Psychophysiological Parameters for Emotion recognition – Conception and first evaluation of a measurement environment

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ABSTRACT

The recognition of emotions is an essential basis of human social interaction. This is relevant at all levels of human interaction. However, the ability varies greatly among people. For this reason, the measurement of emotions is of great interest for a wide variety of applications. Furthermore, it is also an interesting topic in the current COVID-19 pandemic-situation with its restrictions regarding personal contacts. The presented paper focuses on a concept and first evaluation of a measurement environment. A multidimensional approach was chosen for the developed concept. The studied psychophysiological measures were: cardiovascular (ECG) and electrodermal activity (EDA) as well as the forearm and neck electromyography (EMG). In addition, the facial expression was recorded via camera. The results of a first evaluation show, that the combination of the different measures was successful and promising for the use in further research.

Keywords: Emotion Recognition, Psychophysiological Measures, Measurement Environment

INTRODUCTION

Emotions are of great importance for human interaction (cf. Scholl, 2013, Ekman and Oster, 1979, Ekman, 1992, Erickson and Schulkin, 2003). The recognition of emotions is an essential basis for the social interaction of people, relevant at all levels of human interaction. However, the ability varies greatly among people, even to the point of a pathological deficit in autism (e.g., symptoms of "social blindness") (Sigman and Capps, 1997, Frith, 2001, Uljarevic and Hamilton, 2013). Furthermore, it is also an interesting topic in the current COVID-19 pandemic-situation with its restrictions regarding personal contacts and the resulting increase of digital contacts through online communication. Recent research results show first associations between social isolation caused by the COVID-19 pandemic and emotional and social cognitive abilities (Bland et al. 2020, Bland et al. 2021). In addition, Schlegel et al. (2021) showed that participants with higher emotion recognition ability reported less feelings of burden and less negative affect during the first two weeks of public life restrictions caused by the COVID-19 pandemic (March/April 2020).

The measurement of emotions is of great interest for a wide variety of applications. One example is product design and product development (Lee et al. 2009, Shaw, 2007, Hirschman & Holbrook, 1982), there a product must be a sensual and emotional experience to be perceived as special and unique. In addition to that, emotions can also have an influence on purchase decisions. Another example can be the development of trainings e.g., for children with autism (Kandalaft et al. 2013, Yuan & Ip, 2018), leaders and managers (Köppe et al. 2019, Riggio and Reichard, 2008) or for employees working in virtual teams (Holtz et al. 2020).

The presented paper focuses on a concept and first evaluation of a measurement environment. Therefore, the research questions which had to be answered were: Is it possible to combine the different psychophysiological measures to investigate emotions that occur during different tasks in one measurement environment? Which technical aspects have to be considered? Is it possible to synchronize the different psychophysiological measures in an adequate way? Can a setup be found that can be used for future studies?

Based on the objective emotional assessment (OEA) of Boucsein and his colleagues (Boucsein and Schaefer, 2008, Boucsein et al. 2002), a multidimensional approach was chosen for the developed concept. A multidimensional approach is useful because a single measure or even a single psychophysiological system cannot account for all the changes that may be triggered by different emotions (Boucsein, 1989, Boucsein and Backs, 2000). Psychophysiological measures represent a possibility to make emotional experience objectively measurable, for example during product usage or when performing different tasks (Boucsein, 2006, Wagner, 2014, Wagner and Kallus, 2014; 2015, Mandryk and Atkins, 2007, Yagi, 2000). Another advantage of this multidimensional approach is that psychophysiological responses are, under normal circumstances, not volitional controllable by individuals (Boucsein and Backs, 2009) and can be measured using noninvasive techniques (Boucsein, 2006). The studied psychophysiological measures were: cardiovascular (ECG) and electrodermal activity (EDA) as well as the forearm and neck electromyography (EMG). In addition, the facial expression was recorded via camera. The integration of the facial expression is a further development of the previously described approach. During former research of the research group (Project EmTra, grant from the Institute of Applied Research of Furtwangen University), a system for emotional recognition via facial expression was developed (Arabian et al. 2021a, 2021b; Arabian et al. 2021a, 2021b), which should be integrated in the measurement environment. In the future it should be enhanced and used in further studies.

PREPARATION OF THE MEASUREMENT ENVIRONMENT

Psychophysiological Measures

As described in the introduction section, cardiovascular activity (ECG), electrodermal activity (EDA), and electromyography (EMG) should be combined in the measurement environment. In this case, ECG and EDA data were collected using the EcgMove 3 and EdaMove 3 of movisens (2022), the EMG data using the TEA CAPTIV T-Sens EMG of TEA Ergo Inc (2022).

The ECG was recorded using disposable adhesive electrodes which were attached directly at each side of the sensor. The standard sensor position (chest) recommended by movisens was used (movisens, 2022). Electrodermal activity (EDA) was measured using reusable, non-polarizing sintered Ag/AgCl electrodes with a diameter of 10 mm. The electrodes were attached at the participants' non-dominant hand (thenar and hypothenar). To obtain muscle activity, adhesive electrodes were used and attached at the upper trapezius (musculus trapezius pars descendens) and forearm muscle (musculus flexor carpi radialis).

Facial Expression

To recognize the facial expression of the participants, a webcam (Logitech C925e) to record participants' faces was included in the developed measurement environment. The webcam was placed on the top of a computer screen (23-inch HP-screen; distance to the participant: 50 cm).

Synchronization

To combine all psychophysiological measures in one measurement environment, different computers are needed for data recording because the different manufacturers use varying recording methods. Running different recording programs on one device was found to increase the probability of interference between the programs and can cause worse latencies than running every recording program on a dedicated computer. The synchronization-difficulties that can occur using multiple computers, are a well-known problem. The approach to cope with this within the developed measurement environment was to include an additional trigger program as synchronization system.

The trigger program used in this setting was developed in the context of a bachelor thesis project to synchronize measurements between functional near infrared spectroscopy and motion tracking (Birkle, 2021, Claassen, 2021, Picka, 2021). It was updated on a regular basis to gain better latencies and to simplify the usage for the developed measurement environment. The tool utilizes the internet protocol (IP) and sends packages from one transmitter to all the recording devices via the transmission control protocol (TCP). This communication procedure was chosen to guarantee a high compatibility between the different devices. The graphical user interface (GUI) of the trigger tool for both, the transmitter and the receiver view, is presented in Figure 1. It is recommended to use a separate wired local network disconnected from the frequently used network infrastructure to reduce the present network traffic. On the receiver side the trigger program performs the trigger by connecting to the interface of the recording program. If the recording program doesn't have an interface, it saves the necessary trigger information including the corresponding system times into a text file. The round-trip delay never exceeded 50 milliseconds. This value consists of the transmission time from the transmitter to the receiver, the required time to perform the trigger on the receiver device, and the backward transmission time from the receiver back to the transmitter.

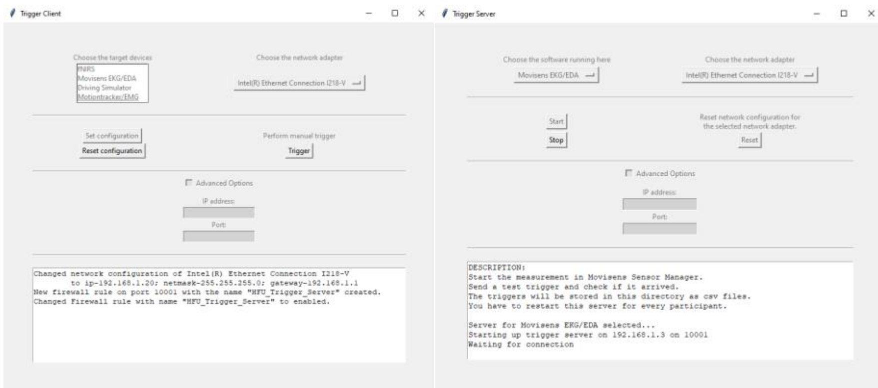

Figure 1. Graphical user interface (GUI) of the trigger tool (left side: transmitter view; right side: receiver view).

It is crucial that the trigger arrives earlier at the recording device than the psychophysiological reactions on the stimulus do. Otherwise, the correct recognition of the physiological reaction to the stimulus during the data analysis is not given. Latencies in this range don't interfere with the reaction times of the human body to a presented stimulus for the used physiological measurements. E.g., the reaction time of the skin conductance varies from one to two seconds, when a stimulus is presented (Boucsein, 2012).

There are two ways to perform a trigger with the help of the developed trigger tool. On one hand, one can select a trigger button with the mouse (c.f. Figure 1, left side) which sends a manual trigger signal to all devices. This procedure was used in the presented measurement environment. On the other hand, there is the possibility to call the trigger function via the python interface from any other program or directly from the command line. Therefore, it is very easy to include the trigger functionality into nearly every digital stimulus presentation tool.

FIRST EVALUATION OF THE MEASUREMENT ENVIRONMENT

Method

Sample. Due to the restrictions regarding personal contacts during the time when the measurement environment was developed (spring 2021, COVID-19 pandemic), only one participant took part in the first evaluation of the measurement environment. The participant was a 22 year old male student.

Study Design, Materials and Procedure. A repeated measurement design was chosen for the evaluation of the measurement environment. After a baseline measurement (overall 5 minutes – mean two minutes were used for the analyses), the participant had to perform five different tasks (each with a duration of two minutes). Each task was followed by a rest measurement of two minutes. The different performed tasks (measurement repetition factor) were: A short game (knife hit from Ketchapp played via app on an iPhone 8), a backward counting task (count backwards from 100 in steps of six and seven), and thinking of different emotional contents (e.g. a quiet place – forest glade; a situation the participant faced in the last days, that was emotionally arousing). The measured psychophysiological responses were cardiovascular (ECG) and electrodermal activity (EDA) as well as the forearm and neck electromyography (EMG). In addition, the facial expressions were recorded via camera (see section “preparation of the measurement environment” for more details). The experimental setup is shown in Figure 2.

Figure 2. Experimental setup

Data Analyses. Cardiovascular and electrodermal activity were analyzed using the software DataAnalyzer from movisens (2022), electromyography was analyzed using the software package CAPTIV from TEA Ergo Inc (2022). The analyzed parameters for cardiovascular activity were heart rate (HR) in beats per minute and heart rate variability (HRV RMSSD). Regarding the electrodermal activity, skin conductance level (SCL), amplitude of non-specific electrodermal responses (NS.SCR amp), frequency of non-specific electrodermal responses (NS.SCR freq) and mean sum amplitude (NS.SCR amp/NS.SCR freq) were used. For EMG the root mean square amplitude (RMS) was included in the analyses.

Results

For the cardiovascular activity (ECG) the results showed that due to a large number of artifacts, data loss occurred for both parameters HR and HRV. The analysis of the protocol and post-tests with the sensor revealed, that one explanation for this can be that the adhesive electrodes attached directly at the sensor and positioned at the chest together with the sensor, were very sensitive to artifacts caused by motion. Regarding the electrodermal activity (EDA) the results suggest no data loss and a good quality of the measurement (Figure 3). In addition, electromyography was measured without data loss in the developed experimental setting. The results suggest that within the used measurement environment electromyography (EMG) of the musculus trapezius seems to be more sensitive regarding motion-related artifacts than the EMG of the forearm muscle. Furthermore, no inherence caused by the different sensors and devices and/or the measurement environment were visible in the different analyzed psychophysiological measures. Additionally, the mimic was recorded without any data loss or motion blur.

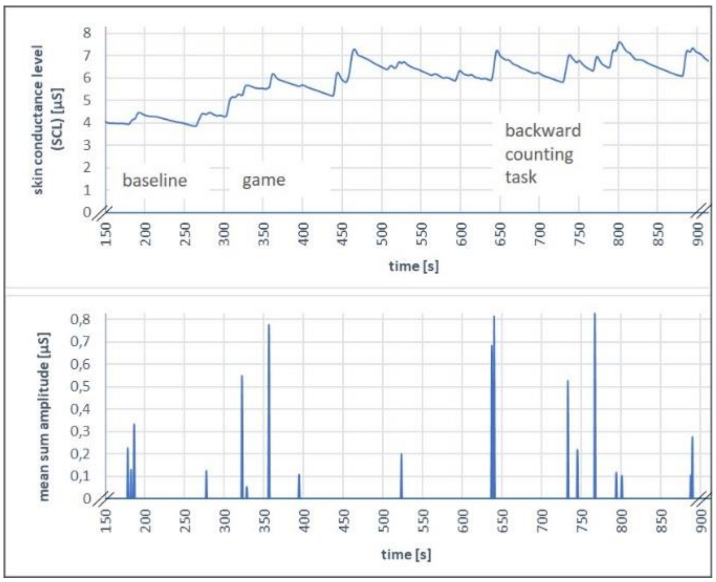

Figure 3. Example for the measured signals of the electrodermal activity

DISCUSSION

The results of a first evaluation (different tasks like a short game, a backward counting task, or thinking of different emotional contents) show, that the synchronization of the different measures was successful and promising for the use in further research. The study was able to show a need for improvement with regard to the derivation of the ECG (chest strap vs. adhesive electrodes). The design of the measuring environment can be seen as successful regarding the combination of the different psychophysiological measures and the different used devices. In the future, an expansion with additional parameters such as pulse volume amplitude (PVA) or eye tracking will be considered.

Furthermore, in future study settings the trigger tool should always be used in an automatic way by implementing it into the stimulus presentation system as described in chapter "Synchronization" (second alternative). With this automatic implementation the impact of human response times can be reduced and human errors can be avoided.

However, the first evaluation of the measurement environment has some limitations. Due to the restrictions regarding personal contacts during the time when the measurement environment was developed caused by the COVID-19 pandemic. So, only one participant was allowed to participate in the first evaluation of the measurement environment. We are aware of the fact that this can be only a first step. Unfortunately, this was the only possibility to receive first data to assess the measurement environment at that time (spring 2021). Therefore, another validation study was conducted when the restrictions were eased and the development of a study with more participants was possible. These results will be presented in the paper of Schmid, Braunmiller, Hansen, Schonert, Möller and Wagner-Hartl (2022; also within this volume).

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