Suitability of Event-Based Prompts in Experience Sampling Studies Focusing on Location Changes

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Abstract. Among others, location changes and activity level are indicators for state changes of patients suffering from affective disorders such as Bipolar disorder, Borderline personality disorder or depression. It is a common means to assess this information via self-report questionnaires. Usually, these are sent out either randomly throughout the day or at fixed points in time. However, this might lead to missing records of location changes. We propose to rely on event-triggers: send out self-report prompts when a location change is automatically detected. We enhanced the ESMAC application by a location change detection event. Then, we created three different study configurations for each trigger type: random, time-based, and event-based. In a three-week within-subject study we let subjects experience each trigger type in randomized order. We found statistically significant differences in favor of the event-triggers in terms of number of prompts, response rate, prompts after detected location changes, and prompts after detected activity changes. We conclude that event-triggers based on a location change detection shall be used as trigger type for experience sampling studies focussing on location or activity changes.

Keywords: Experience sampling method · ESMAC
Location changes · Mobile sensing · User experience

1 Introduction

In clinical psychology the assessment of states and state changes of patients suffering from affective disorders – e.g. depression, bipolar or borderline personality disorder – is important to perform an appropriate treatment [1,2]. Location changes and user activity information are relevant as they can provide insights about motoric activity (lethargically staying at home vs. moving from one place to another) or avoidance of other people (staying at home vs. changing location) which are symptoms of depression [3]. Such context information relates to states and state changes [4]. Psychomotoric changes in patients suffering from

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depression is mirrored in the patient's movement behavior and their location changes [5].

The most common method in clinical psychology to assess user behavior information is to apply experience sampling or ecological momentary analysis to monitor the patient by tracking their daily activities with their smartphones and to prompt them to answer self-report questionnaires. These prompts are displayed in form of smartphone notifications. Related work distinguishes three prompting types: random, time-triggered and event-triggered [6]. *Random* means that prompts are sent our randomly over the day, only the number of prompts is fixed. *Time-triggered* means that prompts are sent out at pre-defined points in time such as every full our between 8 a.m. and 10 p.m. *Event-triggered* means that prompts are sent out if a specific event happens such as a location change or when a certain activity is performed.

We investigated the suitability of these three prompting types for assessing information about the location changes and activities within a field-study and present the results.

2 User Study

Study Design. We wanted to oppose three trigger types and assess how user experience each of them and how they quantify against each other in terms of number of prompts and response rate (number of responses/number of prompts) as well as percentage of prompts after actual location or activity changes. We decided to design the study within-subject with randomized order to counteract carry-over effects. Subjects were prompted for self-reports between 8 a.m. and 10 p.m. to allow them to rest over night without being disturbed. 14 prompts were sent out randomly over the day for the *random* condition. *Time*-triggered prompts appeared at each full hour, i.e. also 14 times. *Event*-triggered prompts appeared at each detected location change, i.e. the number varies per day and per subject.

Location Change-Aware Experience Sampling Application. To assess location changes and activities we required an experience sampling application. We enhanced ESMAC, the experience sampling method app configurator [7]. First, we added a location change detection mechanism as a new event-trigger. We defined location changes as a situation in which a user showed movement behavior six times in a row. Movement behavior was defined as moving at least 60 meters in one minute, i.e. moving with at least 1 m/s. Next, we added questions to be displayed to the user. They consisted of questions about the current and last location and about the current and last activity. Last, we had to configure the trigger type for each study condition. In the end, we had three different configuration files: each one for random, time-trigger, and event-trigger, respectively.

Procedure. At the beginning of the study, we met with the subjects, explained the study and asked them to sign a consent form. Afterwards, we installed the app

with the first configuration and asked for demographic data. The user study itself lasted three weeks, i.e. one week per trigger type. It took place during lecture time to guarantee fairly similar circumstances for each week. We collected data from Monday to Friday. On the weekend, we exported and pseudonymized all log files and questionnaire answers from the smartphone, handed out feedback questionnaires about the experience with our app during the week and installed the new configuration file. At the end of the user study, we assessed the general experience with our app over all three weeks.

Subjects. Initially, 23 subjects participated the study. However, 4 of them quit during the study and for 2 subjects no data was collected due to technical issues. Three of the remaining 17 subjects were female, 14 were male. They were between 18 and 29 years old. We focused on students as subjects as they are digital natives and used to the usage of smartphones in everyday life. In addition, they have a regular week structure which guarantees comparable circumstances for each experimental condition.

3 Results

We looked into number of prompts, response rates, and the accurate detection of actual location and activity changes. The latter will be presented in form of the relation between the number of questionnaires prompted after an actual location or activity change relative to the total number of prompts. Table 1 gives an overview of the results. It might be surprising that some subjects apparently received less than 70 prompts for random and time-triggered which is the expectancy value (5 days, 14 prompts per day). Apparently, some subjects turned their phone off during the study causing less prompts. What is visible is that event-triggered prompts are fewer but more accurate in terms of prompting after actual location or activity changes. This type also shows a higher response rate that might be caused by a higher user compliance due to fewer prompts.

To evaluate if the differences between different trigger types are statistically significant or caused by coincidence, we ran correlation analyses. As the data is not normally distributed, we decided to perform parameter-free Friedman tests. The results are listed in Tables 2, 3, 4 and 5. Differences between event and time and between event and random triggers show p values below .05 and, thereby, statistical significance. This proofs that location-aware event triggers are most suitable in experience sampling studies focussing on location and activity changes.

Table 1. Overview of number of prompts, response rates, and the accurate detection of actual location and activity changes for each trigger type.

	Time	Event	Random
Number of prompts	62.80 (±39.94)	19.50 (±9.55)	62.70 (±35.11)
Response rate	0.37 (±0.10)	0.43 (±0.09)	0.31 (±0.18)
Percentage of prompts after location change	0.28 (±0.16)	0.71 (±0.23)	0.29 (±0.19)
Percentage of prompts after activity change	0.41 (±0.19)	0.69 (±0.27)	0.37 8 (±0.19)

Table 2. Results of the pairwise comparison of all trigger types for the variable "number of prompts". Significant results are marked: *$p < .05$; **$p < .01$

	Time		Event		Random	
Number of prompts	Mean difference	p value	Mean difference	p value	Mean difference	p value
Time			43.3	.014*	0.1	1
Event	−43.3	.014*			−43.2	.005**
Random	−0.1	1	43.2	.005**		

Table 3. Results of the pairwise comparison of all trigger types for the variable "response rate". Significant results are marked: *$p < .05$

	Time		Event		Random	
Response rate	z value	p value	z value	p value	z value	p value
Time			−1.988	.047*	−1.682	.093
Event	−1.988	.047*			−2.497	.013*
Random	−1.682	.093	−2.497	.013*		

Table 4. Results of the pairwise comparison of all trigger types for the variable "percentage of prompts after detected location change". Significant results are marked: *$p < .05$; **< 0.01

	Time		Event		Random	
Percentage of prompts after detected location change	z value	p value	z value	p value	z value	p value
Time			−2.805	.005**	−0.459	.646
Event	−2.805	.005**			−2.701	.007**
Random	−0.459	.646	−2.701	.007**		

Table 5. Results of the pairwise comparison of all trigger types for the variable "percentage of prompts after detected activity change"'. Significant results are marked: $^{*}p < .05$; $^{**}p < .01$

	Time		Event		Random	
Percentage of prompts after detected activity change	Mean difference	p value	Mean difference	p value	Mean difference	p value
Time			0.285	.001**	−0.04	1
Event	−0.285	.001**			−0.326	.048*
Random	0.04	1	0.326	.048*		

4 Conclusion

Within a three-week study we collected location change and activity information from 17 subjects using three different trigger-types for self-report prompts. We opposed all three trigger types in terms of number of prompts, response rate and detection of actual location and activity changes. We found that the event-trigger scored highest in all categories. Statistical tests proof that the scoring differences are significant *between event and time* and *between event and random* triggers. The low number of prompts for event triggers goes together with a high response rate. We assume that this is due to higher user experience: fewer prompts and prompts that relate to the current user context (location and activity change) result in a higher compliance. Hence, we suggest to use event triggers whenever an event trigger is available that relates to items in the questionnaire.

We see a high potential of these findings for context recognition in clinical psychology. Apart from triggering prompts, location changes can reveal regularity, duration, and frequency of location visits. These aspects can give a deeper insight into affective disorder symptoms such as loss of interest to perform usual activities or decreasing motoric activity.

We intend to design and conduct further studies with patients suffering from affective disorders as subjects. Thereby, we want to gain insights about their location change behavior and evaluate the usefulness of our location detection for phase change detection. We might even consider place types[1] [8] or WiFi SSIDs as location [9].

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