Smartphone Based Experience Sampling of Stress-Related Events

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Mobile phones are gaining particular importance in health care services. In fact, the incredible diffusion of mobile electronic devices has opened new scenarios for the assessment of stress-related events. We presented an Android Smartphone based experience sampling method and a real life data set containing stress related events. Data consisted of 12 weeks of 9 trial participants provided with Android Smartphone equipped with a specific experience sampling application.

Keywords- Stress, Experience Sampling Method, ESM, Smartphone, Psychometrics

I. INTRODUCTION AND RELATED WORK

Knowing the stress level and its progress can be relevant for a number of applications. Examples range from psychological therapy monitoring through collecting scientific ground truth information to quantified self interests. Especially research in methods to detect event related stress levels demand ground truth information.

Existing methods to reliably detect a subjects stress level rely on physiological signals like heart rate and galvanic skin response [1], finger temperature [2], rhythm of keyboard input [3], facial recognition [4] and voice analysis for estimating the stress level [5]. Experiments in related work were carried out in psychology laboratories to detect (artificially precipitated) stressful situations by monitoring physiological signals under professional supervision. The fundamental work most similar to ours was done by Gaggioli and colleagues [6] involving Windows Mo- bile based phones. They implemented an application recording accelerometer and ECG data together with a questionnaire on the device. Experience sampling methods were first described in [7] and [8].

The purpose of this study was to evaluate the correlation of experience sampling based stress level and well being statement requests. It is important to mention that the experience sampling data set for stress related event detection was collected in a real workaday scenario of 9 trial participants during 12 weeks. Our approach was to record experience sampling requests directly on a Smartphone which trial participants use as their primary device during the whole time of the trial. This enables research on event related stress detection based on behavioral patterns identified by Smartphone s as a sensor platform. An initial experiment was performed previously were the location, social interaction, telephone call behavior and text message behavior was compared between a two week stressful situation and a two week non-stressful situation [9] with the result of an average behavior modification of 53%. However the previous experiment was intended to analyze a general change in behavior between long term stressful and non stressful periods no experience sampling mechanisms was implemented.

According to Cohen and colleagues [10], psychological stress occurs when an individual perceives that environmental demands tax or exceed his or her adaptive capacity to cope with them. However it is not easy to assess psychological stress in a laboratory setting, or more in general, in absence of ecological validity.

To overcome this limit, self-help approaches and telehealth-based treatments are being developed to enhance treatment fidelity, effectiveness, accessibility and ecological validity [11-25]. Specifically, mobile phones are gaining particular importance in health care services [26, 27]. In fact, the incredible diffusion of mobile electronic devices [12] has also introduced the possibility of setting up and testing effective stress management techniques beyond a clinical setting [28], and more in general the assessment of stress-related events can be more effective by the means of specific mobile applications.

II. METHODOLOGY AND EXPERIENCE SAMPLING DATASET

The foundation of our Smartphone based experience sampling approach is based on the observation that people are used to interact with their Smartphone in every location, in every situation, and at all times. We developed a Smartphone based experience sampling method for collecting stress related events during a long-term trial. The software is implemented as a native Android application. In contrast to a web application we can use core Android OS features to actively present the survey to the user at the desired times even when the device is currently not in use. An experience sampling request is unobtrusive to the outside world of the subject by attracting the attention through a specific vibration pattern and not through visible or acoustic signals. The subject itself is then aware about the upcoming experience sampling request.

Psychological stress has been measured by using a digitalized version of an ESM survey adapted from that used by Jacobs and Colleagues [6, 29] for studying the immediate effects of daily life stressors on mood. The questionnaire included open-ended and closed-ended questions investigating the thoughts, the mood, and the current context (activity, people, location, etc). Following the procedure suggested by Jacobs and Colleagues [29], one scale has been computed in

order to identify the stressful qualities of daily life experiences. Ongoing Activity-Related Stress (ARS) was defined as the mean score of the two items "I would rather be doing something else" and "This activity requires effort." Furthermore, in order to rate the gap between challenge and skills, we used two specific items: (1) an item assessing the perceived level of an ongoing challenge (CHALLENGE) on 7-point Likert; and (2) an item evaluating the perceived level of skills (SKILLS) on 7-point Likert. In addition to those scales (not included in the original survey), we introduced an item asking participants to rate the perceived level of stress (STRESS) on a 10-point Likert scale.

Then, Activity-Related Stress Scale (ARS), Subjective Stress Scale (STRESS), Challenge Scale (CHALLENGE) and Skill Scale (SKILLS) were within-subjects standardized.

Experience sampling requests are made daily (weekdays and week end) from 10 am to 10 pm. The survey is presented 10 times a day at variable time of occurrences. While experience sampling is active during 12 hours of the day we request one experience sampling in a time window of 72 minutes. The request is uniformly distributed in each time window. The exact time of occurrence is not predictable and therefore subjects are not prone to act artificially towards an upcoming request.

We recruited 9 subjects to participate in our trial for stress-related event recording. The trial had a length of 12 weeks. The selected periods of time included term, exam preparation and holiday time. We anticipated to cover different stress levels during those periods. Subjects were told to use the provided Android Smartphone , equipped with our Interstress Android experience sampling application, as their primary phone during the experiment. The motive for this was that participants should be familiar with the Smartphone and recognize it as a non-intrusive device and always to be at hand when a experience sampling request is made.

Figure 1. Start screen of the Android application, which is shown when the application is manually started.

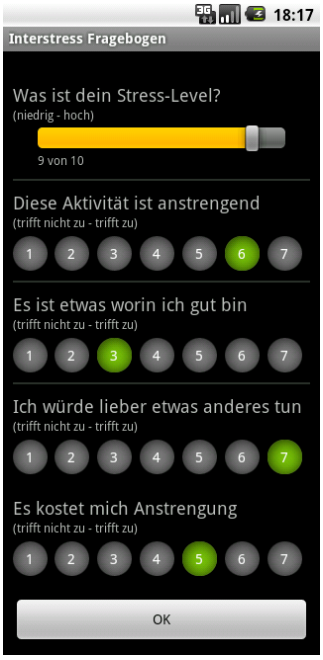

Figure 2. Android application screen with the experience sample request showing a filled in experience sample. The screen is scrollable but shown entirely in this figure. The stress level (top) can be set by a slider user interface element and the other statements (bottom) can be selected by custom user interface elements symbolized as circles. A confirmation Button is located at the bottom of the screen. When the subject taps the button the experience sample is stored together locally on the SD card with the current timestamp. Statements/questions from top to bottom: "What is your stress level?", "This activity is demanding", "This is something I am good at", "I would prefer doing something else", and "It takes me effort".

III. RESULTS

Activity-Related Stress Scale, Social Stress Scale, Perceived Stress Scale, Challenge Scale and Skill Scale were within-subjects standardized. Event-Related Stress Scale wasn't standardized so it was classified as follows: 0 = no stress; 1= low stress; 2 = medium stress; 3 = high stress. The following have been calculated:

- **STRESS**: the perceived level of stress.
- **ZSTRESS:** Z score STRESS subject-level.
- **CHALLENGES**: "This activity is a challenge", an item assessing the perceived level of ongoing challenge.
- **ZCHALLENGES:** Z score CHALLENGES subject-level.
- **SKILLS**:"This is something I am good at", an item evaluating the perceived level of skills.
- **ZSKILLS**: Z score SKILLS subject-level.
- **Activity-Related Stress (ARS):** mean score of 2 items ("I would rather be doing something else" and "It takes me effort").
- **ZARS:** Z score ARS subject-level.

Correlations

		ZSTRESS	ZCHALLENGES	ZSKILLS	ZARS
ZSTRESS	Pearson Correlation	1	.615**	-.427**	.615**
	Sig. (2-tailed)		0.000	.000	0.000
	N		6068	6064	6060
ZCHALLENGES	Pearson Correlation		1	-.442**	.736**
	Sig. (2-tailed)			.000	0.000
	N			6064	6060
ZSKILLS	Pearson Correlation			1	-.635**
	Sig. (2-tailed)				0.000
	N				6060

**. Correlation is significant at the 0.01 level (2-tailed).

IV. Conclusion And Future Work

The preliminary data collected showed really promising perspectives.

Data showed a great internal validity of the Stress questionnaire adapted for Experience Sampling collection. In particular an interesting result is the sign of challenges and skills. In fact challenge are positively correlated with stress scales, while skills are negatively correlated with stress scales.

Further works need to investigate these important aspects using this stress questionnaire but also physiological and activity indexes.

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