MÄNNISKAN I PRODUKTIONSSYSTEMET

04

Project results DIG IN

DIGitalized Well-beINg

2016-03-09

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PRODUKTION2030

Content

Project summary

Purpose

The main purpose of DIG IN is to show that the operator **well-being** can be measured **digitally** and to **demonstrate** how real-time data can be visualised and presented for the operator. Four technical devices, that measure physiological data (heart rate frequency, EEG, arousal and temperature), have been tested in this project during:

- 13 lab-experiments to investigate how external factors (light, sound and temperature) affect operator experience and performance.
- 5 user studies where three activities were carried out to test the devices usability.

Figure 1: The four devices 1-4 (top to bottom) and visualizations of their outputs. 1. Activity bracelet (Empatica), 2. Breathing frequency, 3. Heart frequency bracelet (Sony Smartband 2) and 4. Brain activity (EPOC+)[1]

Goal

The goal of this project was to present a demonstrator where well-being is measured digitally and presented in a simple and relevant way.

[1] 1. Arousal bracelet (Empatica): measuring blood volume (BVP), heart rate variability (HRV), accelerometer and skin conductance (galvanic skin response, GSR) and temperature (TMP).

2. Breathing activity (Spire): Measures breathing activity in the body by abdominal and lung movement. Three types av activities are chategorized: calm, tense and focused.

3. Activity bracelet (Sony smartband 2): Heart rate variability (HRV). The data is categorized according to three stress levels.

4. Brain activity (EPOC+): EEG through: focus, activity, interest, arousal, relaxation and stress level.

Results

Demonstrator

The demonstrator that was developed is an interface that visualises physiological data in real-time (Figure 2). The interface also visualise four work environment factors in real-time: temperature, carbon-oxide, light and sound levels. The field below the work environment indicators is a comment field where notifications are shown if a threshold value is exceeded. For instance, if the temperature is too high (above 23 degrees) a message is given together with a suggestion of what to do. Butler metaphor was used as a method of presenting the feedback and information by suggesting the solution to the operator instead of automatically regulating it.

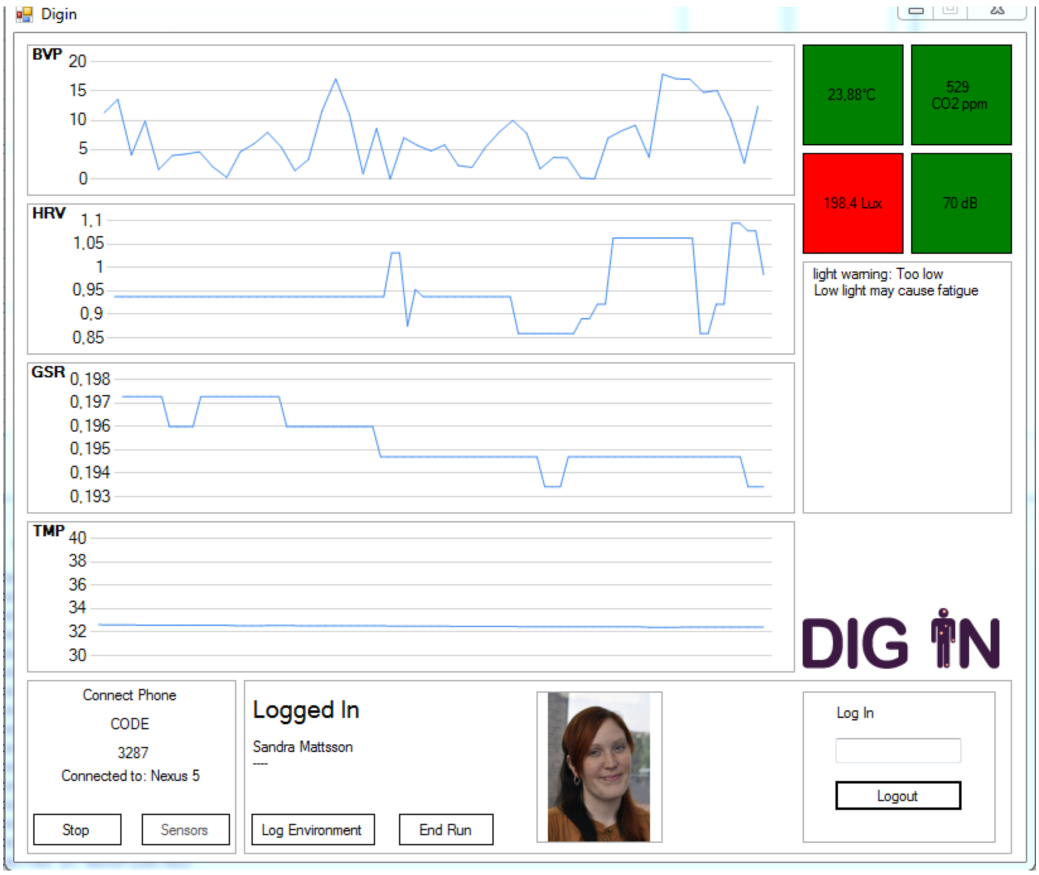

Figure 2: Demonstrator measuring physiological data (digital well-being) and work environment in real-time.

The demonstrator also saves data so that you can study history to compare physiological data with environmental data at a specific time (Figure 3).

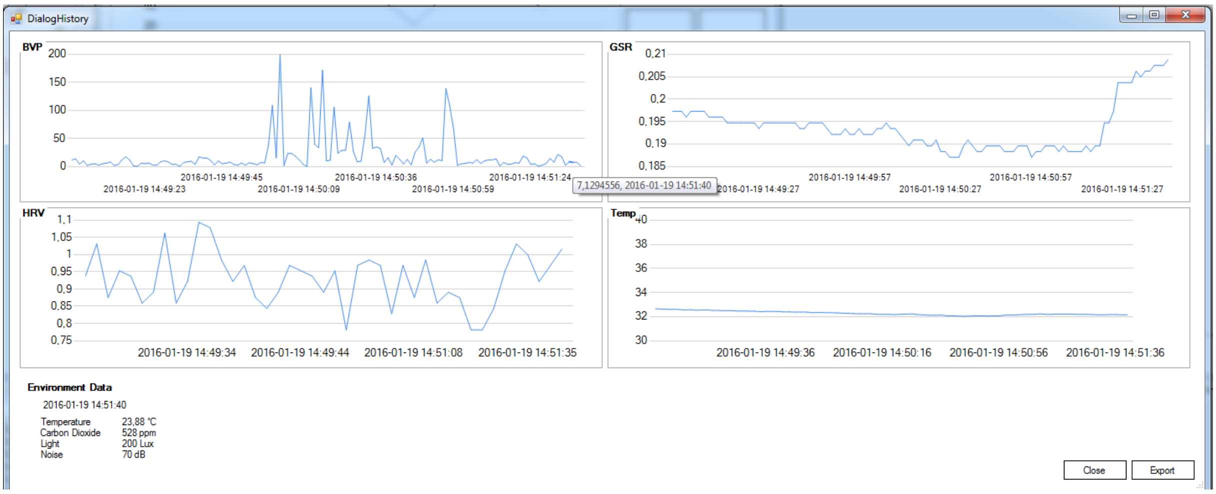

Figure 3: Demonstrator showing history

The demonstrator was evaluated during a workshop where experts from 'People in Production Systems' (Produktion2030, VINNOVA) were invited to participate. The workshop was held on the 20th of January with 15 participants (8 researchers, 3 company representatives and 4 project participants) and ascertained that the demonstrator had potential. The strengths are that it is flexible, mobile based and that you could connect it with many data sources. It was also considered to be a first step to increasing awareness of measuring well-being at the workplace. Some identified weaknesses include that the data is difficult to interpret and that there could be issues surrounding personal integrity that need to be considered (who should have access to the data).

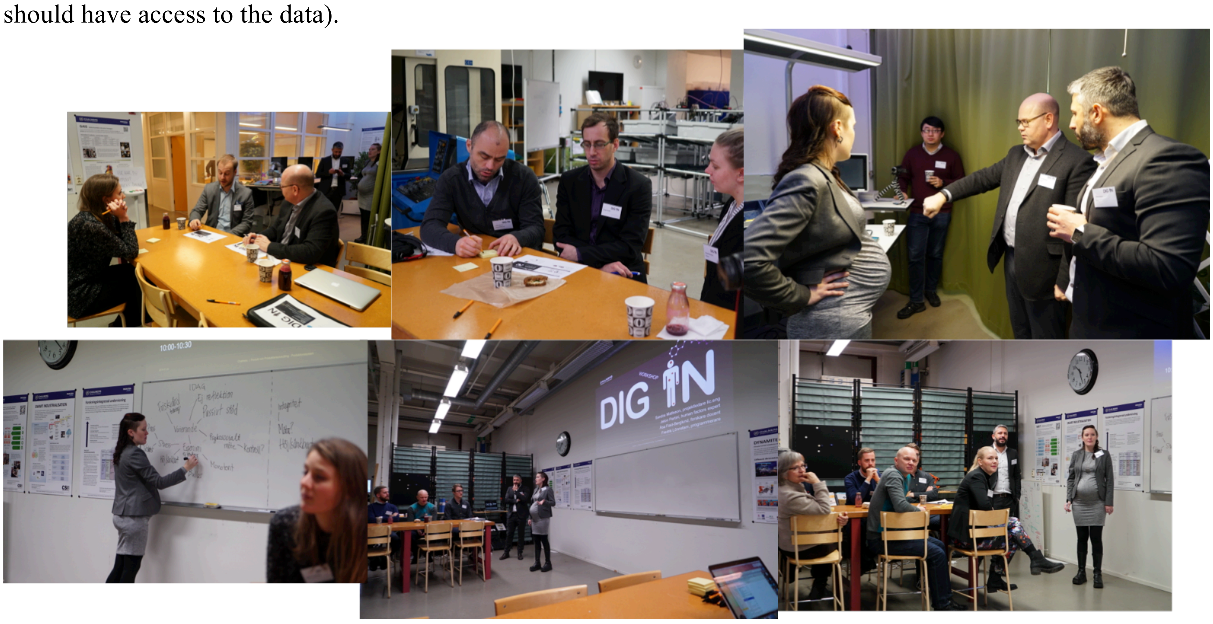

Figure 4: Pictures from the workshop, 20th of January

Experiment results

13 experiments were carried out to test how the operator perceived the devices and the presentation of the physiological data. The operators assembled eight Lego gearboxes and were affected during the first four assemblies by changes in the physical environment. The experiments were carried out at Chalmers Smart Industry lab (CSI-lab) and the sample included the following groups:

- Three age groups: younger than 30, between 30 and 40 and older than 40
- 30 percent females and 70 percent men
- 5 novices, 4 average and 4 experts in assembling that specific gear box

The last device (brain activity, EPOC+) was not included in the experiment. After the experiment participants watched the output from the software and were asked which device and physiological data they thought was the most and the least relevant, and why. The experiment results showed that data from device 1 and 3 was most relevant for the participants. However, physiological data from device 3 and 2 were rated as the least relevant. An interesting finding is that preference of physiological data presentation was based on how participants perceived themselves. For instance one participant said that she normally does not sweat (in general cold) but that she was very used to recognizing change in her heart rate, which is why she preferred device 3 (activity bracelet). Some participants that preferred device 1 stated that all devices could be interesting in the long term but that device 1 seemed more relevant due to its detail level.

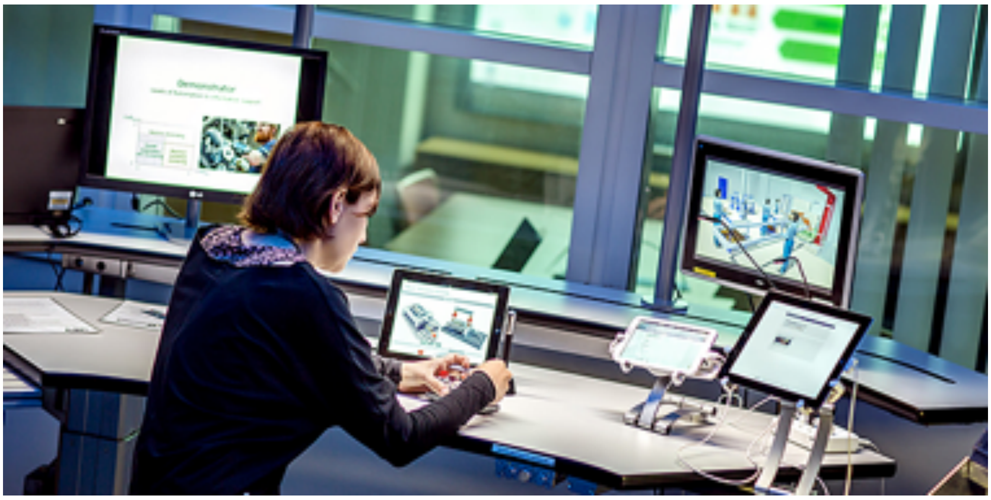

Figure 6: Assembly station at Chalmers Smart Industry Lab

User study results

Five students took part in the user studies testing the devices. First impressions were captured in a survey studying the exterior and the initial perception of the devices. Then three activities were performed and an additional survey was filled in. The survey included questions regarding how well participants' emotion fitted with the devices output data. The three activities *intuition, reasoning* and *physical load* were chosen due to that intuition is often used in assembly (Mattsson et al., 2014) and that complex problem solving (reasoning) might show different values (cognitive load) (Figner and Murphy, 2011, Mendes, 2009). *Physical load* was included due to that production work have been perceived as complex due to both cognitive and physical load (Mattsson et al., 2016).

The evaluation is summarized in Table 1. Results showed that the devices were best fitted to participants' own emotions during the *physical load* activity. Next best was *reasoning* and the least best was *intuition*. Device 2 (breathing activity) was the least sensitive to the activities in general and device 3 was the only device participants considered using both at home and at work.

Table 1: Evaluation of four devices measuring emotion in real-time

Device	Relevance of output data	Industry applicability	Real-time usage	General usability
1. Arousal bracelet	Requires further tests to understand what the data means	Feels like it could brake easily	Sensitive	Feels technical
2. Breathing activity	Unreliable and not relevant	Robust but would get dirty quickly	Takes time before registering data	Easy to use (the mobile app was very user friendly)
3. Activity bracelet	Reliable	Good	Sampling frequency should be higher	Easy to use and discrete
4. Brain activity	The different factors does not give more data than the other devices	Complex to prepare and use, not robust		Usable and easy but set-up time was high

Future

Additional workshop results

During the workshop it was also discussed how well-being is seen at the workplace today and how participants thought that the future would look like. Generally well-bing was considered in a varying way and participants said that the psycho-social perspective and stress were not considered to a high extent today (Figure 7).

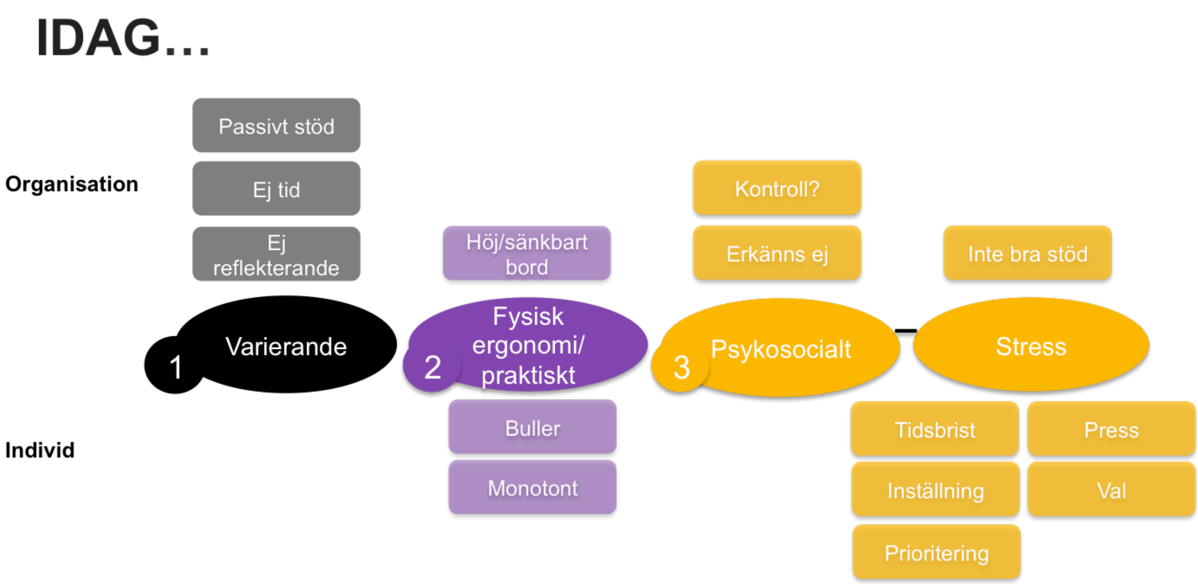

Figure 7: How is well-being considered at your workplace today?

After that participants discussed how they would the future will look (Figure 8). Generally participants thought that work will be more integrated into personal life and that the social aspects will be more important due to that work will be more flexible (risk of loneliness, less innovative).

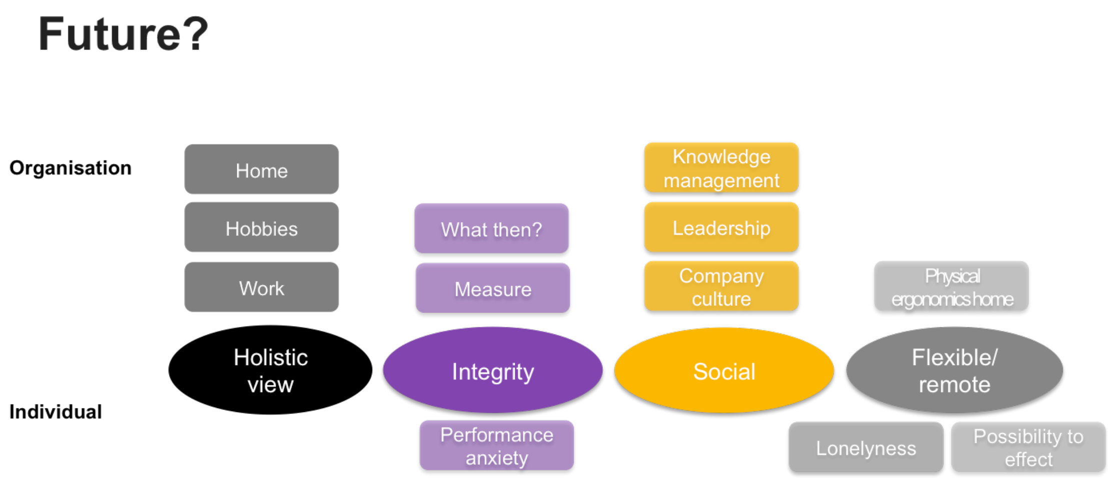

Figure 8: How will well-being be considered in the future?

After that the future workplace was discussed (Figure 9). The workshop also included a discussion of how to design future workplaces based on three Personas. The discussion gave further examples of how to implement ideas.

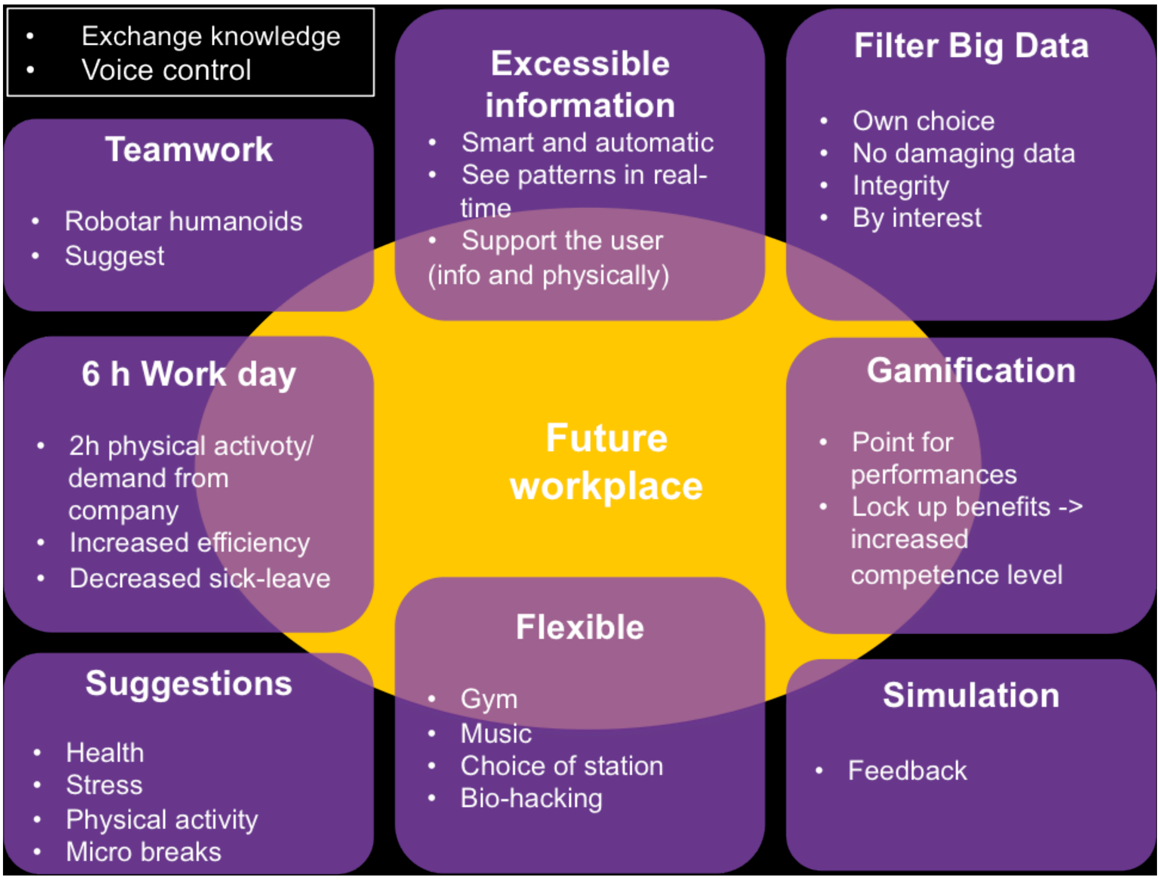

Figure 9: How a future workplace can be characterized

Next step

Discussions held at the workshop provided interesting insights for future improvements and continued research. In a next step research applications are planned that include further development of the demonstrator and the involvement of more industrial fields to be able to study and identify activities where this type of demonstrator may be needed. Within the project two scientific papers were written (one regarding evaluation of the four techniques, submitted to CIRP DESIGN Stockholm, and one regarding personalized future assembly stations, submitted to Swedish Production Symposium, Lund).

DIG IN

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Article about project and results (Swedish):

https://www.chalmers.se/sv/institutioner/ppd/nyheter/Sidor/handledsmatare-kan-forbattra-operatorers-valbefinnande.aspx

http://www.vinnova.se/sv/Resultat/Projekt/Effekta/2014-00600/DIG-IN---DIGitaliserat-valbefINnande/

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CSI LAB CHALMERS SMART INDUSTRY LAB
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