Motivation and User Acceptance of Using Physiological Data to Support Individual Reflection

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Abstract. While research comes up with new sensors and physiological data is gaining more attention in private usage, sensors play no role in professional learning. In this paper we shed light on the motivation to use physiological sensors in the workplace. Three user studies have been conducted in five companies to assess the motivation to (a) wear sensors and (b) reflect on physiological data during work. Based on these studies, we show that workers would be willing to use physiological sensors, but the benefit of the awareness about the own physiological state is often not clear or the usability of sensors is insufficient. Moreover, in stress prone professions like emergency care there are already successful coping strategies in place. Introducing physiological sensors has to provide clear benefits by offering solutions to act on this awareness and focus on the practicability of the sensors.

1 Introduction

The increasing number of applications [1, 14, 2] and research projects [7, 10] reflect that the interest in physiological data and awareness of the own body is growing. There is now a wide variety of sensors capturing several physiological signals e.g. electrocardiogram (ECG) [3], Electro-dermal Activity (EDA) [13] or brain activity [5], but the majority of sensors are still limited to the use in a lab and they have not yet been used in professional training or learning practices in work environments. The absence of physiological data in this area is striking, since professional training could benefit from raising the awareness of the own physiological state. By providing data about e.g. their stress level to employees, we want to trigger reflection processes, as described by Boud et al. in [9]. Employees could re-evaluate their experiences and relate them to their stress level. We expect such learning by reflection about physiological data to have a strong potential towards objectifying the assessment of (individual or organisational) measures to increase work-life balance, as well as towards providing objective data for analyzing the impact of workers' physical well-being on work results.
Within this paper, we focus on the motivation and user acceptance of physiological sensors in work environments and designed our user studies to answer the following research questions:

1. Would potential users actually wear (=use) physiological sensors at work?
2. Do potential users see a benefit in analyzing physiological data?

Note that this paper integrates results that were reported in two separate project deliverables of the MIRROR project ([11, 12]) and provides an additional discussion that became possible through this integration.

2 Scope of Application

Five European companies in different sizes, from different sectors and countries have been chosen to analyze the acceptance of physiological sensors at the workplace. This wide selection of companies should help us to generalize our findings.

NBN The *Neurologische Klinik Bad Neustadt (NBN)* in Germany, deals with neurological emergencies especially with the treatment of strokes. The target group in the below-described studies are 70 staff members including physicians, nurses and therapists.

RNHA The *Registered Nursing Home Association (RNHA)* is a group of registered nursing homes in the UK. The residents are elderly people, many of them suffering from dementia. The target group in the below-described studies are approximately 280 carers and nurses working at two elderly homes of RNHA.

REG *Regola (REG)* is an Italian software company that provides IT solutions for the health and emergency management sector. The target group in the below-described studies are 17 employees of REG.

BT The *British Telecom (BT)* center in the Netherlands has 1500 large and customized contracts that are managed by contract teams. The target group in the below-described studies are 7 members of these contract teams.

INFOM The *Infoman AG (INFOM)* is a german IT consulting company with the objective to analyse and optimise the marketing, sales and service processes of their customers. The target group in the below-described studies are 6 consultants and 4 sales persons working at Infoman.

3 Method and Samples

Our research followed a three step approach. In a first step, a questionnaire was distributed in all testbeds, i.e. all the companies, to collect the specific attitude towards the use of physiological sensors. In a second step, we equipped nurses and physician of one testbed with sensors and interviewed them afterwards. Finally, the results and the specific use of this data for reflection was discussed in three focus groups.

3.1 Questionnaire

Method The general acceptance of sensors was evaluated in all testbeds. All questions could be answered on a 5 point Likert-type scale (strongly disagree,

disagree, neutral, agree, strongly agree). A questionnaire with the following questions was sent to all members of the target group in four testbeds: (1) I would be willing to wear sensors for a certain time. (2) I would wear such sensors only if it was mandatory. (3) Wearing such sensors would be uncomfortable in my job. (4) I would wear sensors if they help me with my daily work. (5) I would wear sensors if they help others at work.
A shorter questionnaire with easier language was used for RNHA, due to the specific nature of RNHA - mainly a lower level of education and concerns about the level of literacy. The modifications were well received by the testbed and likely lead to an increased response rate. Employees were asked (a) if they are used to wear physiological sensors (e.g., to measure pulse, heart rate), e.g., as bracelets or chest belts and (b) if they would like to wear physiological sensors (e.g., to measure pulse, heart rate), e.g., as bracelets or chest belts.

Sample The longer questionnaire was sent to NBN (38 returned questionnaires), REG (13 returned questionnaires), BT (5 returned questionnaires) and INFOM (3 returned questionnaires). The shorter questionnaire was sent to RNHA (71 returned questionnaires).

3.2 User Study on Wearing Physiological Sensors during Work

Method This user study was composed of two phases. During the first four days, the nurses and physicians were equipped with a physiological sensor. After one week of data analysis, individual follow-up interviews were scheduled with the participants. The selected sensor was the ambulatory measurement system from Movisens [3], which consists of a breast belt and a small sensor that captures four different measures: a single channel ECG, the acceleration of the sensor in 3 dimensions, temperature and air pressure. Observers followed a participant during two consecutive whole shifts. The assignment of observers to participants was made taking into account the diversity of the desired data pool. Concretely, the criteria followed to choose the observed participants are different professions, different shifts and different levels of work experience.
In the second part of the study, the follow-up interviews were based on preliminary findings of the observations. During the interview, participants were shown the captured data and encouraged to analyze the data and remember certain events. Finally, they were asked to judge the usefulness of this data for their daily work.

Sample Four doctors and four nurses from NBN took part in the study. Five of them were followed by observers. The participants included all age groups at the stroke unit (22-44), men and women (3:5) and different levels of experience (1.5-25 years).

3.3 Focus Group on 'Technology Support for Learning by Reflection at Work'

Method In order to specifically explore user interests regarding technology support, we conducted three focus groups at NBN. A focus group is essentially a

group discussion with discussion impulses provided by a moderator. In the first part of the focus group, the moderator asked the participants which kind of image about learning by reflection they share in general and about their personal attitudes towards using technological devices to support their work. Secondly the moderator presented different types of triggers. These triggers focus on capturing the learner's physiological reaction to a situation or experience e.g. a device called 'Fitbit' [2], which monitors one's own fitness (e.g. monitoring the steps or calorie consumption of a user). The discussion resulted in information and data, which could be interested for them to support learning by reflection during work.

Sample Three different focus groups were conducted at NBN, one group with 3 physicians, one group with 4 nurses and one group with 4 therapists. The participant's ages range from 20-59, women and men (8:3).

4 Results

In this section we present the results along the different research methods, i.e. the results of the questionnaire, the sensor study and the focus groups separately. Results are conceptually integrated and discussed in Sect. 5 below.

4.1 Questionnaires

The results of the long questionnaire about the motivation of participants to wear sensors are shown in Figure 1. Comparisons between different testbeds are complicated because of the variance in participant numbers. However, two trends can be identified in all testbeds:

1. Employees are neutral or would agree to wear sensors for a certain time.
2. Bad comfort is the most important argument for not using a sensor.

At RNHA, where a shortened version of the survey was conducted, sensors were seen very critical. The average response for both questions was 2.18, where 2 means disagree. The questions at RNHA focused on the correlation between the experience of using sensors and the actual acceptance. When looking at the answers in detail there is a correlation (=0.75) between employees that use sensors privately and the group that would wear a sensor.

4.2 User Study on Wearing Physiological Sensors during Work

General interest and sensor usage The general interest of the participants about the use of sensors for tracking their work activities and doing a subsequent analysis was very positive. They were used to see physiological measures and such curves in their patients' monitors, but had not used them themselves. The own physiological measurement at work was interesting for all of them and the participants expressed their interest about recalling how were their work days and what had happened. Most of them stated that this interest is much higher when they had stressful days and that they would like to compare how

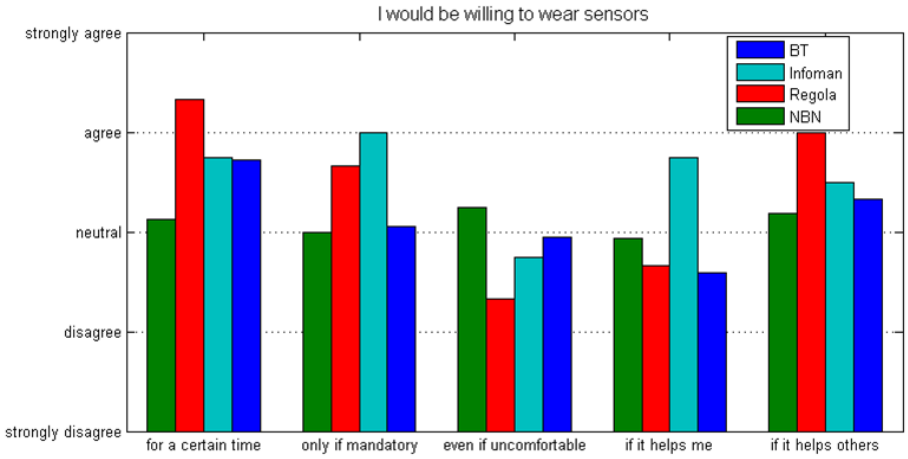

Fig. 1. Acceptance of sensors in testbeds.

the measures look like on different days.
The first reaction of the participants was diverse, but always in a positive way. Some of them could quickly identify what was each measure; others were surprised or showed curious about them.

> *'D4: Amazing, it is easy to understand.'*
> *'D4: I don't like staying in hospitals and going to the doctor. I am not the type of person keen on trying new things out but it was actually interesting for me. I would mainly like to know about activity and movement.'*

In general the participants accepted the usability of the belt for the study but all of them saw room for improvement. Hence, they would not like to wear the sensor everyday. One participant described the belt as a *badly fitted bra that is a little bit inconvenient but still wearable.'* Regarding the usage of the sensors, all participants stated that they would use the system. However, there were different opinions concerning how often they would use them and which visualization they would prefer.

> *'D1: How often I would use it [the sensor]... I can't tell you... For example, I would be more interested if I had a 24 hours shift with 10 admissions with reanimation.'*

Requests for additional features Participants suggested new features and asked for additional sensors or the possibility to compare themselves with others.

> *'D4: It would be interesting to see the blood pressure too. It definitely helps me. Blood pressure would show other things, but heart frequency is quite variable. Together with blood pressure would be better.'*
> *'D2: The comparison with the others would be interesting. Anonymously, of*

course. If I had less activity in comparison to them, then I could say, I do more or less. [I would like to know] If the others organize their day in the same way as I do'

In contrast, another participant stated that he does not have the need to know how his colleagues work.

Aversion and effects on coping strategies One participant mentioned that awareness does not lead to solutions. In fact, it might even worsen the subjective situation of the participant.

'D1: We have to hurry up. On duty you can't do anything against it. What could I do better? You don't think. You are there, and you have to do it.'

Moreover, several participants reported that they are trained to leave the stress behind when leaving the hospital.

4.3 Focus Group

Physicians were very sceptical of measuring their own physiological data, especially since it seemed unclear how they could/should act on the knowledge, e.g. that they were stressed. Physicians were very clear in their opinion that their tiredness or stress level is not allowed to interfere with or even influence their work. If patients are waiting for a treatment, the physicians have to treat them.

Nurses were interested in data about stress level, sleep habits, blood pressure, blood sugar, data from pedometers, etc. Nurses could imagine using this to find out which situations they find stressful and how stress influences their bodies (e.g. sleep). They would see this in the spirit of "practice what you preach", since they often give advice to stroke patients on how to lead a well-balanced life, e.g., sleeping, stress habits.

Therapists could imagine capturing physiological data to find out one's own stress level at work. On the one hand, they could try to learn from other colleagues who seem to deal better with stress situations. On the other hand, such data could be used to prove to management levels that their work is stressful, and to what degree. However, one therapist completely disagreed and did not see the relevancy of capturing physiological data for learning purposes.

Both nurses and therapists would not want to always capture physiological data, but would do this for a limited time period, and then analyse the data.

5 Discussion

We structured the discussion by the two research questions stated above:

Attitude Towards Wearing Sensors at Work The evaluation of the results of the user studies shows that there is no unanimous opinion concerning the physiological data. The questionnaire has shown that most of the participants of the user studies are neutral or would agree to wear sensors during work. They could imagine to learn from their own data and use this new gained knowledge to help others more than themselves. Additionally they find it interesting to compare (a) their captured data of stressful days with their data of average days and (b) their data with colleagues.
However, participants in the focus group mentioned that they could not imagine to wear such sensors every day. Wearing them during their work shifts would need too much time and effort to settle the sensor down and take care of it. Furthermore, this would produce too much data and create an information overflow for them. Participants could not envision what the captured data could be used for and how they can benefit from it, because they are convinced that they already know how they feel.

We therefore conclude that in order to make potential users capture physiological data, we need to motivate them to try the sensors out. Additionally it would be helpful to accompany users in the initial stages more intensively during the introduction phase and as a result show them what they could learn from the captured data or give them advice on how to react, e.g. on rising stress levels.

Benefit of Analyzing Physiological Data Related to Work Participants stated that the captured data does not lead to any solution or does or even cannot have any influence on their current work. The physiological data creates awareness of issues but does not point to potential solutions. Off the shelf solutions could be sufficient in many cases, e.g. relaxation exercises or breathing techniques. More complex cases could be tackled by identifying the specific stressor. Showing them which situations are very stressful for them, could make them aware of such situations and could lead to reflect on how they could accomplish such a situation more calmly next time.

6 Related Work

In athletic training, such reflection has long been considered as essential, for instance when runners check their pulse either during running, or log their paths, velocity, pulse to analyse their increasing performance over a longer time period [6]. These sensors can be used in work environments with a high physical activity to capture the activity.
The interest in physiological data has led to a growing number of commercial tools [2, 5, 4]. They are useful for entertainment and sports but are not suited to detect critical issues like stress. There are now first scientific approaches to build products for daily use [15, 13, 3], but the current research is focussed on improving the algorithms. Affectiva Q [13] and Movisens [3] are two companies that focus explicitly on the practicability of the system.
First experiments with proximity sensors like the sociometric badge [8] have

shown the potential of sensors to alter work practices and behavior. Nevertheless, there are no studies known to the authors that focus on using physiological sensor systems at the workplace.

7 Outlook

In this paper we have shown the potential of physiological sensors to raise awareness of employees towards their own stress level and their work-life-balance. Our research has shown that employees need more support to learn from this data. In MIRROR we aim at developing new methods to support the employees in the reflection process.
Based on our findings, one can see that the integration of physiological data to support workplace learning by reflection on the individual level is a challenging research topic for the near future.

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