Possibilities of Psychophysiological Methods for Measuring Emotional Aspects in Mobile Contexts

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ABSTRACT
Traditional methods to access the emotional experience of a user such as subjective reports have certain disadvantages. Participants have to be asked for their feeelings and emotions which interrupts the process of experience and flow. Psychophysiological methods offer data throughout the process of emotional experience, which unfolds new possibilities for user experience (UX) evaluation. In this paper we provide a short overview of applied psychophysiological methods for human computer interaction (HCI) and the findings of our examinations for mobile motion contexts. Our outcomes will be discussed considering the possibilities, challenges and feasibility of these methods in the area of interaction with systems and emotions. Based on our experience we think that psychophysiological measurements provide important possibilities for applications in the field and can help to deepen and expand the insights gathered by traditional methods.

Keywords
User Experience, Psychophysiology, Emotion, Human Computer Interaction, Evaluation, Movement;

INTRODUCTION
Over the past years there has been increasing interest in emotional aspects of mobile applications. Pleasurable mobile products have to offer more than functionality and usability, they address other aspects such as aesthetics, beauty, or playability, which enrich our experience with interactive systems. In recent years the field of HCI and industry acknowledged the design and architecture knowledge that stimulating experience of a product plays an essential role for mobile UX. However trying to "measure the experience" is a nontrivial task by definition and also regarding a practical approach. UX is embedded in a situational, temporal, individual and product context and difficult to comprehend [12]. Experience with technology as characterized by McCarthy and Wright consists of a sensual, an emotional, a compositional and a spatio-temporal thread [15]. Hence, accessing the emotional state of users is crucial for developing satisfying mobile products that are rich in experience, although emotion is only one out of more aspects.

Methods to Assess Emotions
Traditional methods include questionnaires, interviews, narrative techniques and contextual inquiry. In general, these methods are based on self-reporting and record a user's perception, such as sensual evaluation [10]. The added value of these methods is the possibility of an insight into the person's feelings and preferences. Other possibilities are observational techniques and video analysis, where the evaluation of the material is a very long and laborious process. Moreover, the intersubjectivity and validity of this approach is hard to guarantee. Beside the described techniques, there are approaches to automate expression recognition of speech, faces or gestures [7]. Combinations of these automatic expression recognition methods result in a broader spectrum of emotions that can be detected [5, 8]. The problem that remains unsolved is how these methods support accessing emotions in a mobile context.

Psychophysiological Methods in HCI
Psychophysiological recordings have been shown to be valuable approaches for measuring valence (a quality for positive and negative emotions) and arousal throughout the process of an experience. Asking a participant about its emotional state is crucial, but interrupting the flow of interaction and experience, which is not necessary when psychophysiological methods are employed. Additionally, psychophysiological measurements can help uncovering social masking, which means people often say positive things about a product because they hesitate to be negative. Furthermore, it's possible to analyse data for special situations during the evaluation, e.g. the moment when a participant won a game. Psychophysiological methods support the analysis of certain crucial situations of an experience that are essential for emotional experience, but also provide summative analyses over time [11]. Subjective

reports are prone to the fact that emotions are not always easy to put into concrete words and small but important details are sometimes forgotten.

Psychophysiological methods have some disadvantages as well. They are still costly and complex to apply and people are fitted up with cables and electrodes and therefore restricted in moving and acting freely and without restrictions. Making it more difficult, the setting may cause arousal or different emotions in people and therefore alter the results. Much time is needed to postprocess and interpret all the data that has been acquired during evaluation. Nevertheless, the possibility of obtaining data throughout the whole test is very advantageous. To give more insight into the world of psychophysiology, the following section shall give a short overview of methods we applied for emotional evaluation:

Electromyography (EMG) measures muscle activity by detecting surface voltages that occur when a muscle is contracted. To find out about positive emotions the activation of the *zygomaticus major* muscle, which is activated while laughing, is recorded. Simultaneously, negative emotions are measured by the *currogator supercilii* muscle, which is activated while frowning. EMG was used in a lot of studies to access the valence of emotions [3, 11, 14, 15]. On the one hand, EMG is more accurate than facial expression recognition with video analysis, because low evocative emotions are difficult to recognize visually. On the other hand, sensors with cables are attached in the face, which is obtrusive for participants.

Electrodermal activity (EDA) measures the activity of the eccrine sweat glands and is said to be a linear correlate to arousal [4]. Although room temperature, humidity, participants activities and the correct attachment of the electrodes has to be carefully considered, tonic EDA is a well researched and valid method to record arousal and was used for measuring emotions for interaction with systems [19, 15].

Respiration can be used as measurement for negative valence and arousal [7]. More important, changes in respiration rate affect other psychophysiological metrics such as EDA or cardiovascular functions.

The cardiovascular system offers several measuring options to determine valence or arousal: Blood Volume Pressure (BVP) indicates a correlation between greater dilation in the blood vessels with less arousal [19]. The heart rate (HR) is correlated with arousal as well and variability of the heart rate (HRV) is used as a metric for assessing the positive or negative valence of an experience [1]. HRV is also used as a measure for mental workload. Nevertheless, measuring HR can raise privacy and intimacy issues, as traditional electrocardiography requires the attachment of electrodes in the chest area.

It's important to mention that these methods should not be applied unimodal. A multimodal approach is more accurate and results in a broader spectrum of aspects of emotions, but has the disadvantage that multiple channels have to be combined, analysed and finally interpreted. Every method has its strengths and weaknesses, also strongly depending on the evaluation context.

All these described methods seem to have great potential to be used in UX research, but the question remains whether they can be used in a mobile context. Mobility demands people to be in motion, and this has not only effects on the applied methods. Common sense and results from UX research suggests that the interaction with products, tools, and artefacts can be enriched by allowing people to move naturally and unrestrictedly [17, 2]. If people express themselves with their whole body, they immerse into another world more naturally and easily. There is evidence that there is a strong relation between movement and emotions [13]. With the following report we try to shed some light on the world of psychophysiology for mobile UX research.

AN EXPERIENCE REPORT

Implementing psychophysiological methods has to be done very carefully and with great care due to the many variables that can alter the results. Temperature, humidity, attachment of electrodes, individual differences, differences concerning gender (women even differ depending on the menstrual cycle), age, time of the day, consumed stimulants such as coffee or energy drinks, medicaments, drugs, etc can cause different reactions in sensors and in people. Therefore the former consumption of stimulants from test participants has to be clarified. Care has to be taken for sensor attachment as well: the skin should be shaved if very hairy and not have stains of makeup and skin creme.

In order to access the practicability of such approaches we tried several methods, including EMG, EDA and Respiration, using the ProComp Infiniti System from Thought Technology. Generally, it's a simple task to attach the electrodes and recording the signals compared to the difficulty of psychophysiological signal processing and interpretation of the signals. The signals have to be interpreted but also why participants reacted the way they did in certain situations.

Due to the motion aspect in mobile situations, we conducted research on movement and psychophysiological measuring methods. Our findings and examination of methods suggest that facial EMG is a viable and reliable method to measure positive or negative emotional states, even when participants are moving. Analysis of the signals clarifies explicitly when certain muscles are activated or not (figure 1 and figure 2). Fortunately talking doesn't activate the muscle responsible for laughing in general. Although it can happen that people activate the *zygomaticus* during mimic expressions.

EDA was proven as a viable method to access arousal in several studies. In a movement context, the number of peaks is increasing the more a participant is in motion (see

electrodermal activity in figure 1 and figure 2). Therefore it is very hard to tell the difference between greater arousal because of the movement or enhanced emotions. Our current approach is to record a "movement baseline" to calculate the difference, but further research has to be conducted to shed some light on this matter.

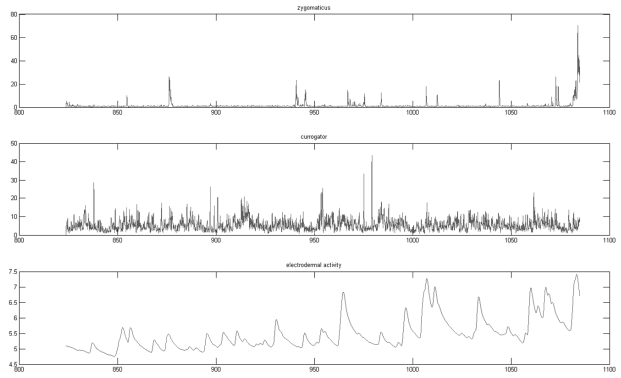

Figure 1: Zygomaticus, Currogator and Electrodermal Activity without movement

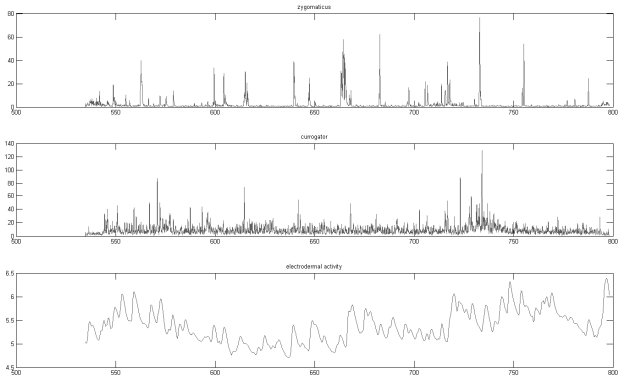

Figure 2: Zygomaticus, Currogator and Electrodermal Activity with participant moving

From our point of view, psychophysiological methods should be supplemented by subjective reports. We used EmoCards, which represent eight faces distributed over the valence arousal space [6], asked participants about discrete emotions such as happiness and anger, and conducted qualitative interviews.

Our next steps will be to employ EMG, EDA and Respiration really in the field. The ProComp Infinity System can store the data also on Flash Memory.

CONCLUSIONS

Based on our first hand experience we think that psychophysiological methods are very well applicable in gaming and entertainment industry, as during gameplay or watching a movie intense emotion and their dramaturgy are a crucial element. This fact makes it easier to analyse and interpret the emotional scope. Psychophysiological measurements of the user's emotions and experiences can help to finetune gameplay and plot composition in the process of developing mobile entertainment systems. However, psychophysiological measuring techniques are not appropriate for all contexts and the decision of which methods to choose has to be adapted in accordance to the system or product that has to be evaluated. Most important of all is to consider the setting, the system and the context before choosing which psychophysiological methods to apply. Not every method is suitable for evaluation of a certain type of interactive system, as invasiveness, privacy and other aspects of psychophysiological methods should be taken under consideration.

A lot of studies aim at assigning discrete emotions (anger, happiness, fear, pleasure, etc.) from psychophysiological recordings. From our point of view emotions are so complex themselves and vary individually and culturally, so that it's vague to create discrete models. Moreover, discrete emotions are not clear to differentiate on a psychophysiological level, and an emotional experience consists of more than one emotion. For those reasons we think that psychophysiological methods are inappropriate for measuring discrete emotions.

Sooner or later psychophysiology will hopefully work non-invasively (advanced video analysis, speech recognition and other refined future technologies) and hence offer great opportunities for mobile emotional experience evaluation. Though, also other areas of interest such as affective computing would benefit from such technical solutions. During an interaction with an affective system the emotional state of users could be determined and the system will react to it appropriately. This could help to enhance technology acceptance for human robot interaction, increase the UX or even a learning process with a system. An example for non-invasive measuring is Anttonen's EMFi chair (a chair equipped with electromagnetical film), where attachment of an electrode is reduced to the ear to record the heart rate [1]. HR would also be potentially interesting for mobile UX, as there are special systems for conductiong the heart rate of patients in the field of cardiology. These systems could be used for measuring HR(V) of participants.

Regarding mobile contexts, it's crucial to provide methods that don't restrict users in moving, feeling and interacting freely.

Psychophysiological methods are not ideally applicable for such contexts because movement of participants alters the signals such as increased heart rate and electrodermal activity. Furthermore, almost all electrodes and sensors are sensitive to movement. Despite of these drawbacks, our findings suggest that facial EMG is a viable and reliable method to measure positive or negative emotional states, even when a participant is in movement. We are working on the implementation of other methods such as EDA as well,

if possible to get viable results even for moving participants.

Psychophysiology in the field of mobile UX is in its infancy and further research is necessary to meet future challenges. We think that EMG is ready to be implemented in certain areas such as the mobile entertainment and gaming industry. At the moment we consider psychophysiological methods as a valuable complement to qualitative and quantitative subjective reports and observational analyses. It has to be taken into account, that psychophysiological methods are restricted in their scope. They enable to measure certain aspects, but not the holistic emotional experience in all its complexity. Further research has to be done to improve these methods and develop non-invasive technologies.

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