1] A smartphone is a mobile phone whose most distinctive ability is that of install and run 3rd parties' applications. Antonym: *feature phone*.

[2] In this work we use interchangeably the words *contextual services* and *contextual applications*.

MobileHCI '11, August 30 - September 02 2011, Stockholm, Sweden

tities of nearby people and objects, and changes to those objects. Location appeared from the beginning as the key parameter to define context, albeit often leading to reductionist models of context [19]. This definition was later refined by Dey [7], who defined context as *any information that can be used to characterize the situation of an entity*(a person, place, or object that is considered relevant to the interaction). According to Zimmermann *et al.* [23], the elements for the description of contextual information fall into five categories: *individuality*, *activity*, *location*, *time*, and *relations*.[3]

Contextual needs. Researchers in the past have looked at *mobile information needs*. Sohn *et al.* [21] conducted a diary study of how and why information needs arise when the user is on the go. They focused on the contextual factors that prompted each need and influenced how it was addressed. Participants indicated that 72% of their reported information needs were prompted by some contextual factor. In the same year, Dearman *et al.* [6] published the results of a 4-weeks diary study on how information needs can be supported by individuals in the social network. They found that the timeliness of the message and the trust relationship with the source of the answer were variables that participants took into account to evaluate the usefulness of the received information. While these studies recruited average users, Heimonen [11] conducted a study with active mobile internet users and found an increased number of situations in which mobile information needs were addressed using mobile devices. These findings were later on extended by the work of Church & Smyth [3] that focused on the actual goals behind the needs. Needs can represent intermediate states to achieve more complex goals. Interestingly, they found that 42% of the reported needs were *non-informational*, suggesting that information needs could be a subset of contextual needs, thus motivating this research.

We therefore formulate our first research question as: *what are the human needs that support the adoption of contextual services and applications?* (**RQ1**). Considering the wealth of studies presented above, we take a *larger scope* by looking not only at the situations in which a person needs to receive or share information with other entities, but also at situations in which the person needs to support a cognitive process. For example, recalling a mobile number that was previously used.

Relationship between contextual needs and human needs. One of the most basic questions that arises when dealing with human motivation and technology is whether the needs that drive adoption can be explained by general human needs. Hence, we formulate our second research question as: *How do contextual needs find their correspondence to general human needs* (**RQ2**)?

To answer this question, we refer to the theory of human motivation formulated by Abraham Maslow [15] in 1942. Maslow organized human needs into a hierarchy (pyramid) of five groups, from bottom to top of the pyramid: physiological needs (level 1), the needs for safety and security (l. 2), the needs for love and belonging (l. 3), the needs for esteem (l. 4) and the need to actualize the self (l. 5). The theory postulates that the levels operate according to a principle of *homeostasis* and *saliency*. When a certain need is unsatisfied then it becomes salient until it is satisfied. The hierarchy defines the importance of the need. If the individual does not satisfy the most basic needs then these become salient and do not allow other higher unsatisfied needs to become salient as well. The theory was later on expanded by Alderfer [1], who challenged the idea that the needs were organized hierarchically. More recently, BJ Fogg introduced a behavior model that is particularly useful when describing adoption of technology [9]. We choose to use Maslow's theory because it is one the most popular and widely used theories of human motivation and it offers an ordinal relation between the needs that allow categorization of empirical evidences.

Barriers for adoption. In our work we also study the *barriers in the adoption* for contextual services. In this regard, it is relevant to mention the work of Kaasinen [14] who conducted a qualitative study of mobile services that could be enhanced with location-aware features. In the paper, the author draws conclusions about key issues related to user needs. *Topical information – i.e.* information that might change while the user is on the move, turned out to be important to the user (*e.g.*, weather forecast, train schedule). Users reported the need of having detailed search options, the ability of personalizing the interaction with the service, and that of contributing to the system with data. Privacy was also mentioned.

More focused studies on contextual services that led to design implications were conducted by Cheverst *et al.* [2], who designed and evaluated an electronic tourist guide, and discussed implications related to the degree of *personalization* offered to the user. Dey and Abowd [8] designed and evaluated a context-aware system to support reminders, and discussed issues in these systems related to the *complexity* of asking users to explicitly introduce their context. Finally, Iacchello *et al.* [13] proposed a location-enhanced messaging service and confirmed the importance of supporting plausible *deniability* in communication. Hence, our third and last research question is: *What are the most/least relevant barriers that people face to adopt mobile phone contextual services* (**RQ3**)?

METHODOLOGY

Answering the research questions formulated in this paper required different methodologies. We therefore organized the work in two different studies. In the first study, we were interested in exploring the *widest range of situations* in which people expressed needs that required contextual information to be solved (*i.e.*, contextual needs), and the barriers they encountered when they dealt with applications that might satisfy these needs. We opted for conducting ethnographic observations *in situ* and we complemented this method by asking participants to keep a paper and video diary whose content was debriefed through interviews. The same combination of techniques was used in the study of mobile information needs by Sohn *et al.* [21], and in the study of handset usability by Palen *et al.* [17]. In situ observation (*i.e.*, shadowing) and interviews were used successfully by Tamminen *et al.* [22]. Finally, Church & Smyth [3] and Grinter *et al.* [10] used diary studies to capture contextual elements that

[3]In the remainder of this paper, we will refer to 4 contextual dimensions: *spatio-temporal*, combining location and time; *activity*; *social*, referring to peer-to-peer relations; and *personal*, referring to individual context.

played a role with mobile technology.

In the second study we focused on understanding whether our findings from the first study could be generalized to a larger population. We therefore deployed a large-scale online questionnaire that casted the qualitative results of the first study on a quantitative scale. The same technique has recently been used with positive results by Oliveira *et al.* [5]. The advantages of this technique is that it allows gathering large amounts of data with relatively little effort, enabling the generalization of the results.

STUDY 1: CONTEXTUAL NEEDS

Participants

For the first study we recruited 8 smartphone users (female:4; median age 30 years, min 21, max 37) through a recruitment agency. We asked the recruitment agency to screen interested candidates in order to capture a diverse selection of participants in terms of demographics, social lifestyle and interest in smartphone use. Six of them were smartphone 'power users' being always up-to-date in terms of installed applications and new technological trends. The last two (subj. 1 & 6) were beginners: they had bought their smartphone just a few months prior to the study and did not have any applications installed. All participants were Apple iPhone users.

Participants did not know each other and lived in different parts of a large city in Spain. They had different socio-economic status and worked in different sectors. Three of them were immigrants (subj. 5, 6, 8). Spanish was the native language for all of them but one (subj. 5). Five of them were single while the other three were living together with a partner (subj. 1, 3, 5). One of them had children (subj. 1). Table 1 summarizes the main demographic information of the participants.

Subj.	Age	Gender	Occupation	Subj.	Age	Gender	Occupation
1	31	F	Saleswoman	5	26	M	CEO
2	34	M	Video editor	6	33	F	Lab analyst
3	26	F	Insurance agent	7	21	M	Sound engineer
4	37	M	Graphic designer	8	29	F	Saleswoman

Table 1. Main demographic information of the participants.

Procedure

Three one-hour face-to-face interviews were conducted with each participant. During the interviews, we followed a list of questions but also left the conversation open-ended, such that issues that were unique to each participant could emerge, be discussed, and documented. The first set of interviews ($I1$) took place in the authors' office location. The second set ($I2$) in a city area chosen by each participant where s/he usually spent time during the week. The final interview ($I3$) was conducted in the participants' home. All sessions were audio recorded with the participants' consent. Two researchers were present in each session: one researcher – native in Spanish – drove the conversation while the other took notes. The relevant elements of each session were debriefed by the researchers immediately after the meeting.

During the first interview, we briefly gave an overview of our research interests. The interview was designed to capture the elements that made an experience to be enriching for the person (*i.e.*, *I saw something special, This place has changed, I bumped into..., I attended an exclusive event*, etc.). We focused the conversation on the contextual elements that had contributed to creating each enriching experience or informing the user about it. Particularly, we aimed at understanding the needs that the user had in a certain situation. For instance, if a participant was telling the story of how she had to find a post office nearby to mail an important letter, we then extracted a contextual need that we labeled as *"Search location of static entities"*. We were also interested in understanding the reasons why a particular need that could have been addressed using a contextual application ended up being solved without the use of a mobile device (RQ3). For instance, if a participant told us that he felt uncomfortable using his mobile phone in the subway to locate the platform of where he had to take the train from, we then noted the episode as being *"Embarrassing"* for the user. At the end of the session we gave each participant the kit to produce the video and paper diary (described in the next subsection **Materials** and represented in Figure 1) and showed them how to use it. The study lasted 2 weeks during which participants were free to use interchangeably these two diary types depending on the situation they were in. If for example, they were in a public place and felt embarrassed about shooting a video in public, they could use the paper diary.

The second interview took place one week after the initial meeting and probed the user's perception, needs and wants for contextual services. We also focused on understanding and characterizing the attributes of context beyond location (*i.e.*, environment/time/location, identity/mode/mood, process/activities, community/social network) that play a role in defining the user's context while on-the-go. During the interview, the participants were free to move around, go shopping, eat, and interact with objects and other people. Interviewers followed the participants, took notes, asked questions, and took part in the activities the participants were engaged with.

The final interview took place at the end of the study. During the meeting we collected the diaries and looked at some of the entries together with the participant who produced the entries. The focus of the conversation was to understand the contextual needs that the participant had and barriers of use of contextual services that they reflected upon during the 2 weeks of the study.

After the fieldwork, two researchers independently coded each entry in the transcript using an *ad-hoc* coding scheme that was created by looking at random entries in each transcript and agreed between the two coders. After a first pass, there was a nominal disagreement. These differences were resolved via discussion. Participants received an economic incentive to participate in the study.

Materials

Participants received the kit shown in Figure 1. The kit included a paper diary with a small pen, smiley stickers, a camcorder (maker: Flip video, model: FlipHD), and some symbols edged on cardboard that participants could use in their videos to highlight the information they would have liked to receive – or to communicate – from the hypothetical contextual service. We advised the participants to carry the video

and paper diary with them all the time (small and discrete), leaving the other tools optional to use. The first two pages of the paper diary contained instructions and an example on how to fill the entries. Each entry contained the date, the place where the entry was created, the activity the participant was currently involved with, and space to describe the contextual need or situation. Finally, the subject could rate the entry with a smiley to tell us whether they felt the experience they had was negative or positive.

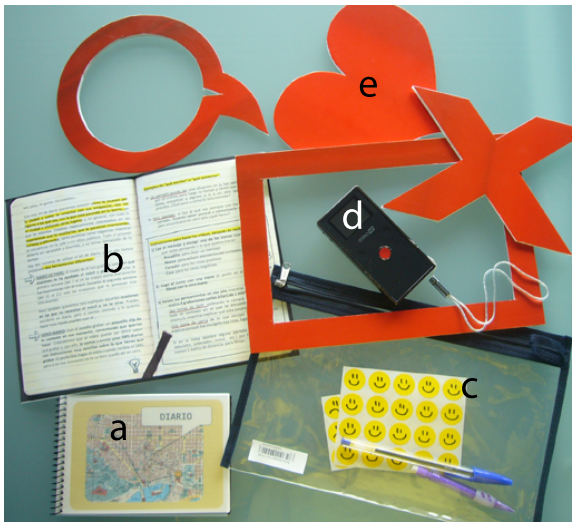

Figure 1. Materials assigned to each participant of the qualitative study: a) paper diary, b) instructions, c) smiley stickers to rate entries of the paper diary, d) camcorder to record video diary, and e) paper frames to enhance explanations in the video diary

Results

Our study generated 116 paper diary entries with a median of 15 entries per person. When we looked at *where* the entries were generated, we found that: 46% of them were created while participants were *on the streets*; 15% when participants were *visiting* a friend or a family member; 14% while they were spending time in *bar and restaurants*; 12% when they were commuting to work or using other forms of *transportation*; 11% when they were *at home*; and 2% *at work*.

In terms of *whom* the participants were with when the entries were created, 38% of the entries were generated while subjects were *with friends*; 37% when participants were *alone*; and 25% when they were *with family* members. Concerning how participants rated the experiences reported in the paper diary, in 85 cases (73%) they had had a positive outcome of the interaction with the contextual services. Conversely, 31 situations (27%) were classified as negative. Regarding the video diaries, participants created a median of 16.5 entries per person with a median duration of 40 seconds per video.

The main analysis of this study required coding all the transcripts of interviews and diaries. We observed 24 contextual needs. Table 2 presents these needs organized by the overarching contextual dimensions [23]. We could observe contextual needs for each of the four contextual dimensions. The majority of the needs that we could observe in our dataset belonged to the spatio-temporal dimension (8 entries) and to the social and personal dimension (6 entries), while we could observe only 4 needs in the data that belonged to the activity dimension. Next, we describe how we assigned the needs to each contextual dimension. We include quotes – translated from Spanish – from the transcripts to exemplify how we solved coding conflicts.

Spatio-temporal. The contextual needs that we observed and that we grouped under this dimension deal with geographical locations. The element of the context that is common for all these needs is the *location* at which a person or a resource stands. Participants reported often the needs of locating specific resources near their position (# n. 2 and 4, table 2) or the need of knowing the whereabouts of friends and family members (# n. 3). Knowledge of positions was also important to optimize journeys (# n. 2 and 5) and to fill idle times (# n. 1, 5, and 8). Lastly, participants often reported the needs to enhance their local experience, by growing their knowledge about opportunities nearby (# n. 1, 6, 7, and 8).

Activity. The element of the context that is common for the observed contextual needs that we grouped under this dimension is the *activity* the person is (or will be) doing regardless of the current location. These pursuits are typically structured, planned, and recurrent. During the planning phase of the activity, participants mentioned the importance of evaluating adverse conditions, such as bad weather, to avoid wasting their time (# n. 12). Participants reported often the need to receive recommendations about things to do during free time (# n. 9 and 10, table 2). Finally, participants reported the need to enhance their experience of the activity by receiving additional information while the activity is still ongoing (# n. 11).

Social. The needs grouped under this dimension focus on the *interactions with a group of peers* which might be located in different geographical positions and engaged in different activities. Participants often reported the need of being connected with the rest of the peer group by receiving updates from friends (# n. 13, table 2), by sharing bits of life with them (# n. 17), and by physical encounters (# n. 18). Also, participants expressed the need of expanding the connections of their social network by adding new people encountered at social events (# n. 15) or people that share common interests (# n. 16). Finally, sometimes they expressed the need of communicating with people outside of their network without the goal of adding them to their group (# n. 14).

Personal. Some of the needs that we observed during this study were personal needs beyond the person's current geographical position, activity and group of peers. These pursuits are typically more serendipitous and ad hoc. For example, participants reported the need to entertain themselves during idle times (# n. 19, 20 and 21, table 2). In addition, participants expressed the need to monitor their own physiological conditions (# n. 22), receive support to remember things (# n. 23), and perform collaborative problem solving with remote peers (# n. 24).

Barriers for adoption

During the study we could observe 9 recurring reasons why participants refrained from adopting existing contextual services. Some reasons dealt with the quality/quantity of the data provided by the service (B1, and B6, table 2), or the way private information was handled (B2). Other reasons focused on the interaction design of the service (B4, B5,

	#	CONTEXTUAL NEED	DESCRIPTION	EXAMPLE	HUMAN NEEDS 1	2	3	4	5
spatio-temporal	1	Recommend places	Receive location-based recommendations while on the go to fill idle time. [B1]	*"I would like to receive alerts of interest points or interesting facts when walking" [subject 7]*			○	○	X
	2	Search/Track personal location	Locate my position when moving in an unfamiliar place, or to optimize the journey.	*"It helps me a lot to know where I am" [subject 3]*		X	○		
	3	Search/Track location of close peers	Locate close friends and family members. [B2, B3]	*"I would love to know where my mum is" [subject 2]*		○	X		
	4	Search location of static entities/objects	Locate a specific resource nearby so to minimize walking distance or the time required to reach the destination.	*"I look for Basque restaurants in [omitted]. I find many, but they are too far." [subject 1]*		○	X		○
	5	Search/Track location of dynamic entities/objects	Locate trains, buses, and the like, so to optimize the journey or the waiting time.	*"I am using the application to see that the next bus will be 20 minutes late (the screen of the bus stop is not working)" [diary, subject 3]*		X	○	○	
	6	Advertisement on the spot	Receive location-based discounts. [B6, B8]	*He is going to a bar for work reasons. He would like to receive notifications in his mobile about special offers. [video, sub. 7]*					X
	7	Purchase on the go	Find specific locations where a certain service can be bought.	*"We decide to go to the cinema after dinner, so we search for cinemas close to our position. Finally, we go to the shopping mall in [omitted] to see Alice in 3D." [diary, subject 3]*					X
	8	Historical view	Learn historical facts about the city one lives in. [B5]	*She is walking in [omitted]. She would like to learn the history of the square. She seems to remember that in the underground there was a refuge used during the 2nd World War. [video, subject 8]*					X
activity	9	Recommend activities	Receive/share advices related to events happening in the city.	*"If I am in a neighborhood I am not familiar with, and I would like to know about entertainment options nearby, I tend to ask locals." [subject 6]*					X
	10	Search/Track activity in static entities	Find information about events (and receive reminders) happening in the places where one usually spends time.	*"I always forget the dates of the jazz concerts and I miss them because of that." [subject 4]*					X
	11	Search/Track information related to an event/entity	Find information to complete or complement the activity one is currently carrying out.	*"We went to have dinner with friends, and one guy in the bar started playing guitar and tried to get everyone to sing a popular song but we did not know the song's lyrics. I was looking for them on my mobile!" [subject 4]*					X
	12	Evaluate possible obstacles to an event	Foresee obstacles related to a future activity.	*"I would like to have an updated information of how much people are in each bar so that I know whether a pool table is free." [diary, subject 5]*		X	○		
social	13	Social awareness	Discover what friends are doing / where they are to understand whether they are available for social activity. [B4, B7]	*"I often look at the status on* Watsapp *to decide whether is a good time to pay a visit to a friend." [subject 8]*			X		
	14	Communication outside of social network	Establish communication with people outside their social network.	*She spent a weekend in Cordoba for tourism. She would have liked to leave a message in a forum where citizens of Cordoba usually write to thanks them for the ospitality. [video, subject 3]*					X
	15	Networking	Expand one's social network by easily sharing contact information with new acquantecence. [B9]	*He is riding his bike to [omitted]. He says that he would like to discover whether the people around him have a Facebook profile. [video, subject 7]*			○		X
	16	Collective initiatives	Engage in civic actions with other interested people that do not necessarily belong to their social network.	*"I would like to leave a message to the owner of the car that is blocking the entrance to my garage." [video, subject 7]*					X
	17	Sharing the moment with close peers	Share moments of one's life with friends and family members.	*"I have taken a picture of a very dirty bathroom and I have posted it on* Facebook *NOW." [subject 2]*			X	○	
	18	Serendipitous meetings	Supporting unplanned gatherings.	*"We are going out for dinner. We leave our son with the grandparents. Once in the restaurant we meet a school mate of my son with his parents. It is a pity. I should have brought my son." [diary. subject 3]*					X
personal	19	Game	Entertainment, killing time.	*"I often play games when I am commuting." [subject 6]*			○		X
	20	Music					○		X
	21	Reading							X
	22	Physical exercise (or sports)	Track physiological conditions while excercising and model personal status.	*"When I do some workouts I usually wear a cardio sensor." [subject 4]*		X	○		
	23	Memory prosthetic support	Support for storing and retrieving information one collects during daily life.	*"I adore this restaurant but I struggle all the time to remember its name or where it is located." [subject 4]*			○	X	
	24	Remote/asynchronous collaboration	Provide or receive help from colleagues while on the go.	*"I take a picture of the defective material and I send it to the technician of my company to get some information on the problem." [diary. subject 1]*		X	○		

				1	2	3	4	5
barriers	B1	Trust	Lack of trust in the information provided by the service	*"I do not trust the recommendations in* Around Me *because the majority of these have been left by English-speaking users." [subject 3]*				
	B2	Privacy	Privacy is at risk by using the service	*"I feel I am not in control of the information the service gathers." [s. 1]*				
	B3	Popularity	Lack of coverage of the service on relevant stakeholders	*"My social network is not using the service, so it is of no use for me." [subject 2]*				
	B4	Difficulty	Troubles understanding/interacting with the service	*"I do not understand how to use* Latitude." *[subject 7]*				
	B5	Embarassement	Interacting with the service exposes the user	*"I do not feel using* Layar *in public." [subject 5]*				
	B6	Overload	Lack of control over the quantity of information received from the service	*"I fear that by signing up to this service I will receive lots of advertisement material." [subject 4]*				
	B7	Usefulness	Lack of benefits from using the service	*"I feel traditional methods that do not involve mobile technology are more appropriate to satisfy my need". [subject 3]*				
	B8	Personalization	The data presented by the service does not match with the user profile	*"The offers I get in* Groupalia *are not interesting for me." [subject 1]*				
	B9	Dangerous	Using the service is dangerous	*"It is better not to use* Google Maps *while biking". [subject 8]*				

Table 2. Contextual needs (top) and barriers for adoption (bottom) reported by the participants of study 1. On the right, contextual needs were fitted onto the five human needs [15] according to the way subjects expressed them during the interviews ('X': primary; '○': secondary). Conflicts were resolved during the interviews. Some details from the examples were [omitted] to protect participants' privacy. Examples in quotes are sentences of the participants while those without quotes are interpretations of the researchers.

and B8) that did not correspond to the users' needs. Finally, some reasons focused on the lack of inclusion of the service in the ecology of routines and technological artifacts already in use in the users' daily lives (B3, B7, and B9). The identified barriers were often associated to specific contextual needs (see references in square brackets in table 2).

Correspondence to the more general human needs

We investigated the connection between the contextual needs identified in this study (as reported by participants during interviews) and the five human needs as originally proposed by Maslow [15]. The main goal of this exercise was to understand whether the empirical accounts that we observed covered all the human needs as described by Maslow's theory. The first and the second author coded the contextual needs. Validity of the results was ensured by maintaining a good inter-coder reliability. Results are reported on the right hand-side of Table 2. For example, finding a restaurant was not coded as a physiological human need because participants did not mention it with a life-threatening connotation (*i.e.*, if the need is not fulfilled, serious physiological consequences are to be expected). As another example, when

participants reported the need of tracking their personal location, they mostly discussed situations in which they were lost, therefore we coded the need as pertaining to level 2 –safety– of Maslow's pyramid. However, sometimes they referred to this need in the context of rendezvousing with friends, therefore we added a secondary coding referring to level 3 of the pyramid.

We observed that most of the contextual needs were associated to high-level human needs: 14 needs were classified in level 5 (corresponding to 58%). Furthermore, 1 need (or 4%) was assigned to level 4, 4 needs to level 3 (or 17%) and 5 needs to level 2 (or 21%). We found no example of contextual needs that could be associated with physiological needs.

Discussion

Contextual services have often been studied in the past by means of *breaching experiments*. Our work contributes to the design of innovative context-aware applications by reporting *naturalistic* observations from a group of users who regularly use contextual services in their daily life. We identified 24 contextual needs that bring people to use contextual services, thus we provide data to answer **RQ1**. We do not argue that this list is complete as our study was exploratory with a limited sample and observation period. However, we do believe that the identified contextual needs are representative of a larger set of contextual needs for the population under study as they cover all the contextual dimensions and are recurrent in the observed dataset. Hence, the goal of this list is not that of offering a valid coding scheme to the reader but to give examples of contextual needs that belong to each of the four contextual dimensions.

Some of the contextual needs that we found are covered by the topical list of information needs generated by prior work [21, 6, 11, 3]. The larger overlap falls within the spatio-temporal category. For instance, the "Search/Track location of static entities" (# n. 4, table 2) is phrased as "Directions" by Sohn [21], as "Finding – Locate" by Dearman [6], as "Public transportations" by Heimonen [11], and as "Travel & Commuting" by Church [3]. Other contextual needs that we identified and that overlap with information needs identified by previous literature are: "Search/Track location of close peers" (# n. 3) [21, 6, 3], "Purchase on the go" (# n. 7) [21, 6, 11, 3], and "Recommend places" (# n. 1) [21, 6, 11]. Additionally, we found overlap between 2 other needs, although our definition of the contextual need includes more use cases than the definition of the corresponding information need that we found in the literature. We found this kind of overlap with the "Evaluate possible obstacles to an event" (# n. 12), that was identified with "Traffic" or "Weather" information only by previous literature [21, 6, 11, 3]. Similarly, we found a partial overlap with the "Social awareness" need (# n. 13) that was identified as information about peers' "Schedule" by previous literature [21, 6, 11, 3]. While for many needs the goal is that of increasing personal knowledge about things (*e.g.*, weather forecast) –that is the *informational nature* Church and Smyth talk about [3]– other needs have different goals, for instance supporting a physiological function. For instance, the end goal of "Memory prosthetic support" (# n. 23) is not that of *receiving information* but that of *supporting cognitive processes*, such as memorizing.

When we mapped the needs reported by our participants to the five levels of Maslow's pyramid, we found that all the contextual needs correspond to human needs in the higher levels the pyramid. Hence, the more basic needs seem to be excluded. This result provides an initial support to **RQ2**. However, we wondered whether the gender, the socio-economical status or the level of technological expertise could play a role with a larger sample.

Another finding of this study were the issues (barriers) identified by participants that prevent their adoption of contextual services. In particular, we identified 9 different reasons. While some of them have been identified already by previous work, such as "Trust" [6], "Privacy" [17, 14], "Difficulty" [8], and "Personalization" [2, 14], the other barriers seemed more specific to the variety of contextual services that emerged during the study. As some of these seemed related to specific contextual dimensions, we decided to verify this conclusion through the quantitative study in order to understand whether this qualitative finding could be extended to a more general population.

STUDY 2: QUANTITATIVE VALIDATION

This study was designed to leverage on the main findings obtained with Study 1 in order to shed light on our research questions **RQ2** – *How do contextual needs find their correspondence to general human needs?*– and **RQ3** – *What are the most/least relevant barriers that people face to adopt mobile phone contextual services?* Hence, a large scale survey was deployed reusing the qualitative information obtained *in situ* about people's contextual needs and barriers towards addressing them when using mobile phones. Quantitative findings from this survey enabled us to: (1) extend our observations on how general human needs are associated with contextual needs, and to (2) properly measure each barrier's relevance under the four contextual dimensions, thus creating a prioritization scheme that can help today's mobile practitioners to better direct their resources when designing/maintaining contextual applications. We shall describe next this study in more detail.

Participants

395 subjects (52.9% male) participated in this study. Their mean age was 37.5 years old ($s = 10.4$) and all of them had finished at least primary school. In terms of their technology acceptance profile, almost all participants (99.2%) had at least one mobile phone, 95.7% made/received phone calls at least once a week (74.4% every day), and 78.8% also sent SMS on a weekly basis (34.9% every day). The majority owned a feature phone (59.5%) and 87% of them never browsed the Web or read e-mails using their mobile device. Conversely, 40% of the smartphone users (40.5% of the entire sample) reported performing these tasks with their mobile phone every day.

Procedure

Recruiting. All participants answered an online questionnaire that had been advertised on the main page of a famous online news portal in Spain. In order to increase the diversity of the sample, the advertisement banner lasted for three hours per day during four days at different periods of the day (*i.e.,* morning, afternoon, late afternoon, evening). The call for the survey announced three 100 euro vouchers (about

130 USD) to be raffled among participants that finished the questionnaire and it did not impose any eligibility criteria.

Data Filtering. Three conditions were used to filter potential noisy data. Subjects should have: (1) answered all of the questions, (2) spent at least a minimum duration filling out the questionnaire[4], and (3) provided ratings that were *not* all the same to the Likert scales contained in the questionnaire. The last condition was introduced to filter out subjects who probably wanted to finish the questionnaire as fast as possible without reasoning about the questions.

Questionnaire Design. In order to create an unbiased comparison among contextual dimensions, we reused findings from Study 1 and composed the 20 statements from Table 3[5]. This approach guaranteed that for every contextual dimension we would have five examples of contextual needs covering the five major human needs and thus reduce bias in the answers. address a particular need.

Participants rated in a 7-point Likert scale the importance of each of the 20 statements from Table 3 (1: not important, 7: very important). They also rated how often they fulfilled the needs expressed by these statements (1: never, 2: less than once a month, 3: once a month, 4: 2-3 times a month, 5: once a week, 6: more than once a week, 7: every day).

For the evaluation of each contextual dimension, participants were presented with the corresponding five examples of contextual needs (see Table 3) and asked to report their main approach towards fulfilling them (*i.e.,* using the phone or doing something else). In addition, for those who mentioned not liking today's mobile phone contextual applications that fulfill these needs, we further asked them whether: (1) they do not **trust** the information provided, (2) they do not think these services respect their **privacy**, (3) they do not think they can cope with the information **overload** generated by these services, (4) the services are not **popular** within their social network, (5) they are **difficult** to use, (6) they are **embarrassing** to use in public, (7) they are not really **useful** to them, (8) they are not **personalized** to their needs, or (9) they are **dangerous** to use. These complaints were obtained from Study 1 and respondents to the online questionnaire rated their level of agreement with each one using a 7-point scale (1: do not agree, 7: agree) for each contextual dimension.

In order to provide a general view of today's barriers to mobile contextual applications, we computed the median of each subject's response to a certain complaint for all contextual dimensions. For example, consider a participant who provided ratings 3, 3, 2, and 5 to his/her level of agreement with the phrase *"I do not trust the information provided by these services"* for the spatio-temporal, activity, social, and personal contextual dimensions respectively. Therefore, the median 3 in a 7-point scale was considered to be the level at which this participant agrees that today's mobile phone contextual applications in general are not trustful.

[4]We identified an average of 16 minutes to complete the questionnaire at a comfortable speed. Therefore, we considered half of this duration to be the minimum threshold (*i.e.* 8 minutes).

[5]The authors created examples of contextual needs to fill out the blanks in Table 3 given that the needs identified from Study 1 were not enough (*e.g.* examples of physiological human needs). These handcrafted examples were composed based on the authors' knowledge of existent applications that address the non-filled needs (*e.g.,* Have2P.com and SitOrSquat.com: applications to find a toilet nearby; PolarUSA.com watches and iRunner: heart rate monitors that could be redesigned to prevent heart attack, etc.)

Statistical Analysis

Non-parametric analysis was applied due to the ordinal and nominal nature of the observed variables. The Binomial test was used to evaluate differences between dichotomous variables (*e.g.* phone usage for social *vs.* personal contextual dimensions) and the Wilcoxon Signed Ranks test to evaluate differences between ordinal variables (*e.g.* trust *vs.* privacy with today's mobile phone contextual applications in a certain contextual dimension). Associations between dichotomous variables were evaluated using Chi-square and their strength reported by the Phi coefficient (ϕ). The level of significance was taken as $p < .05$.

Results and Discussion

Human needs vs. Contextual needs

Findings from this study extend those obtained in study 1 towards addressing our research question **RQ2**. Particularly, they confirm Maslow's theory of motivation given that participants considered contextual needs derived from basic human needs ($\tilde{x}_{physio} = 6$, $\tilde{x}_{safety} = 6$) as more important than those derived from high-level human needs ($\tilde{x}_{social} = 5$, $\tilde{x}_{actual} = 5$, $\tilde{x}_{esteem} = 4$; $p < .01$). Moreover, the frequency with which participants currently address these needs is inversely proportional to their level of importance (*e.g.* $\tilde{x}_{physio} = 2$ *vs.* $\tilde{x}_{actual} = 3.5$). These results might be related to the fact that participants lived in a developed country and therefore had a somewhat privileged socio-economical status (*e.g.,* only 11% unemployed, 98% finished at least secondary school, 99% own at least one mobile phone, 95% use computers every day, *etc.*). Hence, these subjects most likely have already fulfilled their basic human needs and now find themselves more engaged in addressing their high-level human needs. Furthermore, our findings reveal that although smartphone and feature phone users perceive love/belonging human needs and self-actualization human needs with the same importance ($\tilde{x} = 5.5$ $p = .44$), the smartphone group addresses love-belonging needs more often than self- actualization needs ($\tilde{x} = 4$ *vs.* $\tilde{x} = 3.5$ respectively, $p = .01$). Note that the presence of more females in the feature phone group (65% *vs.* 45%) was not a co-factor, given that the correlation between gender and frequency of addressing love/belonging human needs was not significant ($\rho = .083, p = .10$). Therefore, these results could provide evidence that today's mobile contextual applications tend to focus more on the upper part of Maslow's pyramid of human needs.

Barriers in the adoption of mobile contextual services

In order to address our research question **RQ3**, we first identified the proportion of subjects that reported *not* using mobile phones to address their contextual needs under each contextual dimension. Next, we split this fraction of the sample based on the reasons why they do not use mobile contextual applications. Finally, we discuss each of these reasons aiming to provide bridges for such barriers in the adoption of today's mobile phone contextual services. Following we present the major outcomes of the proposed data analysis procedure.

The majority of participants reported *not* using their mobile

Human Needs	Contextual Dimensions			
	Spatio-temporal	Activity	Social	Personal
1. Physiological	find a place to go to the bathroom when you are on the go	find whether some food your are eating is contaminated	be alerted on whether people around you have a transmissible disease	monitor the current physiological status of your body to prevent a heart attack
2. Safety	look up your personal location when you are lost	evaluate possible obstacles to an activity (e.g., checking the weather before going out to prevent getting a cold, avoiding long lines in the movie theaters to save time, etc.)	have friends and family members that can help you in case you need financial support	do physical exercise to be healthy
3. Love/belonging	locate places or objects for social gatherings (e.g., finding a restaurant to go out with the family, a coffee shop to hang out with friends, etc.)	track the activity of your friends, work colleagues and family members	share the moment with friends and/or family (e.g., photos, videos, letters, telling stories, etc.)	increase your social bonds (e.g., find new friends, have kids, etc.)
4. Esteem	share physical places where you live/work/visit in order to increase your sense of achievement and/or respect that others have of you	share the things you do to increase your sense of achievement and/or respect that others have of you	track what peers are doing/have in order to increase your self-esteem	store permanently memories of events you live and things you do to increase your sense of achievement and/or respect that others have of you
5. Self/actualizat.	spontaneously look for recommendations of places to visit when you are on the go	track the activity of static entities for curiosity (e.g., what is going on in a certain place that you like, a bar that you usually go to, etc.)	meet with friends, family and/or other people that you know without planning it, while you are on the go	nurture your knowledge by learning interesting cultural facts of the city/neighborhood you live and/or work in

Table 3. Contextual needs used in the questionnaire to exemplify different human needs addressed by any given contextual dimension.

phones to address contextual needs in each of the contextual dimensions (spatio-temporal: 57.2%, activity: 65.1%, social: 61.8%, personal: 67.1%). The most relevant reason pointed out by our participants was their *lack of knowledge* that mobile phones can be used to fulfill these needs (spatio-temporal: 23.3%, activity: 27.6%, social: 28.9%, personal: 32.2%). Note that significant associations were found between having a smartphone and knowing that mobile phones can help to address most of the contextual needs (spatio-temporal: $\phi = .20, p < .01$; activity: $\phi = .16, p < .01$; personal: $\phi = .14, p < .01$), thus suggesting that feature phone users are probably the ones lacking this knowledge.

The second major reason for not using mobile phones to address contextual needs was that, although some participants are aware of mobile contextual applications, they *do not like* them (spatio-temporal: 14.9%, activity: 19.3%, social: 18.5%, personal: 19.5%). Their most relevant complaints were related to privacy, poor personalization of applications to the users' needs, and lack of usefulness and trust in the information provided. The feeling of embarrassment by using these applications in public was considered to be the least important issue. The complaints on the spatio-temporal and activity contextual dimensions had the same ranking of importance and they did not highlight the importance of trust as much as in the social and personal contextual dimensions.

Finally, additional barriers to adoption are associated to those users that are aware of the existence of contextual applications and do not dislike them, but are not willing to pay for expensive data plans, find that the data connection is often slow, dislike being constantly updated, or simply do not see their mobile phone as the best device to fulfill those needs. Table 4 summarizes the main descriptive statistics obtained about our participants' mobile phone usage to address their contextual needs.

Bridging the adoption of mobile contextual services
For those who did not know mobile phones could help ($23 - 32\%$*).* Our findings suggest that unawareness is the most important barrier to adoption. However, the significant association found between mobile phone type (*i.e.* smartphone *vs.* feature phone) and lack of knowledge reveals that feature phone users are the main population affected by this barrier.

contextual dimensions	use phone (%)		do not use phone (%)		
	often	rarely	do not like current applications	do not know applications can help	other
spatio-temporal	20.8	22	14.9	23.3	19
activity	14.9	20	19.3	27.6	18.2
social	17.7	20.5	18.5	28.9	14.4
personal	13.9	19	19.5	32.2	15.4

Table 4. Mobile phone usage to address contextual needs.

Hence, we would expect its relevance to gradually decline – at least in developed economies – as smartphones represent a larger percentage of the mobile phone market. This finding is not only encouraging to advertisers and market researchers in general, but also to practitioners in the field of Persuasive Technologies [9]. Research in this area shall contribute to reduce the effects of this barrier by identifying more appropriate motivational schemes to promote and adapt mobile contextual services for feature phone users.

For those who do not like current mobile contextual applications ($15 - 20\%$*).* Table 5 summarizes the main reasons why participants reported disliking these applications in each contextual dimension and how these barriers relate to each other with respect to their relevance. We expect the table to serve as a prioritization scheme when developing and maintaining mobile contextual applications. For example, let us consider a project manager in charge of increasing the user base of an online mobile social network service. Among several strategies to reach this goal, s/he is particularly undecided of whether more resources should be allocated to conduct marketing campaigns or to implement novel privacy-awareness features. After consulting information on Table 5, s/he realizes that the most relevant barriers for the adoption of mobile contextual services in the social dimension are their privacy, usefulness, and personalization related issues (written in **bold** letters in Table 5.3). Moreover, by looking into the column *"more important than"*, the manager verified that privacy issues are actually more important barriers than the service popularity (abbreviated as *"po"*). Therefore, s/he decides to give special attention to the novel privacy-awareness feature proposed by the R&D department. This strategic decision could be taken as a starting point being later refined by further studies whenever needed.

Table 5.1. All contextual dimensions:

this is...	more important than...	as important as...	less important than...
trust	$po/di/e/da$	$u/pe/o$	pr
privacy	$t/po/di/e/o/da$	u/pe	
popularity		$di/e/o/da$	$pr/u/pe/t$
difficulty	e	$po/o/da$	$pr/u/pe/t$
embarrassment		po/da	$pr/u/pe/t/o/di$
overload	e	$t/po/di/da$	$pr/u/pe$
usefulness	$po/di/e/o/da$	$t/pr/pe$	
personalization	$po/di/e/o/da$	$t/pr/u$	
dangerous		$po/di/e/o$	$t/pr/u/pe$

Table 5.2. Spatio-temporal/Activity contextual dimensions:

this is...	more important than...	as important as...	less important than...
trust		$po/di/e/o/da$	$pr/u/pe$
privacy	$t/po/di/e/o/da$	u/pe	
popularity		$t/e/da$	$pr/di/o/u/pe$
difficulty	po	$t/e/o/da$	$pr/u/pe$
embarrassment		$t/po/di/o/da$	$pr/u/pe$
overload	da/po	$t/di/e$	$pr/u/pe$
usefulness	$t/po/di/e/o/da$	pr/pe	
personalization	$t/po/di/e/o/da$	pr/u	
dangerous		$t/po/di/e$	$pr/o/u/pe$

Table 5.3. Social contextual dimension:

this is...	more important than...	as important as...	less important than...
trust	$po/e/da$	$o/u/pe/di$	pr
privacy	$t/po/di/e/o/u/pe/da$		
popularity		$di/e/o/da$	$t/pr/u/pe$
difficulty		$t/po/e/o/u/da$	pr/pe
embarrassment		$po/di/da$	$t/pr/o/u/pe$
overload	e	$t/po/di/da$	$pr/u/pe$
usefulness	$po/e/o/da$	$t/di/pe$	pr
personalization	$po/di/e/o/da$	t/u	pr
dangerous		$po/di/e/o$	$t/pr/u/pe$

Table 5.4. Personal contextual dimension:

this is...	more important than...	as important as...	less important than...
trust	$po/di/e/da$	$pr/o/u/pe$	
privacy	$po/di/e/o/da$	$t/u/pe$	
popularity		$di/e/o/pe/da$	$t/pr/u$
difficulty		$po/e/o/pe/da$	$t/pr/u$
embarrassment		$po/di/da$	$t/pr/o/u/pe$
overload	e/da	$t/po/di/pe$	pr/u
usefulness	$po/di/e/o/da$	$t/pr/pe$	
personalization	e/da	$t/pr/po/di/o/u$	
dangerous		$po/di/e$	$t/pr/o/u/pe$

t: trust; pr: privacy; po: popularity; di: difficulty; e: embarrassment; . o: overload; u: usefulness; pe: personalization; da: danger

Table 5. Relationship among participants' complaints about current mobile phone contextual applications. Bold letters highlight the most important barriers for each contextual dimension.

GENERAL DISCUSSION AND IMPLICATIONS

The two studies reported in this paper contribute to our understanding of the reasons for the adoption of mobile contextual services and the barriers against them.

In the first study we identified 24 contextual needs. The **first contribution** of this paper was to demonstrate that for many contextual needs *the goal is not that of increasing personal knowledge about things* (*i.e.*, they have a non-informative nature), thus complementing previous research in the field [21, 6, 11, 3]. The identified contextual needs were used to design the quantitative questionnaire of the second study. The results of the second study confirm one of the findings of the first study: users address contextual needs that are in the top-part of Maslow's pyramid of needs [15] more often than other needs lower in the pyramid. This result is probably due to the fact that we deployed the study in a Western developed country where most of its citizens have their basic needs satisfied. This finding constitutes an empirical validation of the theory that can help stakeholders identify the most appealing areas for creating innovative services. For example, in developed economies contextual applications that address needs related to *love-belonging*, *esteem*, and *self-actualization* have more chances to be successful than applications focused on other types of needs.

Furthermore, in the first study we identified 9 barriers for adoption. The questionnaire in the second study provided information on how people satisfy their contextual needs and how relevant these barriers are in influencing their behavior. We learned that the majority of respondents do not use mobile phones to address the range of contextual needs that we asked about. This result is consistent with the work of Sohn *et al.* [21] who also found that the majority of information needs they observed were satisfied without a mobile device.

The **second contribution** of this work is that of providing an *actionable list of obstacles that prevent contextual services to reach a larger audience*. Table 5 completes this finding by assigning a ranking to these barriers. Using the information of this table, designers and developers of contextual services can prioritize budget and resources to increase the popularity of a service and the users' satisfaction.

Through the second study we also learned that the most common barrier for adoption is the lack of knowledge of what existing contextual applications can do. This finding has not been previously reported in the literature and suggests that adoption could be increased by better advertising to users what need(s) the applications can satisfy, such as a recent campaign launched by Apple Inc[6] did. The results of this work suggest that designers could leverage on Fogg Behavior Model [9] towards investigating the core motivating factors (*e.g.,* how to increase pleasure, hope, social acceptance, *etc.*) and abilities (*e.g.,* how to minimize time/money constraints, physical/mental effort, *etc.*) required to change the behavior of non-adopters of mobile phone contextual services. As exemplified by Fogg, Facebook uses a successful strategy to bring back those users that have not been using the service for a long time by sending them an email (trigger) with a direct link to their profile page (simplicity) where they could accept their friends requests (social acceptance).

The results described above were obtained by looking at the entire sample. However, one of the interests of this work was understanding whether we could identify differences in behavior and preferences between smartphone and feature phone users. In this regard, the second study allowed us to differentiate responses of these two sub-populations. From the obtained results we draw a few implications for the design of mobile contextual applications.

Opportunities for mobile development. When we looked at the percentage of time that participants satisfied their contextual needs by means of their mobile phones, we found

[6]See the original ad: `http://goo.gl/yb6u`, last retrieved September 2010.

activity and *personal*-related needs to be the least satisfied. However, the contextual needs in these two dimensions were pervasive in the lives of our first study participants. Note that almost in 20% of the cases, participants reported not liking existing applications in these two dimensions. Hence, our findings suggest that there is a need – and an opportunity – for novel mobile contextual applications that fulfill needs in the activity and personal dimensions. For example, a mobile application that monitors their users' physiological state while exercising and helps them achieve pre-defined exercise goals [16].

The challenge of feature phones. Many of the feature phone users in our study did not know that contextual applications could help them satisfy their needs. The reality today is that there are limited tools for feature phone application development, there is no application store and feature phone typically have more limited computation and sensing capabilities when compared to smartphones. At the same time, the vast majority (about 90% [20]) of mobile users in the world – and particularly in developing countries – use feature phones. Hence, there is a need and an opportunity to develop intelligent contextual applications for feature phone users. One idea would be to move the applications' intelligence to the cloud, thus bypassing the phones' limited computational power. For example, simple location-based services could compute the approximate location of the users by looking at the closest BTS that (s)he is connected to.

In developing countries, a non negligible fraction of users are still fighting to satisfy their basic needs (*e.g.*, safe food, basic health, safety, etc.). Given that most of them do have a feature phone, the challenge would be to not only build a smart device whose cost should be comparable with that of a feature phone, but also to *develop contextual applications that could address more basic human needs*. For instance, we can think about a service to map contaminated wells through user-generated content, or an application to share recipes to prepare well balanced baby-food from nutrients available in local markets. We plan to focus on these challenges as part of our future research agenda.

To conclude, this work contributes to the understanding of why people use contextual services and why some mobile phone users do not adopt these services for their contextual needs. The provided results can inform designers and developers of these services in order to reach out to a larger population.

Acknowledgments. Telefonica Research participates in the Torres Quevedo subprogram (MICINN), co-financed by the European Social Fund, for researchers recruitment.

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