Facial skin temperature during deception

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ABSTRACT

Measuring peripheral tissue temperature is a well-known methodology to assess different physiological states of a body. It is also widely used in a clinical environment. On the other hand, measuring facial skin temperature for the identification of the psychological state of a person is not so common. This article will provide information on non-contact measurements of facial temperature in comparison with established psychophysiological measuring systems (electro-dermal activity and heart rate) for 24 participants. The experiment consisted of two different states of cognitive loads which were expressed through the narration of a true and untrue story. During a narration, on selected regions of interest (ROI), subjects were monitored using a thermographic camera. Although the results did not show statistically significant differences between the true and untrue story for facial thermal measurement (in inter-person and intra-person comparison), some differences did appear. Results of this study showed, a critical approach using information on a camera's accuracy, human skin properties, and other technical concerns) is needed when using facial temperature measurements with a thermographic camera for a reliable evaluation of different psychological states or loads.

KEYWORDS

Psychophysiology, thermal imaging, facial temperature, deception

1 INTRODUCTION TO THERMAL IMAGING

Historically, body temperature measurement for monitoring illness was very important. In early examinations, physicians observed mud when applied to the skin, on areas over the tumor mud was drying faster. First clinical thermometer was developed by Carl Wunderlich in 1868 and its principle is still in use [1]. Thermal imaging camera was invented by Hungarian physicist Kalman Tihanyi in 1929 for anti-aircraft defense in Britain [2]. Firstly thermal imaging cameras were long been in use for specialized law enforcement and military applications and soon later by the fire services [3]. A major development of electronic sensors for infrared radiation was in the early 1940s with indium antimonide, and the first medical images were made in London in 1959 – 1961 by a technique called thermogram [1]. Articles with thermal imaging correlating of psychophysiology are not so common but some studies have proven that with thermal imaging one can detect deception or lie with great accuracy [4–8].

2 METHOD

Research is based on an experiment with various measurements of physiological parameters. As a baseline method for psychophysiological measurements, electrodermal activity measurements were used [9–12]. In the experiment volunteered 24 healthy participants, of those 15 men and 9 women aged from 20 to 45 years old 23,9 ± 5,0. After reviewing the measured parameters, we included data from 9 persons in further analyzes, because, due to incomplete data or inadequately measured parameters. Monitoring parameters were: electrodermal activity, skin temperature, and heart rate. Psychological evaluations were done through interviews and standardized STAI-X1 agitation questionnaires.

2.1 ELECTRODERMAL ACTIVITY

Electrodermal activity (EDA) is a dermal property that is caused by different responses in electrical characteristics of the skin [13]. EDA has two components, the skin conductance level (SCL) and skin conductance response (SCR). SCL value describes the level of person psychological excitement, and SCR is the number of responses to the stimulus. The peak amplitude is typically reached within 1 to 3 s after the onset of the response [14]. EDA was measured with Biopac MP150 system (BIOPAC Systems, Inc., USA) and unit Biopac GSR 100C connected to silver electrodes on index and ring finger pads of nondominant hand as shown in figure 1. EDA data was processed by BIOPAC AcqKnowledge 5.0 software.

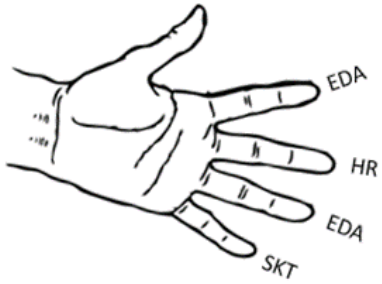

Figure 1: Illustrated human hand with corresponding signals measured on finger pads. Electrodermal activity on the index and ring finger, heart rate on the middle finger, and skin temperature on the little finger

2.2 SKIN TEMPERATURE

Skin temperature depends on the blood flow to the subcutaneous tissue. It may also depend on external factors such as exercise, ambient temperature, or medical condition. The temperature was measured on a little finger pad of the non-dominant hand (Figure 1). Contact temperature measurements were done with Biopac SKT 100C connected to the thermocouple. Contactless skin temperature measurements were done with a black-body calibrated Flir 650sc camera (FLIR Systems, USA). Camera uses a microbolometer type of detector with a resolution of 640 x 480 pixels. The camera was positioned 1 meter in front of the participant. Emissivity was set to 0.98 [15]. We have analyzed three main regions on the face. Size of regions of interest (ROI) were 2512 pixels for the forehead, 445 pixels for the nose, and 710 pixels for cheeks as seen in figure 2. Sampling frequency was set to 15 frames per second. Temperature was recorded as mean value with standard deviation for each ROI last 100 frames of each story and analyzed with FLIR ResearchIR Max software.

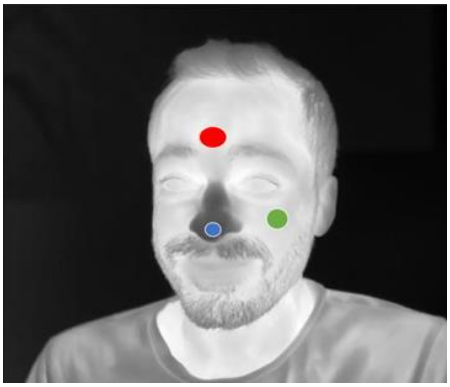

Figure 2: Capture from video taken with Flir 650sc, marked with positions of ROIs (red - forehead, blue - nose, green – cheeks)

2.3 HEART RATE

The heart cycle is the action of the human heart from one heartbeat to another. The cardiac cycle consists of two periods of time when the heart muscle relaxes and fills with blood (diastole) and the time of intense contraction and pumping of blood (systole). Heart rate is stable in a healthy adult at a rate of between 60 and 100 beats per minute. Heart rate was measured with Biopac module PPG 100C and an optical sensor placed on the middle finger pad of the nondominant hand (Figure 1). Heart rate and heart rate variability were processed with BIOPAC AcqKnowledge 5.0 software.

2.4 EXPERIMENTAL SETUP

Prior measurements, the experimenter records the temperature of the room, prepares a statement, psychological questionnaires, and calibrates the electrodes to measure the electrodermal activity of the skin. Participant is invited to the room and is asked to turn off cellphone and any other potentially disturbing factors. Experiment begins with an introduction interview, sensors placement on the participants hand (Figure 1), and STAI-X1 agitation questionnaire followed by the experimenter's general neutral questions designed to relax participant. During this period participant also acclimatizes to room temperature. Participant is asked to tell two stories, one true and the other untrue. The stories should last for a maximum of 2 minutes each and should relate to the events of participants previous day. The participants choose the order of true and untrue stories by themselves. Before storytelling, a thermographic camera is set to recording. The recording was started remotely via a computer, eliminating the disturbance of the experimenter. After storytelling was completed, participants revealed which story was true and which not, at the same time, experimenter stopped all measurements. At the end of the experiment, participants resolved the STAI-X1 agitation questionnaire.

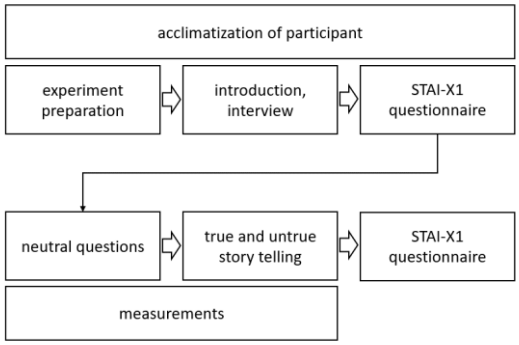

Figure 3: Block diagram of experiment flow

3 RESULTS

Measurements for forehead and nose were calculated with statistical Wilcoxon signed-rank test. Results showed that forehead temperature between untrue story (Mdn = 35.13) and true story (Mdn = 35.17) does not show statistically significant differences, $Z = –0.451$; $p < 0.652$; $r = 0.101$. Also, temperature of a nose between untrue (Mdn = 28.54) and true (Mdn =28.53) did not show statistically significant differences $Z = –0.568$; $p < 0.570$, $r = 0.127$. For temperature of the cheeks we used two-tailed test for the dependent samples which showed us there is no statistical difference between the untrue story M = 34.04; SD = 1.77) and true story (M = 34.07; SD = 1.60) $t(8) = –0.214$; $p = 0.836$.

For the EDA, two-tailed paired t-test did not show statistical difference between untrue story (M = 6.22; SD = 3.03) and true story (M = 5.78; SD = 2.59) $t(8) = 0.627$; $p < 0.548$.

For the finger temperature calculated with statistical Wilcoxon signed-rank test we did not find statistical difference between untrue story (Mdn = 24.49) and true (Mdn = 24.88) story, $Z = –1.035$, $p < 0.301$, $r = 0.231$. Also, we did not find statistical difference for heart rate between untrue story (Mdn = 95.66) and true (Mdn = 93.12) story, $Z= –0.339$; $p < 0.734$; $r = 0.0759$.

4 DISCUSSION

The major limitations of this study are: i) complexity of the psychological phenomena under observation (lying is difficult to induce), ii) moving artefacts due to the physical movement of the

face, iii) small number of participants, errors in measurements (EDA electrodes, calibration interval of IR camera).

Measurements were performed with different techniques to prove different psycho-physiological responses between true and untrue storytelling. The sample of 24 participants decreased to a total of 9 participants due to incomplete data or inadequately measured parameters. For thermal camera measurements, we excluded data of persons wearing glasses. Glass is not transparent for IR waves, and the method for measuring minimum temperature of a nose compromised the measurements. Also, there was a lot of face movement present in IR video and this made it difficult to determine temperature of an ROI. In some cases, camera performed calibration and focus corrections when recording in this case we excluded measurements for those participants. For EDA measurements we excluded participants with poor contact with silver electrodes. Although none of the tested parameters showed significant statistical differences, there are some differences between untrue and true storytelling. The temperature of the forehead ROI was 2,0 % lower, temperature of a cheek 0,1 % lower, and a nose 1,7 % higher, respectively there are more SCRs in EDA data and the finger temperature is lower when telling an untrue story.

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