Reconexp: A Way to reduce the Data Loss of the Experiencing Sampling Method

Vassilis-Javed Khan, Panos Markopoulos, Berry Eggen, Wijnand IJsselsteijn
Eindhoven University of Technology, Den Dolech 2, 5600MB
Eindhoven, The Netherlands
{v.j.khan, p.markopoulos, j.h.eggen, w.a.ijsselsteijn}@tue.nl

Boris de Ruyter
Philips Research, Media Interaction
Prof. Holstlaan 4, 5656AA
Eindhoven, The Netherlands
boris.de.ruyter@philips.com

ABSTRACT
This paper presents Reconexp, a diary method supported by a distributed application, which partly runs on a mobile device and partly on a website, enabling us to survey user attitudes, experiences and requirements in field studies. Reconexp combines aspects of the Experience Sampling Method and the Day Reconstruction Method aiming to reduce data loss, improve data quality and reduce burden put upon participants. We discuss our first experiences of using this method in the context of a study of communication needs of working parents with young children.

Categories and Subject Descriptors
H.1.2 [Information Systems] User/Machine Systems – Human Factors;, User-Centered Design; D.2.2 [Design Tools and Techniques]: Miscellaneous

General Terms
Measurement, Human Factors.

Keywords
Experience Sampling Method, Day Reconstruction Method, Awareness Systems, Family Communication.

1. DIARIES, EXPERIENCE SAMPLING AND DAY RECONSTRUCTION
A major challenge in designing systems that fall under labels such as 'ubiquitous computing', 'pervasive computing' and 'ambient intelligence' is the need to extend requirements capture and evaluation methods outside the laboratory and into the field [14]. Such contextualized methods of data collection should allow reports of attitudes, opinions, or appraisals of subjective experiences to be captured close to the moment that a particular experience occurs and in the context that events and activities unfold. Such sampling of user attitudes can occur repeatedly over time, allowing the study of behaviours and experiences over medium or long periods of time. Diary methods are one way of meeting these needs, where informants are asked to keep a journal or a log, where they record events, activities and experiences as required by the researcher over a specified period of time. In traditional diary studies it is left up to the informant to capture data, usually in writing, but often combining written records with other recording media, see for example [2]. When the initiative for capturing information is left completely up to the informants several systematic errors can occur. Informants will often forget to fill in diaries, or they might fill them at moments that they have the time and appetite to do so, rather than the ones of interest to the researcher. This can lead to loss of data and systematic response bias.

For these reasons, the Experience Sampling Method (ESM) is gaining ground in HCI studies for understanding human needs and behaviour, or for conducting evaluation studies in the field. The ESM is a quasi-naturalistic method that involves signaling questions at informants at random times throughout the day [6]. The unique advantage of ESM is its ability to capture daily life as it is directly perceived from one moment to the next [4], providing a rich set of data to researchers. Informants may be given a pager or even an alarm through which they are reminded to respond to questions in a diary. To allow for flexible sampling and surveying approaches, researchers have turned to the use of handheld devices (Smartphones or PDA's), that participants are expected to carry through the study period and through which the question-asking protocol is effected.

ESM is growing in popularity in the field of human computer interaction. Consolvo and Walker [3] have used the ESM for evaluating an Intel Research system called Personal Server. Hudson et al. [7] have used the ESM to explore attitudes about availability of managers at IBM Research. Froehlich et al. [5] used ESM to investigate the relationship between explicit place ratings and implicit aspects of travel such as visit frequency.

Related to this growing popularity of ESM as a method, is the development of research tools to support it. Intille et al. [8] have developed software that enables researchers to acquire feedback from participants only in particular situations that are detected by sensors connected to a PDA. Froehlich et al. [4], developed MyExperience, a system for capturing both objective and subjective in situ data on mobile computing activities. A common characteristic of these works is that they aim to improve the method by optimizing the choice of when to prompt informants with a question; this choice can be based on previous answers of a participant or on inferences made regarding their activity based on context sensing (see for example, [10]).

Current research in this field is concerned with addressing some of the inherent shortcomings of ESM: sampling interrupts informants from their activities, or it inquires at inappropriate

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moments. Moreover, ESM is expensive; it puts high burden on participants, and provides little information about uncommon or brief events, which are rarely sampled [9].

Loss of data seems to be a major problem. Froehlich et al. [5] report completion rate of 80.5% and Consolvo et al. [3] also report a 80% completion rate (on average 56 out of 70) with as low as 28.5% (20 out of 70). Even worse, these numbers are silent regarding the significance of the data lost. It is reasonable to assume that the data loss occurs when people are busy or engaged in social or professional activities. These might be precisely the situations that researchers are interested in studying.

An alternative to ESM, proposed by Kahneman [9] is the Day Reconstruction Method (DRM), which was designed to assess how people experience their various activities and settings of their lives. Subjects in this case are asked to record a detailed diary of activities and events during one day. These do not relate directly to the focus of inquiry of the researcher, but are meant as a memory aid, a kind of scaffolding, to allow informants to recall and reconstruct experiences and feelings of the last day during a follow up interview. This is an in-depth semi-structured interview, during which the researcher probes regarding experiences and feelings that the investigation aims to explore.

Kahneman produced strong evidence regarding the efficacy of this method; however DRM suffers from low accuracy regarding factual aspects of the experience (e.g., time when events occur, factual details and environmental aspects which are easy to capture with ESM).

In our efforts to better understand the communication needs of busy parents we developed Reconexp. Reconexp is a distributed application partly running on a Smartphone (from now on mentioned as "device") and partly on a website. Reconexp allows the inquiry to build in some of the key elements of ESM and DRM. The key characteristic of Reconexp is that it combines a website where participants can review data they have provided during the day by using the ESM running on a handheld device. By using the website they can compensate the data loss incurred by the ESM.

Before describing the method and the tool support in more detail we present the context of this research, which motivated the survey in question. The context was our aim to explore how ubicomp applications can support working parents with young children to communicate and coordinate through the day.

2. SURVEYING COMMUNICATION NEEDS OF BUSY PARENTS

Two facts of modern life put family communication needs of busy professionals into pressure: less time to spend in social communication and having to work in distant locations from their family. Current communication media like mail, instant messaging, telephony, satisfy those needs only partly because one has to spend time and effort to keep in touch, initiating a communication often presents a threshold, see for example [15].

From a technical perspective, the advance of computing will soon enable environments to sense and partly understand the context of the people inhabiting it. Therefore, environments can have information they can share with their inhabitants or with other people with the goal of helping people to keep in touch with a minimum effort. We envision that mobile devices and objects of the environment can exchange information semi-automatically regarding the whereabouts and activities of people residing, working, or even passing through these environments. We call the technology that shall enable this exchange Pervasive Awareness (PA); see [12][13]. The research reported is part of an investigation regarding how such a technology can support intra-family communication and more specifically fit the patterns of daily life for "busy parents". We define "busy parents" as individuals who are married or cohabiting, both work at least part-time and have at least one young, dependant child.

Communication needs of busy parents vary dynamically. For example, one might want to reveal his location only when a certain event occurs, e.g., departing from workplace, but not the rest of the day. The same holds for the recipient's interest in such information; it only becomes relevant at particular times and in relation to specific activities. To capture related communication needs methods of flexible and context sensitive methods are needed, fitting into their activities, social and physical contexts.

This issue was highlighted during an interview study with 20 busy parents [11], a field study of a rudimentary PA system [12] and an online survey with 69 participants [13]. The three studies produced partly conflicting results and could only provide coarse information relating to participant's experiences and needs that were expressed outside a specific time and space context.

A natural progression for this investigation was to use ESM. We created appropriate tools to execute the method and planned a field study. However, during the pilots for this study with 2 participants (as well as 2 members of the research team) for a period of one week each we came to experience and realize some of the inherent shortcomings of ESM as discussed above.

Further to improvements relating to the tools, concerning usability, readability of questions and the way answers were entered, the main outcome of the pilot concerned the ESM protocol itself. This was perceived as tedious as there was a single question that was asked repeatedly soliciting repetitive answers. There were many inconvenient moments that participants could not answer questions and participants missed feedback that their input was actually used and acknowledged by the system. Having experienced the shortcomings we set out to improve upon these flaws by tying up the ESM with the DRM.

3. METHOD

The combination of the two methods aims to compensate the complementary shortcomings of each. Participants are prompted for questions using an ESM protocol. In cases where they are unable to respond, and to reduce data loss, they may answer at a later time using a website (on the same or the next day), in which case recollection is supported by the ESM logs.

The ESM is carried out with using a mobile device and the DRM using a website. As a bootstrapping for the combined survey techniques, participants are first asked to use the website to provide information about the places they will be at and the activities they engage in. This initial information is solicited out of context at the start of the sampling period; it helps personalize the inquiry and optimize the question answering protocol of ESM reducing the need of data input via the ESM. This initial information about places and activities is then transferred to the mobile device.

For example, in our study, participants were asked to provide what information they are willing to share with their partner but also to define the place they are at and the activity they are engaged in.

An important concern in designing the survey questions was to limit the text input through the mobile device. We did so because from our experience with pilots we saw that it was cumbersome for participants to enter large quantities of text directly on the mobile device. Information provided on the website was used to populate drop down menus, through which participants can quickly select among previously entered activities and places.

Finally, the website offers to informants the possibility of returning to previously unanswered questions and supply comments on answers given already. Moreover, the participant can always insert more places and activities (both on mobile device and on website), or even update the existing ones.

4. RECONEXP: THE APPLICATION

Reconexp (called from now on "the application") is a distributed system which partly runs on a smartphone and partly on a website.

4.1 Technology

We used three QTek 9090 and five HTC Touch P3450 smartphones. QTek runs Windows Mobile 2003 Second Edition. HTC runs Windows Mobile 6 Professional. We programmed the application using Microsoft's .NET Compact Framework in C#. We used OpenNetCF libraries for controlling the WiFi adapter of the device. We kept the participant's data in MS SQL Server CE and used the replication features of Microsoft's SQL Server to merge the data with the central database.

For the website part, we used Windows XP as platform, Apache as web server, Microsoft SQL Server as database server, PHP as back-end scripting language and the jQuery framework for implementing user interface features.

4.2 Using Reconexp in the context of our research

After participants accept to take part in the study, they are directed to the website where they are asked to provide information about their context by using the website [Figure 1]. By "context" we mean places and activities [Figure 2] participants visit and perform during a usual working day of theirs. In the third and final step of this boot-strapping phase on the website we ask participants to imagine what information they would like to communicate while being in a specific place doing a certain activity [Figure 3].

After the device is initialized it is handed over to a participant for one week. We request participants to keep the device in close proximity constantly.

An audio notification alerts the participant when it is time to record information. The application [Figure 4] gives the participant five minutes to respond to three questions: a) about the place where the participant is at the moment, b) about his/her current activity and c) about the information the participant would like to have sent to his/her partner automatically. For the latter question, the participant can choose from a list of statements representing the range of awareness information that busy parents might want to communicate to each other.

Figure 1: Naming places visited on a typical working day

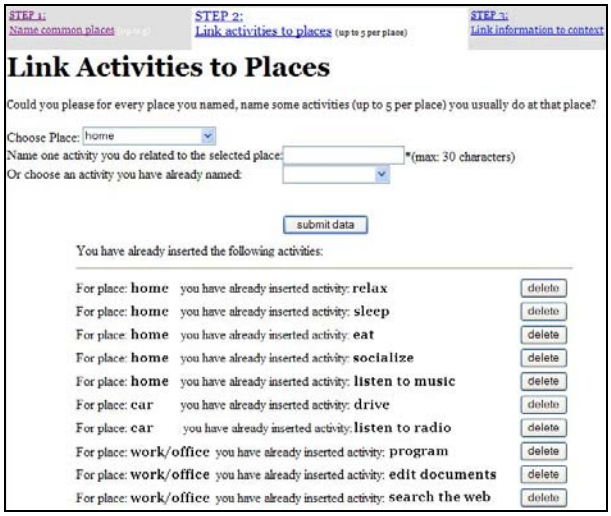

Figure 2: Naming activities performed on a typical day

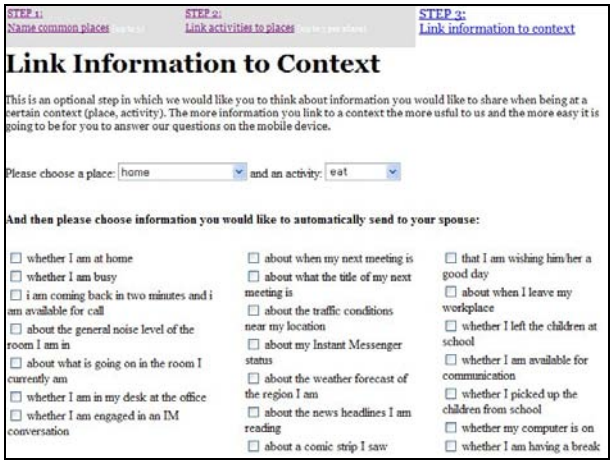

Figure 3: Linking information to context

To compile this list of statements, we reviewed related literature on awareness systems published in CHI, Mobile HCI, CSCW and Ubicomp. In each case, we examined the essence of the information that the system communicates abstracting away from specific context capture mechanisms the presentation medium.

For example, Cadiz, et al. describe [1] a system that displays among other information traffic conditions at a particular location. For our purposes we retained only the fact that traffic conditions are communicated. In total we included in this survey 16 papers and derived in this manner 41 seed statements describing awareness information that can be exchanged between busy parents by using an awareness system.

This list is of course not exhaustive; rather it was meant to capture the variety of awareness information considered in current research prototypes. F, the participant can insert new statements through the website.

For every question presented on the device, the participant has the option to answer "Other". For the last question if the participant does not check any item from the list, this is recorded as "Nothing", meaning that the participant does not want to send any information to her/his partner at all.

Figure 4: The three questions posed at the device

We asked participants to place the device in its cradle (connected through a USB port to their PC) and to synchronize the data at the end of every day during the sampling period. After synchronizing the data we encourage the participant to log onto the website to review the data [Figure 5]. While reviewing participants can fill out omissions of the experiencing sampling obtained during the day on the device. There are actually two kinds of omissions that the participant can correct at this stage. Answers she gave as "Other" (if for example she was in a place that is not covered in the existing places presented in the drop-down menu on the device) [Figure 6, Figure 7] and questions she left unanswered. At the end of the week we conduct a semi-structured interview.

4.2.1 Query mechanism

The sampling protocol combines time based and event based sampling. First, we check when the last answer of the participant was given. If that was more than an hour earlier, we query the participant. However, if that was between 30-60 minutes earlier, we check whether participant has changed place. If that is the case then we issue a question.

To find out whether the participant has changed place we compare surrounding WiFi access points (APs) with the stored WiFi access points of his last answer. This helps identify fine grain movements, e.g., away from and to a desk.

Figure 5: overview of answers given at the device

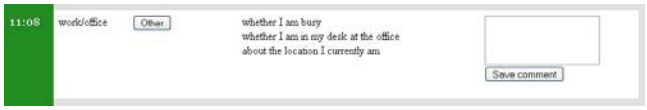

Figure 6: case where participant answered "other" as activity

Figure 7: "Other" activity can be now named at the website

4.3 Participants

A drawback we came to realize while conducting the study was that some participants had a difficult time synchronizing the data. Factors such as firewalls, anti-viruses, having a proxy prevented 9 out of 20 participants (45%) to synchronize their data and have the opportunity of filling out the unanswered questions posed in the device at the website. Thus the results we report are from 11 out of the 20 participants we recruited. Seven out of those 11 participants were men and four women.

Some demographics of our participants:

- Mean Age: 38 (max: 44, min: 28, $\sigma = 5.72$)
- Mean Number of children: 1.91 (max: 4, min: 1, $\sigma = 0.79$)
- Mean Age of children: 5.47 (max: 8.5, min: 0.7, $\sigma = 2.57$)
- Mean Years of marriage: 10.86 (max: 20, min: 2, $\sigma = 5.22$)
- Mean Hours of work per week: 28.18 (max: 40, min: 20, $\sigma = 6.63$)

- Mean Spouse's work hours/week: 30.91 (max: 50, min: 20, σ = 8.92)

Participants fitting the profile of a busy parent were recruited through a local community group, a participant database managed by our university and personal contacts. All participants were Dutch citizens, married or cohabiting, from two large Dutch cities.

4.4 Log

We logged the following 12 participant actions:

- Log into the system
- Link information statements to previously not answered question
- Name Activity which was not answered
- Name Activity which was not answered using existing value
- Name Location which was not answered
- Name Location which was not answered using existing value
- Name "Other" Activity
- Name "Other" Activity using existing value
- Name "Other" Information
- Name "Other" Information using existing value
- Name "Other" Location
- Name "Other" Location using existing value

5. RESULTS OF THE STUDY

At first glance of the data we can conclude that the website was used a lot. The total performed actions were 612 and therefore a mean number of actions performed: 55.64 (logins are not counted in these numbers). Of these actions 15% were performed in the morning (between 6:00 and 12:00), 22% in the afternoon (between 12:00 and 17:00) and 64% in the evening (after 17:00). In Table 1 we report the results of the logged data.

What is also evident is that several questions were not answered using the handheld device. For example, the mean percentage of non response to the second question ("What are you active in now?") was 48.81%. However, a significant amount of those (60.13%) were recovered by the use of the website.

When considering answers given for all questions using the device and the website then the overall response improvement of the website to the Experience Sampling Method is: 29.35%.

Table 1: Results of logged data

Mean number of actions performed (logins not counted in this number)	55.64
Mean logins (in 5 days)	2.91
Mean times participants were questioned (for the period of the PDA part, that is at least 5 days)	57
Mean times the 2nd question (about activity) was not answered	27.82
Percentage of mean number of activities (2nd question) not answered:	48.81%
Mean of percentage of activities recovered (with the website use)	60.13%
Overall improvement of the website to the method is	**29.35%**
Total comments	33
Number of participants who gave comments	8 (out of 11)
Mean comments	4.125

During the debriefing interview we asked the participants how difficult it was for them to remember location, activity and information for past occasions when they had not responded to the device's prompt. All but one said that it was easy for them to remember and accurately answer related questions. They mentioned two reasons. First, that when trying to remember and fill out the unanswered questions these concerned situations that were recent. Second, that the website provided them with a frame of reference, (which was the motivation for doing so based on the Day Reconstruction Method). For example, when a participant could not answer a question posed at 13:30 but did answer several questions before and after that, these answers would help recall whereabouts, activities and what information this participant would have liked to exchange in such a context.

6. DISCUSSION

From a methodological perspective, the results of this inquiry seem to support the rationale of combining the Day Reconstruction Method and the Experience Sampling method. The Reconexp distributed application clearly allows for reduction of data loss and also, some streamlining of the effort required by participants.

When combining elements of the two methods, one might raise the question of the DRM possibly inducing "postponing behavior" i.e. participants might decide to postpone their answer on the device to a later moment at the website. This would mean that the ESM component of the combined method, underperforms in this context and perhaps accuracy of data is lost as a whole.

To eliminate this explanation, future investigations should aim to compare ESM on its own against its adapted version with DRM inside Reconexp. We should mention that we have not found any evidence of such practice on the part of informant; although not explicitly asked, none of our participants mentioned such a behavior when interviewed.

Further, it seems that even if such a practice does take place, the overall effect of the combination of the methods is positive with: Completion rates with Reconexp were considerably higher than those typically reported in the literature. For example, Froehlich et al. [5] report completion rate of 80.5% and Consolvo et al. [3] 80% whereas ours was approximately 52%.

7. MARKET RELEVANCE

As product evaluation practices need to move beyond lab experiments, companies interested in consumer electronics, health services and mobile services are in need of appropriate survey instruments and tools. Tools like Reconexp are suitable for long term studies in the field. We will present two examples to make our case concrete.

Consider that a mobile phone operator wants to introduce a new service and is conducting a pilot trial with several potential customers. Our application could be used to find out the overall satisfaction of customers at particular points during the day as well as find the problems they face. This can help the operator with both their service and marketing strategy.

Consider a government's health department is interested in the daily diet habits of a diabetes patient. Our application could be used to capture those habits over time and help the department issue advice for patients as well as prioritize their policies.

Outside the context of evaluation Reconexp offers advantages in studying people's activities in the field, understanding daily rituals, temporal patterns of behavior and contextual factors relating to their activities. These are important in order to obtain customer insights and to recognize areas where innovation can provide real value to users. Tools and methods like those discussed in this paper are essential tools for understanding people beyond their behaviour in the lab as test-participants or in the shop as buyers.

8. CONCLUSIONS AND FUTURE WORK

This paper has presented a distributed platform developed to support the combination of two research methods for collecting subjective data in field studies regarding experiences and feelings of informants: Experience Sampling and Day Reconstruction. This method is part of a line of research started in recent years to support Experience Sampling tools with the use of mobile devices and context sensing technology.

Compared to related systems, Reconexp is the only one complementing the use of a handheld device for reporting brief notes in situ, with surveying recollection of informants using a website. Related is the work of Froehlich et al. [4] who combined ESM with web diaries; note that they have used web diaries as a qualitative supplement to the quantitative data gathered through ESM. Compared to their system Reconexp offers the advantage that it allows participants to review and fill out the gaps created by ESM, rather than just elaborate on earlier records.

There is a lot of scope to develop this method further. Potential improvements include a more flexible and attractive user interface of the website, a more sophisticated sampling protocol and a more usable and attractive interface on the mobile device. Moreover, the annotation of questions of other types of data such as voice and photos will make considerable improvements to the existing system.

The first trial of this tool in our research has proven its value. It has enabled a highly contextualized survey of what awareness information parents wish to share with each other that was not available from our earlier studies (interviews, web survey and field trial with interviews).

These first experiences confirm the value of complementing the mobile experience sampling tools with data collection on a website, allowing the reduction of data loss and the improvement of the quality of the data collected. Follow up studies are needed to consolidate these methodological results and to effect relevant improvements on the tools.

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