Well-being by Design - The Moderating Effect of User Experience on the Impact of User Characteristics on Successful Well-being Implementation in Intelligent Systems

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Kurzfassung: Employees subjective well-being as purpose for system development receives increased attention. We created an intelligent system that strives to improve well-being and to decrease stress through capturing physiological and psychological states in real time. To ensure an effective and accepted system we draw on a holistic approach in system development in which users are involved from an early stage. In this regard, we are in the process of conducting experiments to test and train the system. We expect that data on user experiences and characteristics in particular will provide insight into how the intelligent system can be used to reduce stress and successfully implement well-being.

Schlüsselwörter: positive technology, well-being, intelligent systems, machine learning, physiological measurement, user characteristics

1. Introduction

Holistic development of computer systems in terms of continuous user participation during development has become important in information system engineering (Zhang et al. 2009; Riva et al. 2012). Especially intelligent systems using machine learning depend on future user's data to become functional. Therefore, systems using machine learning and users form a co-dependent relationship, since the systems need users' data to learn and users depend on effective systems that support them. Systems are increasingly being designed that are intended to ensure the well-being of end users (Calvo et al. 2014), especially in the private context such as fitness trackers, different mobile applications as well as augmented or virtual reality applications. The development and use within the work context to promote employee well-being has been largely neglected. For this reason, we are in the process of developing an intelligent system that supports nurses in hospitals maintain and enhance their well-being during their demanding work which is characterized by exceptional physical and psychological demands which can affect their well-being and health (e.g., Roelen et al. 2018).

The system's main task is to simultaneously track and monitor the nurses' physiological states to give feedback when critical states are reached to provide the opportunity for intervention. The system itself becomes a coach that supports users in maintaining their well-being and reducing their stress. In order to obtain an accepted system, we consequently involve the end users and ask them to give feedback for the system (Davis 1989). Nevertheless, creating a system for maintenance of employee’s subjective well-being remains a complex task that may be successful or fail likewise.

2. Subjective Well-Being

Subjective well-being (SWB) is defined and operationalized in multiple ways, most commonly as positive and negative affect and life-satisfactions (Diener 2009). While life satisfaction refers to the question of how desirable people currently evaluate their lives and mostly include cognitive evaluations; affects comprise moods and emotions that can be positive such as experiencing enjoyment or contentment or negative such as anger or depression in the long-run. Although these forms of SWB are assumed to be distinct due to their different origins (cognitive vs. affective), they are correlated (Diener et al. 2018). The pursuit of subjective well-being seems to be a major motive shaping people's life choices. Therefore, it seems that people are highly motivated to use technologies that help them maintain positive states.

SBW correlates with several other psychological motivations and states, such as meaningfulness, loneliness, work performance, and stress (Diener et al. 2018; Cacioppo et al. 2008), and may make people more resilient to stress (Diener et al. 2017). Experiencing positive emotions helps people expand their repertoire of thoughts and actions, whereas negative emotions adversely affect cognitive states (Fredrickson 2005).

3. Implemented SWB

The development of technologies and interactions motivated by user well-being has gained significant attention in recent years (e.g., Gaggioli et al. 2017), and several technologies have emerged that aim to enhance users' SWB. Most of these relate to use in the private sphere rather than at work, such as fitness apps, health apps, or relaxation apps (e.g., Serino et al. 2014).

In the work context technologies or systems that target employee’s SWB are sparse. To our knowledge, Laschke et al. (2020) first attempted to scientifically translate motivation for SWB into software used by professionals at work. A holistic involvement approach was used to enhance radiologists' SWB at work. In general, however, current efforts to increase or maintain SWB at work tend to focus on mindfulness training, yoga classes at work, or work conditions that allow for work-life balance (Robertson et al. 2011).

Research and development in this regard appears to be at its early stages. For this reason, we pursue to develop a system that supports employees to maintain or increase their subjective well-being and to keep further threats such as physiological and psychological stresses at a low level. The present system aims at subjective well-being and significant stress reduction that may cause more awareness in critical situations and may contribute to behavioral change that then leads to increased life-satisfaction. In line with positive technology demands the system is supposed to take the role of a "digital coach" (Diefenbach 2018) to assists its users to maintain subjective well-being and to possibly initiate behavioral change. In this regard Diefenbach (2018) reports that users accept systems as coaches and authorities that provide them with informed advice, although advice is known to be based on algorithms. Moreover, the particular interaction between systems and users seems to be pivotal for the implementation of subjective well-being.

Unlike other systems such as mobile apps on smartphones or smart watches, we developed a system that interacts with its users through data glasses. Especially in occupations in which professionals need their hands to be free for actions (e.g., logistics, precision mechanics) or occupations, which have specific hygienic demands such as nurses at hospitals, data glasses are at advantage. Smartwatches are not an alternative, as they must not be worn by nurses or other employees for reasons of hygiene and risk of injury.

4. User Characteristics

Empirical research on user characteristics that influence technology interaction typically refers to age, sex, and certain personality traits such as the Big Five (e.g., Hamburger et al. 2003; Venkatesh et al. 2012) assuming that rather young people are capable and willing to use technology, rather men than women and rather extroverted people who show some experience in using technology. In addition, we consider computer literacy (e.g., self-efficacy, actual user skills) to be essential due to their positive influence on the interaction with technology (Riva et al. 2012; Scherer et al. 2015).-Based on these assumptions we state the following research questions:

- RQ1: How will user characteristics influence user experience, stress and SWB?
- RQ2: How will user experience affect stress and SWB?
- RQ3: How will user experience interact with user characteristics and determine users stress and SWB?

5. Methods

5.1 Design

In order to examine our research questions, we are in the process of conducting an experiment with nurses in which the developed intelligent system is subject to participants' evaluation. We employ a 2x(work interruptions) x2(time limit) within-subject design which translates into four experimental walkthroughs with the system. Due to the repeated measurement procedure, we will approximately need 25 participants to obtain sufficient data. Besides the recording of physiological data, we will also capture survey data before and after participants do the walkthroughs. This further allows to match both data sets to inform the system.

5.2 System Overview

The developed system comprises four pivotal components: the *Caring Environment* which represents the core intelligent system, multimodal sensors that capture users' physiological states, a smartphone and data glasses. To get insights into the user's physiological state a multimodal sensor is used that is placed on users' chests. The sensor can record electrocardiography (ECG) and acceleration data, which is sent to, analyzed and stored in a central component, which we named *Caring Environment.* The *ECG-Sensor* first sends the data to a smartphone, which then forwards the data using the *Caring Environment App* to the *Caring Environment* in which the data is analyzed using methods of digital signal processing and machine learning. Models may be trained through previously recorded data and/or participants specific data.

Given the physiological state by evaluating the trained models the system derives recommendations or warnings. Users are supposed to receive these instructions using the data glasses. Figure 1 shows an overview over the entire system.

In our experimental setup instructions are sent to the data glasses to instruct participants solving a fixed number of nurse related tasks; the task sequence though is randomly generated by the *Caring Environment* for each walkthrough. Participants have to interact with the data glasses to start and finish tasks, and the start and finish times of tasks are reported to and stored in the *Caring Environment*. Using this data along with the recorded ECG and acceleration data we investigate the physiological state during nurse related tasks.

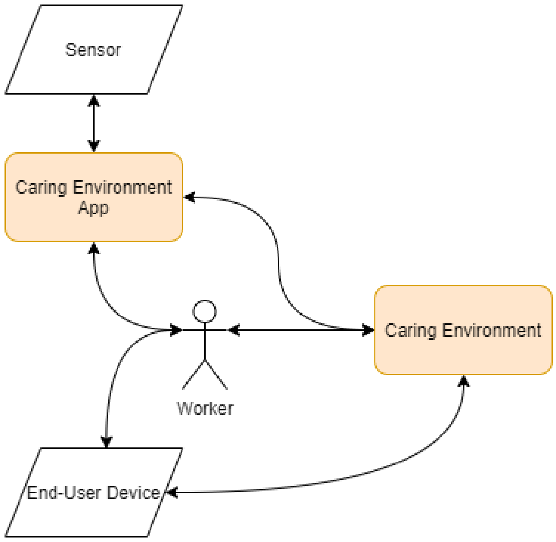

Figure 1: *Overview and interaction of components. Physiological states are evaluated using the data recorded by the sensors. The Caring Environment App forwards the data to the Caring Environment, which is responsible for the analysis, recommendations and warnings improving the well-being of workers.*

5.3 Procedure

During the experiment, the participants wear a chest strap sensor and data glasses. The participants make the settings on the data glasses themselves (e.g., arrangement of the display, wearing comfort). The experimenter then starts the experiment via the Caring Environment app with a test run that mirrors the different experimental conditions to achieve familiarity with the experimental setup and the data glasses. Each walkthrough consists of the same tasks that are modeled on the daily tasks of the nurses. The tasks range from concentration tasks to memory tasks to emotion tasks. Participants are fully instructed by the data glasses, e.g., which is the next task to accomplish. In addition, the experimental manipulations (interruptions and time limit) are presented through the data glasses. In case of unforeseen events the experimenter can manually stop and (re-) start recordings using the *Caring Environment App*. The *Caring Environment* continuously collects data during the experimental procedure.

5.4 Measurement

SWB. In addition to recording the physiological data, we will also carry out further measurements using the following questionnaires: We measure positive and negative affect before and after the experiment with the 20-item PANAS Scale (Krohne et al. 1996). Stress states are measured with the 7-item NASA Task Load Index (Hart 2006) and the Rating Scale Mental Effort (Ghanbary et al. 2016).

User Experience. In assessing the user experience, we will evaluate both the well-being-oriented interaction with a) the data glasses and b) with the caring environment. For this reason, we will use the User Experience Questionnaire (UEQ; Laugwitz et al. 2008).

Technology Literacy. To cover a broad range of concepts that contribute to technology literacy we are going to capture: General Computer-Self-Efficacy (Scherer et al. 2015), advanced and basic operational skills (Marakas et al. 2007) and technology commitment (Neyer et al. 2012).

Sociodemographic data. We ask for participants age, sex, educational background, and professional work experience.

6. Outlook & Conclusion

The current paper refers to work in progress and a full analysis is pending. Currently, we are evaluating the data from a pilot study with 2 experts. The post-task interviews led to improvements in the perceptibility of information in the data glasses and the avoidance of potential confounds in the cognition and emotion tasks that may arise due to complex user interactions. According to our research questions, we assume direct effects of user characteristics on SWB, stress, and user experience. In addition, we assume that user experience will moderate the relation of user characteristics and SWB, and stress. The results will help us to revise the system to contribute to SWB through its use and meanwhile reduce stress in the user. The system may serve as an exemplary system within the job context to support employee's SWB, which in the long run may prevent burn-out, depression, absenteeism and other health impairments besides more conservative methods usually applied within workplace health promotions.

The results of our experiment will be integrated in the further development of the caring environment, which will roll out in pilot phase in a nursing station. The pilot phase will show us how nurses will interact with our learning system under real work conditions. An additional exciting component to be investigated in the real environment will be which effects data security has on the subjects. The question will be whether this security component will be perceived as an additional stressor that may reduce well-being.

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