Stress Aware: An Investigation of Everyday Real-Time Stress Feedback

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Abstract
Nowadays, more and more commercial health and fitness sensors (e.g. pedometers, heart rate sensors) are available for customers. While some of the measured values are understandable for average users (e.g. heart rate), some of them are not (e.g. heart rate variability). In this paper we investigate how a person's stress level, derived from the skin conductance, can be visually represented. To do so we handed three early design drafts of an Android widget, showing the real-time stress level, to our study participants. Based on qualitative interviews we identify the most important design factors and give suggestions on how the stress level might be represented in future applications.

Keywords
Mobile Sensors, Health State Visualization, Galvanic Skin Response, Stress, Affective Computing

ACM Classification Keywords
H5.2 User Interfaces: Prototyping, Graphical user interfaces, Style guides.

General Terms
Design, Human Factors

Introduction

With more and more portable health sensors available, the number of mobile, gadget-like fitness- and health-trackers has increased over the last years. In addition, these sensors have lost their image to be a medical device. More, they become everyday companions for monitoring our personal well-being. One famous example for these devices is FitBit[1], an accelerometer-based activity sensor, which won the CES Innovation Award in the Health & Wellness category in 2009.

Mostly, either the device itself or a connected mobile device is able to give the user feedback about the most recent measure in a mobile situation. In case of an activity sensor like the FitBit, the visualization can be reasonable simple as shown in Figure 1.

Figure 1: The FitBit (left) indicates the activity by showing a growing flower. The Philips Direct Life[2] (right) represents the activity through an LED progress bar.

With increasing health literacy, more and more professional medical sensors are used for the daily monitoring of the personal well-being. However, an increased medical precision will cause additional insecurities in the interpretation of the data.

In example, most people are aware of typical and healthy values a heart rate sensor indicates (e.g. 119 BPM). However, many of them will be surprised if confronted with the Heart Rate Variability (HRV, e.g. [1]) phenomenon and the corresponding meaning.

In consequence, we argue for further investigation of:

a) Which health information significantly contribute to constitute the individual's feeling of well-being?
b) How can this information be visualized appropriately in a mobile context?

In this paper we investigate which information of the Galvanic Skin Response (GSR) provides a value to be considered in a potential visualization, and how to actually visualize this information accordingly. Based on an exploratory, qualitative design study with 4 participants, we conclude our paper with some design suggestions.

Design

Galvanic Skin Response describes the skin conductance. Depending on the skin moisture the resistance between two measuring points varies. The moister the skin is, the lower is the resistance and the higher is the skin conductance. The change in the skin conductance can be used as a vague measure for stress or emotion [2]. However, as the skin conductance can be influenced by many other factors this paper is not focusing on medical correctness. More, the focus of this paper is on the user interaction and user experience part. We

[1] http://www.fitbit.com/, last visited June, 14 2011.
[2] http://www.directlife.philips.com/, last visited June, 14 2011.

partially followed existing design guidelines for persuasive technologies [3] to develop our system.

Technical Background

We used a Shimmer2r[3] board with GSR top-enclosure and an open-source firmware, intended for use with the BioMOBIUS software. The device is typically connected with two electrodes to certain places of the human body, e.g. between two fingers or two toes (see Figure 2). Bluetooth can be used to connect to the sensor. The sensor streams the measured value at a rate of 32Hz.

Figure 2: The Shimmer2r GSR sensor measures the skin conductance between two electrodes attached to e.g. the finger or the forearm.

Interpretation of the Measures

We map the raw measures to five stress categories to give the user a better and more concrete understanding of the measure. The five stress categories are: very stressed, stressed, neutral, relaxed and very relaxed. The neutral value is user-specific and thus, needs to be defined on a per user basis. Typical neutral values we observed for the Shimmer2r were about 300,000 to 400,000 Ohm.

[3] http://www.shimmer-research.com/, last visited June, 14 2011.

Three Visualization Techniques

Coming from these five categories we invented three different designs, which give the users feedback on their current stress level. To have the visualization present all the time, we decided to realize our approach similar to [3, 4] as an Android widget.

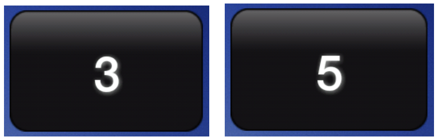

Figure 3: The image on the left indicates a neutral stress level, while the image on the right shows the maximum stress level.

The first visualization technique maps the five stress level categories to numbers, ranging from 1 to 5. For this design 1 needs to be interpreted as very relaxed, while 3 is neutral and 5 is very stressed. The latter two are shown in Figure 3.

Figure 4: The yellow circle on the left indicates a neutral stress level. The red circle on the right represents the maximum stress level.

While the first visualization technique uses numbers and thus looks rather technical and precise, the second visualization technique uses colors. We hope that this makes it more non-technically looking and maybe more appealing. For the colors we decided on the classical traffic-light metaphor. Red means very stressed, orange means stressed, yellow means neutral, light-green means a bit relaxed, and green means very relaxed. As example, two visualizations are shown in Figure 4.

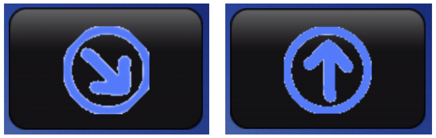

Figure 5: The trend visualization shows the change in comparison to the earlier measured stress level.

The third design shows the difference between the earlier measured stress level and the recently measured stress level. This results in a trend, if the stress is strongly increasing (difference +2 or more), increasing (+1), neutral (0), decreasing (-1) or strongly decreasing (-2 or less). E.g. an increase of the stress level from 1 (very relaxed) to 3 (neutral) results in a strong increase (+2). The five trends are visualized by an arrow as shown in Figure 5, showing upwards, slightly upwards, etc.

Pilot Study

We conducted a pilot study to identify how the presence of the stress widget changes one's behavior and feeling of well-being. Further, we are interested what people think about our design proposals and which they like most.

Method

4 volunteers participated in the study, 2 of them were female. The participants were between 23 and 27 years old. All participants are friends or colleagues of at least one of the authors. However, they were not informed about the intention of the study ahead.

As we want to test the whole system for one complete working day, we met with the participants in the morning. Then we conducted a semi-structured interview on how they generally deal with stress and stress symptoms. We then applied the Shimmer2r GSR sensor with the two electrodes to either the left forearm or two fingers of the participant and handed an HTC Desire Android 2.2 phone, running the widget, to the participant. The system has been re-calibrated for each individual user. We then let the participant explore the different visualizations and explained their meanings. A participant was able to freely change between the three different visualization techniques by clicking on the widget throughout the day.

At the end of the working day we met again with the participant and conducted another semi-structured interview. This time we were interested in how they used the application and if they experienced the stress different than before. We finally discussed ideas on how they could think, how such an application should look like.

Results

For the first participant we weren't able to cover a whole working day. In that case our Bluetooth implementation drained the battery of the phone that quickly that we were able to only cover half of a day. Luckily, we were able to optimize the application for the other participants, where we consequently recorded a complete working day.

In the interview ahead of the study, most participants said that they typically recognize stress as a feeling of: rush, time pressure, disturbance, nervousness, and a noticeable higher heart rate. Most participants actively think about stress several times a week, in particular if too many things are happening/required at the same time. The participants stated that they are vulnerable for stress in particular shortly ahead of any deadline. As countermeasure most of the participants try to actively relax/calm down themselves, also by trying to be better prepared and well trained.

After the study all participants stated that the system helped to feel their own level of stress somehow. Three participants stated that they liked to have the additional objective support, aiding their personal individual feelings. Three participants said that the stress representation is appropriate, one participant was skeptical towards the correctness. Three participants preferred the numerical (1 to 5, see Figure 3) stress presentation over the other two because of the additional precision. One participant preferred the color representation instead, which actually has exactly the same precision as the numerical presentation. None of the participants used the trend visualization. Also none of the participants was able to name a situation, where the system provided an additional benefit. More, all participants stated that the use of the system didn't affect their life in any way. However, three participants would like to continue using the system. To improve the system, the participants mostly wished a better wearing comfort. Some participants could imagine another feedback system, which doesn't need a mobile phone. Two participants required a more summarizing, long-term representation of the data, e.g. over a whole day or week.

Discussion

In summary, our system helped the participants to reflect their own impression on how stressed they are by providing an additional objective, and according to most participants also precise measure.

Interestingly, none of the participants feel that the system has actively supported them in any situation. One reason for this is the non-proactive, non-intervening design we've decided on. However, we've hoped that a participant would experience some more stressful situations a day and then consequently actively consults our system. It seems that this was not the case, where one reason might be the limited time frame we observed or that the participants didn't have a stressful period while being observed. The value of our system in very stressed situations might be observed in long-term studies, with participants which are regularly affected by stress.

Anyway, three participants would like to continue using this system. In consequence, there already is a significant value when using the system also on non-stressful days. Through the interview we found that the objective assessment is helpful to better assess one's individual stress situation. Thus, participants liked to have this device to control their own feelings.

Obviously our results are quite limited at the moment, as we have only observed 4 participants for a limited period.

Conclusions

We conclude that Galvanic Skin Response (GSR) can be used to sufficiently derive a user's stress level. As the users tend to use the measure to control and support their subjective, individual feeling, no extremely high precision is needed. For this paper we decided to go for five categories on a scale ranging from very relaxed to very stressed, which was precise enough for our study participants. We learned that the users prefer concrete numbers over more abstract colors over a trend visualization regarding the representation of the stress level. In our opinion that has been done to maintain the comparability of individual stress levels. This is more difficult for colors or the also proposed trend visualization.

For future application in the field of mobile wellness we recommend to consider the stress level as an important measure. Regarding the visualization we suggest a representation on a simple scale, either by some kind of progress bar (e.g. Direct Life, see Figure 1) or as we did by showing numbers (see Figure 3). In addition to the real-time feedback we propose to provide some kind of long-term feedback, e.g. through a web interface.

For the future work we are very interested to actually prepare and deploy our system for a long-term study. In the next step we want to investigate how our system can become interactive and proactively help users to reduce stress in automatically detected stressful situations.

Author's Work in Related Domains

Benjamin is currently pursuing his PhD studies on how various sensors can be used for unsupervised observation of study participants in the wild. Further, as part of the HaptiMap EU project, he is developing a navigation aid for cyclists with touristic background. *Janko* started to work as a researcher on a regional project in March 2011. He is interested in how various medical sensors can be reliably used in outdoor scenarios. He plans to use this medical information to assist patients with heart diseases while navigating in the wild. Benjamin and Janko both work under the supervision of *Wilko* and *Susanne*.

Goal for Participation in the Workshop

We are interested in how health data can be sufficiently visualized to allow people reflecting on this information and potentially change their behavior. We can provide other workshop participants with experiences in mobile health application development and with applications of the Shimmer sensor platform (e.g. ECG, EMG, GSR).

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References

[1] Rowe, Dennis W.; Sibert, John; Irwin, Don. *Heart Rate Variability: Indicator of User State as an Aid to Human-Computer Interaction*. CHI 1998.

[2] Healey, Jennifer; Nachman, Lama; Subramanian, Sushmita; Shahabdeen, Junaith and Morris, Margaret. *Out of the Lab and into the Fray: Towards Modeling Emotion in Everyday Life*. Pervasive 2010.

[3] Consolvo, Sunny; Mc Donald, David W.; Landay, James A. *Theory-Driven Design Strategies for Technologies that Support Behavior Change in Everyday Life*. CHI 2009.

[4] Consolvo, Sunny; McDonald, David W.; Toscos, Tammy; Chen, Mike Y.; Froehlich, Jon; Harrison, Beverly; Klasnja, Predrag; LaMarca, Anthony; LeGrand, Louis; Libby, Ryan; Smith, Ian; Landay, James A. *Activity Sensing in the Wild: A Field Trial of UbiFit Garden*. CHI 2008.