# D3.9 Mental effort assessment tool

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## Summary

In this document we describe our mental effort assessment tool. The software tool deduces an estimate of the mental effort of an person by aggregating sensor data values that correlate with that. The correlation coefficients have been determined from earlier work on our SWELL dataset. This document describes how this tool connects FaceReader and CommonSense by deducing the estimate from real-time FaceReader output and posting it in CommonSense framework. The mental effort values can then be used as monitoring feedback in our golden demos: dashboard.

# Contents

# 1 Introduction

In our connected environments, it can be hard to work in a calm and focused manner. Ruff (2002) speaks of 'plugged in compulsion' and 'hurry sickness', which easily cause interruptions and time pressure. Mark, Gudith and Klocke (2008) investigated the cost of interruptions and came to the conclusion that "after only 20 minutes of interrupted performance people reported significantly higher stress, frustration, work-load, effort and pressure". Certainly, some amount of stress is not harmful and might even be beneficial to gain concentration and focus. However, extended periods of stress can be a danger to health. Bakker et al. (2012) explain that stress can either directly lead to illness through its physiological effects or indirectly, through maladaptive health behavior, like smoking, poor eating habits or lack of sleep.

In our project SWELL (smart reasoning for well-being at home and at work) we aim to improve well-being at work by supporting knowledge workers. We define knowledge workers as people who use and produce information as their main task, and frequently use computers. Well-working could be defined as "being and feeling in control", with a positive impact on work efficiency and effectiveness, work pleasure, mental and physical health status (see deliverable D3.8).

In order to validate the effectiveness of SWELL concepts, we develop SWELL@Work applications that include the following (see deliverable D3.1b update):

- SWELL Fishualization board;
- Personal feedback tool: the *Happy Worker App* (HWA);
- E-mail organization assistant;
- SWELL golden demos (Fishualization, Dashboard, B-WELL App).

In the following we present a software implementation of the computation of the 'mental effort' of a knowledge worker by means of a camera and software system. The mental effort computation is used in the SWELL Dashboard golden demo.

# 2 Functionality

The mental effort computation is done on basis of output of the FaceReader[1] software program. FaceReader is an advanced tool for automatic analysis of facial expressions to make an objective assessment of a person's emotion from a camera. It can automatically analyze the expressions: happy, sad, angry, surprised, scared, disgusted, and neutral, see Figure 1 a). Besides expressions FaceReader can also output the state of specific facial action units, see Figure 1 b) and c). Typical facial action units include:

- Inner brow raiser (FaceReader action unit no. 1)
- Outer brow raiser (FaceReader action unit no. 2)
- Brow lowerer (FaceReader action unit no. 4)
- Upper lid raiser (FaceReader action unit no. 5)
- Cheek raiser (FaceReader action unit no. 6)
- Lid tightener (FaceReader action unit no. 7)
- Nose wrinkler (FaceReader action unit no. 9)

[1] http://www.noldus.com/human-behavior-research/products/facereader

- Upper lip raiser (FaceReader action unit no. 10)
- Lip corner puller (FaceReader action unit no. 12)
- Dimpler (FaceReader action unit no. 14)
- Lip corner depressor (action unit no. 15)
- Chin raiser (FaceReader action unit no. 17)
- Lip puckerer (FaceReader action unit no. 18)
- Lip stretcher (FaceReader action unit no. 20)
- Lip tightener (FaceReader action unit no. 23)
- Lip pressor (FaceReader action unit no. 24)
- Lips part (FaceReader action unit no. 25)
- Jaw drop (FaceReader action unit no. 26)
- Mouth stretch (FaceReader action unit no. 27)
- Eyes closed (FaceReader action unit no. 43)

Note that some facial action units come in opposite pairs, for example 'Lip corner puller' and 'Lip corner depressor', because action do not have a direction only an activation value. When analyzing camera or video ,FaceReader will determine for each action unit whether it is activated and if so, it will estimate the amount of activation on a 5 point scale (1 to 5).

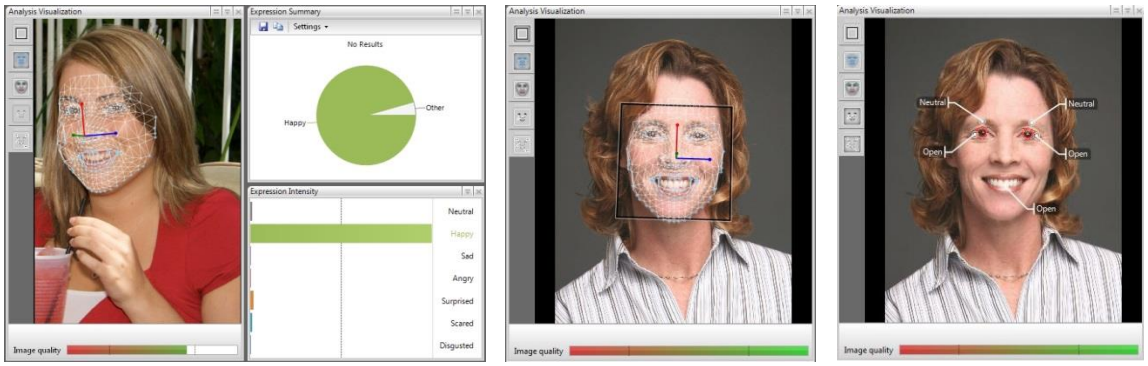


Figure 1: FaceReader, from left to right: a) real-time analysis of facial expressions and user emotions b) 3D active appearance model c) some specific facial action units and their state.

In previous work by Koldijk (2013) we deduced and validated experimentally that mental effort correlates with sensor data of facial expressions and action units, see Figure 3. The experiment constituted of 25 participants performing typical knowledge worker tasks: writing reports and making presentations. All participants worked under different stressor conditions:

- Neutral (45 min)
- Email interruptions (45 min)
- Time pressure (30 min).

Moreover, data from a 10 minute relaxation phase was included, in which participants watched a video clip.

Various forms of (sensor) data were collected, see Figure 2:

Figure 2: SWELL experiment set-up with one participant monitored with multiple sensors.

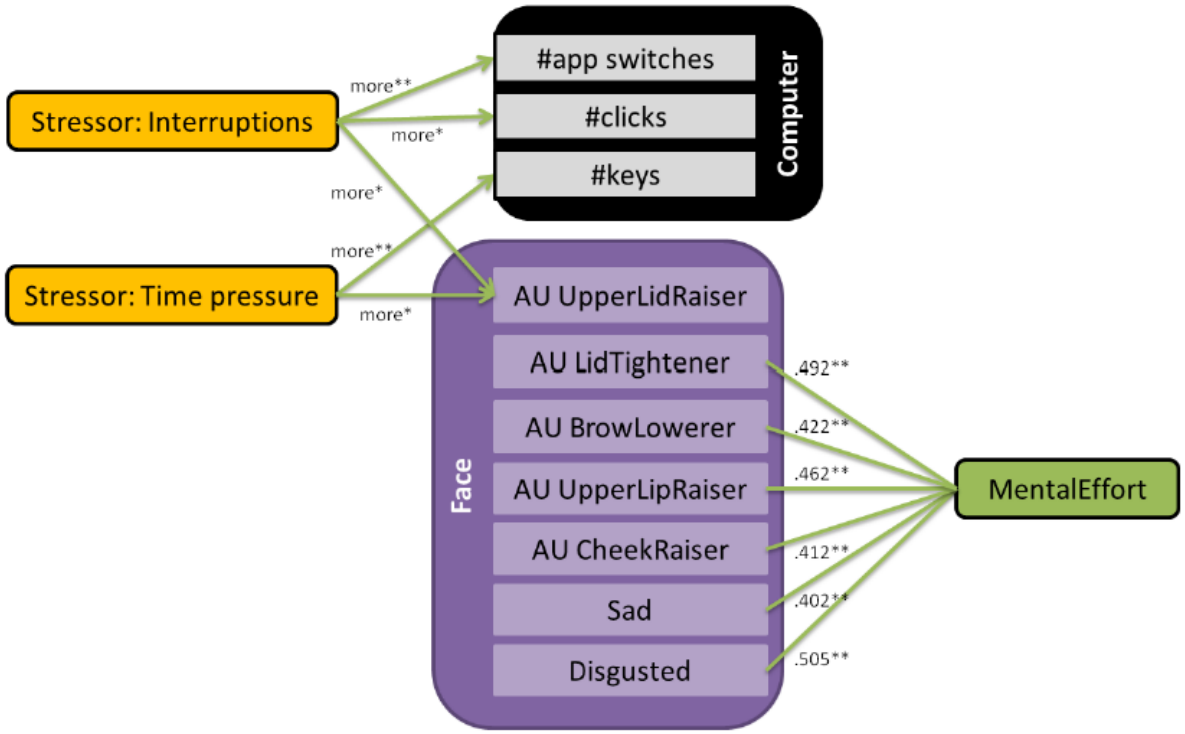


Figure 3: Mental effort correlates with sensor data of facial expression analysis, from Koldijk (2013).

Besides sensor data, we also collected subjective ratings after each condition. The participants rating on mental effort was assessed with the validated questionnaire RSME (Zijlstra, 1985). For the relaxation phase we assumed 'almost no mental effort'. (Note: For convenience, we use a scale of 0-15 instead of 0-150).

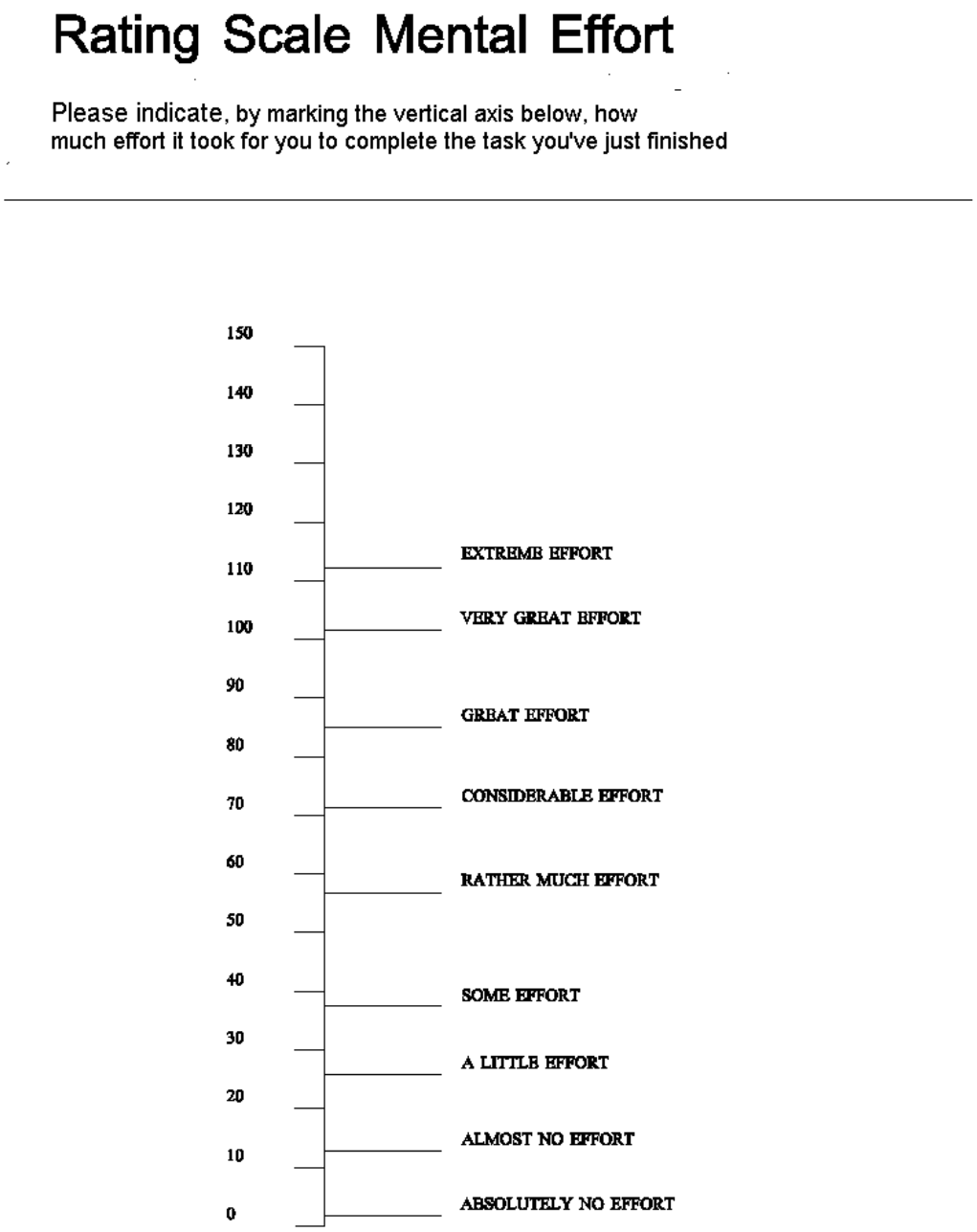


Figure 4: Rating scale mental effort (Zijlstra 1985).

In order to calculate an estimate of the mental effort from facial action units a linear regression was performed in Weka[2]. We calculated average activation scores for each facial action unit per minute. We then used these features to predict the mental effort score given by the participant. The resulting regression formula is the following:

[2] http://www.cs.waikato.ac.nz/ml/weka/

MentalEffort =

0.6816 * AU01_InnerBrowRaiser +

-0.218 * AU02_OuterBrowRaiser +

0.4188 * AU04_BrowLowerer +

-0.2496 * AU05_UpperLidRaiser +

-0.6028 * AU06_CheekRaiser +

1.4125 * AU07_LidTightener +

1.4202 * AU10_UpperLipRaiser +

-1.345 * AU12_LipCornerPuller +

0.4198 * AU14_Dimpler +

0.4045 * AU15_LipCornerDepressor +

-0.2243 * AU17_ChinRaiser +

-0.4253 * AU23_LipTightener +

0.8434 * AU24_LipPressor +

-0.6901 * AU27_MouthStretch +

0.6483 * AU43_EyesClosed +

4.6521

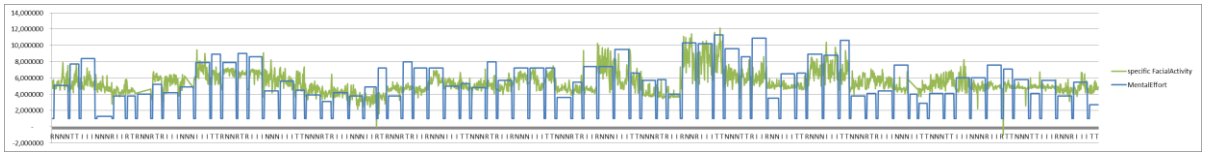


Figure 5. Blue: Subjective ratings of mental effort for the relax, neutral, interruption and time pressure conditions, lined up for all 25 participants. Green: Mental effort predicted from 3140 minutes of facial action unit activation.

The fit of the formula was determined with 10-fold cross validation. We had 100 ratings of mental effort, one for each 30-45 minute condition. In Figure 5 you can see the subjective ratings in blue. We had 3140 instances (minutes) of facial activation data. The predictions of mental effort are depicted in green.

The correlation coefficient was 0.4502 and the root relative squared error = 89.2856 %. The high error term is easily explainable: For each participant we only had one rating for a complete 30-45 minute lasting condition, but we wanted to predict mental effort for each minute of facial activity data. This means that in some minutes participants probably showed more facial activation related to mental effort than in other minutes, yielding noise.

Moreover, we included 25 different participants in our analysis. This means on the one side, that we got one generic formula that works for all users. On the other side, individuals may differ in facial action activations. This would plea for a regression model for each single participant. For purpose of a general usable mental effort estimator, however, we chose to create one generic formula. In later versions user profiles might be used.

# 3 Software implementation

The mental effort is computed in an 'Adapter' program between the FaceReader program and the CommonSense data storage. The Adapter is a .NET C# program that makes connections to both FaceReader and CommonSense to allow the real-time storage of aggregated FaceReader data in the cloud.


Figure 6: Use-case/system diagram.

The Adapter receives events via the .NET connection with FaceReader when the FaceReader has processed a video frame and has determined the expressions and action unit activations. The expressions and action units are aggregated over a time interval of 1 minute and then averaged and posted to CommonSense using the API[3]. The mental effort is computed on the averaged values of the action units and expressions using the formula from Section 2.

Figures 7 and 8 show some screenshots of the Adapter program and settings dialog.

[3] http://developer.sense-os.nl/

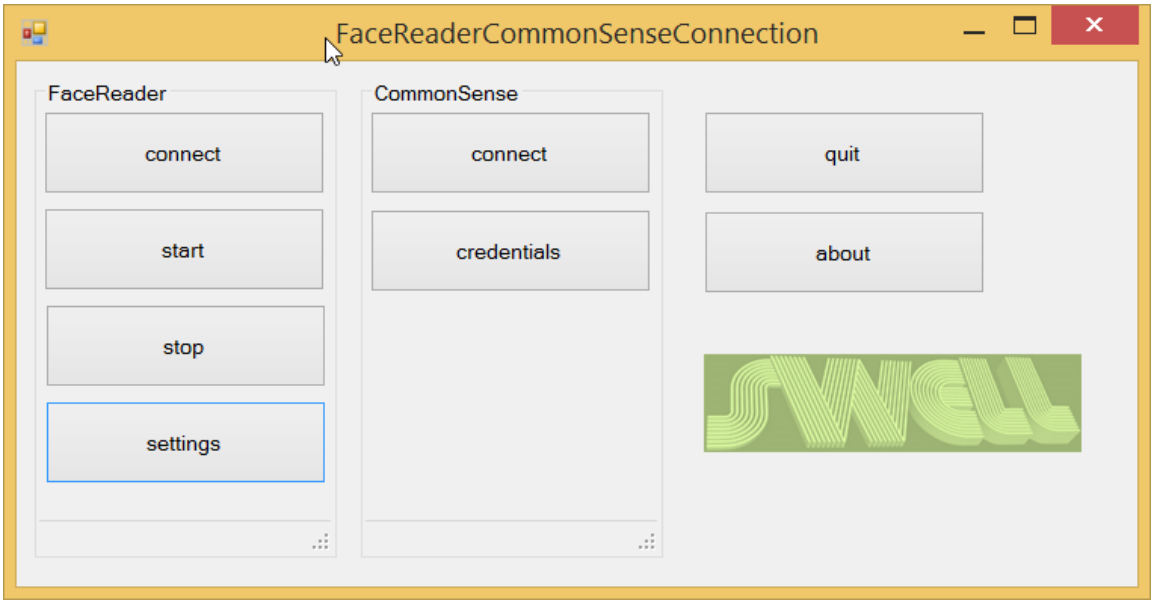


Figure 7:The FaceReader – CommonSense adapter program that makes a real-time connection between FaceReader and CommonSense and computes Mental Effort on-the-fly.

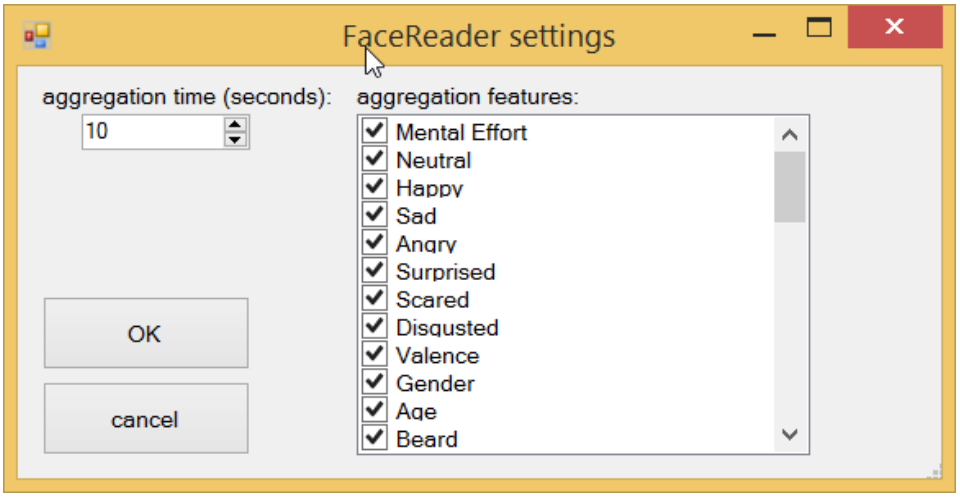


Figure 8: The FaceReader – CommonSense adapter program settings: allowing different aggragation time intervals and selection of facial expressions and action units posted to CommonSense.

# 4 References


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