License to chill! How to empower users to cope with stress

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ABSTRACT
There exists today a paucity of tools and devices that empower people to take control over their everyday behaviors and balance their stress levels. To overcome this deficit, we are creating a mobile service, *Affective Health*, where we aim to provide a holistic approach towards health by enabling users to make a connection between their daily activities and their own memories and subjective experiences. This construction is based upon values detected from certain bodily reactions that are then visualized on a mobile phone. Accomplishing this entailed figuring out how to provide real-time feedback without making the individual even more stressed, while also making certain that the representation empowered rather than controlled them. Useful design feedback was derived from testing two different visualizations on the mobile in a Wizard of Oz study.. In short, we found that a successful design needs to: feel alive, allow for interpretative openness, include short-term history, and be updated in real-time. We also found that the interaction did not increase our participants stress reactions.

Categories and Subject Descriptors
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
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Stress monitoring, empowerment, Wizard of Oz study, behavior change

1. INTRODUCTION
Health is a product of not only physical but also mental well-being. Exposure to high stress levels for too long of time periods endangers health and may not only lead to states such as being 'burned out' but also to physical diseases such as obesity, diabetes, or high blood pressure [20]. These kinds of diseases are increasing in both the Western world, but also, recently, in third-world countries. The reason behind this development is complex and multi-faceted, but the work- and life styles have changed and are considered to be more stressful and psychosocially endangering [4].

The healthcare systems in the Western world cannot cope, neither financially nor resource wise, with the increasing demands emanating from these kinds of diseases. A more holistic perspective on well-being is needed. People need to learn to listen to their bodies, take control over their lifestyles and change their attitudes towards work and leisure activities. Recently, there has been quite some attention within HCI towards building systems to support behavior change [e.g. 3]. But the question is how to design such systems which lead to a long-lasting behavior change? Furthermore, how can we do so without infringing on people's autonomy or adding to their stress levels? Is it even possible to design for a positive, fun, aesthetically pleasing and empowering interaction that not only 'controls' users' behavior but becomes a valued addition to their lifestyle?

These are some of the issues that we needed to answer in our design process towards designing and implementing what we have named the *Affective Health* system. The idea builds on a previous system, the *Affective Diary*. That system consists of a software client on the mobile phone, digital diary software and biosensors. It works by capturing sensor data from the user and uploading it to the digital diary installed in a computer, together with other materials from the phone such as text and multimedia messages, photographs, Bluetooth presence, etc. A colorful shape is then formed from the sensor data and is associated with the other collected materials. In a user study of the system, we found that users could identify and start understanding some of their own stress related situations. They learned, reflected and even trained themselves to behave differently [30].

However, the *Affective Diary* system was not specifically aimed at stress and it did not provide feedback in real-time. In *Affective Health* we would like to provide for such a biofeedback loop through using real-time feedback on a mobile phone. This entailed figuring out how to provide real-time feedback without causing users further stress. It was also crucial that they could identify with the representation and feel empowered rather than controlled by the system.

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We needed very practical results in order to continue on the right path in the design process. Here we present a Wizard of Oz study which is aimed at circumventing the technical difficulties, by allowing us to simulate parts of the system's functionality without the participants being aware of this fact.

We then report on how the participants understood the system, how they related to it, what they liked, what they did not like as much, as well as what they thought on the different aspects of the designs. We also present meta-results on the study method collected from the participants.

2. AFFECTIVE HEALTH

There exists today a paucity of tools and devices that empower people to take control over their everyday behaviors and balance their stress levels. This is where a mobile service, like the system we will discuss here, *Affective Health*, could prove useful. By providing users with easy-to-grasp visualizations that enable biofeedback loops, it could be one useful tool in a repertoire of health improving actions.

The idea behind the *Affective Health* mobile system builds upon physiological reactions common to all people, regardless of race, sex, age, creed or culture [2].These fundamental human reactions emanate from the autonomic nervous system: they are essential survival reactions. These reactions are not consciously controlled by us, but are instead indirect reactions to what our senses perceive and how we act in the world [2,16]. If mirrored back to the user, the relationship between activities in the world and how their bodies respond to them might become one starting point for users to begin building meaningful relationships between what they are exposed to and how that affects their bodies. This in turn empowers them to take control and avoid stressful activities, increase activities that promote their well-being, or simply change their attitudes about certain aspects of their lives, thereby reducing its impact on their stress levels [18].

Stress reactions are related to a range of factors in our lives which trigger various emotions. These in turn trigger our bodily reactions [2,20]. Emotions, such as fear or anger, make our autonomic nervous system react, changing the hormonal levels in our body, altering our facial expressions and the focus of our senses and cognition, thus preparing us for flight or fight behavior [9]. Other emotional processes, such as shame or pride, which are crucial to our ability to maintain social relationships, also have associated corporeal processes affecting similar factors [9]. If there are many threatening stimuli in a person's life, paired with little or no control for how to deal with them, their bodies can stand on full-alert for too long and the normal, adaptive coping mechanisms that the body uses to restore its capacity, such as rest, sleep, and ways of reducing stress levels, will have little effect [6].

The body can lose its ability to adapt to higher and lower levels of activity – it becomes stiff/rigid in its reactions to the world [20].

But we do not make sense of our emotional and stress reactions solely as biological processes nor are we predetermined to react in only one way to a particular circumstance. Emotional and stress reactions are social and dynamic communication mechanisms [22]. We learn how and when certain emotions are appropriate to display and we learn what in our lives constitutes a threat and what is good for us. A life with no stress at all is not necessarily good either. A healthy life includes both highs and lows, but foremost, it is a life where our bodies cope with the changes and are capable of adapting to them.

The way we make sense of our own emotional and stress reactions is a combination of the experiential processes in our bodies and how emotions arise and are expressed in specific situations in the world, in interaction with others, colored by cultural practices that we have learned. We can teach ourselves to deal with threatening stimuli without alerting our entire, bodily and emotional reaction system [7].

In considering the design of IT-applications that reflect emotional and stress-related processes, Boehner and her colleagues [1] have drawn on what might be called a socially situated perspective of emotion. These provide a set of requirements for systems that engage users in a reflective, empowering process which they named the interactional approach. Their ontological view on emotion is that it is "culturally grounded, dynamically experienced, and to some degree constructed in action and interaction". Emotions are created in a co-constructed, co-interpreted fashion between people in social situations. Hence, in designing for emotional experiences Boehner et al. contends that the focus should be moved "from helping computers to better understand human emotion to helping people to understand and experience their own emotions" [1].

In our own related research, we have attempted to expand on this interactional design approach by directly addressing everyday, physical, bodily experiences—capturing aspects of the experiential as well as cultural bodily influences on emotion [e.g.13,14,30,31]. Our efforts have, in essence, been directed toward building systems that re-unite the physical and cultural features of our embodied experiences. We see that it is not only problematic to reduce emotions to their physical, corporeal processes but that it is similarly problematic to separate emotion from physical experience. Our design research has therefore aimed to mirror some of the aspects of everyday physical experiences while, at the same time, leaving room for users to actively interpret them. Our position has been that data recorded from the body should be represented in ways that feel familiar to end-users, but still be open-ended and ambiguous in such a way that they can recognize them, make sense of them and appropriate them for their own purposes [14].

The aim of the *Affective Health* system is to provide a holistic approach towards health by enabling users to make a connection between their daily activities and their own memories and subjective experiences. This construction is based upon values detected from certain bodily reactions that are then visualized on a mobile phone.

3. WHAT IS STRESS?

In 1936 Selye formulated the General Adaptation Syndrome (GAS) theory [28], based on the idea that the body achieved its balance through a process of homeostasis. This concept, first formulated by Cannon [2], has its roots in the Greek words *homeo*, meaning "same", and *stasis*, which can be translated as "stable" or "stability". Selye's idea was that the body achieved stability by remaining constant. He believed that our bodies have internal parameters for heart rate, blood pressure, body temperature, etc. and those parameters have absolute, fixed values which are ideal for a good functioning. The body, according to Selye, responds to

external stimuli that might alter these values, with an opposite 'force' needed to bring them back to their ideal value.

Up to this point everything seems reasonable. The body adapts and maintains stability, which is good, but we all know how one can only take a certain amount of external stimuli. Selye called this adaptation energy. According to him this "energy" is a finite resource and represents the limit for homeostatic adaptation. If we are exposed to stressors too frequently, we might run out of this energy and start suffering from various health problems. Stress was thus, for the first time, being seen as a potential source of illness.

3.1 Mind-Body Connection

Up to this point, the cognitive perception, or emotional experience, of the stress experience had been left unaccounted for. The focus had been given purely to the physiological aspects of stress while individual psychological attitudes were not taken into consideration. Lazarus and Folkman later proposed a transactional model of stress [19] in which they set forth the concepts of primary and secondary appraisal. These represent, respectively, the perceived demand and perceived ability to cope with a given stressor. By considering individual perception of the stress experience, both in demand and coping, they present us with an important step forward in this field. We now know that the impact of the stressor to one's health is not determined by the stress stimuli or stress response alone, but by a relationship between both at a cognitive level.

The way the stressor is perceived, as well as the way a person feels they can cope with it can be either aggravating or attenuating factors for the potential impact on oneself. Despite a general disagreement over the definition of psychological stress [2] there are several generally accepted situations that may lead to chronic stress [20]: Failure to habituate to frequent exposure to the same stressor, inability to shut of the stress response even though stress exposure has terminated, or situations that cause regulatory disturbances of the stress system.

Later, the Cognitive Activation Theory of Stress (CATS) [33] was developed to extend the Interaction model proposed by Lazarus and Folkman. In this theory, the expectancy for the outcome of the stress exposure is fundamental. If there is not a cognitive hope that the stressor can be handled positively (coping), the exposure to the stressor can lead to a state of helplessness or hopelessness. Each of these involves a lack of control; the former implies the incapacity of choice in a given situation whereas the latter arises when the possibility of choice exists but all available outcomes are perceived with negative expectancy. Thus, it becomes apparent that focus should be given to *coping with stress properly*. This is because stress is not good or bad in and of itself. What can potentially cause damage is the frequency, lack of habituation or failure to 'unwind' and/or cope. Since these are strongly subjective, self-reflection and self-awareness are keys in addressing such issues.

3.2 Previous systems

There are a range of systems, both from commercial and research entities, that attempt to address stress relief. In common to most of those is their focus on diagnosing users' stress and providing this feedback. Their aim is not to allow for users to create meaning themselves and start linking stress to everyday behaviors – becoming empowered to take action for themselves. Rather, their overall approach is more behaviorist, where bodily stress is treated as separate from our social context and our own will to make sense of, and deal with, our lives.

3.2.1 Commercial

The emWave is a small device that picks up on Heart Rate data from the thumb, displaying a linear scale of LEDs, supposedly indicating stress level (www.emwave.com/) A lack of scientific foundations for their technique and the diagnostic nature of the system were two aspects we were apprehensive about.

The eWatch, a wrist watch that displays stress level, has attributes of mobility and seamlessness that we found interesting (www.heartmath.com/). It detects body temperature which, as we have read in several studies, could be used to pick up on stress reactions. This is, however, a limited parameter and also prone to errors. Many devices exist on the market that use the same approach, such as stress cards or thermometers (www.cliving.org/stresstools.htm).

The CocoroMeter (www.nipro.com) is yet another system that, by collecting regular saliva samples from the user, provides its' results to a small device that generates a very simple stick figure that appears more or less stressed. The graphical design is not very explicit, leaving it open for interpretation, which is a quality we were also looking for. The invasiveness of collecting the saliva samples regularly and the impossibility of making this process seamless for the user were the main drawbacks.

3.2.2 Research

A study on stress using an affective approach [23], concluded that the inference done by the system, using heart rate data, and the user's self report did not differ significantly, thus providing a pathway to automated stress detection and diagnosis.

The problem with providing diagnosis from data picked up from wearable sensors, which also applies to the commercial systems listed above, is that these sensors, are extremely error prone. This is due to the setting of their usage (day-to-day usage in real life situations), meaning that we incur the danger of providing false diagnoses. By adding a layer of ambiguity the errors that the sensors generate could be integrated into the representation, minimizing the effect of possibly incorrect data.

The UbiFit garden [3] is a physical exercise motivation tool that monitors the users' movement. It has a visual representation consisting of a garden whose quantities of flowers vary according to the amount of movement picked up from the user. The user is free to set their own goals in terms of exercising. If those goals are achieved butterflies appear in the garden. Although this system does not deal directly with stress, the representation used is in agreement with our approach toward designing lifestyle applications. This is because it does not provide a diagnosis but instead an indirect visual representation. Also, the system is intended to be used for behavior change, another of our design goals.

4. DESIGN ISSUES

In summary, we are building a lifestyle application and, as such, we made no attempts for creating any sort of diagnostic tool. All interpretation of the system should be left to the user, because as previously noted, stress reactions are not good or bad in themselves. The user should be empowered to deal with stress in everyday life; the system should serve the user and not dictate to the user. Increased identification with the design and the system leads

the user to enter an embodied [10] experience. Such are the ideals that we should strive for to achieve this empowerment: Bridging this dualistic chasm by helping users to learn more about themselves by presenting to them part of their bodily feedback so they can in turn connect it to their subjective experience.

The use situations that we envision are regular ones--we want the users to have this on them at all times. The quality of the sensors and the meaningfulness of the representation are thus fundamental requirements. People do not want to wear uncomfortable technology and they will not use a system that does not interest them.

The targeted user group consists of any adult interested in maintaining a good life style, who wants to prevent acquiring stress-related diseases, or people in early stages of such diseases, but not those who are already ill and in need of professional medical care. By empowering users through tools for reflecting upon their actions and how their bodies respond to different situations, the technology outlined here guides and motivates them to make better and healthier choices of action in the daily life activities.

4.1 FIRST DESIGNS

As hinted above, we needed feedback early on in the design cycle so that we would not build a system that increased stress rather than empowered users to deal with it.

A system that provides real-time feedback might be increasing stress simply by adding to worries we have when we are in the middle of a stressful situation. The user might already be aware that a particular situation is not good for them, or that their body is now reacting in a bad way. If the system confirms this by signaling some kind of alarm, the user might feel really scared and their stress level might increase, thereby making it yet another stressor in the environment. It was therefore important to try and expose a set of participants in our Wizard of Oz study to a stressful situation to receive feedback on whether this stressed them even more.

Related to this, we needed to know how quickly the system should update its readings from the users' body sensors. It might be that the real-time feedback needed to be slowed down in order to not overwhelm the user with data. Real-time is often defined as the "time at which events occur". Not only is this hard to determine for most bodily signals, as they are not discrete like digital systems, but we also wondered if this was the appropriate time frame.

To become empowered, it is important that users can identify with the representation shown on the mobile. They must be able to feel that this is really them – not only some weird representation of a body they cannot connect with, a body that lives a life of its own volition, not related to what they experience themselves. Wearable technology is difficult to design in general since it changes our bodily perception as well as social interaction [32].

So the goal is to design for interpretation and openness. The ideal would be to make the interface ambiguous enough that valence is withdrawn from the representation. But the representation, besides being fuzzy (Gaver et.al talk about using ambiguity of information as a resource in design [11]), must also be consistent. This can open up for the user to create their own "story" on what they are visualizing.

Guided by literature [e.g. 16] and meetings with medical doctors, we chose to represent three dimensions closely related with stress and lifestyle assessment: *movement*, *arousal* and *intensity* of the stress experience. The *movement* dimension represents how much a user moves and is therefore useful to assess activities in everyday life. *Arousal* is a valence-free measure of excitation. One can have peaks in arousal from positive experiences such as laughing, or negative ones, such as witnessing an accident. Finally, because the heart is directly influenced by the autonomic nervous system [16], the *intensity* dimension tries to capture the load imposed on this system by stressors, measuring the heart activity.

4.2 CHOSEN DESIGNS

Graphic designers on our team provided two alternative representations to use in our study for the mobile (see Figure 2). The dots are a discrete environment where information seems to be popping up on the screen. The background, on the other hand, was more analog and smooth, covering the whole screen with a wavy gradient.

Dots. The first design is a dot cloud represented against a dark background. Concerning the dimensions previously described, we have made the following mappings (Cf. figure 2):

Movement is represented by small movements of the dots in a 2-dimensional space. The more the user has been moving, the more intensive the movement of the dot will be.

Arousal is represented by the colors of the dots. For example, the more aroused the user is, the more saturated the red color of the dot becomes. When less aroused a lighter blue dot would appear. The power of color as a means to convey emotion has been known for centuries [12]. Typically, in Western culture, red is often seen as containing the most energy while on the other end of the scale, we find blue colors possessing the least amount [29]. The analysis and choice of colors was based on our previous work in color as emotion expression [31] Colors are interesting as they do not have a definite meaning, are inherently ambiguous, and yet still we attribute meaning to them.

Intensity, as picked up from the sensor data, is mapped to the distance of the dots to the center of the display. The more intense it is, the closer to the center the dots will be .

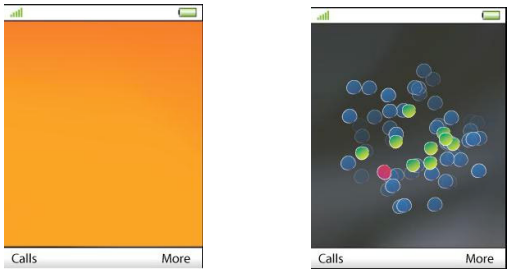

Figure 1. On the left the background representation in a relatively aroused state, on the right the dots showing a low arousal level with a slightly tendency of rising (the new dot is the violet one near the center).

Floating Background. The second representation is a textured background. The mapping done was:

Movement is represented by how much the background is moving.

Intensity is mapped to the color of the background.

Arousal was a bit trickier to implement in this representation as it would seem we are lacking one dimension in itself. The way we accomplished this was to switch the color of the background faster

if we detected peaks in the arousal level. It was then reset to the level indicated by the intensity.

5. WIZARD OF OZ STUDY

To answer the questions above and to get as much feedback as possible in this early phase of the project, we conducted a Wizard of Oz study. The guiding principle of such a study is that a human, called the wizard, is between the system and the actual user. The user is led to believe that their interaction with the system is direct while in reality, the wizard is simulating the system.

This kind of study setup, widely used in natural language processing and the development of intelligent agents [5], has also been used previously in Affective Interaction studies [21], providing us the means to circumvent the practical difficulties and test the system.

5.1 Participants

The aim for the study was to attempt to put the user in a stressful situation and see if different ways of presenting the feedback affected the user differently, particularly in their reflection and interpretation of the real-time data.

Hence, we started to design the study by conducting a first phase with three participants which also are involved in the project at our lab. There were two reasons for this. First, we wanted to make sure that our Wizard of Oz study set-up was realistic enough and that we could place the participants in both a stressful and relaxed situation so that we could properly test the system. Therefore we needed some space to define such situations and identify the important qualities in them. Second, we believe that it is important that we would experience the system ourselves. Additionally, we wanted to make certain that future participants could get involved with the system and not feel deceived by this approach.

After testing the system and user study method on ourselves, we recruited seven participants to the final stage of our study. They were recruited through mailing lists at companies and educational institutions in the area of Kista, Sweden. In the invitation we explained that we wanted to get feedback on a lifestyle stress management application and were seeking people who were interested in self-reflection. Most of the answers we received expressed either a concern over stress in their lives or a willingness to learn more about themselves. We avoided bringing in users with real stress-realted illnesses; this was due both for ethical reasons and because our application is aimed for personal reflection and interpretation, rather than replacing professional medicine.

The participants in the first phase were one female professor, one female researcher, and one male researcher. In the second phase we had seven participants; three women and four men. The participants were given two cinema tickets in return for participating in the study.

5.2 Study Set-up

In total, we studied ten participants using and interacting with the system. The first phase, with three fellow colleagues as participants, provided useful data as well as opportunities to alter details and fine tune the Wizard of Oz study for the second phase. The objectives and structural set-up for the study remained unchanged throughout the entire study period.

We met each participant individually and each session was approximately two hours long, including preparation, experiencing a stressful situation, experiencing a calm situation and an interview and debriefing session. Our assumption that the timing of the real-time feedback is one of the most important properties of a system like this made us build the study on four types of feedback that we wanted to evaluate. Hence, every participant was put into two situations divided into four time periods where we would present the user with four different types of feedback. The four is derived from two graphical representations in two time scales, real-time and delayed.

The delayed time scale was obtained through averaging the values collected for a period of 5 seconds and then updating the interface according to the value obtained.

In preparation for the session, each participant put on the wearable sensors and was informed of the video recording during the study. The purpose of the design and research of the Affective Health prototype was carefully explained in order to avoid false expectations and concerns over how the data is displayed to others; it is not a medical application providing any sort of diagnostic, but is instead a lifestyle application that can only be meaningful to the user themselves.

Table 1: Participant classification

Part.	Age	Gender	Job Description
1	35	F	Researcher
2	43	F	Professor
3	36	M	Researcher
4	32	M	Research Engineer
5	26	F	Research Engineer
6	26	M	Systems Engineer
7	37	M	Medical Doctor
8	41	M	Researcher
9	41	F	Receptionist
10	62	F	Public Relations officer

5.2.1 First study, Talk in front of an audience

The first preparatory study consisted of three colleagues. After the introduction and preparations, the users were asked to give a presentation to a live audience. They had not been given any time for preparation, but the presentations were their own, typically given several times before in other contexts. The idea was to stage a realistic situation that might put them under some stress, as talking in front of an audience can be, even for experienced researchers. We felt that by doing this we would simulate a commonly experienced real-life situation in the participants professional lives, an activity that is still stress inducing even after years of practice. This situation was both realistic to simulate in lab environment as well as relating to their lives.

The invited audience was instructed specifically to provide as little positive feedback to the presenter as possible, since this was purposefully designed to be a stressful situation.

Since we wanted to test four types of feedback, they were interrupted every five minutes during their presentations, to alert them on changes in the visual feedback. The three users in the first phase used different displays for the feedback; a PDA, a laptop and a large screen projection. However, we did not identify any benefits using these types of (larger) displays. For the remaining studies, the participants used the display on a smart phone, as the final implementation of our affective health system is intended to run on mobile phones.

5.2.2 Second study, Apply for a job

After the first phase of our study, we chose to change the stressful situation to a role playing job interview where each participant was the applicant for a job and we as researchers acted as jury of three people (among which was the wizard). This idea was adapted from the Trier Social Stress Test [17] which is a validated stress inducing situation. This test has a component in which the subject is asked to talk for five minutes, to a jury of three people, about themselves. The jury has instructions to provide as little feedback as possible, i.e. avoiding nodding and smiling, as this reassures the subject. We adapted this test by substituting the discourse about oneself for a job interview, to make it resemble a real life situation that most people have experienced. Role playing was chosen as it has been proven to generate very realistic experiences for the persons involved. One notable example is the famous Stanford Prison Experiment (http://www.prisonexp.org/).

The users were provided with a Nokia N95 8GB cellphone with the system, as shown in the study setup, Figure 2, as the final system is intended to run on that particular device.

The participants were given the same preparatory instructions and information as in the initial study, but were now instructed that they should act in a role-play as applicants for a job. They were asked to imagine being very interested in a specific job and also trying to convince the jury in the room. The jury posed questions such as: *"What was your biggest job-related mistake?"*

The "job interview" was interrupted every five minutes to inform the user that the feedback would change to the next type.

5.2.3 Relaxation, interview and debriefing

Following the stressful scenario we proceeded to the coffee room, where we offered the participant some coffee or tea, engaged in small talk to get everyone to relax a bit before we proceeded with the questions.

The participants were invited to continue trying out the system as the wizards continued to simulate it, still without the users awareness. The conversations loosely followed a question guide we had developed. We made sure to cover all the areas, but the participants often took the conversations in directions other than the ones we anticipated or planned for.

The most delicate moment came when we would explain that the system was not really working. We broached the topic as delicately as possible, ensuring them that we were indeed observing real data from the Polar watch and were carefully examining their movements, and in that sense the results were not completely false.

5.2.4 Our reflection on our method

Our experience during the study, combining the Wizard of Oz method with the Trier Social Stress Test, was that it was not an easy task, for non-actors such as ourselves, to play the role of a completely non-empathic jury. To put up the stone "face" proved to be extremely hard as it is a natural (and strong) instinct to reply when someone requests feedback, just by looking into your eyes.

Introducing real-time data in a system, for a long period of time, is a hard job for humans that requires a great deal of concentration and in the end the wizards were mentally exhausted.

The role-playing, from our perspective, and even before taking into consideration the feedback from the participants, seemed very successful in immersing the participants in their role.

6. RESULTS

We divided our results into: how well users were able to identify with the interface, whether they felt empowered by it, or, if instead they felt intimidated and controlled, and issues related to what it would feel like to wear this on an everyday basis.

Let us start by describing what happened with participant 7 (P7) to give a flavor for the experiences our participants went through. P7 is 36-years old medical doctor, specialized in cardiology, and currently on parental leave. When he arrived at our lab, he said he felt quite relaxed although curious, and even slightly apprehensive, as he had not done many job interviews before. The experimental leader explained the set-up and how it was the task of one of the three members on the reviewing panel to try and stress him. Sensors were strapped onto his body – around the chest and on the wrist – and he was told that those communicated with the cellphone he was given. He was shown the two interfaces and received a brief explanation of what they meant.

He placed the phone in front of himself on the table. During the first part of the interview, P7 repeatedly tried to make eye-contact with, and get some positive confirmation from, the reviewing panel, but throughout the interview, they kept avoiding providing anything but a blank face in response. In response to certain questions, we could see from how his pulse increased, as well as his overall appearance, that he became stressed. During the job interview, which lasted for 20 minutes, he only glanced at the cellphone a few times – predominately towards the end of the interview. Afterwards he explained that he was not really looking at the interface on the mobile, but rather tried to avoid looking at the three review panelists since they were giving so little facial feedback.

Afterwards he, similar to all the other participants, said that the reason he only seemed to look at, but not really processed what was on the cellphone display, was because he was too stressed and involved in the interview situation to be able to process the information there and then. Similar to all our other participants, he also claimed that this is probably how he would act in most stressful situations. He had not felt stressed by glancing at the interface and seeing some red dots there from time to time.

But now, after the interview was finished, he was really curious about what the system had been able to register during his stressful situations. He would like to scroll back and to be able to relate his reactions to the different parts of the job interview. He felt that this could be a good way to train himself for future interviews.

The experimental leader then took him for a coffee break, still with the sensors attached and with the cellphone in hand. He was told to simply relax, have a look at the interface to confirm that he was able to relax, and chit-chat with us. During this phase, he consciously tried to make the interface respond by altering breathing patterns or even by standing up and running around the office just to check the impact on the display.

Afterwards, P7 claimed that he preferred the dot interface--"I could relate more to the dots somehow". He identified with the dots and liked to see them in real-time because he wanted to be aware of his bodily experiences as they were happening. He wanted to be in control, and thought that a more fine-grained

timescale empowered him in this sense. In the end he was quite enthusiastic about the system, suggesting that it could have a very positive impact in the way people learn and reflect about themselves.

6.1 Design feedback

One of our driving forces for this project is the idea that the system will extend users' bodies and minds. We wanted to learn from this user study if the users' identified with the representations presented to them. To determine whether they did or not, we tried to learn what features in the design did, or not, catalyze this identification process.

Need for interactivity. Overall, the participants related more to, and were more positive toward, the dot representation. For example, P1 compared the two graphical designs in terms of the connection she felt from her experience with both:

P1 *"I was making it do something. I am having an impact here and I mean with the background* [representation] *it was so smooth so I didn't really see much there."*

P6 made the same kind of comparison:

P6 *"In general I would say that the dots were superior to the background changing. That felt very vague, whereas the dots feel more, I don't know, not as abstract."*

This feeling was similar across the users without them necessarily being able to verbalize their experience. The choice was often based on an emotional level:

P6 *"For some reason the dots just spoke more to me than the background did."*

P4 *"I guess this is just on a very emotional level that I like this one."*

However, when we insisted a bit more on developing the reasons they preferred the dots to the background, other insights came up. Interactivity was a desired quality, apparently more strongly connected to the dot layout:

P7 *"I still like the dots more because somehow I like when things are moving.* [It feels] *more interactive somehow."*

Quantity of information was another possible reason brought up, where, for example, P8 felt that the dots gave away more information and P7 reflected the fact that indeed the background lacked a level of information:

P7 *"From the dots I get even one more level of information, not only the color but also how they are spread"*

P2 thought it was "beautiful", but at the same time she was also the only one that unequivocally detached herself from the graphical design:

"*This thing feels much more unconscious and so I don't feel that I am interacting with this thing at all. [...] I feel detached from it and I feel that I can't do anything, I can't click on these things. I breathe, I do things and it's like not part of me yet, it might become part of me. But right now it feels like it's not part of me."*

Her words expressed the frustration of not being able to interact with these dots that were popping on the screen. She felt that she could not change the dots either by altering her bodily state and thereby make the dots change, or by actively selecting them with the screen cursor to move them around.

Representation of stress trends. Another difference between the representations was the fact that the dots, by remaining on the screen for a period of time after popping up and then slowly fading away, were a visual representation of recent history. The background representation did not offer such a history. Most of the users found representing history to be useful in order to get a quick perspective over the recent evolution.

P8 *"You don't know if you are building up to a climax or if you are coming down from one. Kind of if it makes it hard to see trends, sort of, what is happening, where am I going, am I becoming more and more stressed or am I sort of starting to relax."*

Some participants felt that this particular choice of representation was confusing at times:

P4 *"Even if you look at the dots you can see that some of them are fading away but they are superimposed so you are not getting it at the same time as you get it from a plot."*

This user pointed out that excess information can overwhelm the representation, making it unclear and hard to follow the sequence. This does not mean that users to not want to see aspects of the past, but it does tell us that this representation of time progressing has to be very clear to users. Otherwise they will not be able to infer the progression of events.

Open for Interpretation. Our design aim is to leave the representation 'open' for interpretation so that our users can read their own embodied physical, emotional and social experiences into what the system shows them. To make user identification possible, we need to provide enough openness to allow for their own interpretation while still showing real and concrete data.

As discussed above, we used colors to represent different arousal levels. The advantage is that colors are very open to interpretation, but as discussed above, people may attribute different meaning and value to them depending on their culture and personal experiences. Most of our participants mentioned this and assumed that it would be possible to read differences between positive and negative valence into the colors.

The participant P5, for example, assumed a valence for a particular color but was unsure whether the system reflected her own personal interpretation:

P5 *"So when I would see one of the bubbles in a blue-greenish that means that I would say at this moment like I am not really fully relaxed at this point, it's* [...] *being a little bit excited I would say, but does it reflect that?"*

When asked if the color currently shown on the screen reflected him at that moment, P6 answered:

P6: "*If that means that I am calm and relaxed, yes, I think so."*

He suggested, as others did, that with time and the consequent habituation to the system, he could possibly derive other meanings from the colors:

P6 "*If I was at home and relaxed just watching TV and it was blue, aha, I would think when I am relaxed it's blue. And then I was out running on a treadmill or something and oh, it's red or anything, I am in a car accident and it gets really red. Then it would be OK, I would sort of understand the different meanings".*

P7 was very assertive in deriving meaning straight from the colors:

P7 *"Of course blue often represents calm"*

In general all the participants attributed some way or another valence to the colors being shown, although the interpretation derived from the colors was not constant throughout the interaction for the same user.

P5 provided a good example when she changed her interpretation of the blue color on the dots before the interview started, realizing that this was a make-believe situation, and during the interview when she was caught up by the atmosphere built around her.

P5 *"No, actually it was all blue I think in the beginning when I was kind of relaxed because I said yes, I am in this interview. I have a job!"*

P5 *"So when I would see one of the bubbles in a blue-greenish that means that I would say at this moment like I am not really fully relaxed at this point, it's a point of being a little bit excited."*

The other aspects of the representation such as the movement or, in the case of the dot representation, how much the dot cloud was spread, did not elicit valence interpretations in themselves. Users did connect these to what they were feeling, instead of assuming a particular implicit significance.

More interesting in our view was when participants related the same type of visual feedback to different experiences.

P5 *"I thought I could see another red dot that came after that when actually I started laughing, so I don't think that I was seeing the peak really of arousing at that level and at that point."*

Even though her arousal was arising from a positive situation (she reacted to a funny comment by laughing), she thought that it must have been some kind of mistake in the interface that the dots were red. This came from her previous interpretation of the red dots during the stress situation that they implied something negative.

At this point, we reinforced to her the idea that the same type of arousal can come from situations with different valences associated to them.

Contextual information. All of the users noted that in order to make sense of the data *a posteriori*, it should be associated with data taken from the environment.

P10 *"You need to have some kind of hooks if you run it backwards [...] because otherwise it's just colors, if you cannot relate it to a specific moment in the interview. Because when you are in a situation like that and you replay it afterwards, you need both* [the representation and the contextual information]. *OK, you got stressed there, but why?"*

When asked if he would be interested in making sense of the data after a specific situation, P6 replied:

P6 *"If you could see what triggered a certain event perhaps, yes."*

P5 *"I would really like to see how actually the level of stress increases or decreases, or when do you feel that you are comfortable with the question or not. I mean more or less you do remember the questions in the order that they are being asked so I would say that would give quite a good indication of [...] your weak points."*

In one way or another all the participants suggested the addition of contextual information as a means of enhancing self-reflection.

Scrolling for reflection. The two representations tested in this study did not allow for scrolling back further in time. The dot representation showed some data from the previous 60 seconds (in the real-time mode) or 5 minutes (in the delayed mode), but did not allow for scrolling backwards between those. The necessity of having the possibility of scrolling back was discussed by all the participants who, during the interview (stressful) part of the test did not have time to look at the interface.

P6 "*If you are doing an interview like this and you are sort of living yourself into it, you are not going to watch the phone all the time"*.

So the possibility of looking into the past is something that our users believed would empower them in the sense that they have more control over the representation of their own bio-data and also opens up for reflection.

However, seeing past stressful experiences in retrospective can be disturbing for some users. Participant P8 was especially sensitive to this possibility:

P8 *"If I really thought it was a very stressful experience perhaps not, because that would be a bad experience. it could be interesting of course to see if I, on the other hand, thought that I did well, then I would be interested to look at it just sort of trying to confirm that."*

P8 also expressed a need to scroll further back in history:

P8 *"I can sort of look at afterwards to see, how is my development going, how was this week for instance"*.

This participant thought about a use of the system as long-term reflection tool, like a diary:

P8 *"It would give me a chance to do it sort of offline and not just a tool to see how am I feeling at the moment. But also to use it more in a diary sense"*

This was confirmed by other participants as well. P7 made an analogy with exercise support systems. Some people do their running and then afterwards they feed the gathered data into their computer and then they have all the tables and that. He saw the need for looking into representations of their responses to stress experiences after some days or weeks.

The need for training. Following the identified necessity of having a scroll back feature in the system, a new question arose: can reflecting on past stressful events help people to deal with new situations of stress? When asked about the prospect of using the system to achieve this goal, participants almost unanimously replied that a continued interaction with the interface would give them the possibility to learn more about their lives and train themselves to deal with stress more effectively.

P10 "*I think I could learn more from it really because job interviews are really like a thing like acquired taste, you know, and you have to train for it."*

No increase of stress. After analyzing all the transcripts we could not find any observation made by the users that indicated becoming more stressed because of the system. We asked several leading questions about this, like "If you think back to a stressful period in your life, would you have become more stressed by having a system like the one presented here?" But our users consistently claimed that this would not be the case, especially as they could not see themselves actually looking at the interface when in the middle of a stressful situation. And if they would see stress reac-

tions in the interface when they were supposed to be relaxed, they would find that useful.

Obviously, we cannot draw too many conclusions from this since our users are reasoning about a hypothetical situation here, a situation that they would not really be able to correctly assess without using the system for a longer time period. Also, even if a couple of our users had gone through very stressful periods in their lives, verging on being "burned out", none of them had actually become seriously ill from stress. What we can say with certainty is that during this study, none of them became stressed by seeing the interface and there were no indications that they felt that the system was working like an alarm clock or a diagnostic tool.

6.2 Everyday use

Affective Health is designed for everyday use. Though the present study did not address usage of the system in this setting, all the participants expressed a desire to use it for a longer period of time.

P7 *"I think it was really interesting and of course the application could be very, very good for everyday life. Not only as a fun thing for people to have but also to maybe learn something from, especially if you know that you get stressed in certain situations and then maybe you could do something about it."*

This connects with the previous observations, related with the possibility of using the system for training and the necessity of scrolling back to look into the past. These features make more sense if the system is used for a long period of time.

Developing an application for everyday use poses challenges that transcend the interface design. The sensors used (chest band and a wrist sensor) were considered by most of the users to be bulky and uncomfortable and would not qualify for everyday usage.

P2 *"The strap is strapping my chest so I felt like I wanted to take a deep breath."*

P9 *"This is a big heavy tool and you don't feel you would like to move it. I was afraid that with my arm I would hit someone"*

6.3 Meta-feedback on study setup

The two phases of the conducted study, though different in methodology, were able to induce stress in all the users. The first phase, however, did not take into account coping strategies of the participants, and thus the level of induced stress varies. The first participant, P1, said that she deals with most of the stress before a presentation begins:

P1 *"I have a strange stress code. I would have been stressed yesterday if I had an official presentation today, I am usually stressed like before. And then on the stage it is OK."*

No such commentaries were made on the second variant of the study, based on the Trier Social Stress test, a proven stress-inducing procedure. The reaction of all the participants was similar.

P9 *"Even if I know this is role playing it stresses you anyway."*
Regarding the interface design evaluation, some participants referred that the 5-minute period of familiarization with the application was not enough to really grasp the meaning of the representations of their bodily data.

P9 *"If this would be sort of a lifestyle application like it's intended to be, I expect you would be using it continually and then you would learn how it functions."*

The WoZ setup was also able to make the participants believe that the sensors were actually working and communicating directly with the mobile phone.

Regarding the ethics of the study, during the debriefing phase, none of the users expressed resentment against the experiment team because of having been stressed and misled about the functioning of the system.

7. DISCUSSION

From the results, we gained important input for the continuation of designing and developing the Affective Health Project. Some of the most interesting ones were:

Identification and interpretation

The fact that the participants generally requested contextual information as a means of complementing their physical data shows that, by itself, the data collected is of little value in lifestyle applications. In fact, they needed to know what was happening around them in order to assert if those reactions were positive or negative. One of the first lessons we have from studying stress is that, by nature, a stressful experience is not good or bad in itself. Better yet, it is generally good to have stress reactions unless the situation we are in is a negative one with little cognitive hope of improvement. To assert if some reaction fits in this category, one must not only know that they were aroused at a certain point in time but most importantly the situation in which this occurred. Of more interest is that without our suggestion, all of the users naturally pointed to this necessity.

Bits of the past

A representation of a short-term history (or trend) in real-time usage portrayed in the dot cloud was considered useful by most of the participants. The extra information carried by this design, not only what is happening now but also what happened just before, allows users to more easily grasp the meaning of their own state in the present.

Reflection and training

We have not yet tried the system in everyday life, which will be the next step. However, the willingness of users to train themselves for the future by reflecting on their past experiences is encouraging. If this system can help people to better deal with daily events it is definitely a positive benefit. In today's society where life moves quickly and people have less and less time to stop and reflect on their own lives, such a system can help increase self-awareness, help people prepare better for their daily challenges and, hopefully, in the long run, improve their quality of life.

Real-time is not a problem as it enhances empowerment

Contrary to what we had feared in the beginning, that users of such a system might dislike or even feel scared by constant updates, the users reacted differently. Some mentioned they wanted to have control, to see what was happening, as it was happening in order to be able to do something about it. They did not want us to censor information for them.

Throughout we have argued for empowering users. In the study, we found that users seemed to want to control the situation, and in that sense real-time was not a scary perspective for most of them.

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