

Application for ethical approval at DTU Compute's Institutional Review Board

Project title:

Analysis of emotions using physiological signals: a pilot study

Principal investigator:

Line Katrine Harder Clemmensen, Associate Professor, DTU Compute

Other investigators:

Sneha Das, Postdoc, DTU Compute

Nicklas Leander Lund, Research Assistant, DTU Compute

Date: September 26, 2022

Contact person: Nicklas Leander Lund (nickle@dtu.dk)

1 Project background, objectives and hypotheses

1.1 Background

The body's response to stress is controlled by the autonomic nervous system (ANS), which has two interacting parts: the sympathetic and the parasympathetic nervous system. The sympathetic nervous system prepares the body to deal with threat by increasing respiration, heart rate, blood pressure, and sweat secretion - characteristics of high arousal. The parasympathetic nervous system has opposing effects, slowing breathing and lowering heart rate - characteristic of low arousal. The level of flexibility in switching between high and low arousal depends on how quickly the ANS can change heart rate and is the physiological basis of emotion regulation. Physiological measures such as pulse or heart rate and electrodermal activity capture arousal levels, where as heart rate variability is a measure of emotion regulation [1].

Previous studies have demonstrated that experimenter induced stress leads to increased electrodermal activity acceleration and heart rate compared with resting conditions [2] [3]. Increased heart rate and skin conductance level, response rate and response magnitude are also associated with negative emotions such as sadness and fear [4]. One study was able to discriminate between fear, sadness, anger, contentment, and amusement using skin conductance and heart rate patterns on dimensions of activation and approach/withdrawal [5].

1.2 Objective

The goal of this project is to study the relationships between measures of physiological arousal (electrodermal activity (EDA), blood volume pulse (BVP), motion-based activity acceleration (ACC) and skin temperature (TEMP)), stress and specific emotions.

In our NNF funded research project WristAngel, we will use (some of) these physiological measurements (biosignals), acquired with the Empatica E4 wristband, to detect distress and emotion in children with obsessive compulsive disorder (OCD). This pilot study aims to setup a baseline for pre- and post-processing of biosignals as stress and emotion indicators, which will enable us to write a more detailed statistical analysis plan for WristAngel.

Furthermore, the collected data will be meaningful to use in DTU's 02445 course, statistical evaluation of AI. Therefore, we intend to make a project in this course with a pseudo-anonymized version of the experimental data.

1.3 Hypothesis

We hypothesize that changes in the acquired physiological signals, i.e., BVP, EDA, TEMP and their derived features are correlated to the changes in the emotional state (e.g., experimenter induced frustration and self-reported emotions). The null-hypotheses include:

1. There is no difference in biosignals among resting, stress and recovery conditions.
2. The biosignals cannot discriminate among dimensions of emotions (activation and approach/withdrawal).
3. The biosignals cannot discriminate among specific emotions.

2 Study methods

2.1 Experimental design, measurement and post-processing

Experimental design: Participants are divided in multiple teams of two and compete in a puzzle competition. Four teams will be competing in an alternating fashion while the remaining teams will be in either the pre- or post-task resting phase. The competition consists of four rounds and has a duration of 76 minutes. The task of the competition is to solve as many tangram puzzles as possible in total during the four rounds. The task is designed to be difficult. A solved puzzle yields one point and the team with the most points at the end of the competition wins.

A round consists of 1+3 phases: wristband calibration (1 minute), pre-task resting (5 minutes), in-task puzzle solving (5 minutes), post-task resting (5 minutes). 60 seconds at the end of the pre-task, task and post-task phases are reserved to answer the emotion evaluation questionnaire. A timeline of a round is seen in Figure 1. The phases are indicated as follows by the instructions in Appendix V.

A team is handed a 7-piece tangram puzzle and a set of sketches of various puzzles. The participants of the teams have one role each: an instructor and a puzzle-solver. The puzzle-solver is the only one who is allowed to touch and assemble the puzzle pieces. The instructor is the only one who is allowed to look at the puzzle sketches. As a team they help each other to solve the puzzles. At any point a puzzle can be skipped and another can be chosen to be solved. Team roles stay fixed throughout the competition.

The order of puzzle-sketches are the same before hand-out such that all teams have puzzle-sketches in the same order.

Thus, participants are exposed to two conditions:

- **Resting condition:** Before and after the stress-inducing puzzle task participants will be asked to find a comfortable sitting position and sit quietly and rest for 5 minutes.
- **Stress/frustration condition:** The participants are asked to solve as many tangram puzzles as possible in 5 minutes.

After end experiment participants will be debriefed about the stress to which they have been exposed by a trained psychologist.

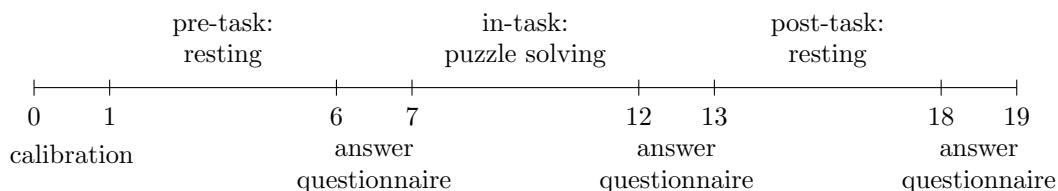


Figure 1: Timeline of a round of the puzzle competition depicting how phases and questionnaire answering periods are arranged. At the end of each round the participants are to turn off their Empatica E4 wristband. Numbers, [0 : 19], below the vertical line indicates the time in minutes since the beginning of the round.

For each round, at the end of the pre-task, in-task and post-task phases, participants will be asked to rate their feelings of a variety of emotions and how difficult it was for them to solve the task using the following questionnaire:

1. On a scale from 0-10, where 0 is not frustrated at all and 10 is extremely frustrated, how frustrated are you feeling right now?
2. On a scale from 0-10, where 0 is not upset at all and 10 is extremely upset, how upset are you feeling right now?
3. On a scale from 0-10, where 0 is not hostile at all and 10 is extremely hostile, how hostile are you feeling right now?
4. On a scale from 0-10, where 0 is not alert at all and 10 is extremely alert, how alert are you feeling right now?
5. On a scale from 0-10, where 0 is not ashamed at all and 10 is extremely ashamed, how ashamed are you feeling right now?
6. On a scale from 0-10, where 0 is not inspired at all and 10 is extremely inspired, how inspired are you feeling right now?
7. On a scale from 0-10, where 0 is not nervous at all and 10 is extremely nervous, how nervous are you feeling right now?
8. On a scale from 0-10, where 0 is not determined at all and 10 is extremely determined, how determined are you feeling right now?
9. On a scale from 0-10, where 0 is not attentive at all and 10 is extremely attentive, how attentive are you feeling right now?
10. On a scale from 0-10, where 0 is not afraid at all and 10 is extremely afraid, how afraid are you feeling right now?
11. On a scale from 0-10, where 0 is not active at all and 10 is extremely active, how active are you feeling right now?
12. (Only asked in the task phase) On a scale from 0-10, where 0 is not difficult at all and 10 is extremely difficult, how difficult did you find the task?

Measurement: The participants will be fitted with an Empatica E4 wristband on their non-dominant wrist. Each wristband will be associated with one participant and will be assigned an ID to match experimental data physiological signal and emotion-questionnaire answers). The wristband will measure the participants; blood volume pulse (BVP) and inter-beat-intervals (IBI) via photoplethysmography (PPG), electrodermal activity (EDA) via an galvanic skin response (GSR) sensor, peripheral skin temperature via an infrared thermopile sensor and motion-based activity accelerations via a 3-axis accelerometer.

The biosignals will be extracted from the Empatica E4 wristbands via the E4 Manager application on a PC/Mac at the end of the experiment and stored on a secure drive.

Post-processing: Post experiment, a variety of features will be derived from the biosignals (e.g. heart rate variability from BVP) using appropriate software.

2.2 Tasks

The primary goal of the study is to design data processing pipelines to process physiological data collected with the Empatica E4 wristband and to test and develop models to detect the influence of frustration on the acquired biosignals. The overall goal can be subdivided into the following tasks:

1. *Pre-processing:* This step involves removal of acquisition- and sensor-noise from the biosignals, and evaluating the suitability of the obtained signals for further processing.
2. *Influence of task-induced emotions on the biosignals:* How strong is the influence of changes in emotional states (if any) on the biosignals. Furthermore, we investigate the sensitivity of each biosignal to the emotional state changes.
3. *Tracking changes in the biosignals:* Granular analysis of the biosignals to detect signal regions where signals deviate from resting (reference).
4. *Individual differences in the biosignals:* Study the uniqueness of biosignals among individuals to gauge transferability and generalizability to data within vs. across participants in the study.
5. *Synchrony between pairs:* Coherence of biosignals between team members.

2.3 Analysis

Signal processing: Filtering, peak-picking, normalization and outlier analysis will be employed to pre-process and clean the signals.

Statistical analysis: Time-domain, frequency-domain and non-linear features will be used to obtain descriptive statistics of the signals [6]. We will perform statistical tests on phase-level to investigate for significant differences in the biosignals during the three phases of the competition, with $\alpha = 0.05$ as the significance level. The null-hypothesis is that the task-induced frustration does not have an influence on the biosignals. The Benjamini-Hochberg False Discovery Rate (FDR) will be used to address false discoveries due to multiple hypothesis testing. Mixed effect models will be made to test relationships between emotions and biosignals. The null-hypothesis is that biosignals have no relation to emotions.

Classification, anomaly detection and transfer learning: Bayesian learning, clustering and transfer learning using conventional machine learning and deep learning will be explored for the aforementioned tasks in tracking signal change-points and studying the limits of generalizing the above methods to biosignals from unseen subjects/phases, in particular we want to study the differences between generalization within vs across participants in the study. Anomaly detection relates specifically to handling low signal-to-noise ratios in the raw physiological signals.

Software packages: Python (version $\geq 3.9.7$) and associated packages will be used for pre-post-processing, analysis and learning.

3 Participant

We will recruit a maximum of 24 participants. Participants are invited by email.

3.1 Inclusion criteria

1. Age ≥ 18
2. Member of the section of Statistics & Data Analysis at DTU Compute
3. Affiliated with the WristAngel research project

3.2 Exclusion criteria

1. Known cardio vascular diseases
2. Use of heart medication or any other medication known to affect heart rate
3. Age < 18

3.3 Reimbursement

Each participant will be compensated with food and drinks for their participation in the study.

4 Ethical considerations

Written consent is obtained from the participant before the experiment begins. If a participant withdraws during the experiment, the data will be deleted. However, the data will not be deleted after the experiment has finished.

4.1 Ethical implications

The tangram puzzle task is designed such that it should be very difficult for the participants to solve and thereby elicit frustration and possibly other negative emotions. The competitive format of the experiment is chosen to further stress participants.

The experiment task and format are necessary for the purpose of the pilot study and the data collected comprise of signals reflecting on the emotional state of a participant. The tangram puzzle task is an emotional regulation task designed to elicit emotions in children with OCD as well as healthy children - it is designed so that it is safe for children. Therefore, the task is considered safe for adults as well and the induced mental stress by the puzzle task is expected to have no negative effect on the participants mental state and health.

4.2 Data protection and handling

Before the experiment the participants will sign the consent form in Appendix III/IV. The consent forms include sensitive information (name and signature) and will thus not be assigned any form of key or ID which could link the sensitive data and the experimental data (physiological signals and emotion-questionnaire answers). The signed consent forms will be stored by the leader of the

experiment and will not be digitalized. The Empatica E4 wristband and emotion questionnaires of a participant will be signed a common random key in order to match experimental data (physiological signals and emotion-questionnaire answers). The key will be stored separately from the experimental data without the possibility of tracing back to the individuals from the data. The experimental data will be stored in a dedicated folder on the DTU Compute network, and this folder will only be accessible by the investigators of this pilot study. The physiological signals are pseudo-anonymized as it is considered biometric data which means that there is a potential risk of identifying participants by their data.

4.3 Data sharing and dissemination of results

A pseudo-anonymized version of the resulting dataset(s) will comprise of physiological measurements and emotion-questionnaire answers only, and will be used for further educational purposes at DTU.

The findings from the study will be submitted for publication in a peer-reviewed journal and we anticipate at least one scientific paper resulting from the study. All publications will be performed such that the identity of the participants is protected.

4.4 Future implications

The results of this pilot study will inform the establishment of data processing pipelines for a clinical study and give a preliminary look at using physiological signals to detect and predict mental states (frustration, other emotions, mental effort).

4.5 Study period

The study period will begin at the beginning of the experiment and end ultimo 2022.

4.6 Finances

This pilot study is financed by the “Exploratory Interdisciplinary Synergy Programme”, grant reference number: NNF19OC0056795.

References

- [1] B. M. Appelhans and L. J. Luecken, “Heart rate variability as an index of regulated emotional responding,” *Review of general psychology*, vol. 10, no. 3, pp. 229–240, 2006.
- [2] S. Ollander, C. Godin, A. Campagne, and S. Charbonnier, “A comparison of wearable and stationary sensors for stress detection,” in *2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, pp. 004362–004366, IEEE, 2016.

- [3] R. Goel, M. An, H. Alayrangues, A. Koneshloo, E. T. Lincoln, and P. E. Paredes, “Stress tracker—detecting acute stress from a trackpad: Controlled study,” *Journal of Medical Internet Research*, vol. 22, no. 10, p. e22743, 2020.
- [4] S. D. Kreibig, F. H. Wilhelm, W. T. Roth, and J. J. Gross, “Cardiovascular, electrodermal, and respiratory response patterns to fear-and sadness-inducing films,” *Psychophysiology*, vol. 44, no. 5, pp. 787–806, 2007.
- [5] I. C. Christie and B. H. Friedman, “Autonomic specificity of discrete emotion and dimensions of affective space: A multivariate approach,” *International journal of psychophysiology*, vol. 51, no. 2, pp. 143–153, 2004.
- [6] D. Makowski, T. Pham, Z. J. Lau, J. C. Brammer, F. Lespinasse, H. Pham, C. Schölzel, and S. H. A. Chen, “NeuroKit2: A python toolbox for neurophysiological signal processing,” *Behavior Research Methods*, vol. 53, pp. 1689–1696, feb 2021.



Appendix I: Informationsbrev

Informationsbrev til deltageren (DK)

Kære deltager,

I dette brev oplyser vi dig om eksperimentets formål og fremgangsmåde. Det er vigtigt at du læser brevet omhyggeligt. Hvis du har nogle spørgsmål, skal du ikke tøve med at kontakte os (Line H. Clemmensen, lhkc@dtu.dk) for præciseringer.

Dine rettigheder som deltager

Din deltagelse i dette eksperiment er frivillig. Det betyder at du til enhver tid kan forlade eksperimentet uden at det har nogle konsekvenser for dig, uden at du behøver at give en begrundelse. Data, der er behandlet i forskningsprojektet inden du trækker dit samtykke tilbage, vil ikke blive slettet. Hvis du trækker dit samtykke tilbage midt i forsøget, vil vi slette dine data, og de kan dermed ikke behandles i forskningsprojektet. Vi vil bede dig om en erklæring om informeret samtykke til at deltage, efter at du er blevet informeret om eksperimentet.

1 September 2021
LKHC

Formålet med forskningsprojektet

I dette forsøg undersøger vi fysiologiske signaler som måles under en stressfremmende øvelse. Vi er især interesseret i at undersøge sammenhængen mellem de fysiologiske signaler og forskellige følelser som opleves under øvelsen. Forskningsresultaterne skal etablere metoder til at pre- og post-processere det indsamlede data, hvilket bl.a. kan bruges til at udvikle digitale assistenter til børn med psykiske lidelser som fx OCD (Obsessive-Compulsive Disorder).

Lagring og håndtering af data

Dine fysiologiske signaler vil være pseudo-anonymiseret da de anses for at være biometrisk data, hvilket betyder at der er en risiko for at du kan identificeres ud fra disse data. Alt registreret forskningsdata (fysiologiske signaler og besvarelser på følelses-spørgeskema) vil blive opbevaret pseudo-anonymiseret og vil ikke have nogen forbindelse til dit navn, din adresse, dit CPR-nummer eller andre oplysninger, der gør det muligt at identificere dig. For at imødekomme dette opbevares din data under en nøglekode, som kun forskerne er bekendt med og som vil blive slettet, når den ikke er nødvendig længere (efter dataanalysen). Personlige oplysninger som dit navn vil blive opbevaret separat og lagret sikkert af forsøgslederen. En del af forskningsdata (fysiologiske signaler og svar på følelses-spørgeskemaer) vil blive gjort tilgængelig via DTUs datalager i pseudo-anonymiseret form med et tilfældig ID, som ikke er gemt eller kendt af forskerne.

Detektering af forskelle mellem opgave udført under stress og målinger umiddelbart før og efter opgave

REG-no. DK 30 06 09 46

DTU Compute
Department of Applied Mathematics
and Computer Science

Richard Petersens Plads
Building 324
2800 Kgs. Lyngby
Denmark

Tel. +45 45 25 30 31
Fax +45 45 88 13 99

lhkc@dtu.dk
www.compute.dtu.dk



Vi vil benytte os af electrodermal activity (EDA), blood volume pulse (BVP), aktivitets baseret bevægelse acceleration (ACC) og hud temperatur signaler målt under en stressfremmende opgave til at designe data processerings pipelines, baseret på de forskelle vi observerer pre-opgaven, under opgaven og post-opgaven. De fysiologiske signaler bliver målt med et Empatica E4 armbånd, hvilket er en sikker og ikke-invasiv metode. I forsøget bliver du bedt om, af flere omgange, at være med i en konkurrence, hvor man skal løse puslespil på tid. Du vil endvidere blive bedt om at besvare et spørgeskema omkring de følelser du registrerede under udførelsen af denne opgave.

Der vil være instruktioner og en forsøgsansvarlig til at hjælpe dig gennem forsøget.

Skulle du have spørgsmål til eksperimentet, de anvendte metoder eller din egen sikkerhed samt dine rettigheder, så tøv ikke med at kontakte os per e-mail (lkhc@dtu.dk) eller telefonisk (+45 45 25 37 64).

Med venlig hilsen,
Line H. Clemmensen, Lektor

DTU privacy rules:

Error! Hyperlink reference not valid.

https://www.dtu.dk/Om-DTU/strategi_aarsrapporter_mv/Politikker/Privatlivspolitik



Appendix II: Information letter

Information letter for participants (EN)

Dear participant,

In this letter we will inform you about the procedure and purpose of the experiment. It is important that you read the letter carefully. In case of any question do not hesitate to contact us (Line H. Clemmensen, lhkc@dtu.dk) for clarification.

Your rights as participant

Your participation in this experiment is voluntary. This means that you at any time can leave the experiment without an explanation and without suffering any consequences. Data which has been processed in the research project before you withdraw your consent will not be deleted. If you withdraw your consent during the experiment, we will delete your data and it will not be treated in the research project. We will ask you to declare informed consent after you have been informed about the experiment.

1 September 2021
LKHC

Objective of the research project

With this experiment we want to investigate physiological signals measured during a stress inducing exercise. We are especially interested in investigating the link between the physiological signals and different emotions measured and experienced during the exercise, respectively. Based on the results we will establish methods for pre- and post-processing of the collected data which can be used to develop digital assistants for children and adolescents with mental health disorders like e.g. OCD (Obsessive-Compulsive Disorder).

Data management and storage

Your physiological signals are pseudo-anonymized as they are considered biometric data and thus come with the risk that it could be used to identify you. All registered research data (physiological signals and answers of emotion-questionnaires) will be stored pseudo-anonymized and will have no link to your name, address, CPR-number or other identifiable information. To accommodate this your data will be stored with a key which only the researches know, and which will be deleted when it is no longer necessary (post data analysis). Personal information such as your name will be stored separately and securely by the leader of the experiment. Part of the research data (physiological measurements and answers of emotion-questionnaires) will be made accessible in DTU's data storage in a pseudo-anonymized version with a random ID which is neither stored nor know to the researchers which means that this part of the research data cannot be used to identify you

REG-no. DK 30 06 09 46

DTU Compute
Department of Applied Mathematics
and Computer Science

Richard Petersens Plads
Building 324
2800 Kgs. Lyngby
Denmark

Tel. +45 45 25 30 31
Fax +45 45 88 13 99

lhkc@dtu.dk
www.compute.dtu.dk



Detection of differences in physiological signal and emotions during task-solving under stress and just before and after task-solving

We will use electrodermal activity (EDA), blood volume pulse (BVP) motion-based activity accelerations (ACC) and skin temperature signals measured during a stress inducing task to design data processing pipelines, based on the differences we observe pre-task, during the task and post-task. The physiological signals are safely and non-intrusively acquired using the Empatica E4 wristband. In the experiment you will be asked to participate in a puzzle-competition in which you will solve puzzles in a limited time. Furthermore, you will be asked to answer a questionnaire related to your feelings of emotions while performing the task of solving the puzzles.

There will be an instructor and an experiment responsible available to guide you through the experiment.

In case of any questions related to the experiment, the applied methods, or your safety as well as your rights do not hesitate to contact us via e-mail (lkhc@dtu.dk) or by phone on (+45 45 25 37 64).

Best regards,
Line H. Clemmensen, Lektor

DTU privacy rules:

Error! Hyperlink reference not valid.

https://www.dtu.dk/Om-DTU/strategi_aarsrapporter_mv/Politikker/Privatlivspolitik



Appendix III: Informeret samtykke

Erklæring om informeret samtykke (DK)

Eksperiment: **Tangram Puzzling on time for WristAngel**

Forskere: Line K. H. Clemmensen, Lektor, Sneha Das, Post doc, Nicklas Leander Lund,
Forskningsassistent

Erklæring om informeret samtykke

1 September 2021
LKHC

Jeg bekræfter at:

- Jeg er blevet tilfredsstillende informeret om det pågældende forsøg, både mundtligt og skriftligt i form af informationsbrevet.
- Jeg har haft muligheden for at fremlægge spørgsmål vedrørende forsøget og at disse spørgsmål er blevet besvaret på tilfredsstillende vis.
- Jeg har overvejet min deltagelse i eksperimentet omhyggeligt.
- Jeg deltager af min egen fri vilje.

Jeg er enig i at:

- Mine data vil blive indsamlet og opbevaret til videnskabelige formål som nævnt i informationsbrevet i pseudo-anonymiseret tilstand, dvs. med en nøglekode som kun forskerne er bekendt med.
- Mine data må blive delt i en offentlig forskningsdatabase i pseudo-anonymiseret tilstand, med en tilfældig nøglekode, der ikke er gemt af forskerne. Dette inkluderer f.eks. BVP (blood volume pulse) samt labels med den følelse jeg har vurderet bedst, beskrev min tilstand under forsøget. Navn, alder og køn er IKKE inkluderet.

Jeg forstår at:

- Min deltagelse er frivillig og jeg har ret til at trække mig fra eksperimentet til enhver tid uden at give en begrundelse.
- **Mit forskningsdata indsamlet før tilbagekaldelse af deltagelse i forsøget må anvendes til forskningsformål.**
- Mit privatliv er beskyttet i henhold til dansk lovgivning og europæiske retningslinjer (GDPR; EU 2016/679).

Jeg giver mit samtykke til at deltage i dette eksperiment

REG-no. DK 30 06 09 46



Fulde navn

Dato, Sted, Signatur



Appendix IV: Informed consent

Declaration of informed consent (EN)

Experiment: **Tangram Puzzling on time for WristAngel**

Researchers: Line K. H. Clemmensen, Lektor, Sneha Das, Post doc, Nicklas Leander Lund,
Research Assistant

Declaration of informed consent

1 September 2021
LKHC

I confirm that:

- I have been satisfyingly informed about the experiment, both verbally and written in the form of an information letter.
- I have had the opportunity to ask question regarding the experiment and that these questions have been answered satisfyingly.
- I have thoroughly considered my participation in the experiment.
- I participate by my own free will.

I agree that:

- My data will be collected, pseudo-anonymized and stored for a scientific purpose as described in the information letter – i.e. data is stored with a key which only the researches know.
- My data can be made accessible in a public research database in a pseudo-anonymized version with a random key which is not stored by the researchers. The data include physiological signals and emotion-questionnaire answers registered during the experiment. Name, age, and gender is NOT included.

I understand that:

- My participation is voluntary, and I have the right to withdraw from the experiment at any given time without reason.
- **My data collected before my withdrawal from the experiment can still be used for the purpose of the experiment.**
- My privacy is protected according to Danish law and European guidelines (GDPR; EU 2016/679).

I declare my consent to participate in this experiment

REG-no. DK 30 06 09 46

DTU Compute
Department of Applied Mathematics
and Computer Science

Richard Petersens Plads
Building 324
2800 Kgs. Lyngby
Denmark

Tel. +45 45 25 30 31
Fax +45 45 88 13 99

lkhc@dtu.dk
www.compute.dtu.dk



Full name

Date, Place, Signature



Appendix V: Instructions

INSTRUCTIONS

- 1) You will be given a copy of the consent form. Please read it carefully and let us know if you disagree with any of the terms.
- 2) If you agree with it, kindly sign the consent (add your name below your signature).
- 3) The competition lasts 76 min and is divided into 4 rounds of 1+3 phases: calibration (1 min), pre-task resting (5 min), task (5 min), post-task resting (5 min). For each round 3 min are reserved for rating of feelings of emotions.
- 4) Before the competition begins, you will be given an Empatica E4 wristband to wear for the entire duration of the competition. Please read the instructions included to understand how to operate the wristband.
- 5) In the calibration phase, turn on the wristband. At the end of the calibration phase press the button to mark the end of the phase.
- 6) At the end of the pre-task and task phases press the button to mark the end of the phase and use 60 seconds to rate your level of emotions according to the provided questionnaire. After having answered the questionnaire press the button to mark the beginning of the following phase.
- 7) At the end of the post-task press the button to mark the end of the phase and use 60 seconds to rate your level of emotions according to the provided questionnaire. After having answered the questionnaire turn off the wristband.
- 8) Step 5), 6) and 7) are repeated for each round.
- 9) Your teammate and you are handed a 7-piece tangram puzzle and a set of solutions to various puzzles. The task is to solve as many puzzles as possible in total of during the 4 rounds. One of you, the puzzle-solver, is the only one who is allowed to touch and assemble the puzzle pieces. The other one of you, the instructor, is the only one who is allowed to look at the puzzle solutions. The instructor chooses what puzzle to solve and instructs the puzzle-solver in how to assemble the puzzle pieces to solve the puzzle. You may at any point skip a puzzle and choose another one to solve. You maintain your team roles throughout the competition.
- 10) Feel free to ask in case of any questions.