Mobile Experience Sampling Method: Capturing the Daily Life of Elders

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Abstract. The aging of populations worldwide has emerged as an important focus of research and policy. Concomitantly, capturing the daily life of elders is becoming a major task for researchers and service providers. In a mobile internet environment, traditional methods are not adequate to support contextualized information behavior research on the elderly. Based on a comparison of six methods from four perspectives (context, time, user, and data), this paper introduces the mobile experience sampling method (mESM) as an effective approach to the study of elders' everyday information behaviors. An overview of mESM is presented, and a general three-stage framework is proposed to discuss its implementation. We also offer suggestions to improve the efficacy of mESM in addressing the real conditions and characteristics of the elderly and discuss the method's advantages, disadvantages and related problems from the perspectives of researchers, elders, and policymakers. Overall, we find mESM to be an ideal longitudinal method for capturing the contextualized day-to-day information behavior of elders.

Keywords: Mobile experience sampling method · Daily life · Elders · Longitudinal research · Real situation

1 Introduction

The world population is aging rapidly. It is estimated that by 2050, the proportion of the global population aged 65 and over will reach 20% [1]. This demographic shift has emerged as an important focus of both research and policy planning worldwide. Within the field of information behavior research, capturing the daily life of older people has become an overarching task for researchers and service providers, who hope to understand the needs of older people and thus provide more effective information services for them. However, in the emerging mobile internet environment, elders' information behaviors are highly situational, and traditional methods are thus sometimes inadequate to capture the day-to-day information behaviors of elders. This study aims to introduce a new approach—the mobile experience sampling method (mESM)

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—with which to investigate elders' everyday information behavior. Two principal questions guide our research:

1. Why is mESM suitable for capturing the daily life of the elderly in the emerging mobile internet environment?
2. What are the necessary steps to implement the mESM approach? How can mESM be employed to effectively explore elders' information behaviors?

2 Why mESM?

Traditional methods for capturing data from the elderly include interviews [2–8], surveys [9–11], experiments [12], diary-keeping [13], and general ESM [14, 15]. In addition, sensor-based method can provide real-time monitoring of older people [16–18]. Together, these methods have played an important role in collecting qualitative or quantitative data from elders. However, in the current mobile internet environment, elders' information behaviors are always rooted in specific contexts. Accordingly, when we try to go deep into the everyday life of the elderly, we need to capture not only the qualitative or quantitative data of needs, behaviors, experiences and emotions in a given time and place, but also the corresponding real-life situations in which data are generated. Meanwhile, if a method can easily support repeated measurements of daily life and build cumulative data sets for comprehensive and fine-grained analysis, it will help us more accurately understand the rhythm and regularity of elders' day-to-day information behavior. These research requirements prompt us to seek a more suitable longitudinal method of capturing intensive information from the real-life situations faced by the elderly.

The criteria for selecting such a method can, we suggest, be viewed from four perspectives: context, time, user and data. Such an analysis suggests that traditional methods may not be adequate for current daily-life research. The pertinent issues are summarized in Table 1. First, in terms of ecological validity, interview, survey, experiment and diary methods each face great limitations in collecting real-situational data. Researchers using these methods obtain only fuzzy recall data, not a real-time sample. Although a diary may help the respondents recall incidents and situations, it can hardly capture the real situation in the moment. The general experience sampling method (ESM) is designed to facilitate data collection concerning both the context and content of individuals' daily life [18]. The sensor-based method likewise derives greater ecological validity from its provision of context-sensitive raw sensor data in real time.

From the perspective of time, interviews, surveys and experiments usually collect transverse data at a specific point of time. They are implemented only once and are typically classified as one-shot evaluation methods. Diary, general ESM, and sensor-based methods, in contrast, permit repeated measurements of variables and collect data cumulatively; they can be grouped as intensive longitudinal methods [19, 20]. With respect to the user's participation and perception, most of these methods (interview, survey, experiment, diary and general ESM) require active participation or self-reporting, and the whole process is made explicit to the users. An exception is the

sensor-based method, which collects data directly without user's participation and can thus be characterized as implicit and passive, reducing the interruptions experienced by users.

Table 1 also presents five aspects of data as they apply to each method: data characteristics, data size, the collection of emotional or experiential data, the data's semantic richness, and the presence of retrospective bias. In general, data collected via interviews and diaries will be qualitative, whereas surveys, experiments, and sensor-based methods usually collect quantitative data. Notably, general ESM can capture both [18, 21]. In terms of data size, surveys usually allow for a large sample, whereas interviews, experiments, diaries, and general ESM are often restricted to a small sample size; the sampling size of sensor-based methods can be large or small. Diary, general ESM and sensor-based methods can collect cumulative data, while the other methods obtain one-shot data. Sensor-based methods yield raw sensor data without semantics, which gives rise to a problem of interpretation. Such methods, unlike the others, cannot supply information about individuals' experiences and emotions per se. Since sensor-based methods and general ESM can capture real-time data, these two methods have a smaller retrospective bias.

The above comparison shows that traditional methods, such as interviews, surveys, experiments and diary-keeping, cannot effectively capture real-situation data or facilitate longitudinal research. Although sensor-based methods can be applied to large or small samples with implicit data collection, the data obtained by this method is only raw sensor data, lacking semantic information. General ESM provides a good methodological framework for studying daily life, helping to capture real situations and supplying intensive longitudinal data; it can collect both qualitative and quantitative data and supply semantically rich descriptions of experiences and emotions, but it is complicated and inconvenient to implement (a point developed further below), especially when being used to study the elderly, and a small sample size is typical. Thus, in a mobile internet environment, it is necessary to improve general ESM to allow for the effective and convenient study of elders' day-to-day information behaviors.

Information and communication technology (ICT) offers tremendous opportunities for both researchers and the elderly. As mobile technology gradually integrates into our lives, a mobile phone has become a necessity, not a luxury. Increasingly, older adults use mobile phones or smartphones to satisfy their everyday health, social, and leisure needs. The corresponding information behaviors have been of great interest to researchers. Meanwhile, more and more researchers have adopted mobile technology to facilitate their elderly-related studies. In this paper, mobile experience sampling method (mESM) is proposed as highly suitable for research on the day-to-day information behavior of the elderly within this emerging mobile internet environment. mESM is a longitudinal method that uses mobile technology to study behaviors and experiences occurring naturally in people's everyday life. It is, in essence, an experience sampling method that inherits the implementation framework of ESM and improves upon it with mobile technology. Herein, we aim to introduce mESM and its implementation framework, and to contemplate potential improvements to mESM for studying the daily life of the elderly.

Table 1. Comparison of six data capture methods

			Interview	Survey	Experiment	Diary	General ESM	Sensor-based method
Context	Ecological validity		Low	Low	Low	Low	High	High
Time	Transverse		✓	✓	✓			
	Longitudinal					✓	✓	✓
User	Participation	Active	✓	✓	✓	✓	✓	
		Passive						✓
	Perception	Implicit						✓
		Explicit	✓	✓	✓	✓	✓	
Data	Characteristics	Qualitative	✓			✓	✓	
		Quantitative		✓	✓		✓	✓
	Size	Sampling	Small	Large	Small	Small	Small	Large or small
		Cumulative				✓	✓	✓
	Emotional or experiential		✓	✓	✓	✓	✓	
	Semantic richness		High	High or low	High or low	High	High	Low
	Retrospective bias		Large	Large	N/A	Large	Small	Small

3 How to Use mESM

3.1 Make Good Use of the Implementation Framework

mESM is a descendant of the *experience sampling method* (ESM), a systematic phenomenology approach proposed at the University of Chicago in the 1970s [18]. Typically, general ESM uses a tool to signal participants, allow them to answer questions at random moments every day or complete a report following a particular event of interest, achieving the purpose of data collection. It is essentially a self-report method. Because participants voluntarily and spontaneously perform their reports in a real and natural situation, ESM is ecologically valid. Through repeated measurement, ESM can help to explore people's dynamic and complex behaviors, experiences and emotions.

Generally, the signaling tool and experience sampling form (ESF) are the two important components of ESM [18], as shown in Fig. 1. Early ESM studies used a setup known as paper-based ESM (ESMp), with pagers for signaling and paper ESFs for data collection. After receiving a signal, ESMp participants filled out the paper ESF immediately and mailed it back to the researcher as soon as possible (e.g. at the end of the day) [22]. It was understandably difficult for ESMp researchers to control this cumbersome process, and participants may have felt inconvenienced as well. Computerized ESM (ESMc) was welcomed by researchers because it alleviated some of these problems, allowed researchers to better understand the process of participants' completion of the forms, and reduced the cost of data transcription. The ESM programs ESP and iESP, for example—both developed by Intel Research [23]—used a PDA to signal participants and collect data. However, researchers still needed to download and aggregate data from every participant's PDA after finishing their research. This created

problems with data synchronization and prevented ESMc from attaining popularity as a tool for large-scale field research. The development of mobile devices, the proliferation of wireless networks, and the growing popularity of online surveys led to the creation of mESM, which highlights the advantages of using mobile technology. Modern mESM software usually runs on smartphones, supports both signaling and ESF completion, and has servers to support real-time synchronization of data. Some mESM tools can even support context awareness and signaling based on sensors (e.g. GPS sensors). Therefore, mESM greatly improves the convenience of everyday-life research and makes it possible to enlarge the sample size. In addition, a mESM tool with sensors may collect both explicit self-report data and implicit sensor data, thereby obtaining more richly contextualized data and semantics. In short, mESM is an ideal method for everyday-life research.

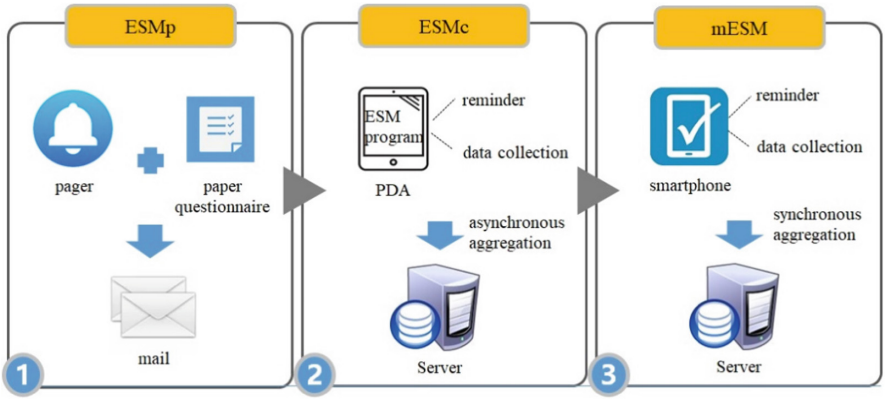

Fig. 1. Evolution of ESM tools

Table 2 shows a detailed implementation framework for mESM. It can be divided into three stages: before implementation (BI), during implementation (DI) and after implementation (AI). In the BI stage, researchers need to select a sampling method, determine a timeframe, choose an mESM tool, and design the ESF. Next, they must recruit, select, and orient participants. Within ESM, there are generally three classes of sampling method from which to choose (Table 2). In *time-contingent sampling*, participants are signaled at random times or at different time intervals every day [19]. For example, researchers may send a certain number of signals randomly between 7:00 am and 10:00 pm every day. The *event-contingent sampling* method solicits self-reports following a specific event of interest [18] (e.g. an interaction in social media). *Mixed sampling* usually combines time-contingent sampling with event-contingent sampling; for example, researchers may signal readers to complete self-reports at specific times; at the same time, the readers may complete their reports once they have finished reading an e-book.

The timeframe decision concerns how many days participants will be asked to report (*research cycle*) and how many times per day they will be signaled to provide these reports (*daily sampling frequency*). Together, these two criteria determine the sampling schedule. Some guidance can also be obtained from researchers' long experience with general ESM: studies shows that a seven-day cycle is likely to yield a fairly representative sample of the various activities individuals engage in and to elicit multiple responses from many of these activities [18]. The most common daily sampling frequency is three times per day (e.g. in the morning, at noon and at night) [24]. Sampling for longer than seven days or more frequently than six times per day may place an excessive burden on some participants [18, 25].

Although there are some ready-made mESM-style tools (e.g. *Ohmage*, *Open Data Kit*, *Paco*, *LifeData*, *Ilumivu*, *MetricWire*, *Movisens*, *Expimetrics*, *Aware*, *ESM capture*, and *Piel Survey*) [21], researchers must still decide between a ready-made tool and a custom tool according to the needs of research. It is also necessary to design an ESF that can be completed within five minutes or less to reduce the burden borne by participants.

In principle, anyone who can read and operate a smartphone can participate in a mESM study. It is essential, however, that individuals voluntarily participate in the study and can guarantee their completion of the entire research process. Because of the richness of the data, studies with as few as 5 or 10 participants can produce enough data to be used reliably in simple statistical analysis [18]. Certainly, with the support provided by an mESM tool, a larger sample size is possible. However, before actually going into the field, researchers should have an orientation meeting and implement a pilot test. Orientation will provide instruction about the procedure and strengthen the research alliance by providing further explanation of the study's goals and answering any questions.

In the DI stage, participants first receive SMS or other signals, then fill in and submit ESF anytime and anywhere. Researchers should track the research every day to find missing data and send reminders to corresponding participants. Incentivization (whether material or nonmaterial) and retention of participants are necessary; to realize the latter, it is beneficial to provide a thorough and honest explanation of the study and establish a relationship of trust. In this stage, researchers are highly recommended to write memos every day, because memos provide more extensive and in-depth data and thinking for mESM research.

In the AI stage, a debriefing interview may help researchers get more extensive information. For example, participants are often asked whether they felt that the period of signaling represented a "normal week" in their lives and whether any specific activities or situations caused them to fail to answer the signal. After data cleaning, the process of data analysis includes both *response-level* and *person-level* analysis [18]. The former involves the raw data submitted after each individual signaling, while the latter involves summarizing and analyzing the raw data for each individual. According to the underlying purpose of the research, this analysis may be qualitative (e.g. case analysis) or quantitative (e.g. ANOVA, ordinary least squares (OLS) or hierarchical linear modeling (HLM)) [18].

Table 2. Implementation framework for mESM

Stage	Contents	Details
BI	Determine sampling method	• Time-contingent sampling • Event-contingent sampling • Mixed sampling
	Determine framework of time	• Research cycle • Daily sampling frequency • Signaling schedule
	Decide on mESM tool	• Choosing a ready-made or customized tool
	Design ESF	• Controlling items of ESF
	Recruit, select and orient participants	• Basic requirements for participants • Prerequisites of participation • Number of participants • Orientation
DI	Send signals	• SMS or other signals
	Participants fill in and submit ESF	• Anytime, anywhere
	Track the research	• Anytime, anywhere
	Reminder participants to fill in	• Timing and frequency of reminders
	Incentives and retention	• Material or nonmaterial incentives • Explain the study and establish relationship of trust
	Create memo	• Provide extensive data
AI	Interview	• Debriefing interview
	Process and analyze data	• Data cleaning • Response-level analysis • Person-level analysis

Note: BI: before implementation; DI: during implementation; AF: after implementation

3.2 Improvements for the Elderly

The above implementation framework provides basic guidance for mESM field studies. However, there are some specific improvements to consider in studying the day-to-day life of elderly people (those who use smartphones). First, older participants may not be comfortable reading text in small fonts, so picture, voice, and video channels may be a good choice. For example, items in the ESF may be displayed as pictures or videos, and participants may complete their report as a voice recording. Second, researchers should consider allowing elderly respondents to capture their experiences by taking photos, which can also assist in recollection after the fact [26]. Third, the cognitive load of the elderly should be taken into account: it is recommended to use mESM tools with a simple interface and a simple feature set. Fourth, it should be acknowledged that health problems are prevalent among the elderly; a large amount of sensor data involving position, movement, etc., can be integrated into health information behavior research conducted on elderly subjects. Fortunately, all of these criteria can be satisfied with smartphone-based mESM; accordingly, our team are developing a mESM tool tailored

to the elderly. In addition, the sampling method, timeframe, orientation, sampling schedule, incentives, and retention practices should be tailored both to the age of the participants and to the purpose of the research.

4 Discussion

From a researcher's perspective, mESM has become an ideal method for capturing the day-to-day information behaviors of the elderly. Compared with general ESM, mESM is more convenient and can capture qualitative or quantitative data explicitly or implicitly for a large or small sample size. In addition, mESM tools are readily combined with other methods, such as ethnography or field experiments [21]. Therefore, widespread adoption of mESM is expected in various fields, including clinical medicine, healthcare and pharmaceutical research, mobile health management, mobile social and mobile education. However, repeated signaling inevitably disturbs the elderly, and the development or selection of a tool, combined with orientation and the provision of a monetary incentive, will tend to increase the cost of this method. Additionally, if a study integrates sensors, the investigators will face the challenges inherent in dealing with heterogeneous data.

The perspective of the elderly, too, must be taken into account. Researchers should favor reporting methods that are accessible, easy to navigate, and not cognitively burdensome. Moreover, an effort must be made to improve the ICT literacy of the elderly, and the privacy issues arising in an mESM-based study should be managed so as to protect elders' rights.

Policymakers also have a role to play. Given the method's potential value for understanding the needs and challenges of the elderly, the government should encourage mESM studies with elderly respondents. Official guidance for research and related industries is also important, as are clear policies on mESM-related privacy protection.

5 Conclusion

In sum, mESM is an ideal research method that combines the strengths of classic ESM with current mobile technology. Although there are still some challenges in applying the method to the day-to-day life of older people, mESM shows evident promise in this field. With the support of mESM-based studies, we may understand the elderly more accurately, facilitate older adults' self-management of daily life, choose policies that better match the needs and characteristics of elderly citizens, and enable service providers to provide more accurate context-based services for this growing demographic.

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