BIOSIGNALS: MEASUREMENT AND ANALYSIS WITH APPLICATIONS IN PSYCHOLOGY

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Human body functioning can be directly or indirectly assessed by measurement and analysis of biosignals. These procedures commonly result in the extraction of features i.e., biomarkers that can be further used for description or prediction of various psychological functions and processes. Biomarkers serve to provide additional validity to obtained data and to address some of the issues inherent to commonly used psychological techniques, such as self-report, behavioral, and task-performance paradigm. The benefits of including the physiological approach in psychology research include in-the-moment, automatic assessment of the subjects' reactions, and detection of reactions when no change in behavior or task performance can be observed. The most commonly used measures in psychology are heart rate (HR), heart rate variability (HRV), electroencephalogram (EEG), galvanic skin response (GSR), respiration, jaw-clenching, eye movements and blink interval (measured for example with electromyography – EMG and electrooculography – EOG). Due to the intricate nature of biosignals, measurement and analysis can be rather complex. Biosignals have commonly small signal-to-noise ratio i.e., can be vastly affected by external and internal artifacts, and persons' physiological response(s) are compound in nature and can be influenced by a relatively large number of factors which can make feature extraction diligent or even impossible. Therefore, appropriate procedures for measurement and analysis must be carefully considered and precisely followed. For example, simple electrophysiology measurement can be affected by numerous factors, like skin-electrode impedance, electrode placement, physiological cross-talk (e.g., interference with other physiological signals), cable movements, power hum, etc. To design appropriate protocols for biosignal application in psychology, close collaboration between biomedical engineers and psychologists is a prerequisite for successful scientific study. We present an overview of biosignal-based assessment procedures with selected examples from applications in psychology. Additionally, we discuss how these biomarkers reflect changes in the sympathetic and parasympathetic nervous system activation, and how they should be used in psychological research. A possible implementation of biomarkers in studies

assessing emotional and cognitive load will be presented.

IMAGINAL PROVOCATION TEST AS A WAY TO INDUCE EMOTIONS IN THE LABS

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The Imaginal Test Provocation Procedure (IPTP) is based on the idea that the respondent's emotions can be induced through storytelling and that these emotions can have a significant impact on other psychological constructs (e.g., moral judgment, decision-making, learning, retrieval). The IPTP requires a respondent to imagine an emotion-provoking scenario involving herself as the protagonist of the story. Immediately after, the respondent rates the degree of targeted emotion experienced in imagining the scene, and how she would have responded had the situation depicted actually have happened. If there is a correspondence between the reported and the scenario-targeted emotion, the procedure is deemed successful. The IPTP usually serves as an experimental treatment, while the respondent's self-report is taken as a measure of treatment success. However, the self-report measure of the respondent's emotional state does not have to correspond with the psychophysiological component of the reported emotion, i.e., the respondents might report about their hypothetical emotional reactions to the scenarios, and not experience actual emotions. We pretested ten anger-provoking scenarios of similar narrative structure and length. The respondents rated six emotions aroused by scenarios and plausibility of each scenario. The average anger ratings ranged from 5.04 (SD = 1.58) to 6.24 (SD = 1.02), whilst the average rating for other emotions ranged from 1.20 (SD = .85) to 5.32 (SD = 1.65), with surprise having the highest score, however still significantly less intense than anger ($t(87) = 5.55$, $p < .000$). The respondents were exposed to the scenario that was rated the most plausible and unequivocally targeted anger (M = 6.02, SD = 1.20). The protagonist in the scenario needed to finish the group project and pass the exam while confronting rude colleagues who passed their part of the work onto her. The scenario was auditively presented to respondents via headphones; they were asked to try to experience the event as vividly as possible and imagine people they knew as characters in the episode. Our aim was to validate the IPTP by obtaining the physiological measures of arousal during the treatment, examining the changes from baseline arousal and comparing the degree of activation between pre- and post-treatment assessments, so as to compare the respondents' self-reports with their psychophysiological print.

IN PURSUIT OF OBJECTIVITY: PHYSHIOLOGICAL MEASURES AS A MEANS OF EMOTION INDUCTION PROCEDURE VALIDATION

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Psychological research in the field of emotions and affects usually relies on self-report measures and questionnaires, and as such, arguably lacks objectivity. An approach combining physiological measures with classical psychological methods may provide a solution to the issue of objectivity, particularly regarding emotion induction in experimental conditions. Triggering emotions in an artificial setting is not a straightforward task as it might seem, nor are the means of assessing its successfulness. For that reason, we explored the possibility of evaluating the effectiveness of an experimental anger induction procedure and assessed it via several physiological parameters. Fifty-nine healthy participants (9 male, age M = 19.92, SD = 0.57) took part in the experiment in which Electrodermal Activity (EDA), Electrocardiography (ECG) and Impedance Cardiography (ICG) outputs were recorded using BIOPAC equipment. Physiological parameters were collected during 3 phases, each of which lasted approximately 2 minutes: 1) relaxation period, i.e., baseline recordings, 2) experimental manipulation in which participants were subjected to anger-evoking audio material, as part of a standard procedure named guided fantasy technique, and 3) post-manipulation period. Subjects were then asked to rate the degree to which they experienced each of six basic emotions (anger, disgust, fear, happiness, surprise, and sadness) and aggressive behavioral tendencies during the course of anger-inducing guided fantasy. We expect significant differences in physiological responses during baseline and anger induction phase if the guided fantasy has a genuine effect on the subjects' mood. Obtained data provide support for such an assumption. Namely, the values of average tonic EDA, as well as heart rate, were greater during the second phase in comparison to the baseline period (F (2, 104) = 28.478, $p < 0.001$; F (2, 114) = 4.641, $p < 0.05$), while Pre-Ejection Period (F (2, 114)=5.899, $p < 0.01$) and Systolic Time Ratio (F (2, 114)=6.769, $p < 0.01$) have significantly decreased. Specific physiological measures used in this experiment and their relations with self-report data will be discussed in further detail. The benefits and drawbacks of using objective, physiological, parameters in emotion research are discussed.

EFFECTS OF VIOLENT VIDEO STIMULI ON GASTRIC ACTIVITY: ELECTROGASTROGRAPHY-BASED CASE STUDY

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The functionality of the human gastrointestinal tract can be affected by emotional arousal as a result of the autonomic nervous system function. Electrogastrography (EGG) as a non-invasive technique for direct assessment of gastric electrical activity can be used for gastric motility evaluation in relation to the induced emotion. In this work, we aim to investigate the potentials of the EGG technique in testing the somatic markers hypothesis. Specifically, to investigate whether EGG can be used for a quantitative assessment of a *gut feeling,* EGG

alterations induced by violent video stimuli were examined. Data were collected in two respondents with no known gastrointestinal disorders: ID1 – female, 29 years old, height 172 cm, and weight 64 kg; ID2 – female, 23 years, 168 cm, 56 kg. Subjects were asked not to consume solid food for 6 hours and liquids 2 hours prior to the fasting recording session and for postprandial session (after meal intake) subjects were asked to consume commercial oatmeal of 274 kcal. Recording consisted of three sections: baseline recording (resting), EGG during the presentation of the violent video stimulus, and EGG recording after the presentation of the video. We recorded two sessions per subject for both fasting and postprandial states with a total of four EGG recordings. The following EGG-based features were calculated: dominant frequency – DF, median frequency – MF, crest factor of power spectral density – CF, and root mean square – RMS of EGG amplitude for each recording. MF and RMS increased from baseline to violent video recording in three out of four obtained recordings by more than 20%. DF increased only in recordings from subject ID2 for more than 39%. CF variations were consistent since an increase in all four recordings was detected (>15%). In summary, though some subject-specific differences were noticed, violent video stimulus caused a certain change in EGG morphology. Our preliminary findings obtained on four recordings from two subjects suggest that violent visual stimuli can cause changes in electrical gastric activity and can be quantitatively detected by analysis of surface EGG biosignals. These findings give support to the somatic markers hypothesis and suggest that changes in EGG caused by violent video stimulation can be related to empathic feelings provoked in the subjects. We discuss possibilities and potential drawbacks of electrogastrography in detecting personality correlates.

CARDIOPRINT: INDIVIDUAL FEATURES HIDDEN IN ELECTROCARDIOGRAM AND IMPEDANCE-CARDIOGRAM

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Electrocardiography (ECG) recordings have been previously proposed for person verification with comparable results to handprint-based identification. Here, we present a novel hybrid biometric system based on ECG and impedance cardiography (ICG) signal analysis with its robustness to emotional load. We hypothesize that unique biometric features can be detected to allow for precise identification of an individual. For each examinee, signals were acquired in three intervals (of approximately 2 min duration for each phase): (1) recordings during relaxation, (2) recordings while anger-inducting audio material was played, and (3) recording in post-anger phase. All three intervals should allow for accurate identification of individuals. The sample consisted of 62 respondents, average

age 19.9 years (*SD* = 0.57), 85% female. Amplitude and temporal features were extracted to describe examinees' signal-specific morphologies, which were used to form training and test sets. Linear and Random Forest (RF) classifiers were constructed with different input features. The training set consisted of 450, while both test sets consisted of 449 inputs. The best accuracy (93.8%) was accomplished with RF when ECG and ICG features from all three phases were used as classifier inputs. We correctly classified 421 (out of 449) ECG-ICG inputs with top features being: (1) QRS interval (mean minimum depth 3.32, times-a-root 38, $p < 0.001$), (2) RS amplitude (2.2, 87, $p < 0.001$), (3) RQ amplitude (2.47, 69, $p < 0.001$), (4) RC interval (2.6, 80, $p < 0.001$), (5) CX amplitude (2.92, 59, $p < 0.001$) where X is a characteristic point in ICG, and (6) right-sided T-wave amplitude (3.12, 48, $p < 0.01$), while other features showed no statistical significance. Our results are promising and indicate that combined individual features from ECG and ICG signals recorded during relaxation and during induced emotional response can be used for highly accurate (~94%) biometric authentication systems with relatively simple classifiers. Future studies should focus on the correlates of ECG and ICG features in individual differences, like personality traits. Furthermore, a more in-depth analysis of the obtained results using a larger sample is needed to obtain more reliable conclusions.