Relaxation methods and their effects

Investigating objective and subjective measurements

Master's Thesis 2016
Engineering Psychology
Aalborg University

Louise Worsøe og
Herle Haahr Hvelplund

AALBORG UNIVERSITY
STUDENT REPORT

Title:
Relaxation Methods and their effects: investigating objective and subjective measurements.

Theme:
Master's Thesis

Project period:
10th semester, spring 2016

Project group:
16gr1081

Members:

Herle Haahr Hvelplund

Louise Worsøe

Supervisor:
Lars Bo Larsen

Copies: 4
Number of pages: 146
Appendix no.: 13 + CD
Finished the: 2nd June 2016

Department of Electronic Systems
Engineering Psychology
Fredrik Bajers Vej 7
9220 Aalborg

Abstract

This project is investigating a difference between ways to induce relaxation. This is done by conducting an experiment while measuring the subjects' physical and psychological responses, when they are placed in a chair and is instructed to relax. This is done in cooperation with Bang & Olufsen, who have implemented a biofeedback system in a chair. The objective measurements are galvanic skin response (GSR), heart rate (HR), brain activity (EEG), and memory capacity. The subjective measurements are questions regarding how relaxed the subjects' feel and their preferences.
Five different ways to induce relaxation are tested with 20 subjects, that participated in the two and a half hour experiment. The experiment consists of: a guided meditation with focus in their breathing (Meditation), biofeedback by playing a sound scape that incorporated their breathing rhythm (Biofeedback), listening to a relaxing song they chose themselves (Relaxing music), playing music used for vibroacoustic therapy where the chair vibrates however without the chair being one designed for that purpose (Vibroacoustic), and a condition without any music used as a control to test if they could relax without additional stimuli (No music).
The results show that a decline in GSR can be used to indicate the body's response to relaxation over a period of time. However the overall GSR is sensitive to subjects' preferences. HR can also indicate the body's response to relaxation when comparing different conditions, but does not seem to be in accordance with the subjects' preferences. The brain activity measurements for workload can give a measure of whether or not the brain gets to unwind when relaxing. The workload results are however not in accordance with the subjects' preferences.

PREFACE

This report was written on the 10th semester at Department of Electronic Systems at Aalborg University by two students from Engineering Psychology between 1st February to 2nd June 2016. The project group 1081 had Lars Bo Larsen as supervisor. This semester was the *Master's Thesis* and the date set for the exam was 16th June.

Reading guide

Terms within this report will be indicated in *italics* the first time they occur. Source references in this report will follow the Harvard method, where references appear with the author's last name and the year of publication. Additionally a bibliography for websites, manuals and guides is created, where the source reference is by name and an indication of what is being referenced. These two bibliographies can be found on the last pages of the report after the appendixes.

Throughout the report there will be referred to the Appendix and Attachment. The Appendix can be found after the report and consists of additional material connected to the report's chapters. On the Attachment the raw data from the experiment, the code from the program developed by the project group, additional work and notes, and an electronic version of the report can be found. The content of the Attachment can be found on the CD and an overview of content of the Attachment can be seen in Appendix M.

Thanks to

The project group would like to thank Bang & Olufsen and Ditte Hvas Mortensen for their cooperation. A thanks to Claus Vestergaard Skipper for helping with the broken chair and measuring sound pressure level and vibrations. Also thanks to iMotions for their support regarding the software. Additionally thanks all the subjects who were willing to participate in the two and a half hour long experiment.

CONTENTS

CHAPTER 1

INTRODUCTION

This chapter include references to Appendix A, Appendix B, Appendix C, and Appendix D where additional information about the relaxation studies and terms described in this chapter can be found.

The basis for this project was a collaboration with Bang & Olufsen who has an interactive chair with two built-in loudspeakers. *The Interactive Chair* was designed to give people an *immersive* experience with a sound scape that would adapt to the person's breathing rhythm. The creation of the interactive sound scape was based on the an assumption that it will create increased body awareness and relaxation (Appendix A). Immersion can to different degrees make people disengage with the physical reality and have their minds create a second meditated world (Vidyarthi et al., 2012).

The Interactive Chair is a prototype and has not been tested before on a group of participants. It is therefore not known if The Interactive Chair has the desired effect regarding the increased body awareness, and if it needs to be conscious awareness in order to have an effect. The idea behind The Interactive Chair's sound scape resembles *biofeedback*.

Biofeedback is when a form of device gives people information about their body. The aim is to unite the body and mind, and with this knowledge potentially help people heal their body (West, 2007). A study compared two forms of biofeedback to examine which one the participants better could actively modulate their physiological arousal state with. This was measured as heart rate controlled for respiration rate. The difference between the biofeedback systems was that one used a sine-tone, and the other incorporated music as the signal that gives information about the heart rate. The results showed that the participants could modulate their physiological arousal state just as well with music biofeedback as for biofeedback using a sine-tone, and both better than the control where they only listened to music without biofeedback. The participants should both try to raise and relax their heart rate during the different condi-

tions (Bergstrom et al., 2013).

The idea for The Interactive Chair is to get disconnected and relax, where a study made for *Kulturministeriet* in Denmark regarding to the Danes' cultural habits in their everyday life has investigated what the Danes do to relax. The questions were about the situations when people are listening to music, reading a book, or watching TV. The results showed that 52% of the Danes listen to music when they want to relax. For the same reason 26% of the Danes read a book and 75% of the Danes watch TV (Bak et al., 2012) (Appendix B.1). A study found that people often watch television in the background while doing other things, and when sitting down to watch, they preferred to watch alone to better follow the story, and feel that watching with a group disrupts their attention (Cha, 2016).

The focus of this project will be on different ways to relax and since there are various way to do this, it was decided to focus on those that can be performed in The Interactive Chair. In order to compare other forms of relaxation to the biofeedback in The Interactive Chair these are chosen to only include sounds or music as well. This means that an additional visual variable will not be included, like there would have been for watching TV or reading a book. The following sections describe the different ways to relax that will be included in this project and what effect it can have on relaxation.

Music effect on relaxation

The study for Kulturministeriet showed that many people listen to music to relax, and is one that many have easy access to. When including this form of relaxation it could be examined if it is necessary to have a biofeedback system in order to get people to unwind.

A study examined how the brain perceives and processes music and found how music can influence physiological systems such as heart rate, blood pressure, breathing, skin temperature, galvanic skin resistance, and brain waves (Bonde, 2011, pp. 68).

Music that stimulates will increase the body's energy, generate body movements, and increase the heart rate and blood pressure. Opposite will relaxing music reduce the heart rate and blood pressure, and generally have a calming effect. It can be difficult to link a certain type of music to a specific physical response because of individual differences in response to different parameters in the music. Individual music preferences also have an effect, where some people can relax when hearing classical music and others like to relax to rock (Bonde, 2011, pp. 68) (Appendix B.2).

Meditation and its effect

When exercising *meditation* there is no goal of trying to get anywhere or feel anything special. The process is to keep attention on the breathing and focus on it for a period of time. If thoughts enter the mind, just let them go and focus the attention back on the breathing. The experience is not about rejecting, judging, suppressing or controlling the thoughts that unfold. The point

is for the mind to be in the present and getting familiar with the actual experience from moment to moment. The relaxation comes with continued practice, when applying meditation and attention to people's everyday life (Kabat-Zinn, 2004).

A study tested yoga postures and guided meditation in an office workspace and measured the participants' perceived stress along with blood pressure, heart rate and respiratory rate. The results showed that the brief yoga postures and guided meditation practice both reduced the participants' perceived stress, and the effects were maintained throughout additional fifteen minutes. The blood pressure, heart rate and respiratory rate also showed improvements when performing yoga and meditation compared to the control group who continued doing office work (Melville et al., 2012).

Two other studies worked with meditation where the difference between five days of meditation to a control group performing relaxing muscles training for the five days were compared. The results from the first study showed that the meditation group had significantly better attention and control of stress than the control group (Tang et al., 2007). The results from the second study showed that both the meditation group and the control group had a positive change for the physiological measurements, heart rate, skin conductance response, and respiratory amplitude and rate. There was furthermore a significantly better physiological change for the meditation group than the control group (Tang et al., 2009). The results also indicate that it is possible to measure a difference after only five days of meditation training, and maybe it is also possible to find an effect after a shorter period of time (Appendix B.3).

Meditation can both be used as a way for people to connect with and focus on their body, and as a method for disconnecting with their surrounding by focusing on the present instead of past and future thoughts. It is assumed that the biofeedback in The Interactive Chair can contribute to both of these by making people aware of their breathing and creating and immersive experience. Since these two forms of relaxation have similar traits a comparison could be interesting to investigate.

Vibroacoustic therapy

Since the loudspeakers are built into The Interactive Chair, the sound played through them can be felt like vibrations coming from The Interactive Chair while sitting in it. This is the reason for investigating vibroacoustic therapy that is defined as an auditory and vibratory stimuli that is transmitted to the body, and can have physical and psychological effects (Wigram and Dileo, 1997, pp. 7). An experiment found that vibroacoustic therapy has an effect on moods and states of relaxations. It showed that there was an effect on reduced arousal level and heart rate (Wigram and Dileo, 1997, pp. 87, 95) (Appendix B.4). It could be interesting to examine if the same effect could be found in The Interactive Chair even though it is not constructed for that purpose.

1.1 Problem statement

This project will investigate the different ways to relax, and try to find a measurable effect between them. This will help determine if one method is better than the others or if one method get people to relax faster or deeper than others. The scope of this project does not include looking for long term effect. Different ways to relax were considered, and it was chosen to examine the following five *Relaxation Methods*, and the terms will be used throughout the project. The full description of the Relaxation Methods can be found in Appendix C.

- ***Meditation***: This Relaxation Method will consist of a sitting meditation, where the subjects have to listen to a guided meditation, where no music will be present. The guided meditation will guide the subjects to pay attention to their body by being aware of their breathing. This kind of meditation is chosen to make sure that the subjects who have not tried meditation before will know what to do compared to the subjects who have tried it before. It is expected that those that have experience meditating could get more relaxed than those that have not tried it before. Therefore both subjects that have experience and those that do not will be found for the experiment.

- ***Biofeedback***: The Interactive Chair has a sensor in the backrest that can measure the rhythm of people's breathing. The Interactive Chair provided already has implemented the necessary system to convert the breathing measurements into a sound scape played through the loudspeakers. The project had therefore nothing to do with the design or development of this.

- ***Relaxing music***: Since people's music preferences are different and people relax differently, they get to choose themselves what song to listen to for this Relaxation Method. The subjects however have to choose one that they themselves find relaxing, and explain why they feel the song is relaxing. This is the only Relaxation Method where the subjects will know beforehand what music they will be listening to.

- ***Vibroacoustic***: Because The Interactive Chair has built-in loudspeakers, it vibrates when music is played. It is therefore interesting to investigate if an effect similar to vibroacoustic therapy music can be seen in The Interactive Chair. This is of course not the purpose of The Interactive Chair and it is not known if any vibroacoustic therapy effect can be seen. For *Vibroacoustic* a piece of music that is normally used with a specifically designed bed or chair will be played from The Interactive Chair.

- ***No music***: To investigate if The Interactive Chair itself has an effect it is chosen to have a Relaxation Method without music. Here people will just be sitting in The Interactive Chair relaxing without music. This can also be seen as a kind of control situation where the other Relaxation Methods all include some auditory stimuli.

A way to examine a difference between the Relaxation Methods is through the body's physical responses. There are different ways to measure this, however the chosen measurements for this project are *heart rate* (HR), *galvanic skin response* (GSR), and *electroencephalography* (EEG). HR is included because some of the previous described studies and theories found that

this could be influenced (Bonde, 2011), (Melville et al., 2012), (Tang et al., 2009). GSR is a measure for arousal where the peaks are often examined when e.g. different stimuli are presented in order to determine people's reaction to them. However other studies have used the overall GSR to examine a difference between meditation techniques to indicate relaxation (Boswell and Murray, 1979), (Wenk-Sormaz, 2005), (Telles et al., 2013). Through the EEG equipment available it is possible to get an estimate of five different metrics based on people's brain activity. These are *High Engagement*, *Low Engagement*, *Distraction*, *Drowsiness*, and *Workload*. The following describe the five EEG metrics. A definition of the GSR, HR and EEG can be found in Appendix D.

- High Engagement is based on a benchmark task where subjects have to pick the correct out of three symbols when showing them one at a time. This is considered a high engaging task where subjects have to be focused all the time in order to perform the task correctly (B-Alert, Manual).
- Low Engagement is based on a benchmark task where subjects have to press the space bar every 2 seconds in sync with a flashing red circle on the screen. This is considered a low engaging task where subjects still have to focus on the task, but do not have to use their full attention all the time (B-Alert, Manual).
- Distraction is based on a benchmark task where subjects have to press the space bar every 2 seconds in sync with a sound with their eyes closed. This is not considered a demanding task, and subjects can therefore be distracted from the task while performing it (B-Alert, Manual).
- Drowsiness is based on all the three benchmark tasks, and is calculated based on a *sleep onset* (B-Alert, Manual).
- Workload used for this project is a mean calculated based on two models that are based on a forward digit-span task and a backwards digit-span task (B-Alert, Manual). The way Workload relate to relaxing is, if the Workload is low then there is not a demand on the brain, and when the demand on the brain is low, it can unwind and thereby relax (Wickens et al., 2013).

Additionally a memory task called *backwards digit-span task* is used to measure the subjects' cognitive performance by having them repeat a series of numbers backwards. A study comparing walking in the nature to walking in the city found a difference when their subjects performed this task afterwards (Berman et al., 2008). In order to not only examine the subjects' physical responses, subjective questions regarding their preferences for relaxation are added.

CHAPTER 2

METHODS

This chapter include references to Appendix D, Appendix E, Appendix F, Appendix G, Appendix H, and Appendix J where additional information regarding the experiment can be found.

In order to investigate the difference between the Relaxation Methods an experiment is conducted. The experiment has been through five pilot tests before getting to the setup described below. The pilot tests were made to make sure that the equipment and the setup was working as it should. Between the five pilot tests changes were made (Appendix G).

2.1 Experimental Design

The five Relaxation Methods represent the independent variable for the experiment: *Biofeedback*, *Meditation*, *Relaxing music*, *Vibroacoustic*, and *No music*. The design of the experiment is a within subject design with repeated-measurement, where all subjects are taking part in all the conditions. The subjects perform the Relaxation Methods in five different rounds where they are sitting in The Interactive Chair and are instructed to relax.

In order to measure a difference both objective and subjective dependent variables are used. The objective variables that are measured are: GSR, HR, EEG, facial expressions, and a backwards digit-span task. The latter gives a measurement of the subjects' memory capabilities where different tasks were considered before choosing this (Appendix D.5). The subjective variables are two different kinds of questionnaires, where the first consists of two questions on a *visual analog scale* (VAS). The second questionnaire is called *M-TRACKER 7a.brief* and consists

of eleven questions on a five state *Likert scale* (Appendix F.5), and is used to evaluate people's *relaxation state* (*R-states*) that can determine how relaxed people feel at the moment (1 lowest, 5 highest). Additionally the subjects complete an *initial questionnaire* regarding among others their age, gender, hearings problems, sleeping and eating patterns in the day of the experiment, and if they have tried meditation before, and an *exit interview*. Many questionnaires and studies were considered and used for inspiration (Appendix E). The initial questionnaire is to get some overall information about the subjects, and the exit interview consists of questions about their experience and preferences for the Relaxation Methods. The temperature in the room, where the experiment was conducted, was steady at 22°C or 23°C, where the measurements can be seen on the Attachment.

2.2 Participants

Twenty subjects participated in the experiment. The age difference is between 21 years and 54 years with a mean of 31.35 years (SD = 13.57). Table 2.1 shows an overview of the subjects, where nine males and eleven females participated. Out of the twenty subjects twelve are students at Aalborg University or UCN Aalborg, two subjects are unemployed, four subjects have a job, and two subjects who are no longer working. Appendix J consists of a more in-depth description about the subjects based on their answers from the initial questionnaire. The subjects were not paid to be a part of the experiment and volunteered freely. As a thank you gift for participating the subjects got some chocolate and candy to take with them home.

Subjects	Age	Gender	Subjects	Age	Gender
Subject 1	25 years	Male	Subject 11	62 years	Female
Subject 2	22 years	Male	Subject 12	54 years	Male
Subject 3	24 years	Male	Subject 13	52 years	Female
Subject 4	25 years	Male	Subject 14	23 years	Female
Subject 5	25 years	Female	Subject 15	25 years	Male
Subject 6	26 years	Female	Subject 16	21 years	Female
Subject 7	24 years	Female	Subject 17	26 years	Male
Subject 8	23 years	Female	Subject 18	21 years	Male
Subject 9	22 years	Female	Subject 19	51 years	Female
Subject 10	26 years	Male	Subject 20	50 years	Female

Table 2.1: Overview of the age and gender of the subjects.

Ten of the subjects have tried meditation before, where six of those are experienced. Two of the subjects mentioned in the exit interview that they used meditation technique during the Relaxation Methods (Subject 11 and Subject 12).

The subjects were completing the experiment on three different times daily, beginning at approximately 9:00, 13:30, or 16:00. The subjects have therefore eaten breakfast or lunch before the experiment. Eleven subjects had been drinking caffeine on the day of the experiment, and none of the subjects had been smoking before the experiment.

2.3 Experiment setup

Three computers are used for the experiment and have different purposes, setup and additional connected equipment. In Figure 2.1 and Figure 2.2 the placement of the different equipment and how the different computers are connected can be seen. The loudspeakers in The Interactive Chair are connected through Bluetooth. A more detailed description of the different equipment can be seen in Appendix F.11. With permission from Dr. Jonathan Smith (Appendix

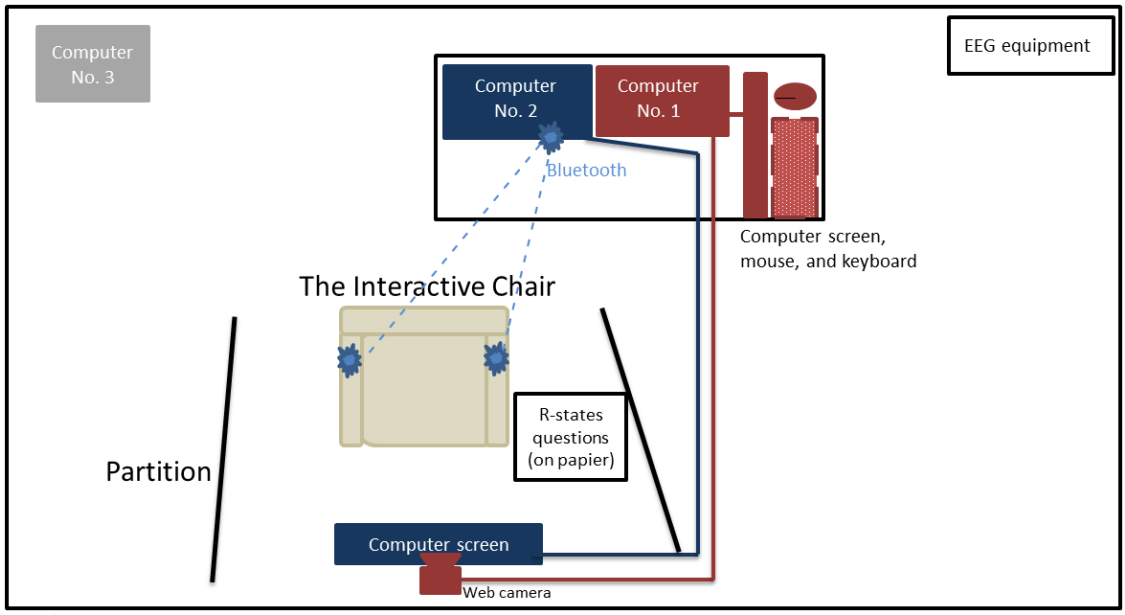

Figure 2.1: The equipment's placement in the experiment room.

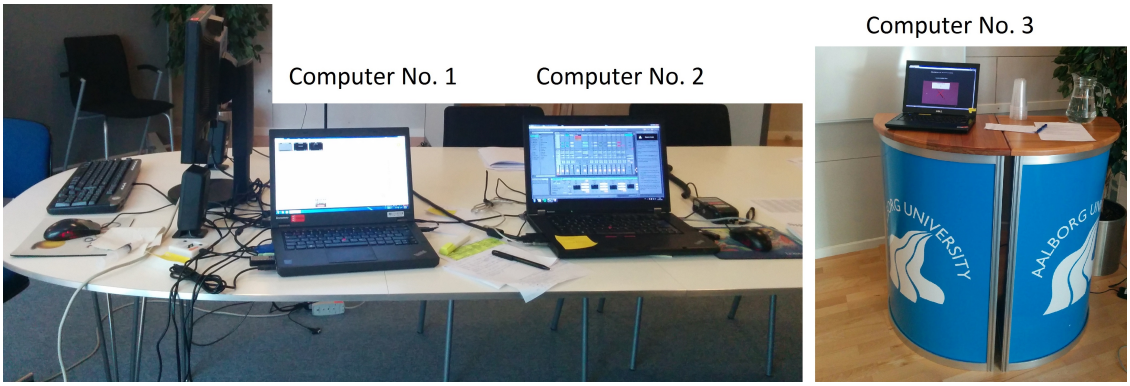

Figure 2.2: The setup of the three computers in the experiment room.

E.2) the R-states questionnaire M-TRACKER 7a.brief is used, where a printed version is placed by The Interactive Chair during the experiment.

For measuring the EEG the model ABM B-Alert X10[1] is used, and for the GSR and HR a

[1] http://www.advancedbrainmonitoring.com/xseries/x10/

Shimmer3 GSR+ Unit[2] is used, where a pulse sensor is connected to measure HR. To measure the facial expressions a web camera is used. The equipment is connected to iMotions software[3] that collects the measurements. The three computers that are used during the experiment are described below:

- **Computer No. 1** is running the program iMotions 6.0 and is used for the initial questionnaire and exit interview. For calibrating the EEG and answering the initial questionnaire the subjects use an extra computer screen, mouse, keyboard, and speakers that are connected to Computer No. 1. A web camera is connected to Computer No. 1 and placed in front of The Interactive Chair to record video (with sound) in order to measure the facial expressions.
- **Computer No. 2** is connected to the loudspeakers in The Interactive Chair through Bluetooth, and controls all the Relaxation Methods' sounds. The volume is set to 100% for *Biofeedback*, *Relaxing music* and *Meditation*, and set to 60% for *Vibroacoustic*. These volumes were assessed to be below a limit that would cause hearing damage (Appendix H.1). This computer also runs the program created to show the VAS questions and performs the backwards digit-span task (Appendix F.12). These are run on the extra computer screen placed in front of The Interactive Chair.
- **Computer No. 3** runs an online multitask game (Appendix F.8).

2.4 Procedure

The experiment takes approximately two and a half hours per subject and consists of: an introduction (Appendix F.1), a consent form (Appendix F.2), the initial questionnaire (Appendix F.3), placing the EEG equipment, calibrating the EEG, placing the GSR and HR equipment, a familiarization round, five rounds one for each of the Relaxation Methods, removing of all the equipment and an exit interview (Appendix F.7).

The five rounds consist of a multitask game while standing, relaxing in The Interactive Chair (the five Relaxation Methods), answering two VAS questions (Appendix F.4), answering eleven R-states questions (Appendix F.5) and performing the backwards digit-span task. Since the R-states questions are in English a Glossary is included and printed with translations of key words (Appendix F.6). This order was used for all the rounds where the VAS and R-states questions were answered right after relaxing in order to have the subjects' immediate feelings about the Relaxation Method. If the backwards digit-span task was performed before the VAS and R-states questions there is a chance that the subjects would forget how they felt during the Relaxation Method.

In Figure 2.3 the procedure and an approximate time for the different tasks can be seen. The experiment took place for seven consecutive days and three subjects were scheduled for

[2] http://www.shimmersensing.com/shop/shimmer3-wireless-gsr-sensor
[3] https://imotions.com/imotions-6-release/

each day (Appendix F.10). To avoid order effect a Latin Square design is used for the different Relaxation Methods where the subjects were randomly assigned to an order (Appendix F.9).

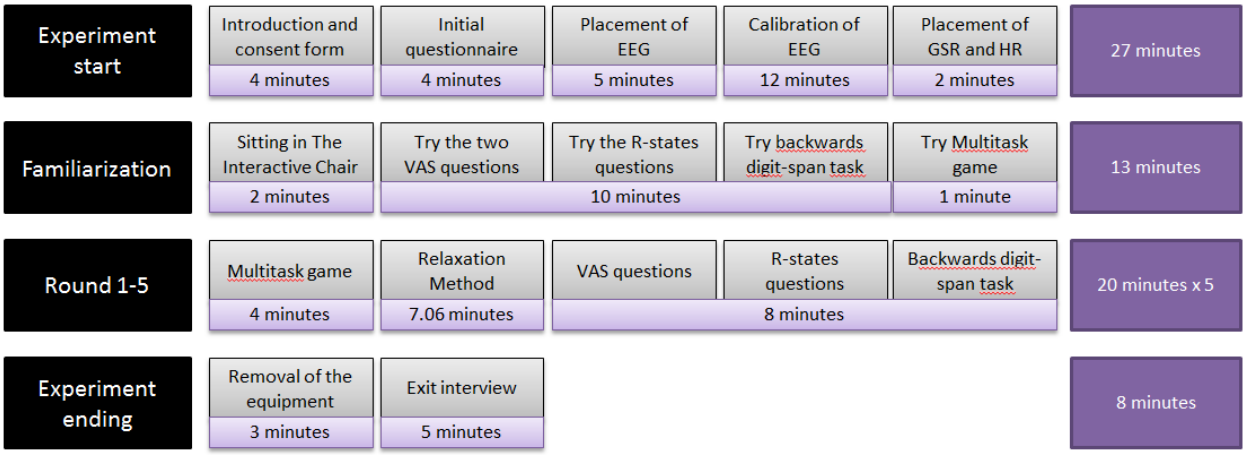

Figure 2.3: The experiment procedure with approximate times, the different parts take to complete.

In the beginning of the experiment there are two facilitators to help with placing the EEG equipment and running the electrode impedance check for the EEG. When the impedance check is completed and accepted, one facilitator remains in the experiment room for the rest of the experiment. After the impedance check a 9 minutes respondent benchmark for the EEG is executed. This is set to take approximate 12 minutes since the subjects also need time to read and understand the information about the three tasks.

During the Familiarization the subjects are presented to The Interactive Chair, and are instructed to sit in The Interactive Chair with their back leaned up against the backrest. When the subjects are sitting comfortably, the VAS questions, R-States questions and the backwards digit-span task are presented and run as it would be in the different rounds. The subjects afterwards get an introduction to the multitask game, and try the game once before Round 1 begins where they get four minutes to play the multitask game and note their scores on a piece of paper.

Round 1 to Round 5 have the same approach, the only difference is the Relaxing Method. The *Relaxing music* will be a song that the subjects themselves find relaxing, and will therefore not be the same for all the subjects. When Round 5 is completed, the subjects get the GSR, HR, and EEG equipment off and are asked questions about the experiment in the exit interview.

The multitask game is used as an anti-relaxing task to make sure that the relaxing effect from one Relaxation Method does not influence the next. The multitask game is performed standing to get a break from sitting, and the game includes controlling multiple mini games at the same time while annoying music is played which can be stressing (Appendix F.8). The VAS questions and R-States questions are used to indicate how relaxed the subjects get during the different rounds, and the backwards digit-span task is used to measure the Relaxation Methods' effect on the memory.

In Figure 2.4 from left to right: a subject completes the benchmark calibration, a subject plays the multitask game, a subject is relaxing in The Interactive Chair, and lastly a subject answers the R-states questions.

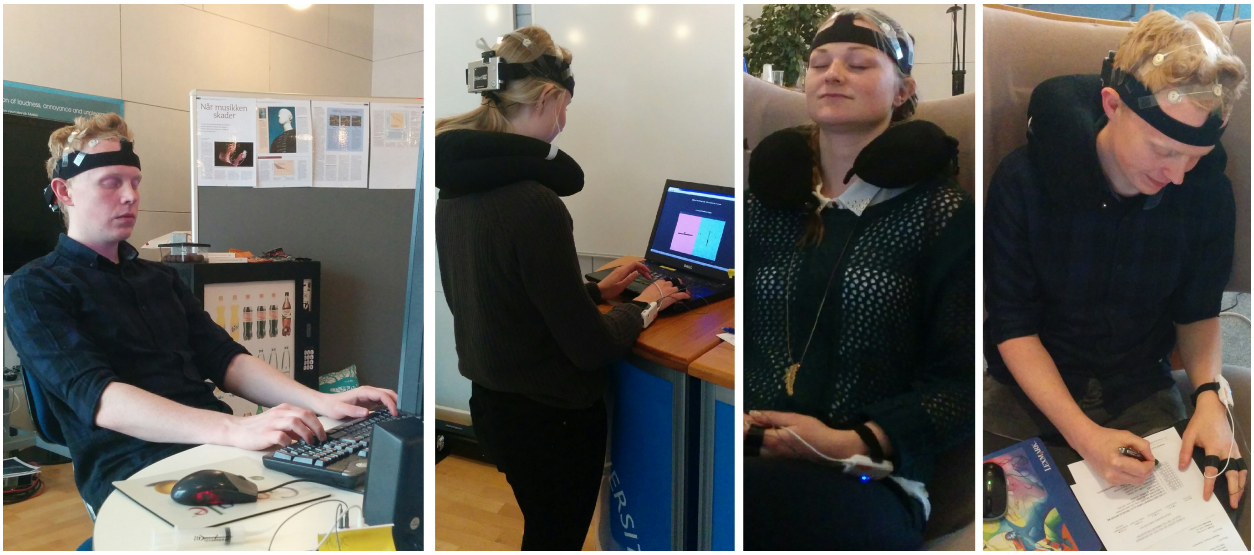

Figure 2.4: Different pictures showing the experiment setup.

CHAPTER 3

RESULTS

This chapter include references to Appendix H, Appendix I, Appendix J, Appendix K, and Appendix L where further information regarding the results can be found. The raw data and all the statistical analyses can be found on the Attachment.

3.1 Sound and vibration tests

Before the experiment was conducted a vibration test of the music used in The Interactive Chair was made, and after the experiment a sound pressure level was measured. The vibration test was performed with an accelerometer to determine how much The Interactive Chair vibrates during the different Relaxation Methods since these could have an effect on the subjects relaxation. The vibration test was performed on the four Relaxation Methods that were the same for all subjects, and a test song representing *Relaxing music*. It showed that *Vibroacoustic* had the highest level of the four Relaxation Methods, however depending on the song played in *Relaxing music*, this could have a high level as well (Appendix H.3).

The sound pressure level was measured for the four Relaxation Methods that were the same for every subject, which means that *Relaxing Music* was not included. A difference in this could have an effect on how the subjects perceived the music from the different Relaxation Methods (Moore, 2003, pp. 133-134). The measurements showed that *Vibroacoustic* had the highest sound pressure level, followed by *Biofeedback*, *Meditation* and in the end *No Music* (Appendix H.2).

3.2 The collected data

Twenty subjects performed the experiment, and data was collected for all Relaxation Methods except one where the EEG measurements failed for Subject 13 (Round 4, *Relaxing music*). During the experiment some small errors occurred (Appendix I). An example of the collected data from iMotions can be seen in Figure 3.1 for one subject during one round. The top five graphs illustrate the five EEG metrics, where the order from the top is High Engagement, Low Engagement, Distraction, Drowsiness, and Workload. The bottom three graphs show the HR, PPG[1] which is used to calculate HR, and in the bottom GSR. Images of all the iMotions graphs can be found on the Attachment for both GSR, HR, EEG and facial expressions for all subjects both during the Relaxation Methods and for the time afterwards where they answer the R-states and VAS questions, and perform the backward digit-span task.

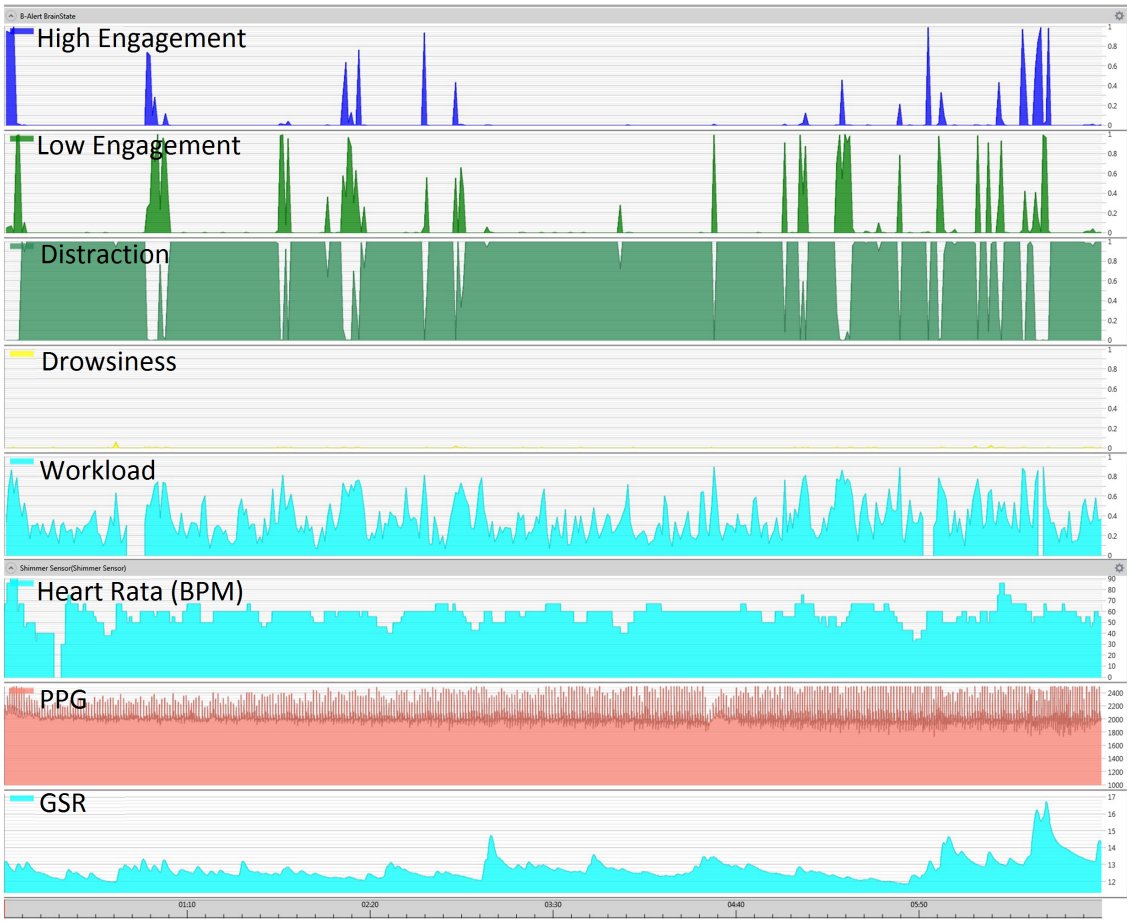

Figure 3.1: The iMotions graphs for EEG, HR and GSR for Subject 1 during *Biofeedback*.

The data that will be analyzed is the collected measurements for GSR, HR and EEG during the different Relaxation Methods, and the answers from the R-states and VAS questions, and the score for the backward digit-span task. An overview of all the data illustrated in histograms,

[1] Photoplethysmograph (PPG) measures blood volume pulse (Calvo et al., 2015, pp. 207-208)

boxplots, Plots of Means can be found in Appendix L. For at description of what has been done regarding missing measurements in the data for GSR, HR, and the EEG Workload see Appendix I.1. The following describe the data that will be analyzed for all the dependent variables.

- For **GSR** the overall data will be used to determine a difference between the five Relaxation Methods. Additionally a mean GSR level for the first and last minute of each Relaxation Method have been calculated. There will both be examined if there is a decline between the first and last minute for each Relaxation Method, and if there is a difference in the decline between the Relaxation Methods.

  For GSR it is also possible to examine a difference between the Relaxation Methods by using the number of peaks for each Relaxation Method for each subject.

- For **HR** the same data will be analyzed as for GSR, except for the peaks.

- For **EEG** the overall data collected for each Relaxation Method for each subject will be used for the five metrics, High Engagement, Low Engagement, Distraction, Drowsiness, and Workload to examine a difference between the five Relaxation Methods.

  Additionally thresholds have been made for four of the metrics: High Engagement, Low Engagement, Distraction, and Drowsiness. The reason that the data is either concentrated around the minimum level of 0 or the maximum level of 1, as seen in Figure 3.2.

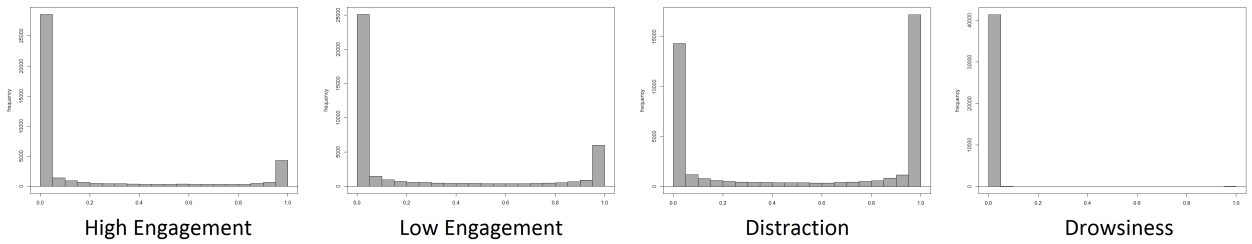

Figure 3.2: Histograms for the four EEG metrics: High Engagement, Low Engagement, Distraction, and Drowsiness. The values on the x-axis are from 0 to 1.

- For **R-states** the data consists of the calculated means based on the subjects answers to the eleven questions. Additionally each question will be examined to determine if some of the Relaxation Methods had an influence on how the subjects answered a particular question.

- For **VAS** there is a score for each Relaxation Method for each subject for the two questions. The first VAS question (VASQ1) was about how relaxed the subjects felt they were, and the second VAS question (VASQ2) was about how long time they felt they sat in The Interactive Chair. Both VASQ1 and VASQ2 will be examined to determine a difference between the five Relaxation Methods.

- For the **backwards digit-span task** two scores have been calculated for each Relaxation Method for each subject. The first score will be denoted as *BDST-O*, where all the numbers

in the correct order must be repeated for it to count in the score. For the second score, called *BDST-N*, only all the numbers have to be correct regardless of the order to count. It is possible to get up to twelve correct during one round.

It is chosen not to further examine the measurements for facial expressions, since it could be seen when examining a sample that the subjects primarily had a neutral facial expression (Appendix L.12). Additionally from the start of the experiment it was seen as an extra feature that could be interesting to analyze if there was time.

3.3 Statistical analyses

The data measured during the experiment was arranged so it could be analyzed using the statistics program R[2] and R Commander[3].

For the statistical analyses an ANOVA will be used, in order to discover if any variance in the data for the dependent variables can be explained by the five different Relaxation Methods as a factor. Additionally the factors Round and Subject are included in the ANOVA to account for an order effect and the subjects' individual differences. The results from the ANOVA will indicate if any of the factors have an effect on the dependent variables.

The ANOVA is based on the following linear model that include Relaxation Method, Round, and Subject as factors where the main effect is included (indicated with "+"). For parametric tests, such as the ANOVA, it is assumed that the data is normal distributed (Field and Hole, 2003). When examining the histograms for GSR, HR, EEG, VAS, R-states and the backwards digit-span task scores it is estimated that all are normal distributed except for the four EEG metrics: High Engagement, Low Engagement, Distraction, and Drowsiness. Even though the ANOVA is used on those four, it needs to be taking into account when evaluating what the results mean, since the data was not normal distributed. This is also the reason for analyzing the different thresholds for these EEG metrics.

Linear model: [GSR|HR|EEG|VAS|R-states|BDST] ~ Relaxation Method + Round + Subject

When performing the ANOVA the factors that are not significant are taking out of the linear model, until only the significant factors remain. The factors, that the ANOVA shows have a significant influence on a dependent variable, will be further examined by looking at the results from the linear model. The linear model shows the relationship between the categories of a factor, by providing an order of them based on the linear model's estimates. Since the linear model does not show how the categories are significantly different from each other, an effect plot is made. The effect plot shows the mean value of the categories along with a 0.95 confidence interval based in the linear model. By examining the 0.95 confidence intervals it is possible to determine if any of the categories of a factor is significantly different from each other. If two Re-

[2]https://www.r-project.org/

[3]http://www.rcommander.com/

laxation Methods' confidence intervals do not overlap there is a significant difference between them.

When a significant difference is mentioned, it means that the p-value for that factor is below 0.05. R also indicates the p-value with significant codes, and these will also be used in the results. If the p-value is between 0.05 and 0.01 it is shown with one star (*), if the p-value is between 0.01 and 0.001 it is shown with two stars (**), and if the p-value is between 0.001 and 0 it is shown with three stars (***).

Table 3.1 shows an overview of the results from the ANOVA tests for all the dependent variables based on the linear model. The table lists the dependent variables and show with a blue color and a significant code for the p-value if a factor from the ANOVA has significant influence on the dependent variable. Table 3.1 shows the results from the GSR, HR, EEG, backwards digit-span task, VAS, and R-states, that also include the results for the individual R-states questions, shortened Q1 to Q11.

Dependent variable	Relaxation Method	Round	Dependent variable	Relaxation Method	Round
Overall GSR	***	***	VASQ1		
GSR Decline			VASQ2		
GSR Peaks			R-States score	**	
Overall HR	***	***	R-States Q1	***	
HR Decline			R-States Q2		
EEG			R-States Q3		
High Engagement	***	***	R-States Q4	**	
Low Engagement	***	***	R-States Q5	**	
Distraction	***	***	R-States Q6		
Drowsiness	***	***	R-States Q7		
Workload	***	***	R-States Q8	***	
Backwards digit-span task			R-States Q9	*	
BDST-O		***	R-States Q10		
BDST-N		*	R-States Q11	*	

Table 3.1: The results from the AVONA based on the linear model with the factors, Relaxation Method, Round, and Subject, as main effects. The boxes with color are the factors that have significant influence on the dependent variable for Relaxation Method and Round.

The ANOVA results show that the factor Subject is significant for all the dependent variables, and therefore not included. Table 3.1 shows that for the overall data from GSR, HR, and EEG both of the factors Relaxation Method and Round have significant influence. Relaxation Method also has significant influence on the R-states score, along with some of the individual questions. The results from the backwards digit-span task have Round as a significant factor. The table also shows that there was not a significant influence for the factors Relaxation Method and Round for the following dependent variables: the calculation of GSR decline and peaks, the calculation of HR decline, and both of the VAS questions. Additionally the thresholds for four of the EEG metrics were analyzed in the same way as the other dependent variables, where the results from the ANOVA showed that only the factor Subject had a significant influence. It is only the results from the ANOVA that show a significant difference for the factors Relaxation Method or Round that will be described further.

GSR

The ANOVA showed a significant difference for the factors Relaxation Method and Round for the overall GSR level. These are further examined through effect plots, where Figure 3.3 shows the effect plot for Relaxation Method and Figure 3.4 shows it for Round. The effect plot for Relaxation Method shows that all five are significantly different from each other except between *Relaxing music* and *Vibroacoustic*. Those two also have the highest overall GSR level, where *No music* has the lowest level. In the effect plot for Round it can be seen that all rounds are significantly different from each other, and that the GSR level increases from the first to the last round.

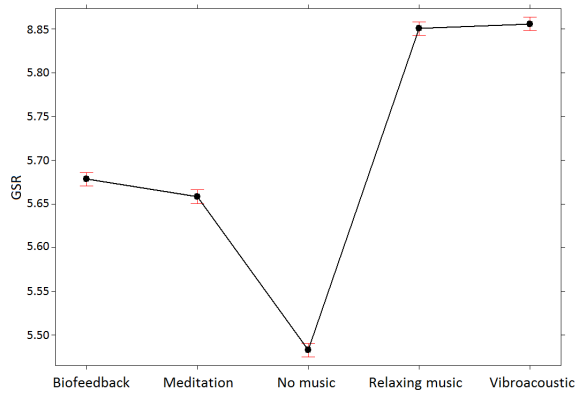

Figure 3.3: Effect plot for the overall GSR level based on the linear model showing Relaxation Method.

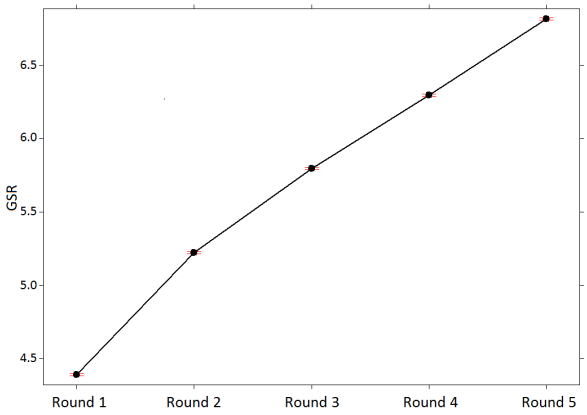

Figure 3.4: Effect plot for the overall GSR level based on the linear model showing Round.

Decline between the Relaxation Methods for GSR

The decline value between the first minute and last minute of the rounds did not show any significant difference between the Relaxation Methods. However it can still be examined if there is a decline for GSR between the mean calculation of the first and last minute for the individual Relaxation Methods. In order to do this a paired t-test is made using the data for the first and last minute. The results from this can be seen in Table 3.2 with significant codes for each. The results show that there is a significant difference between the first and last minute, and that there is a decline from first to last minute.

Biofeedback	Meditation	No music	Relaxing music	Vibroacoustic
**	**	**	***	**

Table 3.2: The significant codes for the paired t-test examining if there is a different between the first and last minutes of the GSR.

HR

The ANOVA showed a significant difference for the factors Relaxation Method and Round for the HR. In order to determine the difference the effect plots in Figure 3.5 for Relaxation Method and in Figure 3.6 for Round are examined. The effect plot for Relaxation Method shows that *Meditation* and *No music* are not significantly different from each other, and have the significantly lowest HR compared to other three Relaxation Methods. The three remaining Relaxation Methods, *Biofeedback*, *Relaxing music*, and *Vibroacoustic* have approximately the same HR, where only *Relaxing music* and *Vibroacoustic* are significantly different from each other.

When examining the effect plot for the factor Round, it can be seen that Round 1 is significantly different from the other rounds with the lowest HR value. The rest of the rounds have around the same HR value, where only Round 2 and Round 3 are significantly different from each other.

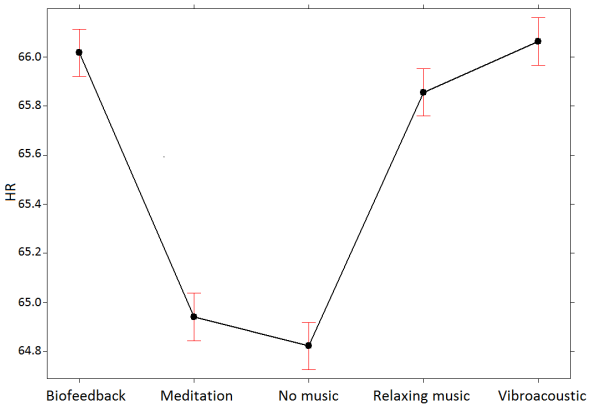

Figure 3.5: Effect plot for the overall HR level based on the linear model showing Relaxation Method.

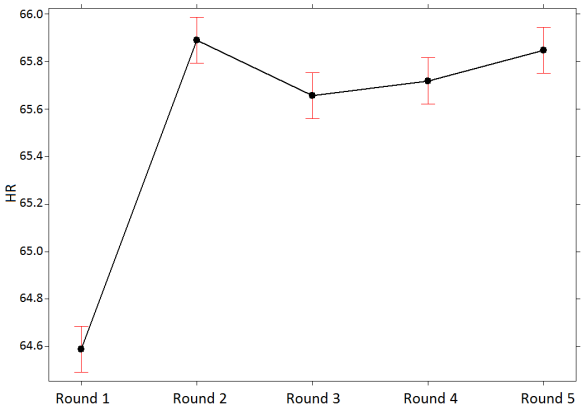

Figure 3.6: Effect plot for the overall HR level based on the linear model showing Round.

Decline between the Relaxation Methods for HR

Similar to the paired t-tests done for decline for GSR, paired t-tests have also been made for HR. Here the results show that there is not a significant difference for either of the Relaxation Methods or the overall data regardless of Relaxation Method. The results from the paired t-tests even show that there sometime was not a decline between the first and last minute, but an increase. These can be seen in Table 3.3 where the direction of the level from first to last minute is shown with arrows.

Overall	Biofeedback	Meditation	No music	Relaxing music	Vibroacoustic
↑	↑	↑	↓	↑	↓

Table 3.3: The paired t-tests did not show any significant difference, and the arrows indicate therefore whether there is an increase (↑) or decline (↓) between the first and last minute for HR.

High Engagement (EEG)

The ANOVA showed that for High Engagement both factors Relaxation Method and Round had a significant difference. From the effect plot in Figure 3.7 it can be seen that only *Meditation* is significantly lower than the rest of the Relaxation Methods. *Relaxing music* has the highest High Engagement, and is significantly higher than all the Relaxation Methods except *No music*. The effect plot for Round in Figure 3.8 shows that all the rounds are significantly different from each other, except between Round 1 and Round 3, and Round 5 has the lowest level.

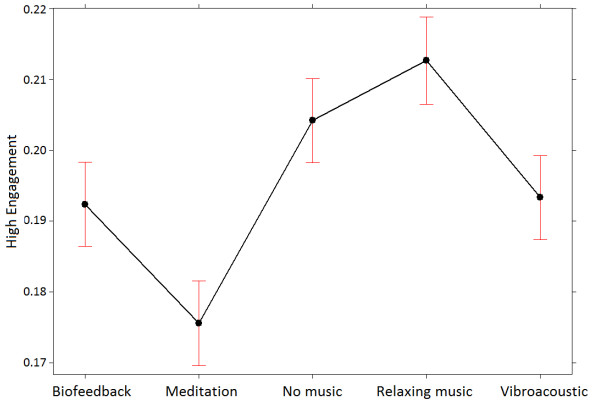

Figure 3.7: Effect plot for High Engagement based on the linear model showing Relaxation Method.

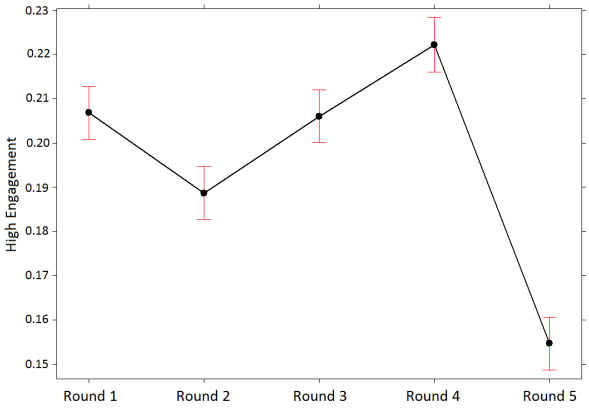

Figure 3.8: Effect plot for High Engagement based on the linear model showing Round.

Low Engagement (EEG)

The ANOVA showed that for Low Engagement both factors Relaxation Method and Round had a significant difference. In the effect plot for Relaxation Methods in Figure 3.9 it can be seen that *Meditation* is significantly lower than the other four, and *Biofeedback* and *No music* are significantly different from each other while the rest are not. From the effect plot for Round in Figure 3.10 it can be seen that Round 3 and Round 4 have a significantly higher value than the rest of the rounds. Round 1 has the significantly lowest value, and Round 2 and Round 5 are not significantly different from each other.

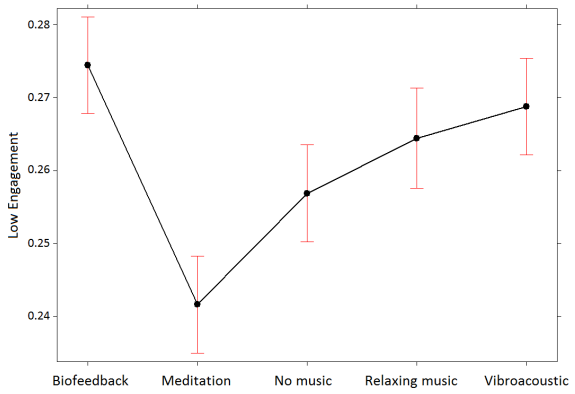

Figure 3.9: Effect plot for Low Engagement based on the linear model showing Relaxation Method.

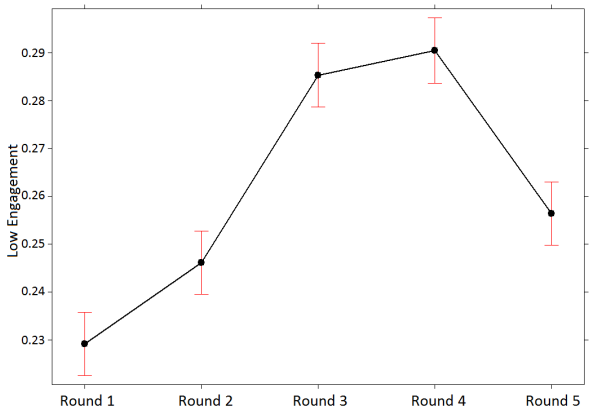

Figure 3.10: Effect plot for Low Engagement based on the linear model showing Round.

Distraction (EEG)

The ANOVA showed that for Distraction both factors Relaxation Method and Round had a significant difference. In the effect plot in Figure 3.11 it can be seen that *Meditation* is significantly higher than the other four Relaxation Methods that are not significantly different from each other. From the effect plot for Round in Figure 3.12 it can be seen that Round 5 has the significantly highest value, where Round 3 and Round 4 have the significantly lowest value compared to the other rounds. Round 1 and Round 2 are not significantly different from each other.

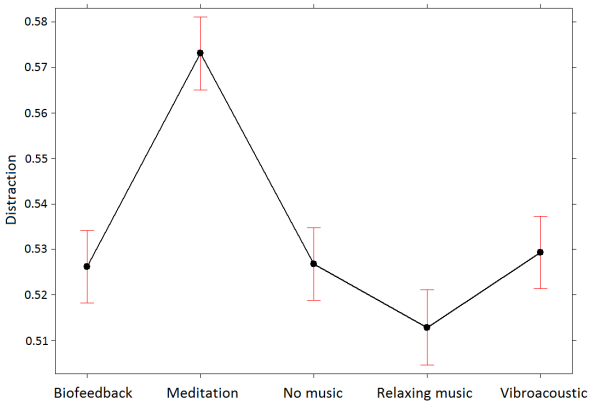

Figure 3.11: Effect plot for Distraction based on the linear model showing Relaxation Method.

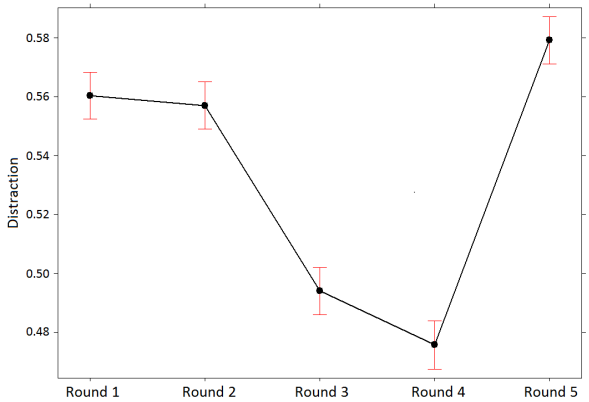

Figure 3.12: Effect plot for Distraction based on the linear model showing Round.

Drowsiness (EEG)

The ANOVA showed that for Drowsiness both factors Relaxation Method and Round had a significant difference. In the effect plot for Relaxation Method in Figure 3.13 it can be seen that *No music* is significantly different from the other four Relaxation Methods that are not signif-

icantly different from each other. From the effect plot for Round in Figure 3.14 it can be seen that Round 1, Round 2, and Round 5 are not significantly different from each other, and Round 3 and Round 4 are not either. However these two groups are significantly different from each other.

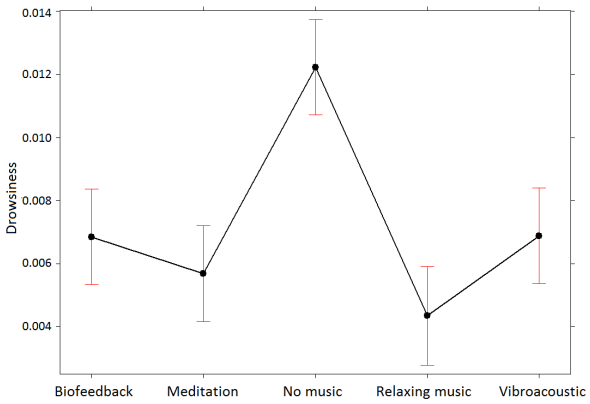

Figure 3.13: Effect plot for Drowsiness based on the linear model showing Relaxation Method.

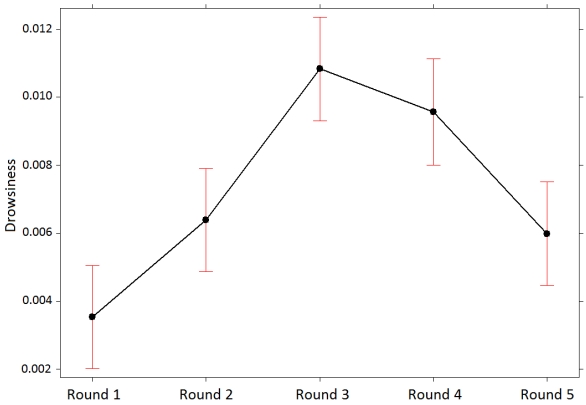

Figure 3.14: Effect plot for Drowsiness based on the linear model showing Round.

Workload (EEG)

The ANOVA showed that for Workload both factors Relaxation Method and Round had a significant difference. In the effect plot for Relaxation Method in Figure 3.15 it can be seen that *Meditation* is significantly lower than the other four Relaxation Methods, and *Relaxing music* is significantly higher. From the effect plot for Round in Figure 3.16 it can be seen that Round 1, Round 3, and Round 5 are not significantly different from each other, where Round 1 is significantly lower and Round 4 is significantly higher.

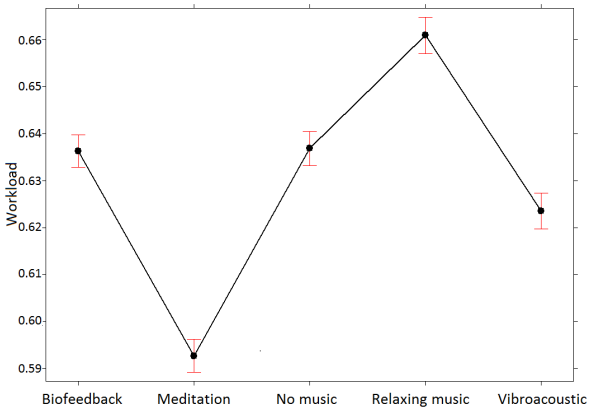

Figure 3.15: Effect plot for Workload based on the linear model showing Relaxation Method.

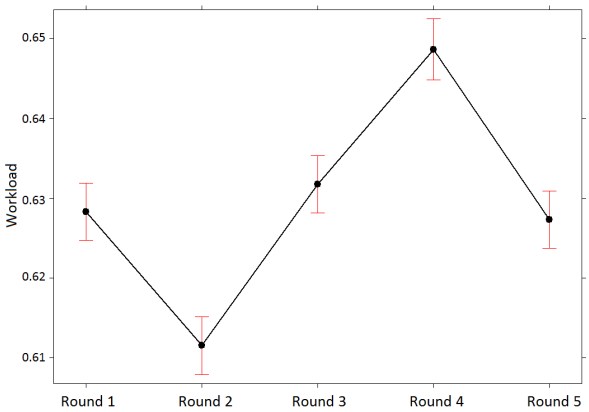

Figure 3.16: Effect plot for Workload based on the linear model showing Round.

Backwards digit-span task

For both BDST-O and BDST-N the ANOVA showed a significant difference for Round. These are further examined through effect plots. Based on the effect plots seen in Figure 3.17 for BDST-O it can be seen that the number of correct answers increases with the rounds, where Round 1 and Round 5 are significantly different from each other. In the effect plot for BDST-N seen in Figure 3.18 it can also be seen that the number of correct answers increases with the rounds, where Round 1 is significantly different from Round 5 and Round 4.

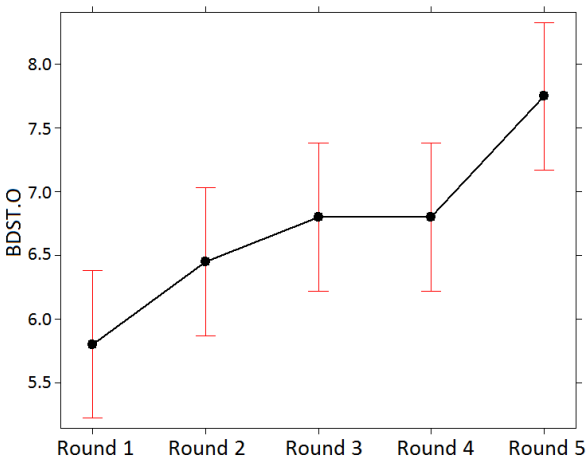

Figure 3.17: Effect plot for BDST-O showing Round based on the linear model with Round and Subject as main effects.

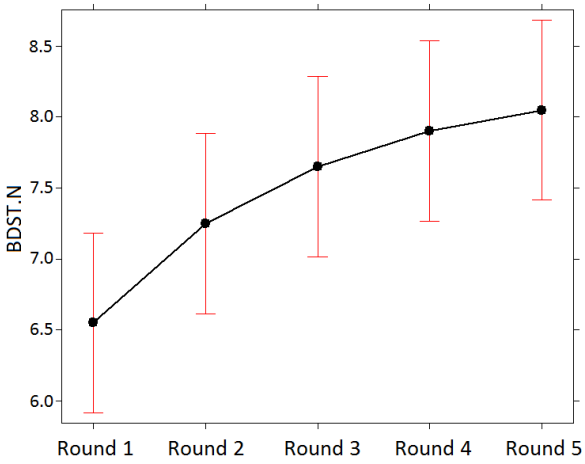

Figure 3.18: Effect plot for BDST-N showing Round based on the linear model with Round and Subject as main effects.

R-states

The ANOVA for the R-states showed that there is a significant difference for Relaxation Methods, where the effect plot for this can be seen in Figure 3.19. The effect plot shows that there is a significant difference between *Meditation* and *No music*, and between *Relaxing music* and *No music*, where *No music* has a lower score than the two others.

The individual R-states questions were also examined using the linear model where the ANOVA showed that six out of the eleven questions have significant difference for Relaxation Method. These are describes below, where the order of the Relaxation Methods are given from highest to lowest score based on the results from the linear model. The description of which of the Relaxation Methods that are significantly different from each other is based on their effect plots, where the linear model only include main effect for Relaxation Method and Subject.

- **Questions 1** is about feeling far away from one's cares and the troubles around oneself. The order of the Relaxation Methods is: *Relaxing music*, *Meditation*, *Biofeedback*, *Vibroacoustic*, and *No music*. Here *Meditation* is significantly different from *No music*, and *Relaxing music* is significantly different from *Biofeedback*, *No music*, and *Vibroacoustic*.

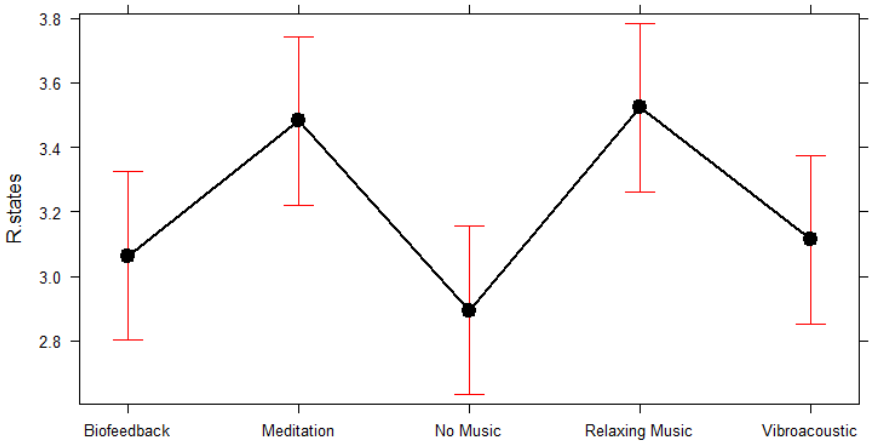

Figure 3.19: Effect plot for R-states showing Relaxation Method based on the linear model with Relaxation Method and Subject as main effects.

- **Question 4** is about feeling at east, at peace and refreshed. The order of the Relaxation Methods is: *Meditation*, *Relaxing music*, *Vibroacoustic*, *Biofeedback*, and *No music*. Here both *Meditation* and *Relaxing music* are significantly different from *No music*.
- **Question 5** is about feeling focused. The order of the Relaxation Methods is: *Meditation*, *Relaxing music*, *Vibroacoustic*, *No music*, and *Biofeedback*. Here *Meditation* is significantly different from both *Biofeedback* and *No music*.
- **Question 8** is about one's mind being quiet, still, with few thoughts. The order of the Relaxation Methods is: *Meditation*, *Relaxing music*, *Biofeedback*, *Vibroacoustic*, and *No music*. Here *Meditation* and *Relaxing music* are significantly different from *Biofeedback*, *No music* and *Vibroacoustic*.
- **Question 9** is about feeling accepting of what one cannot have or change. The order of the Relaxation Methods is: *Relaxing music*, *Meditation*, *Biofeedback*, *No music*, and *Vibroacoustic*. Here *Relaxing music* is significantly different from *Vibroacoustic*.
- **Question 11** is about having deeper feelings. The order of the Relaxation Methods is: *Relaxing music*, *Meditation*, *Biofeedback*, *Vibroacoustic*, and *No music*. Here *Relaxing music* is significantly different from *No music*.

3.4 Exit interview

After completing the experiment the subjects answered some exit interview questions. The main questions were which Relaxation Method they felt was most relaxing and which they liked the best and the least. Fifteen of the subjects thought the most relaxing Relaxation Method was also the one they liked the best. It was therefore chosen to only examine the subjects answers regarding the Relaxation Method they found the most relaxing. The distribution of their answers can be seen in Figure 3.20 showing two pie charts, one showing for the most relaxing and

one for the least liked Relaxation Methods. The figures show that the subjects found *Meditation* and *Relaxing music* to be the most relaxing, and *Vibroacoustic* and *No music* are the least liked. During the exit interview the subjects also commented on the different Relaxation Methods, and gave their thoughts about the experiment, the Relaxation Methods, and the backwards digit-span task. Additionally they were asked what they thought about The Interactive Chair (Appendix K).

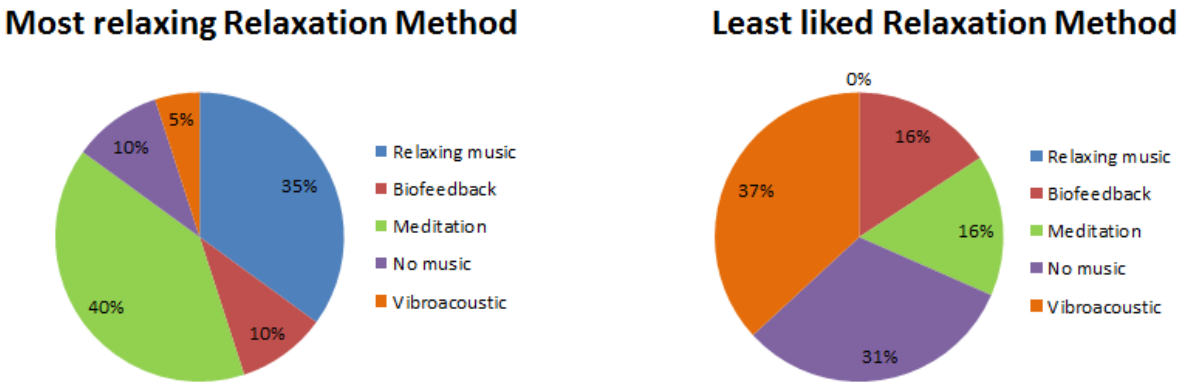

Figure 3.20: The different Relaxation Methods the subjects felt most relaxed to and the one they liked the least.

3.5 Additional factors

The main focus of this project is to investigate a difference between the Relaxation Methods. However since the factor Subject was significant for all the dependent variables, it was attempted to examine these further. This was done by performing an ANOVA on a new linear model. This linear model includes all the factors that were collected regarding the subjects. The factors are: Age (Under 30 or Over 30), Gender (Female or Male), Caffeine (Yes or No), Medicine (Yes or No), Feel stressed (Yes, Sometimes or No), Meditation experience (Experienced, A little or None), and the experiment Time of day (Morning, Midday or Afternoon). A description of these factors can be seen in Appendix L.13 and are based on the subjects' answers to the initial questionnaire (Appendix J).

Linear model: [GSR|HR|EEG|VAS|R-states|BDST] ~ Relaxation Method + Round + Meditation experience + Age + Gender + Caffeine + Medicine + Feel stressed + Time of day

An overview of all the results from the ANOVA can be found in Appendix L.14. It was difficult to determine anything generally regarding the factors. However it was included as an attempt to use the collected information and examine if they could influence the dependent variables.

3.6 Comparison between Relaxation Methods and backwards digit-span task

Since the assumption behind the Relaxation Methods is for the subjects to relax, it is investigated at what level the dependent variables would be for a demanding task. Therefore the measurements for when the subjects were relaxing are compared to the measurements when they performed the backwards digit-span task. Two rounds from two different subjects were randomly chosen and their measurements compared to themselves by performing an independent samples t-test. This was Subject 10 with *Vibroacoustic* and Subject 15 with *Relaxing music*. The tests were performed for GSR, HR, High Engagement, Low Engagement, Distraction, Drowsiness, and Workload for both subjects. The results from the tests can be seen in Table 3.4 where the p-values are indicated by significant codes, and the last columns describe whether the Relaxation Method or the backwards digit-span task had the highest level, and what the difference in mean between them are. There was a significant difference between the Relaxation

Dependent variable	Subject	p-value	Highest mean	Mean difference
HR	Subject 10	***	Backwards digit-span task	4.34
	Subject 15	***	Backwards digit-span task	4.77
GSR	Subject 10	***	Backwards digit-span task	2.32
	Subject 15	***	Backwards digit-span task	0.36
High Engagement	Subject 10	***	Backwards digit-span task	0.34
	Subject 15	***	Backwards digit-span task	0.31
Low Engagement	Subject 10	***	Backwards digit-span task	0.09
	Subject 15	***	Backwards digit-span task	0.24
Distraction	Subject 10	***	Relaxation Method	0.43
	Subject 15	***	Relaxation Method	0.56
Drowsiness	Subject 10	NA	NA	0.00
	Subject 15		Backwards digit-span task	0.01
Workload	Subject 10	***	Backwards digit-span task	0.19
	Subject 15	***	Backwards digit-span task	0.14

Table 3.4: The results from the independent samples t-test with significant codes for the p-value, whether it was the Relaxation Method or the backwards digit-span task that had the highest level, and how big the difference in mean is between the two. The values for the EEG metrics have a level between 0 and 1. The reason for NA for Drowsiness for Subject 10 was that the measurements were always 0.

Method and the backwards digit-span task for all the dependent except Drowsiness. When examining the means to determine if the Relaxation Method or the backwards digit-span task had the highest level, it could be seen that backwards digit-span task had the highest for all, except Distraction. This means that the backwards digit-span task had a higher level for GSR, HR, High Engagement, Low Engagement, and Workload than when the subjects were relaxing. However the subjects had a higher Distraction when relaxing than for the backwards digit-span task.

CHAPTER 4

DISCUSSION

The discussion consists of three parts. The first is a discussion about the dependent measurements, GSR, HR, and EEG and what the results show about relaxation along with a discussion about the backwards digit-span task. The second part discus the VAS and R-states questions, and the different Relaxation Methods used in the experiment. In the end the experiment setup and The Interactive Chair are discussed.

4.1 Objective measurements

GSR

GSR is connected to the arousal aspect of emotion (Calvo et al., 2015, p.210-212). However for this project the overall GSR is used to indicate relaxation, where a lower GSR level would indicate that the subjects were more relaxed. This has also been done in other studies that investigated meditation techniques by measuring GSR to indicate which was more relaxing (Boswell and Murray, 1979), (Wenk-Sormaz, 2005), (Telles et al., 2013).

Following the assumption that the lower the GSR is the more relaxing the Relaxation Method is, then *No music* is the most relaxing according to the GSR results, where *Relaxing music* and *Vibroacoustic* are the least relaxing. One reason for *No music* have the lowest could be that the subjects were not influenced by any auditory stimuli that could arouse them, and thereby raise their GSR level.

If elements in the music change too much and are unpredictable, the listener will be more disposed to feel stimulated and the arousal will increase (Bonde, 2011, pp. 69). This can both explain the low level for *No music* because of its lack of music and thereby do not have any unpredictable changes, and explain why *Vibroacoustic* has one of the two highest GSR, since it does not follow a rhythm and the subjects had not heard the music before.

Interestingly there is a difference between *Biofeedback* and *Vibroacoustic* since the subjects thought those closely resembled each other. This could indicate that *Biofeedback* with a lower GSR does not stimulate the body as much and are more predictable in e.g. rhythm than *Vibroacoustic*, which makes sense since *Biofeedback* is designed to follows the rhythm of the subjects' breathing.

Relaxing music has the other highest GSR which cannot be explained by Bonde (2011) since it says that if the elements in the music are stabilize and predictable, the listener will be more disposed to be more relaxed (Bonde, 2011, pp. 69). Subjects are familiar with the song being played and think it sounds good because it contains instruments and rhythms that they feel are relaxing, and because it gives them a good feeling or produce good memories. The high GSR level for *Relaxation music* could also be because the subjects get a positive arousing feeling during the round, which thereby increases the GSR level. Here The Interactive Chair could have an additional effect because they are hearing their song in a new way.

Another explanation for the high GSR level for both *Vibroacoustic* and *Relaxing music* could be because the vibrations in the music affected the subjects' body (Wigram and Dileo, 1997). The vibration test showed that *Vibroacoustic* gave the strongest vibrations when sitting in The Interactive Chair compared to *Biofeedback*, *Meditaion*, and *No music*. *Relaxing music* could also have a high vibration level, since the test song used for the vibration test had a higher level than *Vibroacoustic* (Appendix H.3). The fact that there is not a difference between *Relaxing music* and *Vibroacoustic* for the GSR is interesting as well, since these are the Relaxation Methods the subjects expressed that they liked the most and the least, respectively. Additionally this could give a negatively emotionally arousal for *Vibroacoustic* that would increase the GSR level, where the positive feelings about *Relaxing music* also could arouse the subjects.

The decline between the first and last minute were examined, where the GSR level was lower at the end of the round for all the Relaxation Methods. This means that the assumption that the subjects' GSR level would decline through the time they were to relax in The Interactive Chair, was correct. Even though there was a decline for all the Relaxation Methods, the decline was not different between them. This could mean that the subjects got relaxed during all of the Relaxation Methods. However just the fact that they were sitting down not doing anything for some time could also affect the GSR to decline.

HR

The results for HR showed that *Meditation* and *No music* had the lowest level compared to the other three Relaxation Methods. It was expected that the HR for *Meditation* could be low, since a study that tested a guided meditation in an office found a decrease for HR that lasted additionally 15 minutes compared to a control group (Melville et al., 2012). Therefore a lower HR would indicate that the Relaxation Method is more relaxing than the others. Interestingly the R-states score shows that the subjects felt *Meditation* was more relaxing than *No music*.

For HR the Relaxation Methods can be divided into two groups, one containing *Meditation* and *No music* with a low HR which have in common, that no form of music is played, and one group with *Biofeedback*, *Relaxing music*, and *Vibroacoustic* with a higher HR which have

in common that music is being played. This can be explained by the term *entrainment*. If for instance some kind of beat or rhythm is felt or perceived it could have an effect the body (Bonde, 2011, pp. 66) and thereby influence the heart rate.

When investigating the difference between the Relaxation Method for HR, it can be seen that the significant difference represents a difference on 1 BPM. Normally when a person is in a resting state, the heart rate for men is between 60-80 BPM and for women 70-90 BPM (Hjerteforeningen, Website). So even if the results show that 1 BPM is a significant difference, it is possible that 1 BPM change for a person is not a physical difference that would result in feeling more relaxed. When comparing the HR when relaxing and when performing the backwards digit-span task, the HR was significantly lower for the Relaxation Method, with a mean different on more than 4 BPM. This indicate that the Relaxation Methods were more relaxing than performing the memory task.

The significantly lowest HR was measured for Round 1 compared to the other rounds. This is a bit surprising since it could be expected that the subjects' HR were higher in the first round since they could be nervous about entering the room for the first time and having expectations about the experiment.

High Engagement and Low Engagement

For both High Engagement and Low Engagement *Meditation* is significantly lower than all the other Relaxation Methods. It was not expected to see a significant difference between the Relaxation Methods, since the task in the experiment was to relax and should not require any engagement or attention. When comparing a Relaxation Method's High Engagement and Low Engagement to the level when performing the backwards digit-span task, it can be seen that the subjects had a much higher level in order to focus on the memory task than when relaxing. This could demonstrate that High Engagement and Low Engagement are best used when there is a definitive task that can be focused on. It seems contradictory for the subjects to be highly engaged and focus their attention on relaxing, which is something they should not have to do in order to relax.

Distraction

Distraction is the opposite of being engaged, and the results show that *Meditation* has a significant higher level than the other Relaxation Methods. This could indicate that the subjects had difficulty keeping attention on their breathing, and their thoughts were wandering. Distraction is also connected with boredom, and it is then surprising that *No music* does not have a high level, since most of the subjects mentioned that they thought this round was boring. The results from the random samples check showed that the level of *Distraction* was higher for the Relaxation Methods than for performing the backwards digit-span task. This could indicate that when the subjects do not have anything to focus on their *Distraction* level rises. However

this still does not explain the high level for *Meditation*, since the purpose was for the subjects to focus on their breathing. In order to further understand the connection between Distraction, High Engagement, Low Engagement, and meditating, it could be interesting to measure a person learning to meditate over a period of time. This could examine how the Distraction level changes when the person gets better at keeping thoughts from wandering.

Drowsiness

For all but six of the subjects, the measurements for Drowsiness had a level of 0 throughout the Relaxation Methods. So when examining the results, that show a significantly higher level for *No music*, it is only based on a limited dataset. Therefore it is difficult to determine anything about the different Relaxation Methods based on Drowsiness. However a higher Drowsiness for *No music* is in accordance with what the subjects said about it being a boring round to complete.

Workload

High mental workload have a high demand on the limited capacity of the brain (Wickens et al., 2013). This means that when there is a high workload, it is not possible for the brain to unwind and relax. *Meditation* has the lowest Workload and *Relaxing music* has the highest Workload, both are significantly different from the other Relaxation Methods. For some subjects it could be considered a demanding task to be instructed to relax, and would have difficulty doing it on command.

The Workload level for *Meditation* was lowest and could indicate that it was not a demanding task for the subjects to perform, since they were only focusing on their breathing. This low Workload would thereby indicate that *Meditation* get the subjects to unwind and relax. This is supported by the HR measurements where *Meditation* is one of the two Relaxation Methods with the lowest HR.

A reason for the higher Workload level for *Relaxing music* could be that the subjects produce memories and feelings related to the song. When examining the results for Workload compared to High Engagement and Low Engagement, the same pattern regarding the Relaxation Methods occurred. This makes sense since, in order to perform a demanding task well, it also requires more focus and attention to the task (Advanced Brain Monitoring, Internal Material).

Interestingly *Meditation* and *Relaxing music* are completely opposite for Workload since the subjects thought that either *Meditation* or *Relaxing music* were the most relaxing when answering the exit interview and indicated by the R-states score compared to *No music*. Here one indicates relaxation as an objective measure where the other is about the subjects' preferences. This could indicate that even though Workload can be related to relaxation, it is not a factor that the subject would be consciously aware of when evaluating how relaxed they are. Of course there could also be a disconnection between what people feel and how their body actually reacts. That is also the reason for including both measurements since there could be a difference in

what people feel are relaxing and what their body indicates.

Even though the Workload is higher for some of the Relaxation Methods, is it still lower than the Workload during the backwards digit-span task. This means that relaxing is not as demanding as performing a memory task.

Backwards digit-span task

The reason for including a test that measures the subjects' memory capacity is to determine if the different Relaxation Methods could affect this. A study used the backwards digit-span task to find a change in their participants directed attention (Berman et al., 2008). Therefore it was decided to include this task in the experiment, where the results did not show a difference between the Relaxation Methods. However the results showed that the subjects got better at performing the backwards digit-span task from Round 1 to Round 5. Even though there was not a significant different for Relaxation Methods, the task was a part of the non-relaxing break between the Relaxation Methods.

4.2 Subjective measurements and the Relaxation Methods

VAS

It was decided to include two extra questions regarding relaxation which were answered on a VAS.

VASQ1 was about how overall relaxed the subjects were in the moment. It was chosen to ask this to make sure that if they had difficulties understanding the English R-states questions, there was one overall question in Danish they could answer. The R-states questions describe different aspects of relaxation, to get an overall score, where the VASQ1 only asked about their overall relaxation state. For this the subjects did not get a definition of what being relaxed means or what experiences or feelings they should focus on when answering. By doing this the subjects had to make up their own minds of what feeling relaxed is for them. The reason was not to influence the subjects' answers in any way. This could however give the subjects some difficulties knowing how to answer to the question. Since the R-states showed a difference between the Relaxation Methods and the VASQ1 did not, it could mean that the subjects could better evaluate their relaxation when using different words to describe it, than for an overall question.

VASQ2 was about how long time the subjects thought they were sitting in The Interactive Chair, using anchor points indicating 0 minutes and 15 minutes. These were chosen to help the subjects when evaluating the time since a VAS without anchor points would be difficult to understand. The same could apply if the subjects were asked to just note the precise time instead of answering on a VAS, since it could be difficult to give a concrete answer. However the subject could still have had difficulties answering a question regarding time based on a VAS. The question was asked to examine if some of the Relaxation Methods would give the subjects

a feeling of losing track of time. If this was to happen the subjects would probably answer that it took a shorter time than was actually the case. This could indicate a form of *flow state* where the subjects feel like it was enjoyable (Csikszentmihalyi, 2014). The subjects also answered in the exit interview that they thought *No music* was boring, which could have been seen in the answers as feeling like they were sitting in The Interactive Chair for a longer time (Stern, 1987). However the results did not indicate any if this, since there was not a significant difference for VASQ2 regarding the Relaxation Methods.

Relaxing music

In the exit interview the subjects were asked what they thought about the different Relaxation Methods. Here it was clear that the subjects liked their own choice of music. This was expected since they are familiar with the song, and the music played for the other Relaxation Methods are unknown to them. Even then the subjects also indicated that they thought *Meditation* was among the most relaxing Relaxation Methods.

To make a more equal comparison between the Relaxation Methods the subjects should also have been familiar with the other Relaxation Methods beforehand. However it would still be difficult to have them be as familiar with those as for their own music. Another way was for the subjects to not be familiar with the song played for *Relaxing music*. However it could be difficult to find a song categorized as being relaxing that neither of the subjects knew beforehand. Additionally finding a song that all the subjects would think is relaxing is also difficult since people's preferences influence what they categorizes as relaxing (Bonde, 2011, pp. 68).

Vibroacoustic

The subjects generally did not like *Vibroacoustic*, along with *No music*. The comments about *Vibroacoustic* were that a lot of things were happening in the music and the vibrations in The Interactive Chair were intense. The *Vibroacoustic* music was not designed for The Interactive Chair, and it was expected that it would not have the same effect that vibroacoustic therapy has in a special designed chair. Additionally the subjects did not know the purpose of the vibroacoustic therapy music, and this could have an affect on how they felt about it since they were only instructed to try and relax. However because of the built-in loudspeakers in the Interactive Chair it was included to examine a possible effect.

No music

The comments about *No music* was generally that the subjects had trouble concentrating on getting relaxed during the round. They said that it was boring because nothing happened. *No*

music was chosen as a control condition to see how The Interactive Chair itself could affect the subjects without giving them any sound or vibration. Additionally it could be relaxing to not experience any extra stimuli as opposed to people's everyday life where things are happening all the time. Therefore it could be relaxing to just be able to sit down in silence. This is supported by the results showing low GSR and HR levels for *No music*. However it seemed like only two subjects thought it was relaxing to perform this Relaxation Method. This could also reflect that people are not used to just being with themselves without doing anything else or listening to anything.

Biofeedback

The subjects had difficulties distinguishing between *Biofeedback* and *Vibroacoustic*, since they both consisted of instrumental music. Some felt they sounded similar which could mean that they did not notice that the sound scape for *Biofeedback* was adapting to their breathing. This could indicate that for the sound scape to have an effect, people need to be aware of its purpose. This could be the case since *Biofeedback* and *Vibroacoustic* do not have a significantly different HR level, and the subjects could therefore have been affected the same with the similar sounding music. However the subjects were not directly asked about the biofeedback in The Interactive Chair.

The *Biofeedback* that was used had not been tested before, and it has therefore not been investigated if the *Biofeedback* used in this experiment could even have an effect. None of the subjects mentioned in the exit interview that they discovered the biofeedback's purpose, so perhaps the feedback regarding the breathing rhythm is too discreet to be noticed among the other elements in the sound scape to have an effect.

Meditation

Some of the subjects mentioned that they had trouble concentrating during *Meditation*, where others thought it was good to be guided through the *Meditation*. There were eight subjects that found *Meditation* the most relaxing, and three subjects that least liked *Meditation*.

There are different kinds of guided meditations, where some only focus on the breathing and some where people have to focus on their entire body (called *body scan*, see Appendix B.3). It was chosen to find a simple guide where the subjects only have to focus on one thing, their breathing, and thereby only learn to do one thing, for the subjects that had not tried meditating before. The support for choosing a simple meditation technique can be seen when examining the Workload, where *Meditation* has the lowest level compared to the other Relaxation Methods.

4.3 The experiment

The experiment lasted two and a half hours for each subject. It was a long experiment, where five different Relaxation Methods were testes. From the experiment a lot of data was collected, where only the VAS questions did not show a significant difference for either Relaxation Methods or Round. This indicates that the measurements chosen to use in this experiment could measure different effects depending on the Relaxation Methods. The experiment is therefore considered a success in regards to examining the problem statement.

It can though be discussed if other experiment setups could give similar results. It was chosen to have a within subject design, where all the subjects experienced the different Relaxation Methods. If a between subject experiment was conducted the subjects should only experience one of the Relaxation Methods and it will hereby make the experiment shorter, which could be more pleasurable from the subjects' perspective. However this would mean, from a statistical perceptive, that more subjects need to conduct the experiment to get enough data for each Relaxation Method.

Since there are different elements that make it difficult to evaluate much about relaxation depending on the EEG measurements for High Engagement, Low Engagement, Distraction, and Drowsiness, these would maybe not be necessary to measure. By excluding the EEG it would shorten the experiment by twenty minutes. However by not including the EEG at all, Workload would not be measured, and it could then be discussed if Workload add considerable data regarding relaxation or if it also could be excluded.

Instead of excluding the measurements the Relaxation Methods could also have been shorted. Here *Vibroacoustic* could be removed since the music was meant to be played in a special designed vibroacoustic chair instead of The Interactive Chair. Since the backwards digit-span task did not show any significant difference between the Relaxation Methods this could have been removed from the experiment as well. However since it is a mental demanding task it could have attributed to the non-relaxing break between the Relaxation Methods.

The R-states score showed a significant difference, where it could be considered using a longer version of the R-states (e.g. SRSI3). Thereby more subjective measurements can be collected, by using the SRSI3 that answers can be separated in scores indicating *basic relaxation*, *mindfulness*, *positive energy*, and *transcendence* (Smith, 2007). It could perhaps give more information about how the subjects feel about the different Relaxation Methods. This would also be better than including the VAS question which did not show any significant different between the Relaxation Methods.

It was chosen to perform all the Relaxation Methods in The Interactive Chair in order to compare *Biofeedback* to the other Relaxation Methods without to many uncontrolled variables. However it was only necessary for *Biofeedback* to be performed in The Interactive Chair. An experiment design idea that was considered for this project was to compare the Relaxation Methods based on scenarios. Here *Meditation* could have been performed while the subjects were lying down or sitting on the floor. This way other Relaxation Methods could have included reading a book, watching TV, and performing yoga. When performing yoga the measurements for GSR, HR and EEG should be measured after, since the equipment is sensitive to movements.

The Interactive Chair

The design of The Interactive Chair could also have an effect on how the subjects perceived the different Relaxation Methods. Subject 14 said that she got an unexpected feeling when listening to *Relaxing music*, because it felt like the singer was whispering in her ear and could feel the bass hit her in the back. When she is listening to the song at home, she feels that the song is relaxing, but did not think that when listening to it during the experiment. Similar, could other subjects have felt that they had a new experience with their song choice because it was played through The Interactive Chair's loudspeakers.

Some of the subjects did not feel like they could sit comfortable in The Interactive Chair, and this could have affected how relaxed they got. However since all the Relaxation Methods took place in The Interactive Chair they should have been affected the same throughout the experiment. Additionally the subjects were instructed to sit with their back up against the backrest, in order to make sure the *Biofeedback* would activate during that round. In order for the rounds to be equal they were instructed to sit in the same position each time. For some subject this would not be the way, they normally would have chosen to sit when relaxing.

The equipment for measuring the GSR and HR was placed on the subjects' non-dominating hand, and the subjects were instructed to keep the hand as still as possible when sitting in The Interactive Chair during the different Relaxation Methods. Subject 8 mentioned that she could not sit as she usually does with her hands between her legs because of the equipment. This again could attribute to the subjects not sitting in a natural relaxing position. No one mentioned that the EEG was annoying to be wearing.

CHAPTER 5

CONCLUSION

There are different ways to relax, where some include sitting in the sofa watching TV or listening to music, while others require more activity such as performing yoga or meditation. Five Relaxation Methods were chosen and their relaxing effect over a short period of time was investigated. As part of the collaboration with Bang & Olufsen their chair with built-in loudspeakers and a biofeedback system was used as one of the Relaxation Methods.

The purpose of this project was not to find the perfect Relaxation Methods, but to investigate how different ways of relaxing could give different physical and psychological effects. This was done to compare the subjective measurements with the objective and determine which can give an indication about relaxation.

The R-states questions were used to get the subjective evaluation of which Relaxation Method the subjects felt was the most relaxing. The results from the R-states questions reflected what the subjects themselves also expressed about the Relaxation Methods during the exit interview. Therefore the R-states score is accepted to give an estimation of the subjective measurements related to relaxation.

The VAS questions however did not show that they felt more overall relaxed or felt it took a longer time for one of the Relaxation Methods than the others. A backward digit-span task was included to investigate if the memory capacity could be affected, which it turned out not to. However the results did show that the subjects got better throughout the experiment at performing the task.

For the objective measurements it was assumed that the lower the level for GSR and HR are the more relaxed the subjects have been when comparing the Relaxation Methods. Through a random sample check, that compared the GSR and HR between a Relaxation Method and performing the backwards digit-span task, it could be seen that the subjects were more relaxed in the Relaxation Methods. This indicates that all the Relaxation Methods got the subjects to relax, however some had a greater effect than others.

The EEG measurements that could be used for comparing the Relaxation Methods are Dis-

traction and Workload. High Engagement and Low Engagement have the same problem about the contradictory of being engaged in relaxing, while Drowsiness cannot be used because of the lack of measurements above zero.

There seems to be some inconsistencies between the results from the R-states, GSR, HR and Workload regarding which Relaxation Method they indicate is the most relaxing. *Meditation* and *Relaxing music* are the most relaxing according to R-states, where these two Relaxation Methods have opposite levels for GSR, HR, and Workload.

Regarding the measurements is it possible to see a decline for GSR that indicates relaxation for when subjects are sitting still. Even though other studies used the overall GSR to indicate relaxation between different conditions, the results from this project showed that the overall GSR could be influenced by the subjects' preferences. This could be seen since the two Relaxation Methods that the subjects liked the most and the least both had the highest GSR level. HR can also be used to indicate relaxation where the results do not entirely consistent with the subjects' preferences. This indicates that what the body finds relaxing does not have to be the same the subjects find relaxing. If the purpose is for the mind to relax and not just body, the EEG measure for Workload could be used.

Further work

An idea for further work could be to examining a long-term effect for the Relaxation Methods. This could be done by choosing one of the Relaxation Methods and incorporating it into people's everyday life. This way a long-term effect could be found that include the effect of people's stressing lives. Incorporating *Meditation*, *Relaxing music* and *No music* are easier since they do not require special equipment, where e.g people need to have a system similar to The Interactive Chair in their homes in order to test *Biofeedback*.

APPENDIX A

THE INTERACTIVE CHAIR

The Interactive Chair is produced in cooperation with Bang & Olufsen. The following information is given by Ditte Hvas Mortensen, an employee at Bang & Olufsen as User Experience Specialist, and the contact person for this project.

Bang & Olufsen has, in collaboration with an experience designer/programmer and a musician, worked with The Interactive Chair so it can give a immersive experience. To do this there have been installed sensors so people can experience an interactive sound. The Interactive Chair registers the users breathing and adapts the sound scape to that. The experience Bang & Olufsen will like to give the users of The Interactive Chair are (Bang & Olufsen, Internal material):

- "Artistic and beautiful. Engaging with the experience should be like experiencing art or music."
- "High degree of bodily awareness."
- "High degree of sensory immersion."
- "Inherently pleasurable to engage in. Either because the person is in flow or because of the sensory aspects of the experience."
- "Require the person to be concentrated and fully focused on what they are doing. This allows people to shut out the outside world and stop multi-tasking."

Ideally Bang & Olufsen hopes that The Interactive Chair creates a meditation-like experience that leaves the user feeling relaxed, mindful and energized. The creation of The Interactive Chair was based on a hypothesis that it will create increased body awareness and relaxation (Bang & Olufsen, Internal material).

Biofeedback description

The Interactive Chair it self has a programmed biofeedback system. The two loudspeakers are B&O BeoPlay A2 (Bang & Olufsen, Internal material). The description of how it works are giving from Bang & Olufsen:

"The system comprises of the experiment chair, breathing sensor, and a PC running Ableton Live music software with custom software plugin and music composed by Henrik Sundh. When the user sits in the chair the interactive composition begins, as the user breathes they hear a deep harmonic sound which fades in as they breath in and fades out as they breath out" (Bang & Olufsen, Internal material).

"As they breath in the chair their breathing begins to generate new melodies and control the sound of the entire composition in addition to the breathing sound. After approximately three minutes the composition begins to slowly get less dense and after five minutes the composition returns to the original breathing sound before fading out" (Bang & Olufsen, Internal material).

"The chair has a pressure sensor matrix installed in the back of the chair, which provides the ability to sense the breathing motion of user sitting in the chair. There are sixteen discrete vertical sensor channels, covering a 30cm x 30cm area where the user's upper back would lean. Algorithms running on a microcontroller connected to the sensor detect breathing in and breathing out movements of the ribcage by measuring the shift of pressure from centre of the sensing area to the outside edges. The microcontroller sends these data to the PC via wireless RF link, and a custom plugin running inside Ableton Live generates signal smoothing increasing when the breathing in message is received and decreasing when the breathing out message has been received. This signal is mapped to a multitude of locations inside the music software, and it's effect depends on how long the user has been sitting in the chair, and which composition theme is playing" (Bang & Olufsen, Internal material).

Other specifications regarding The Interactive Chair

During the experiment the subjects need to be relaxed and therefore sit in a comfortable position. Due to the fact that the respiration sensors are placed on the backrest the subjects need some kind of introduction regarding how to sit to make sure the sensors can measure the respiration.

The body dimensions of the subject could have an effect, since designed shape of The Interactive Chair has fixed dimensions. If the subjects have short legs this can give them an uncomfortable sitting position. Depending on the height of the subjects the loudspeakers will be located differently from their heads. However the biggest concern cold be that tall people do not have any support from the backrest to their neck and head. Therefore a U-shaped pillow was offered to all subjects if they felt that they could relax better using it.

APPENDIX B

STUDIES ABOUT RELAXATION

B.1 When do Danes relax

Epinion And Pluss Leadership have made an investigation for Kulturministeriet of the Danes' culture habits in 2012. The data that will be used in this section are from 3,628 adults over 15 years old (Bak et al., 2012).

In the questionnaire the Danes are asked about their habits in their everyday life, including how much time they spend on e.g. music, TV, radio, or reading a book, and why they are doing it. For the questions there are different multiple choice answers regarding different reasons for why they are using music, TV, radio or reading a book. One of the choices are: "When I want to relax but do not have anything specific I want to listen to"[1] (if the question is related to music). Generally it can be seen from the figures that the Danes are saying that they are relaxing when they are listening to music (52%), watching TV (75%), listening to radio (38%), and reading[2] a book (26%) (Bak et al., 2012). An explanation for why reading a book for relaxation has the lowest percentage could be because it involves a more active activity than the others.

Music

Almost all Danes are listening to music, 79% of them are listening to music daily, 24% are listening at least three hours a day (Bak et al., 2012, pp. 30). From Figure B.1 it can be seen that 52% of the Danes are listening to music to relax when they do not have anything specific they want to hear.

[1] "Når jeg vil slappe af, men ikke har noget bestemt, jeg vil høre." (Bak et al., 2012)

[2] Reading a book also include listening to an audio book.

TV

91% of the Danes are watching TV daily, and 37% watch more than three hours a day (Bak et al., 2012, pp. 139). From Figure B.2 it can be seen that 75% of the Danes are watching TV to relax when they do not have any specific they want to see.

Tabel 1.3: I hvilke situationer hører du normalt musik? (Multipel) (2012, procent af dem, der hører musik)

Mens jeg ordner praktiske ting i hjemmet	71
Under transport	70
Når jeg vil slappe af, men ikke har noget bestemt, jeg vil høre	52
Når jeg er til/holder fest	40
Mens jeg arbejder	40
Jeg "sætter mig ned" for at høre noget bestemt musik	26
Mens jeg spiser	32
Mens jeg træner/dyrker motion	27
Mens jeg bruger andre medier (fx computer, smartphone eller lignende)	27
Når jeg har besøg/gæster	32
Andet	6

Figure B.1: In what situations do the Danes normally listen to music (Bak et al., 2012, pp. 33) (a modified version).

I hvilke situationer ser du normalt TV? (Multipel) Udvalgte situationer (2012, procent af dem, der ser TV)

Jeg 'sætter mig ned' for at se et bestemt program	81
Når jeg vil slappe af, men ikke har noget bestemt, jeg vil se	75
Mens jeg spiser	37
Mens jeg bruger andre medier (fx computer, smartphone eller lignende)	20
Mens jeg ordner praktiske ting i hjemmet	16
Mens jeg læser avis eller bøger	8
Når jeg har besøg/ gæster	7

Figure B.2: In what situations do the Danes normally watch TV (Bak et al., 2012, pp. 149) (a modified version).

Radio

74% of the Danes are listening to radio daily, and 25% are listening radio at least three hours a day (Bak et al., 2012, pp. 154). From Figure B.3 it can be seen that 38% of the Danes are listening to radio to relax when they do not have anything specific they want to hear. Keep in mind that there is an overlap between listening to music and radio.

Books

23% of the Danes are reading fiction daily, and 10% are reading non-fiction daily (Bak et al., 2012, pp. 93). From Figure B.4 it can be seen that 26% of the Danes are reading a book to relax when they do not have any specific they want to read.

Tabel 11.3: I hvilke situationer hører du normalt radio? (Multipel) (2012, procent af dem, der hører radio)

Jeg 'sætter mig ned' for at høre et bestemt program	17
Når jeg vil slappe af, men ikke har noget bestemt, jeg vil høre	38
Under transport	70
Mens jeg ordner praktiske ting i hjemmet	69
Mens jeg spiser	35
Mens jeg bruger andre medier (fx computer, smartphone eller lignende)	20
Mens jeg læser avis eller bøger	16
Mens jeg arbejder	36
Mens jeg træner/dyrker motion	14
Når jeg har besøg/gæster	14
Når jeg er til/holder fest	11

Figure B.3: In what situations do the Danes normally listen to radio (Bak et al., 2012, pp. 156) (a modified version).

Tabel 6.4: I hvilke situationer læser du bøger? (Multipel) Udvalgte situationer (2012, procent af dem, der læser/hører bøger)

Jeg 'sætter mig ned' for at læse i en bestemt bog	76
Når jeg holder ferie	66
Når jeg søger viden og information	60
Godnatlæsning før jeg skal sove	58
Under transport	30
Når jeg vil slappe af, men ikke har noget bestemt, jeg vil læse	26

Figure B.4: In what situations do the Danes normally reading a book (Bak et al., 2012, pp. 96) (a modified version).

B.2 Effects of music

Many different parts of the brain is active when perceiving and experiencing music through the ears and body. Studies of the brain show that different parts are especially active when listening to certain musically activities. They also show that people with music training or skills regarding reading notes, active listening, or compose music influence the way the brain functions (Bonde, 2011, pp. 51).

Entrainment is a term that describes how two different movements over time will synchronize with each other. This is also called rhythmical physiological synchronization when looking at music and the effect on the body. This can happen consciously or unconsciously where people yield to the power of rhythmical music. The body reacts and adjusts to the outer influence. This is illustrated when being at a concert and the audience begin to clap, first it is not synchronized but at some point people have synchronized their clapping to the rhythm of the drum. Music can directly influence the autonomous nervous system and the immune system, and can be used for therapy (Bonde, 2011, pp. 66).

A study that examined how the brain perceives and processes music, found among other things, how music influence the following physiological systems (Bonde, 2011, pp. 68):

- Heart rate
- Blood pressure
- Breathing

- Skin temperature
- Galvanic skin resistance
- Brain wave

Here *Stimulating music* will increase body energy, generate body movements, and increase the heart rate and blood pressure. Opposite music that are relaxing can reduce the heart rate and blood pressure, and generally have a calming effect (Bonde, 2011, pp. 68).

It can be difficult to link a certain type of music to a specific physical response because of individual differences in response to different parameters in the music. Individual music preference also has an effect, where some people can relax when hearing classical music where others like to relax to rock. This means, there is not a general type of music that can produce a desired effect with all people (Bonde, 2011, pp. 68).

When looking at the physiological effect, there are some elements in the music that have an influence on whether the music are relaxing or stimulating. These elements have something to do with the predictability of the music piece. If the elements in the music are stable and predictable, the listener will be more disposed to be more relaxed. If the elements in the music will change a lot and be unpredictable, the listener will probably be more disposed to feel stimulated and the arousal will increase (Bonde, 2011, pp. 69).

It is also possible to get a physical reaction based on an emotional response to the music. A study had subjects report the physical reaction they experienced when listening to classic music. The reaction could be weeping, getting a lump in their throat, goosebumps, changes in their heart beat, shaking and others. The study discovered that the physical reactions could be linked to different musical passages (Bonde, 2011, pp. 70).

B.3 Effect of meditation

The basis for meditation is about paying attention, and when people start paying attention to how their minds work, by meditating, they discover that much of the time the mind is occupied with the past or the future and not with the present. Therefore the mind is often only partially aware of what is going on in the present. It is described as a form of unawareness as being on *automatic pilot* where people are not fully aware of what they are doing and experiencing, as if people only are half awake. Even when trying to concentrate on the task in the present, the mind often wanders and the attention is easily distracted (Kabat-Zinn, 2004, pp. 21-22).

The relaxation comes with continued practice, and by applying mindfulness and attention to people's everyday life. When people live with unawareness, it dominates the mind and affects people's decisions and actions. This can also keep people from being aware of their own body's signals and messages, which in turn can create physical problems. To relax can become difficult when people are unaware of their bodies since stress often can cause tension in muscle groups like shoulders, jaw, and forehead (Kabat-Zinn, 2004, pp. 23, 25, 26).

Seven terms that are essential for people's attitude regarding meditation are: non-judging, patience, a beginner's mind, trust, non-striving, accepting, and letting go. The terms do overlap with each other (Kabat-Zinn, 2004, pp. 32). The factors are described below:

- **Non-judging** is about becoming an impartial witness to your own experience. Doing this requires that people become aware of the constant judging of everything that they experience. The idea is to learn to step back from it. People have a habit of categorizing and judging all their experiences without being aware of it. The purpose of this when handling stress, is to be aware of the automatic judgment and then be able to see through people's own bias and fears. When practicing mindfulness meditation all that is required is to be aware when the judging happens. Only be aware of it, not trying to stop it and not judge that a judging thought occurred, and then go back to paying attention to the breathing (Kabat-Zinn, 2004, pp. 33-40).

- **Patience** is about understanding and accepting that things must take place in their own time. When practicing meditation people intentionally remind themselves that there is no need to be impatient and allow the experiences to unfold in the moment (Kabat-Zinn, 2004, pp. 33-40).

- **Beginner's Mind** is a mind that is willing to see everything as seen for the first time. It is about freeing the mind from expectations based on previous experiences. This allows for new possibilities and prevent people from getting stuck in their own expertise, since two moments are not the same. The beginner's mind reminds people that each moment is unique with unique possibilities (Kabat-Zinn, 2004, pp. 33-40).

- **Trust** is about developing a basic trust in yourself and your feelings. It is better for people to trust their own intuition and authority than to seek guidance from outside. When practicing meditation in this context people take responsibility for being themselves and learn to listen and trust their own being. The more people trust themselves, the easier it will be to trust other people (Kabat-Zinn, 2004, pp. 33-40).

- **Non-striving** is about not having a purpose, getting somewhere or something. Having these is a hindrance for meditation, since the goal is just for people to be themselves. Even though meditation is an act of non-doing it takes hard work and energy. The idea is that when people back off from trying to achieve their goals, and instead focus on seeing and accepting things as they are, movement towards the goals will happen by itself (Kabat-Zinn, 2004, pp. 33-40).

- **Acceptance** means seeing things as they truly are in the present. The idea is to not use energy on denying or resisting things that already are facts in people's daily lives. It prevents positive chance and creates more tension when people try to force situations to what they would like them to be. However acceptance does not mean that people have to like everything as it is and have a passive attitude towards it. It is a willingness to see things as they are, which helps people act when they have a clear picture of what is happening. When meditating acceptance is about being in each moment fully as it is (Kabat-Zinn, 2004, pp. 33-40).

- **Letting Go** is about not holding on to thoughts, feelings or situations. People want to prolong pleasant thoughts or feeling, by stretching them out and thinking about them again. Similarly people want to get rid of and protect themselves from unpleasant, painful, and

frightening feelings and experiences. When practicing meditation people need to let the experience be observed from moment to moment as it is (Kabat-Zinn, 2004, pp. 33-40).

Central to meditation is the breathing rhythm, since it is closely connected to the experience of being alive and a convenient process to focus on since it is something people always can focus their awareness on. When focusing on the breathing it immediately anchors the awareness in the body. This helps calm the body and mind, so people experience a calmness and see thing more clearly and with a larger perspective (Kabat-Zinn, 2004, pp. 49, 56).

Paying attention to the feeling of the breathing does not mean taking control and trying to change the flow or rhythm of the it. Focusing on the breathing does not mean to think about it, but just to be aware of it. The purpose is to center and anchor the attention that helps find a peaceful center which will enhance the overall stability of the mind. The belly is recommended since it represents the *center of gravity* of the body, and the breathing pattern is slower and deeper than chest breathing, which can be more rapid and shallow (Kabat-Zinn, 2004, pp 51-54).

Meditation practices

When practicing meditation there are both a formal discipline and an informal way of doing it. The formal meditation is when people stop what they are doing and only focus on the meditation. The informal meditation is when people practice during the day regardless of what they are doing. Four formal meditation practices are described below (Kabat-Zinn, 2004, pp. 57):

- **Sitting meditation**: This can be practiced sitting either on a chair or the floor, and it helps to sit in a upright and dignified posture where the head, neck, and back are aligned vertically. This makes the breathing flow more easily. People sit relatively comfortable without moving and calmly focus on the present without trying to fill it with anything and being mindful of breathing, having full awareness while breathing in and out, and observing it. When the attention for some reason moves, just let go of the thought and return the attention to breathing (Kabat-Zinn, 2004, pp. 61-62).

- **Body scan**: This technique is used for getting in contact with the body. Performing the body scan involve lying down and moving the mind through all the different parts of the body. Starting with the toes in the left foot slowly moving up the foot and leg while directing attention to the different regions. When reaching the pelvis, the mind goes to the right toe and moves up that leg. From the pelvis the attention moves up through the torso, by moving through the lower back and abdomen, then the upper back and chest, and then the shoulders. After that the mind follows the fingers and move up the arms simultaneously, returning to the shoulders. Then the attention is focused on moving through the neck, throat, and the face, to the back of the head, and finally ending at the top of the head. The idea is that by the end it feels like breathing through a *hole* at the top of the head where the breathing flows through the entire body. As with the sitting meditation the mind must focus attention to each region of the body and feel the sensation as if the body is breathing through that region (Kabat-Zinn, 2004, pp. 76-77).

- **Yoga**: Mindful yoga consists of stretching and strengthening exercises, which are done very gentle, with focusing on the breathing and the sensations that arise from moment to moment, as the body moves in different positions. The purpose is not only to get relaxed and having the body become stronger and mere flexible, but also to learn and experience the mind and body as a whole. The same meditation practices for the mind and attention is used, and is about accepting the body as it is in the present, and maintaining awareness from moment to moment while performing the stretching, lifting or balancing. This also helps discover the body's limitations, and the full range of motion and potential for movements (Kabat-Zinn, 2004, pp. 95-96, 100).

- **Walking meditation**: This is about bringing attention to the experience of walking while doing it. It does not mean looking at the feet while walking or that there is a reason for walking. It involves taking attending to the experience of walking itself. The focus could be on the sensation of the feet or legs, or the feeling of the body moving. This awareness can also be combined with the attention of breathing. As with the other meditation practices when the mind wanders, observe it and bring the attention back to the feet, legs or body. The idea of walking meditation is not to go anywhere, so it can be performed by walking back and forth or in circles around a room or outdoors. The practice of walking meditation can also be used for at more informal meditation in different situations (Kabat-Zinn, 2004, pp. 114-115).

Measurable meditation

A study tested yoga postures and guided meditation in an office workspace and measured various physiological and psychological aspects. The subjects performed 15 min of sitting yoga, guided meditation or normal work. The measurements continued for another 15 min after finishing performing the task. The subjects indicated their perceived stress on a Visual Analog Scale, and their blood pressure, heart rate, and respiration rate were measured. The results show that the brief yoga posture and meditation practice both reduced the perceived stress, and the effects were maintained throughout the additional 15 min. Blood pressure, heart rate, and respiration rate also showed improvement when performing yoga and meditation compared to the control (Melville et al., 2012).

Two different studies have investigated a kind of meditation called *integrative body-mind training* (IBMT). They both compared the difference between 5 days of IBMT to a control group performing relaxation training for the 5 days. The following both describe the IBMT and what relaxation training the control group performed:

- IBMT was developed in the 1990s as a way to combine different meditation techniques with body techniques. It includes concentration, mindfulness, mind control, focus, attention, relaxation, mental imagery. The mental training overlap with the body techniques such as body relaxation, breathing practice. This is performed with soft music in the background (Tang et al., 2007), (Tang et al., 2009), (Xuea et al., 2014).

- Relaxation training (control group) is about controlling and relaxing different muscles groups. This is done in a sequential pattern while the concentration is on feeling relaxed, warm and heavy (Tang et al., 2007), (Tang et al., 2009), (Xuea et al., 2014).

The first study measured the subjects' intelligence and mood state, and performed a stress challenge. The results showed that IBMT group had significantly better attention and control of stress than the control group with relaxation training. The results also indicates that it is possible to measure a difference after only 5 days of meditation training (Tang et al., 2007).

The second study performed different physiological measurements. These included heart rate, skin conductance response, respiratory amplitude and rate. The purpose was to examine the autonomic nervous systems' response to IBMT. The study also recorded brain activity by using EEG. The study showed that both the IBMT and relaxation groups had a positive change for the physiological measurements. There was however a significantly better physiological change for the IBMT group than the relaxation group (Tang et al., 2009).

Hopefully it will also be possible to have a measurable difference even if the subjects only perform meditation once in this project.

B.4 Vibroacoustic therapy

An experiment has investigated that *vibroacoustic therapy* have an effect on moods and states of relaxations. Vibroacoustic therapy can be defined as an auditory and vibratory stimuli that is transmitted to the body. This can give physical and psychological effects. The experiment had two hypnotizes (Wigram and Dileo, 1997, pp. 7, 87-95):

- That arousal levels, blood pressure and hear rate would be reduced when using vibroacoustic therapy, when compared relaxing music and a control condition.
- That the pulse rate, measured continuously over a half hour period, will fall significantly more when subjects receive vibroacoustic therapy compared to relaxing music or a control condition.

The test design consists of three groups with 20 subjects, 10 males and 10 females in each group, which was randomly assigned. All three scenarios lasted 30 minutes (Wigram and Dileo, 1997):

- Group 1 received calming music and a pulsed 40 Hz low frequency sinus wave. Both the music and the sinus wave was played through a vibroacoustic bed.
- Group 2 received *New Age* music from the vibroacoustic bed.
- Group 3 (control group) laid on the vibroacoustic bed but no stimuli was giving.

The vibroacoustic bed consisted of two loudspeakers that were placed under the bed. One speaker was placed under the chest and the other down by the knees when the subject was laying on the bed. When the subjects were laying on the bed, they were instructed to relax and were allowed to think about anything (Wigram and Dileo, 1997).

The subjects' physical changes were measured as blood pressure and heart rate. Additionally they used the UWIST Mood Adjective Check list (UWIST-MACL) to measure changes in arousal. These measurements were collected before and after the experiment, the pulse was measured during the 30 minutes where the subjects lay on the vibroacoustic bed. From the UWIST-MACL the subjects got a checklist with 24 questions where they should indicate on a scale from Definitely - Slightly - Slightly not - Definitely not. The answers they had giving before and after the test was then analyzed and compared between the different groups (Wigram and Dileo, 1997).

The result showed that there was no significant difference when comparing different gender and age between the different groups. It shows that there was a significant difference in Group 1 (vibration and music), for decreased arousal when compared to Group 2 (only music). The same occurred when comparing Group 1 and Group 2 with Group 3 (control). There was no difference in blood pressure and heart rate when comparing the three groups. When examining the control group against Group 1 and Group 2 together, there was a significant difference in reducing heart rate over time in Group 1 and Group 2 (Wigram and Dileo, 1997).

From this it could be interesting to investigate how vibroacoustic therapy can be used in The Interactive Chair, and how the results will differ from other ways of relaxing.

APPENDIX C

THE RELAXATION METHODS

The following describe the five different Relaxation Methods. Each will be performed in the experiment for 7 minutes and 6 seconds. The volume for the music and *Meditation* were on the computer set to 100% and 20 pressed on the volumes on the loudspeakers in The Interactive Chair. For *Vibroacoustic* the volume on the computer was set to 60%, since it otherwise would be too loud.

C.1 Biofeedback

The music for the *Biofeedback* is already defined by Bang & Olufsen, and a description of the *Biofeedback* from Bang & Olufsen can be seen in Appendix A. The Interactive Chair can play three different compositions, but for this experiment it was chosen to use the same composition for all subjects. This was to make the comparison more equal between the Relaxation Methods rounds. To set the compositions to the same, the *ChairCompositionChooser* was set to *Comp1* for all scenes. In Figure C.1 the program and where the compositions were set to be seen. The only way to listen to the composition is to activate the sounds while sitting in The Interactive Chair by activating the sensors in the backrest. The only way to acquire the music was to make a recording while a person was sitting in The Interactive Chair. The recorded file can be seen on the Attachment. Because the music changes depending on the person sitting in The Interactive Chair it will not sound exactly the same for all people, but the same sounds are used for the composition. In Figure C.2 the spectrum analysis of the recorded sound scape can be seen. It shows that most of the music is within 0kHz to 10kHz with the loudest sounds in the bass.

Figure C.1: The program that runs the *Biofeedback*. In the bottom half of the figure, it is possible to see that the compositions are all set to Comp1.

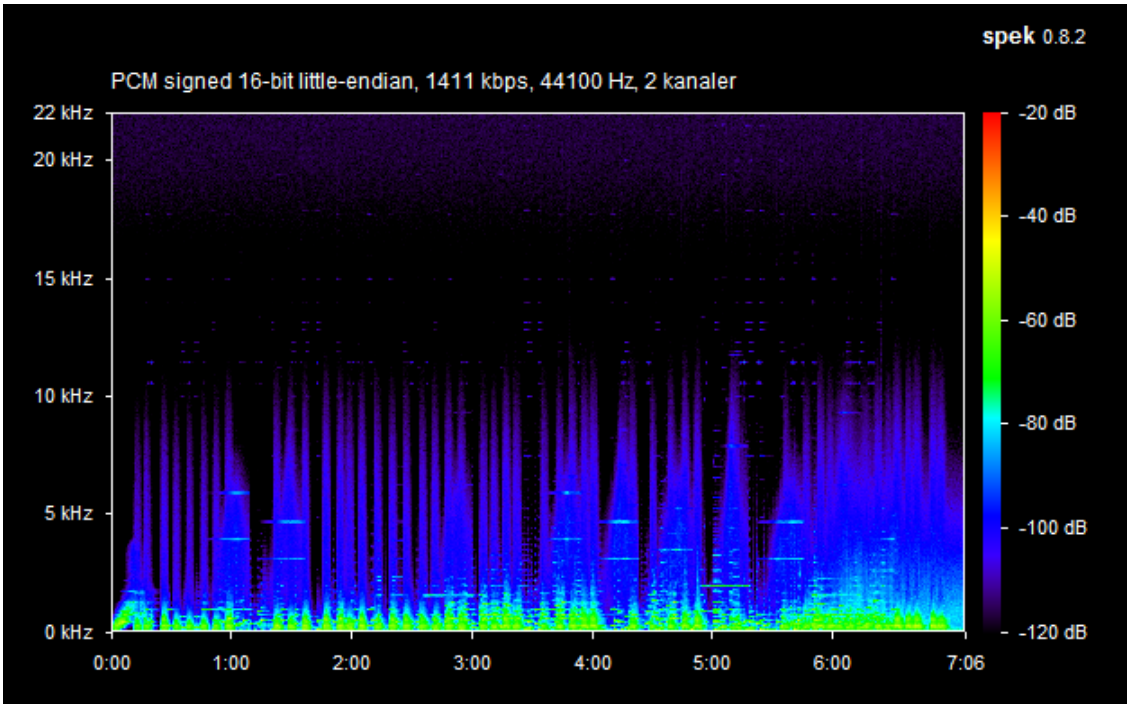

Figure C.2: Spectrum analysis of the 7 minute 6 seconds sound file for *Biofeedback* (using the program Spek, http://spek.cc/).

C.2 Meditation

It is chosen to use a Danish guide about mental training to facilitate the *Meditation*. The speaker is Rikke Østergaard, and the guide that was chosen lasts 10 minutes. The file used is called *Tag tid til dig selv - Få det fulde fokus* and can be found on her website[1]. About the guide she writes:

> "Mentaltræningen kan give én oplevelsen af at være fuldt tilstede i sit eget liv, en taknemmelighed for det der er lige nu og et langt større overskud til at håndtere de udfordringer der kommer, både på arbejdet og privat" (Østergaard, Website).

The guided meditation is about keeping focus and breathing. During the guide she speaks only in the beginning and in the end there are only some light bells playing one time each minute to help the subjects get their focus back on the breathing if their mind had wandered. The subject only get to hear the last two time that the bell rings. Figure C.3 shows the spectrum analysis, where it can be seen when she speaks, and the two times the bells rings at the end. The times without any sounds is where the subjects can focus on their breathing. The following is a transcript of what is said and when, during the 7 minutes and 6 seconds of meditation:

00:03 Bell rings.

00:09 ”Sid på en stol, eller som det passer dig bedst. Med rank ryg.”

00:17 ”Du har indtaget den siddende stilling der gør at du er allermest afspændt og tilstede.”

00:26 ”Du har taget denne tid til dig selv, til at træne dit fulde fokus.”

00:40 ”Tag en dyb lang vejrtrækning, og luk dine øjne.”

00:53 ”Oplev mødet med stemningen i kroppen, og at alt er som det skal være lige nu.”

01:05 ”Hvis du har en anden oplevelse, så er det det du giver plads til.”

01:21 ”Tag en dyb vejrtrækning mere. Denne gang med en oplevelse af hvordan brystkassen og maven bevæger sig i takt med den byde lange vejrtrækning.”

01:39 ”Og oplev hvor naturligt det er at slippe igen.”

01:45 ”Tag nu hele din opmærksomhed for brystkassen og maven, og lad den flyde hele vejen ned i fødderne, og i kontakten med underlaget. Oplev afspændthed, og fuld tilstedeværelse i fødderne.”

02:13 ”Ret nu dit fokus på kroppen. På hele kroppen. Og oplev fuld tilstedeværelse.”

02:42 ”Ret så dit fokus på åndedraget. Oplev hvordan indåndingen tager luften ind i kroppen. Og hvordan udåndingen får den til at forlade kroppen igen. Oplev fuld tilstedeværelse i dette øjeblik, og dit åndedrag lige nu.”

[1] http://erhvervssociologen.dk/mentaltraening/

03:08 ”Og hver gang du finder at dine tanker vandre i den ene eller den anden retning, som de nemt gør. Så bliv opmærksom på dem. Og accepterende giver du slip på dem igen, uden at dømme eller evaluere dig selv eller noget andet. Blot bring din opmærksomhed tilbage på åndedraget, og på kroppen der sidder her i dette nu.”

03:43 ”Fuld fokus på åndedraget, og på brystkassen der bevæger sig langsomt ind og ud i takt med at du trækker vejret.

04:21 ”Rid på bølgen af dit eget åndedrag. åndedrag ind, og åndedrag ud. åndedrag ind, og åndedrag ud.”

04:39 ”Og hver gang jeg ringer med klokken, vil du igen og igen rette dit fulde fokus mod åndedraget.”

05:45 Bell rings.

06:45 Bell rings.

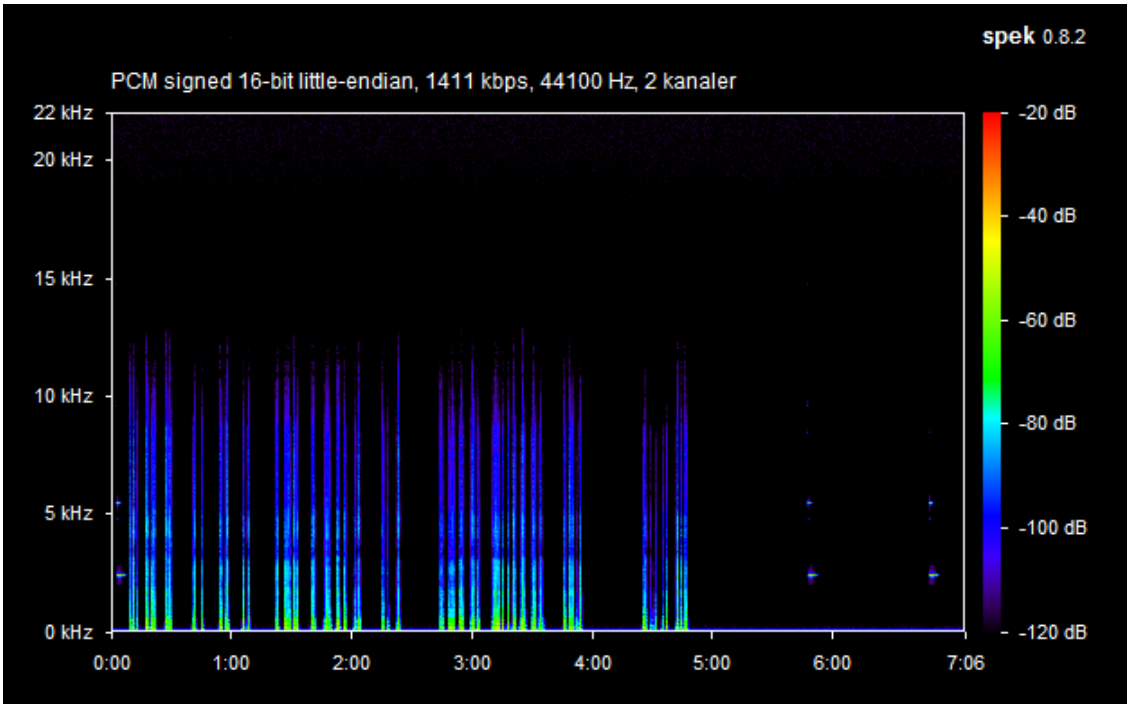

Figure C.3: Spectrum analysis of the 7 minute 6 seconds sound file for *Meditation* (using the program Spek, http://spek.cc/).

C.3 Relaxing music

The subjects have before the experiment found a song that they find relaxing. In Table C.1 the subject's own music choice can be seen. If the music could be found on the music service Spotify[2] it was played from there, otherwise Youtube or a MP3/CD was used. The volume for Subject 6 was turned down to 60% of the computer sound since the music was too loud.

Subjects	**Title**	**Artist**	**Played from**
Subject 1	Spirit	Future Islands	Spotify
Subject 2	Start of Something Good	Daugtry	MP3 file
Subject 3	Fantasy	Alina Baraz	Spotify
Subject 4	Winter Journey	Scott D. Davis	Spotify
Subject 5	Solskin Over Tage	TÅRN	Spotify
Subject 6	Kære linedanser	Per Kærsgsgaard	Youtube
Subject 7	Awakening	Random Forest	Spotify
Subject 8	River Flows in You	Yiruma	Spotify
Subject 9	Don't Stop The Music	Jamie Cullum	Spotify
Subject 10	Piano Man	Billy Joel	Spotify
Subject 11	3 HOURS Relaxing Music with Water Sounds Meditation	The Honest Guys	Youtube
Subject 12	Let thought in	Medwyn Goodal	MP3 file
Subject 13	We are one	Kelly Sweet	MP3 file
Subject 14	Mines	Tina Dickow	Spotify
Subject 15	Music for 18 musicians	Steve Reich	Spotify
Subject 16	Start of Something Good	Daugtry	MP3 file
Subject 17	Push the sky away	Nick Cave & the Bad Seeds	Spotify
Subject 18	Lovely Day	Bill Withers	Spotify
Subject 19	Prologue	The Book of Secrets	CD
Subject 20	La femme d'argent	Air	Spotify

Table C.1: Overview of the Relaxing music the subjects have chosen themselves. The songs that are a MP3 file was played through Windows Media Player.

For the subjects that chose a song from Youtube, the following links were used:

- Subject 6: https://www.youtube.com/watch?v=5z_X-nLtLkI (6 April 2016)
- Subject 11: https://www.youtube.com/watch?v=luRkeDCoxZ4 (8 April 2016)

[2]Spotify premium account

C.4 Vibroacoustic

Because The Interactive Chair has built-in loudspeakers, music with a lot of low tones make The Interactive Chair vibrate. Here it could be interesting to examine if music that is designed for vibroacoustic therapy in special chairs and beds could give an effect when playing it in The Interactive Chair.

The music piece used in the experiment are designed for Vibroacoustic Sound Tables, Loungers, Sound Chairs and other Vibroacoustic Devices. The MP3 file that was used, is called *Conscious Flight, by Chris Deuel and Inner Soulutions*. It is 45 minutes long and is a combination of music, sound, vibroacoustic frequencies and binaural beats (Vibroacoustuc.org, Website). In Figure C.4 a spectrum analysis of the first 7 minutes and 6 seconds of the music piece used for Vibroacoustic can be seen. Here the bass frequencies are very loud, and the sounds were already cut for frequencies above approximately 15kHz.

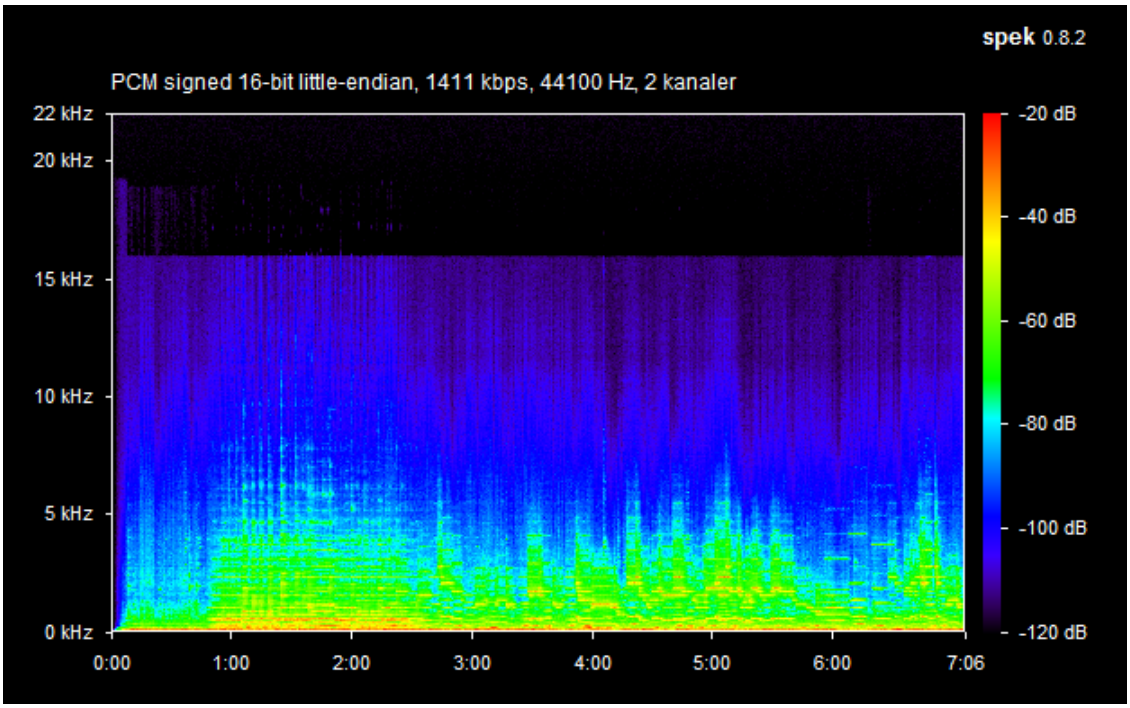

Figure C.4: Spectrum analysis of the 7 minute 6 seconds sound file for *Vibroacoustic* (using the program Spek, http://spek.cc/).

C.5 No Music

During one of the Relaxation Methods rounds the subjects will not hear any music. They here have to sit and relax when there is silent. This is used as a control situation.

APPENDIX D

OBJECTIVE MEASUREMENTS

Aalborg university have a biometric measuring program called iMotions. This program can synchronize different measuring products. In this way it is possible to connect different biometric products to the iMotions and collect data. iMotions can integrate different types of stimuli such as: eye tracking, facial expressions detection, EEG, GSR, EMG, ECG, and surveys. It can also be integrated with 3rd party software and hardware through an API. The version of the iMotions software is *iMotions 6.0* (iMotions, Website).

After investigating what measurements that wound be interesting to examine for this project, the iMotions program was tried out, and pilot test 1 was performed to get familiar with the iMotions program. It was decided that the objective measurements would be: GSR, HR, EEG and video recordings.

D.1 GSR

Galvanic Skin Response (GSR), Skin Conductance (SC), or electro-dermal activity (EDA) is used to measure the amount of sweat a subjects sweat glands contain. The sweat glands are an indicator of sympathetic activation, such as the difference between anger and fear, conflict and not conflict and measuring stress. The GSR can be seen as linearly with the emotional aspect of arousal. When measuring, the equipment is recommend to be placed on the fingers. It works when a small current is sent into the skin on one of the fingers and the resulting changing of voltage is measured on a neighbor finger (Calvo et al., 2015, p.210-212).

iMotions supports two kinds of GSR products, and for this experiment the Shimmer3 GSR+ device will be used. When GSR is measured the unit in iMotions is micro-Siemens (μS). Usually when measuring GSR it is on the non-dominant hand that the sensors are placed. This is done so the subjects still have the opportunity to use their dominant hand during task performances.

Movements of the part where the electrodes are placed should be minimum, and moving the subjects around in different locations during or between tasks can give unstable measurements (iMotions GSR, Guide).

The Shimmer3 GSR+ also has the possibility to add a third electrode. This can be used for measuring heart rate on a third finger which will be used during the experiment. The distance from the experiment computer to the GSR devise should not be longer than 5 meters, due to the Bluetooth reception range (iMotions GSR, Guide). When the experiment have been executed it could be interesting to investigate the following data:

- An overall level between the Relaxation Methods
- The decline between the first and last minute of each Relaxation Method
  - Calculate a mean for the first minute of each Relaxation Method
  - Calculate a mean for the last minute of each Relaxation Method
- The number of peaks between the Relaxation Method

GSR normally give an indication of arousal by examining the peaks . The hope is not to see any peaks since the subjects have to be relaxed. It is also possible to use the overall GSR to indicate a state of relaxation between the rounds where it is assumed that the lower the GSR is the more relaxed the subjects are.

Using the overall GSR has also been done in other studies for examining its effect on meditation. A study compared four treatment groups with different forms of meditation and control treatments, and measured skin conductance after two weeks of practice for five minutes before and after performing the treatment again in a laboratory. They performed an analysis of variance on the log of skin conductance to compare the treatments. Skin conductance was used to indicate autonomic arousal, and the results showed a tendency for a decline between the before and after measurements (Boswell and Murray, 1979). Another study used GSR as a measure for declined arousal to assess the effect of meditation. GSR was measured during the first and last three minutes of a twenty minute session, and when comparing the analysis used the mean GSR level across the two intervals (Wenk-Sormaz, 2005). A third study compared four sessions, two with meditation and two control sessions, where skin resistance was one of the measured variables at 20 second intervals. Here an increase in skin resistance level, measures in $k\Omega$, is interpreted as a decrease in the sympathetic nervous system's activity, and therefore suggest relaxation during the sessions (Telles et al., 2013).

D.2 HR

Photoplethysmograph (PPG) measures blood volume pulse. The sensor track light that reflects from another devise, and it is possible to see how much light that is reflected in the blood over time in the peripheral vessels. The more blood there is in the vessel, the higher is the reflecting reading. It is also possible to measure the vessel constriction of the peripheral blood by looking at the narrowing of the signal. The vessel constriction will increases in response to

pain, hunger, fear, and rage. The vessel constriction will decreases in response to relaxation. The sensor should be placed where the capillaries are close to the surface. From emotional response studies it has shown that the finger is recommended, however the finger must be kept still (Calvo et al., 2015, pp. 207-208).

Heart rate (HR) gives a view over the autonomic nervous system's activity, because it is controlled by the sympathetic and parasympathetic nervous system. The sympathetic nervous system accelerates heart rate and is related to stress or activation, where the parasympathetic nervous system is responsible for relaxing, rest and healing. The parasympathetic nervous system's job is to decrease the heart rate that occur from the sympathetic nervous system. Therefore the sympathetic nervous system increase the heart rate and the parasympathetic nervous system decrease the heart rate (Calvo et al., 2015, pp. 208-209).

For measuring HR a pulse sensor can be connected to the Shimmer3 GSR+. iMotions measures the PPG and calculates the heart rate as beats per minutes (BPM) (Shimmer, Website). When the experiment have been executed it could be interesting to investigate the following data:

- An overall level between the Relaxation Methods
- The decline between the first and last minute of each Relaxation Method
  - Calculate a mean for the first minute of each Relaxation Method
  - Calculate a mean for the last minute of each Relaxation Method

For HR the same assumptions for the GSR can be used. The readings should decline over time to indicate that the subjects are getting more relaxed, and the lower the readings the more relaxed the subjects are.

D.3 EEG

Electroencephalography (EEG) are measuring the electrical activity of the brain. A full EEG consist of more than 128 sensors, where an experiment have shown that it is possible to distinguish between positive and negative emotional valence and different arousal levels. EEG can also be used to track responses using Alpha waves at 8 Hz to 13 Hz, and Beta waves at 14 Hz to 26 Hz (Calvo et al., 2015, pp. 212).

iMotions supports two kinds of EEG products, where Aalborg University has ABM B-Alert X10 EEG, which will be used for the experiment. The ABM B-Alert can measure five metrics: *High Engagement*, *Low Engagement*, *Distraction*, *Drowsiness* and *Workload*. To measure these, a Benchmark is used to create an individualized EEG profile for the *cognitive state* and *workload metrics* (B-Alert, Manual).

- **3-choice Vigilance Task (3CVT)**: The task consists of three symbols that will appear on the screen one at the time. The subject needs to pres left key if the symbol are the correct

one, and right key if the symbol are one of the other two symbols. This task will identify the individuals who are unable to remain engaged (B-Alert, Manual).

- **Visual Psychomotor Vigilance Task (VPVT)**: The task consists of one symbol (a read dot) that will appear every two seconds. The subject's task is to press space every two seconds at the same time as when the symbol appears (B-Alert, Manual).

- **Auditory Psychomotor Vigilance Task (APVT)**: The task look like the VPVT, but instead of getting help from the red dot, the stimuli will now be a sound, and the subject has to complete with their eyes closed (B-Alert, Manual).

The 3CVT measures the High Engagement, the VPVT measures the Low Engagement and the APVT measures the Distraction. The Sleep Onset (Drowsiness) is a regression from the three tasks. These are measured in classification probability between 0 to 1 (B-Alert, Manual). For these four metrics there is a connection between them that span from fatigued and inattentive to highly engaged. Figure D.1 shows the relation between High Engagement, Low Engagement, Distraction and Drowsiness (Advanced Brain Monitoring, Internal Material).

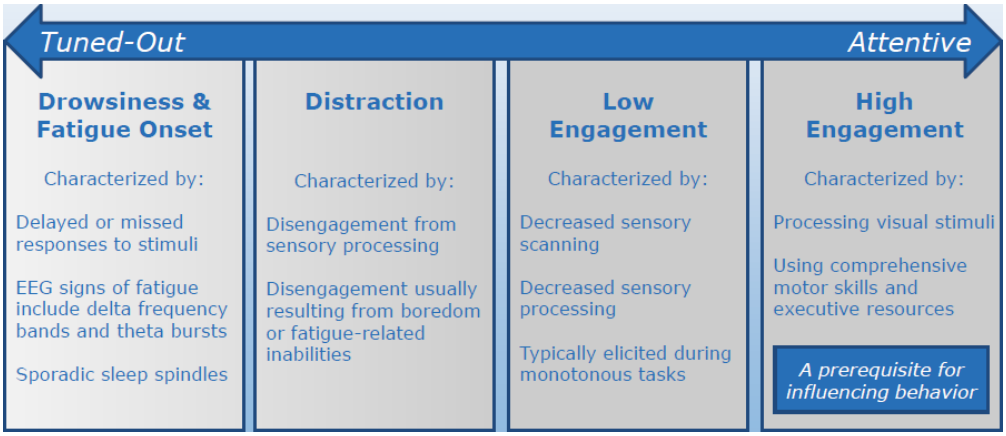

Figure D.1: The B-Alert Cognitive State Metrics (Advanced Brain Monitoring, Internal Material).

For measuring the Workload there are two models, where one is based on a forward digit-span task, and the other on a backwards digit-span task. The forward digit-span task is recommended to use, since it fits for approximately 85% of the population, where the backwards digit-span task fit approximately 15% of the population. The ABM also have a mean calculation of the two models. The higher the probability (the closer to 1) the higher the workload is. This represents an increase in working memory load, difficulty in mental arithmetic and other complex problem solving tasks (B-Alert, Manual).

For the optimal experiment, the subjects should avoid drinking coffee or smoke before performing the benchmark. Experiment should also occur in the morning about 8:00 to 10:00, where the subjects have had a full night sleep to get the optimal benchmark measurements (B-Alert, Manual). Due to the limited time The Interactive Chair is available for the experiment the subjects will be conducting it during three times periods of the day. However this time and other elements that could affect the measurements are noted down as well when executing the

experiment.

In the beginning the plan was to measure the difference in alpha-waves between different Relaxation Methods, since they indicate a relaxed wakeful state. Delta-waves would indicate that the subjects fell asleep during the experiment. Theta- or beta-waves are associated with workload, planning and movement of the body (iMotions EEG, Website). However instead of examining the brain waves directly the iMotions metrics are used for the experiment. Here especially Distraction, Drowsiness, and Workload could be related to relaxation and used to examine a difference between the Relaxation Methods. The following will be examined for High Engagement, Low Engagement, Distraction, Drowsiness and Workload.

- An overall level for each of the five metrics for each Relaxation Method
- For thresholds, under 0.1, over 0.25, over 0.50, and over 0.75 count how many times the level is above it for each of the four metrics (High Engagement, Low Engagement, Distraction, and Drowsiness) for each Relaxation Method.

D.4 Video recording and facial expressions

iMotions has two kinds of facial expressions products available, where the one that will be used are the Emotient engine (FACET previously CERT). The FACET module detects and tracks seven expressions of primary emotion (*Joy*, *Anger*, *Surprise*, *Fear*, *Contempt*, *Sadness* and *Disgust*). These seven emotions can be simplified into *Positive*, *Neutral* and *Negative* distinctions. For optimal performance, a baseline needs to be measured. When the baseline is measured, the median of the baseline is applied during the rest of the experiment for each of the seven emotions. When analyzing, each emotion is given an *evidence* number. These numbers are transformed into a probability between 0 and 1 that indicate the probability of that facial expressions occurrence. The program track as well two advanced emotions *Confusion* and *Frustration*. For optimal facial recognition for each person a 6 seconds baseline is needed before the experiment begins (iMotions FACET, Website).

Video recordings are made during the time the subjects are sitting in The Interactive Chair. This makes it possible to examine any facial expressions, and have a visual and auditory data for what happens during the experiment. The auditory data is helpful when double checking the subjects' answers to the backward digit-span task. Since the subjects will be sitting in The Interactive Chair and relaxing it is assumed that the facial expression data will not give much information about relaxation.

Repository rate (Not included)

Respiration measures physiological signal, such as cardiac activity. There are different ways to do this. One are where a mask is placed over the mouth and nose that measures the gas that are

exchanged in the lungs. This gives some accurate results, but are not practical in non-invasive activities. Here it is possible instead to get some results from measuring the chest expansion. This is done with a strap sensor, but do not give as accurate results as the other method. High respiration activity means physical activity and emotional arousal, and low respiration activity means physical relaxation (Calvo et al., 2015, pp. 213).

The repository rate was wanted, because it is expected that the slower the rate the more relaxed the subjects are. There was currently no equipment available to measure it right away. The Interactive Chair measures the repository rate when the Biofeedback is run. However to get that data from the program, it will include another program that can save that data during the different Relaxation Methods. Due to limited time available with The Interactive Chair, there was not enough time to include this in the project. If the repository rate was measured a lower rate would indicate that the subjects were more relaxed.

D.5 Mental tasks

An additional way to compare the different Relaxation Methods is to include a mental task which the subjects would perform after they have been relaxing. The following is all the tasks that were considered for the experiment.

A study used EEG to validate the user friendliness of onscreen keyboard layouts by focusing on the cognitive load. To get a reference for what low and high cognitive load is for the study's subjects, they measured EEG while the subjects performed a *Stroop test*. The set the study used can be seen in Figure D.2 where the purpose is to say the color of the words and not read the color-words (Sinharay et al., 2013).

Fig. 7. Set for low cognitive load

Fig. 8. Set for high cognitive load

Figure D.2: The sets uses for establishing the high and low cognitive load in the study(Sinharay et al., 2013).

Another study focused on *attention restoration theory (ART)* that is based on attention that is divided into two components, involuntary and voluntary (directed). The former is where the attention is captured by something intriguing or important where the latter is a cognitive-control

process. ART states that the directed attention can be restored by interacting with nature. The study performed an experiment where the subjects either walked in a park or downtown in a city, and afterwards performed a *backwards digit-span task* to determine that directed attention had been replenished for those walking in nature (Berman et al., 2008).

In order to test this, the study measured the cognitive performance by giving the subjects a backwards digit-span task. The subjects heard a digit sequence and should repeat them in backwards order. The length of the sequences were from three to nine digits with two repetitions for each. The sequences were presented in increasing order depending on their length and the whole sequence must be correct before it counted as a correct score independently of the sequence length (Berman et al., 2008).

Two other mental tasks were investigated that also test the capacity of directed attention. The first uses the *Necker Cube* seen in Figure D.3 which people can perceive to have two different orientations. A test using this would be about counting how many times people perceive the necker cube switch between the two orientations (Hayes, 2000). The other is called *Free Recall* which resembles the backward digit-span task only here 10 letters are given and the order of remembering them is unimportant (De Young, Website).

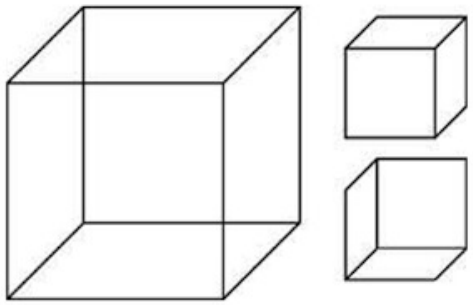

Figure D.3: The Necker Cube (Necker Cube, Website).

The mental task used in the experiment

It is chosen to use the backwards digit-span task, in the same design as mention in the second study, the only difference is that the numbers are presented visually. The task is easy to implement in an experiment, and the study that used the backwards digit-span task found a difference in the number of correct answers between their two groups. In Appendix F.12 the program that run the backwards digit-span task can be seen. It was chosen to present the numbers visually since it could easily be implemented in the experiment setup.

APPENDIX E

SUBJECTIVE MEASUREMENTS

For the experiment it is decided to also have subjective measures regrading the subjects feeling and preferences towards the Relaxation Methods.

Different questionnaires have been tried out, to find one that will fit this experiment best. At first different self report methods were investigated since these can give information about the subjects' experience along with emotions. One method was the *Cirumplex model* and a rotated versions of the model. The idea was that the subjects perhaps should indicate or get some questions that could be related to the model. It was difficult to see how the model or other models working with emotions could be implemented in the experiment and what the results would indicate. Another way to ask the subjects how they felt, could be using the *Self-assessment Manikin scales* (SAM) with its three dimensions. It was decided not to work further with the models since it was chosen to use a VAS instead, if some questions should be asked in that form. The following include studies and questions considered for the experiment.

Questionnaire from Biofeedback study

The study described in the Introduction has investigated how using music as a signal for biofeedback can effect people. In the experiment the participants' states of physiological arousal are measured, such as heart rate controlled for respiration rate. The three different conditions that were tested are (Bergstrom et al., 2013):

1. Listening to pre-recorded music.
2. Listening to sonification biofeedback of the heart rate (sine-tone).
3. Listening ton algorithmically modulated musical feedback signal conveying the subject's heart rate.

The study also used three kinds of questionnaires. These are looked further into, to determine if some of the questions could be used for this project. The three different questionnaires that were used are:

- Specifically questions about the experiment
- Demographics
- Body Perception Questionnaire (BPQ)

The questions specifically related to the experiment, will not be used in this project since the experiments are not alike. Questions that could be used as inspiration for this experiment are the following from the study's demographics questions (Bergstrom et al., 2013, pp. 148-149):

- Are you taking any medication? (Y/N) If yes, please specify
- If you play an instrument or sing: How many hours do you do so per day?
- Do you consider yourself a musician? (Y/N)
- Are you left or right handed?
- Do you have auditory problems? (Y/N) If yes, please specify.
- Do you have motor problems? (Y/N) If yes, please specify.
- Have you had coffee in the last 5 h? If yes, please specify how many.

It is not possible to determine if the study used all 122 questions or a shorter version of the Body Perception Questionnaire (BPQ) (Stephen W. Porges, Website). Some of the questions are for example:

> No. 57. I have difficulty coordinating breathing and eating
>
> No. 77. After eating I have digestive problems.

This type of questions have be answered using the following 5-point scale: rate yourself on each of the statements: a) Never b) Occasionally c) Sometimes d) Usually e) Always. There are also two shorter versions, one with 46 questions in total and a very short with 12 questions (Stephen W. Porges, Website).

To test if the questions could be used for this project, the BPQ questionnaire with 122 questions was completed. Here it was discovered that for part 1, part 2 and part 3 it was difficult to understand what exactly *rate your awareness* means, especially in relation to the questions: does it mean general awareness or only when something happens?. It was decided not to use the BPQ, since the original is too long and some of the questions are difficult to understand and will not suit the experiment. Some of the questions that perhaps could be used for inspiration to this project's experiment are listed below.

- How fast I am breathing
- Muscle tension

- Being exhausted
- Muscle pain
- Goose bumps
- Needing to rest
- Difficulty in focusing
- How hard my heart is beating
- Difficulty in paying attention with my mind wondering or daydreaming
- Difficulty organizing my thoughts
- I feel nauseous
- I feel mental tension
- I feel dizzy

Some additional questions from the BPQ that could be used in the experiment could be: age, gender, height, education, perceived physical fitness, smoking, is there any strenuous physical activity on their current job, and do they engage in regular physical exercise for recreation off the job (Stephen W. Porges, Website).

It was chosen to use some of the questions as inspiration. The questions that are used during the experiment can be seen in Appendix F.3, Appendix F.4, and Appendix F.7.

E.1 Relaxation states

Since the BPQ questionnaire was not suitable for this experiment another way to ask about relaxation was examined. J. Smith[1] has defined 12 relaxation states, called *R-states*. They explain different types of relaxation and are organized in four groups. J. Smith states that a very popular approach to relaxation is to simply define it as the general reduction of neurophysiological arousal. However this does not help understanding the difference among the effect of various relaxation techniques. J. Smith uses his defined six types of self-stressing to find parallel self-relaxation techniques. The four self-relaxation techniques are listed below along with its corresponding R-states (Smith, 2007). From the 12 R-states Smith has constructed a questionnaire called *Smith Relaxation States Inventory 3* (SRSI3).

- **Basic Relaxation**: Generally the experience when practicing relaxation techniques, and can be seen as reduction in tension, fatigue and distress (Smith, 2007).
  - Sleepy

[1] Jonathan C. Smith, PhD. Psychology Department, Roosevelt University, Chicago, IL

  - Disengaged
  - Physically relaxed
  - Mentally relaxed (at ease/peace)

- **Core Mindfulness**: This is based on some of the principles of mindfulness that involves awareness and focused attention, with an absence of elaborative thought, and having nonjudgmental acceptance (Smith, 2007).
  - Awake/focused/clear
  - Quiet
  - Accepting

- **Positive Energy**: Both joyful and optimistic are associated with increased health, immune system functioning, and longevity (Smith, 2007).
  - Joyful
  - Optimistic

- **Transcendence**: The primary principle for this is selflessness, where the focus is on a larger and greater good (Smith, 2007).
  - Prayerful/reverent
  - Mystery
  - Timeless/boundless/infinite/at one

Smith Relaxation States Inventory 3 (SRSI3)

Smith Relaxation States Inventory 3 (SRSI3) have 38 questions about how people feel right now. These questions have to be answered on a 6-step scale. All the questions can be seen in Figure E.1, where it based on the answers can be calculated an overall relaxation score. Additionally it is possible to calculate a score for each of the four groups *Basic Relaxation*, *Mindfulness*, *Positive Energy*, and *Transcendence* based on the answers to the questions (Jonathan C. Smith, SRSI3). For this project it was decided that 38 questions were too many to answer after each Relaxation Method, and it was found that some of the questions were irrelevant regarding this project. Therefore Smith was contacted to discover if it was possible to only use a section of the questions from SRSI3.

SRSI3

HOW DO YOU FEEL RIGHT NOW? PLEASE CHECK ALL THE ITEMS USING THIS KEY.

RIGHT NOW, I FEEL THIS

①	②	③	④	⑤	⑥
Not at All	A Little	. . Moderately . .		A Lot	Maximum

① ② ③ ④ ⑤ ⑥	1. My mind is SILENT and calm (I am not thinking about anything).
① ② ③ ④ ⑤ ⑥	2. My muscles feel TIGHT and TENSE (clenched fist or jaws; furrowed brow).
① ② ③ ④ ⑤ ⑥	3. I feel AT PEACE.
① ② ③ ④ ⑤ ⑥	4. I feel DROWSY and SLEEPY.
① ② ③ ④ ⑤ ⑥	5. Things seem AMAZING, AWESOME, and EXTRAORDINARY.
① ② ③ ④ ⑤ ⑥	6. Right now I recognize the wisdom of sometimes ACCEPTING things as they are.
① ② ③ ④ ⑤ ⑥	7. My muscles are SO RELAXED that they feel LIMP.
① ② ③ ④ ⑤ ⑥	8. I am HAPPY.
① ② ③ ④ ⑤ ⑥	9. I am WORRYING
① ② ③ ④ ⑤ ⑥	10. I feel AT EASE.
① ② ③ ④ ⑤ ⑥	11. I feel DISTANT and FAR AWAY from my cares and concerns.
① ② ③ ④ ⑤ ⑥	12. I feel ENERGIZED, CONFIDENT, and STRENGTHENED.
① ② ③ ④ ⑤ ⑥	13. I am DOZING OFF or NAPPING.
① ② ③ ④ ⑤ ⑥	14. I feel THANKFUL.
① ② ③ ④ ⑤ ⑥	15. I feel like I am living fully and SIMPLY in the PRESENT, not distracted by past or future concerns.
① ② ③ ④ ⑤ ⑥	16. Things seem TIMELESS, BOUNDLESS, or INFINITE
① ② ③ ④ ⑤ ⑥	17. I feel IRRITATED or ANGRY.
① ② ③ ④ ⑤ ⑥	18. I feel JOYFUL.
① ② ③ ④ ⑤ ⑥	19. I feel SAD, DEPRESSED, or BLUE.
① ② ③ ④ ⑤ ⑥	20. I feel AWARE, FOCUSED, and CLEAR.
① ② ③ ④ ⑤ ⑥	21. My hands, arms, or legs are SO RELAXED that they feel WARM and HEAVY.
① ② ③ ④ ⑤ ⑥	22. I feel INNOCENT and CHILDLIKE.
① ② ③ ④ ⑤ ⑥	23. My BREATHING is NERVOUS and UNEVEN (Or shallow and hurried).
① ② ③ ④ ⑤ ⑥	24. I feel LOVING.
① ② ③ ④ ⑤ ⑥	25. Things seem FRESH and NEW, as if I am seeing them for the first time.
① ② ③ ④ ⑤ ⑥	26. I feel INDIFFERENT and DETACHED from my cares and concerns.
① ② ③ ④ ⑤ ⑥	27. I feel PRAYERFUL or REVERENT.
① ② ③ ④ ⑤ ⑥	28. I feel PHYSICAL DISCOMFORT or PAIN (backaches, headaches, fatigue)
① ② ③ ④ ⑤ ⑥	29. My mind is QUIET and STILL.
① ② ③ ④ ⑤ ⑥	30. I feel ANXIOUS.
① ② ③ ④ ⑤ ⑥	31. I sense the DEEP MYSTERY of things beyond my understanding.
① ② ③ ④ ⑤ ⑥	32. I feel RESTED and REFRESHED
① ② ③ ④ ⑤ ⑥	33. I feel CAREFREE.
① ② ③ ④ ⑤ ⑥	34. TROUBLESOME THOUGHTS are going through my mind.
① ② ③ ④ ⑤ ⑥	35. My body is PHYSICALLY RELAXED.
① ② ③ ④ ⑤ ⑥	36. Presently I feel there's no need to try to change things that simply can't be changed.
① ② ③ ④ ⑤ ⑥	37. I feel fully focused and ABSORBED in what I am doing
① ② ③ ④ ⑤ ⑥	38. I feel OPTIMISTIC, HOPEFUL, or TRUSTING that I can rely on someone or something.

Figure E.1: The 38 questions in SRSI3 (Jonathan C. Smith, SRSI3).

E.2 Permission from Smith to use the R-states questions

The e-mail correspondence with the creator of the R-states, Dr. Jonathan Smith, regarding the permission to use the questionnaire can be found on the Attachment. He recommended using the *M-TRACKER 7a.brief* since it is shorter than the SRSI3 with 11 questions. The questions were examined and suitable to be used in the experiment. The M-TRACKER 7a.brief can be seen in Appendix F.5.

E.3 Visual Analog Scale

Due to the fact that the R-states questionnaire is in English, it was chosen to include a Danish question regarding the subjects' overall relaxation. Additionally a question regarding how long time they thought they had been relaxing in The Interactive Chair was included. These should be answered on a *Visual Analog Scale* (VAS).

There are different kinds of scales that can be used when investigating subjective meaning. One is the Likert scale that typical have seven or five points and can e.g. be Strongly agree-Agree-Neutral-Disagree-Strongly disagree. In this way the subjects have a limited number of choices. If more options are needed, more point can be added, or a VAS can be used. On a VAS it is possible for the subjects to answer anywhere they want on a line, where some have two endpoints, that could be Strongly agree-Strongly disagree (Field and Hole, 2003).

An illustration of the VAS can be seen in Figure E.2, which is an open ended scale with three anchor points. The anchor point in the middle represents neutral and have anchor points with the words ”Strongly agree” and ”Strongly disagree”.

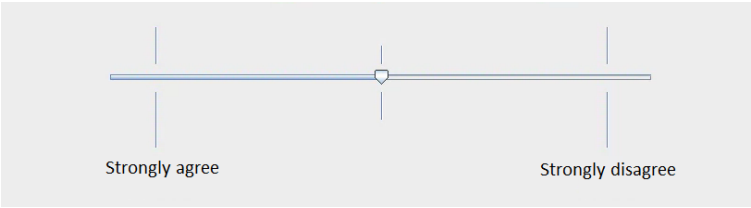

Figure E.2: The design of an open ended VAS.

APPENDIX F

EXPERIMENT MATERIAL

This appendix contains the material used during the experiment. This include the introduction, the consent form, the questions asked both through an initial questionnaire, on a VAS and in an exit interview. Additionally a glossary for the English words in the R-states questionnaire is included. Some of the sections are in Danish since it was the language the experiment was conduced in.

F.1 Introduction

Velkommen til Produkt- og Designpsykologi 10. semester gruppe 1081's forsøg.

Vi er i gang med at undersøge hvordan folk slapper af og hvad dette har af effekt på mentale opgaver. Du vil under forsøget skulle sidde i en specieldesignet stol med indbyggede højtalere. Dele af forsøget foregår på engelsk, og da vi ved at dette ikke er dit førstesprog, vil vi hjælpe efter behov.

Du kommer gennem 5 runder, og hver runde indeholder følgende:

1. Du skal sidde afslappende i stolen
2. Du skal besvare to spørgsmål på en skala (VAS)
3. Du skal besvare 11 spørgsmål på en 5-trins-skala[1] (engelsk)

   Der vil være en ordforklaring, og hvis du er usikker på forståelsen af nogle af spørgsmålene, er du altid velkommen til at spørge.

[1] M-TRACKER 7a.brief af Dr. Jonathan Smith: www.lulu.com/stress og http://drsmith.deltalprinting.com

4. Du skal udføre en hukommelsestest

5. Du skal gå op til det høje bord og udføre en multi-task opgave (engelsk)

Gennem forsøget vil vi måle din puls, hudfugtighed (GSR) og den elektriske aktivitet i overfladen af din hjerne (EEG). Puls og hudfugtighed måles med elektroder, der sidder på tre af dine fingre. Den elektriske aktivitet i overfladen af hjernen måles med ni elektroder, der placeres på hovedbunden. Vi vil gøre opmærksom på, at du ikke vil tage skade af måleudstyret.

Overordnet består forsøget af følgende dele:

- Du skal besvare et initierende spørgeskema

- Vi påsætter udstyret

- Du skal gennemføre en kalibrering af udstyret (engelsk)

- Vi gennemgår alle opgaverne i en runde for at du bliver bekendte med dem (familiariseringsrunde).

- Alle 5 runder udføres

- Vi fjerner udstyret

- Vi afholder et kort interview om forsøget

Selvom du skal sidde afslappende i stolen, vil vi gerne have at din rygsøjle læner sig op af ryglænet og at du sidder stille for at undgå bevægelser, der kan påvirke udstyret.

F.2 Consent form

Jeg har forstået de informationer, som er givet med hensyn til forsøget og indvilger i at medvirke i dette. Endvidere er jeg indforstået med, at jeg på et hvert givent tidspunkt kan afbryde forsøget og det indsamlede data vil dermed ikke blive benyttet.

Jeg giver tilladelse til, at citater, observationer og målinger fra forsøget må anvendes i forbindelse med projektrapporten og projekteksamen på Produkt- og Designpsykologi, 10. semester, som afholdes i juni 2016 for gruppe 1081. I denne forbindelse vil jeg forblive anonym.

Dato og underskrift

F.3 Initial questionnaire

This questionnaire contains questions regarding the subjects. They answer this at the beginning of the experiment while the facilitators prepare the equipment. The questions, the subjects are required to answer, are marked with a *. The questionnaire was presented using Google Forms[2].

- Angiv din alder *
- Angiv dit køn * (Mand-Kvinde)
- Angiv dit job/beskæftigelse? * (For studerende angiv studieretning og semester)
- Angiv din højde *
- Er du højre-eller venstre håndet? * (Højre - Venstre)
- Hvor mange timer har du sovet i nat? *
- Hvornår stod du op i morges? *
- Har du høreproblemer? Hvis ja, hvilke?
- Har du motoriske problemer? Hvis ja, hvilke?
- Har du drukket koffein i dag? Hvis ja, hvad og hvor meget? (Dette gælder både for kaffe, sodavand, energidrik og lignende)
- Har du røget i dag? Hvis ja, hvor meget?
- Angiv hvor lang tid siden du har drukket og spist noget? og hvad det var? *
- Har du taget nogen form for medicin i dag? (såsom blodfortyndende, beroligende eller smertestillende)(Du behøver ikke skrive hvilken, hvis du følger dig utilpas med dette, skriv blot ja)
- Har du musikalsk erfaring? og hvad? (Dette kunne være: spille instrument, arbejde indenfor musikindustrien eller lignende)
- Har du prøvet at meditere før? Hvor erfaren er du? *
- Føler du dig stresset i hverdagen? *

The question about being left or right handed is used to place the GSR on their non-dominating hand. Regarding auditory problems, is it difficult to determine when an auditory problem could affect the results or if it even does, because it also depends on the subject's individual condition. However afterwards it will be possible to examine if the subjects with auditory problems vary in some way from the subjects without auditory problems. The subjects are asked if they have any problem motor skill problems. If they have, they will get the help they need, for example getting up and down from The Interactive Chair.

[2] https://goo.gl/kBYrfX

The age, gender and job are some basic questions to get an idea of who the subjects are. The subjects are asked about how many hours of sleep they got the night before and how long they have been up during the day of the experiment. These questions can give some indication of how tired they are and be used to explain if some of the subjects are falling asleep during the experiment. If they are falling asleep, it can also be because they got bored.

The questions regarding if the subjects have been drinking caffeine like coffee, have been smoking, drinking, eating or taking medicine before the experiment are included because it could possibly have an effect on the measured data. The last question is asked to have an idea what mental state the subjects are in, if people are stressed in their everyday life, it could be difficult for them to relax on command.

F.4 VAS questions

There are two VAS questions that the subjects answer right after they have been relaxing in The Interactive Chair. The two questions can be seen below and in the figures:

- Jeg er fuldstændig afslappet (enig – uenig) in Figure F.1.
- Hvor lang tid følte du, at du sat i stolen (0 min – 15 min) in Figure F.2.

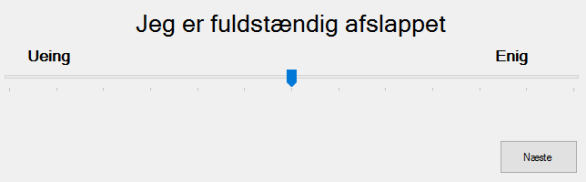

Figure F.1: VAS question 1 with labels.

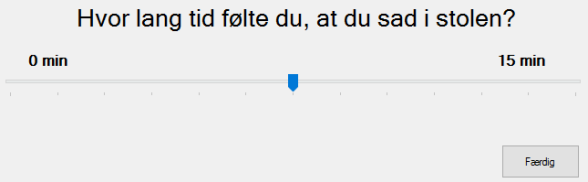

Figure F.2: VAS question 2 with labels.

The purpose of the second question is to examine how long time the subjects feel they are sitting and relaxing in the five different rounds. This was an attempt to discover if the subjects lose tack of time. If this happens it can perhaps be related to the terms of *Flow*, *Immersion* and *Presence*. The VAS used in this project's experiment has values from -120 to -120. A description of the program that runs the VAS can be seen in Appendix F.12.

F.5 R-states questions

In Figure F.3 the questionnaire for the *R-states* can be seen, which aims to determine how relaxed the subjects are after each Relaxation Method. It is called *M-TRACKER 7a.brief* and contains 11 questions that need to be answered on a five point scale.

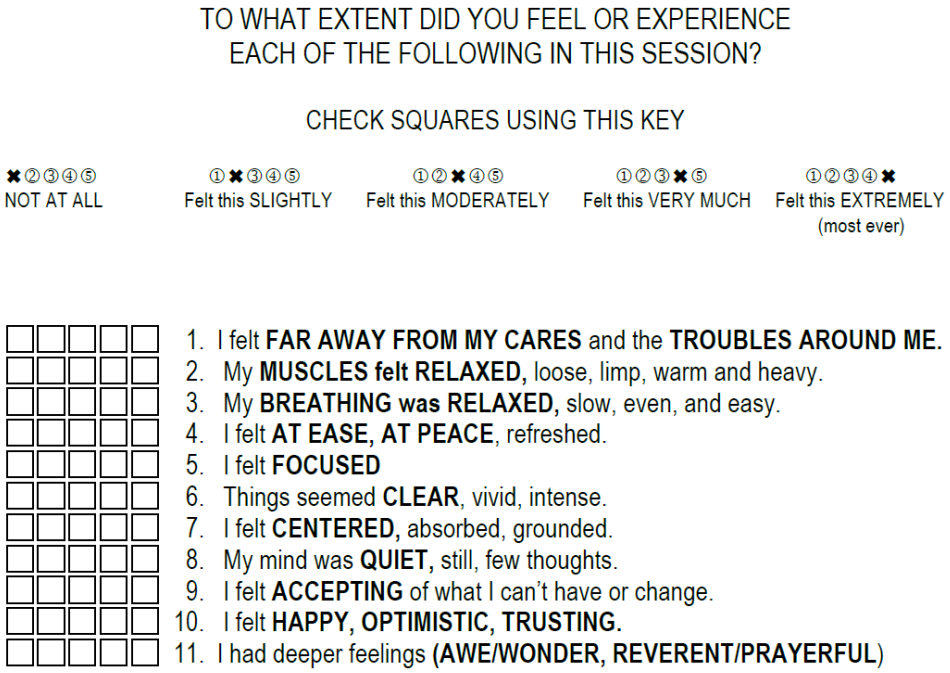

Figure F.3: The M-TRACKER 7a.brief containing the 11 questions (Jonathan C. Smith, M-TRACKER 7a.brief).

F.6 Glossary for R-states

This is the glossary given to the subjects when answering the R-states questions to help them understand some of the English words. It is meant to be used like a dictionary with multiple explanations of the same words.

Ordforklaring viser hvad ordene kan oversættes til[3]:

Spørgsmål 1:

- **Cares**: bekymringer, sorger
- **Troubles**: Vanskeligheder, modgang, besvær

Spørgsmål 2:

- **Relaxed**: afslappet, tilbagelænet
- **Loose**: løs, slap
- **Limp**: slap, slatten

Spørgsmål 3:

- **Relaxed**: afslappet, tilbagelænet

[3]Der er brugt www.ordbogen.com til oversættelserne

Spørgsmål 4:

- **At Ease**: i ro og mag
- **At Peace**: i fred, i ro
- **Refreshed**: frisk, forfrisket

Spørgsmål 5:

- **Focused**: fokuseret, koncentreret, målbevidst

Spørgsmål 6:

- **Clear**: klar, tydelig, åbenlys
- **Vivid**: livlig, levende, klart,
- **Intense**: intensiv, kraftig, intens

Spørgsmål 7:

- **Centered**: centreret, fokuseret, samlet
- **Absorbed**: absorberet, fordybet i, opslugt af
- **Grounded**: jordforbundet, med begge ben på jorden

Spørgsmål 8:

- **Quiet**: stille, rolig, fredfyldt
- **Still**: stille, rolig

Spørgsmål 9:

- **Accepting**: accepterende, godkendende, godtagende,

Spørgsmål 10:

- **Optimistic**: optimistisk, fortrøstningsfuld, forhåbningsfuld
- **Trusting**: tillidsfuld

Spørgsmål 11:

- **Awe**: dyb respekt, ærefrygt
- **Wonder**: forundring
- **Reverent**: ærbødig
- **Prayerful**: bedende

F.7 Exit interview

The interview is performed at the end of the experiment, where the facilitator asks the questions and write down the answers. The answers are saved together with the questionnaire questions in Google Forms. The questions are used to get the subjects' answers to what they thought about the different Relaxation Methods and what they generally thought of the experience.

- Forsøgs Nummer:
- Hvad syntes du om de forskellige gange du sad i stolen?
- Hvilken runde synes du bedst om? og hvilken var mest afslappede?
- Hvilken runde synes du mindst om?
- Hvad syntes du om stolen generelt?
- Hvorfor synes du, at det musik du havde med, er afslappende?
- Andre kommentarer?

F.8 Multitask game

During the experiment, the subjects have to complete five rounds where they are relaxing. In order to get the subjects out of their relaxing state an online computer game is used. The Multitask game is used as a pause between the different Relaxation Methods. The purpose of this task is to get the subjects minds up and running again (a non-relaxing break). When it is time for the subjects to do the multitask game, they need to get up from The Interactive Chair and walk over to a tall table where a computer with the game is ready. This task will be performed standing. The idea with the non-relaxing break is to get the subjects physically and mentally active. Due to the fact that the experiment is long, and with this non-relaxing break, hopefully the subjects will not get too drowsy through the experiment.

The multitask game that is used, is called *Multitask 2*[4]. Multitask 2 claims to test the ability to play multiple mini games at the same time. When the game starts, only one mini game is shown, after 10 seconds, one more game will begin. When a new game starts, a description of how to play the mini game will appear. When loosing one of the mini games, the game is over and a score will be shown. During the experiment the subjects think that the number of scores they get through the four minutes will be a part of the experiment and therefore written down. The game have some background music that will be an extra stressing element. In Figure F.4 the multitask game with three mini games active at the same time can be seen.

[4] http://multitaskgames.com/multitask-2.html (date 14.03.2016)

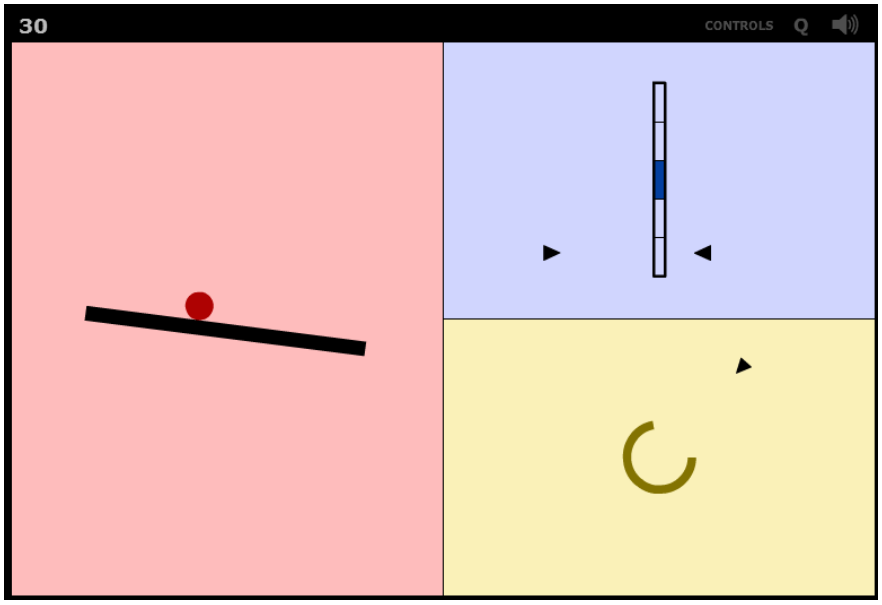

Figure F.4: The multitask game with three mini games active.

F.9 Latin Squares design

A way to deal with order effect in within subject experimental design is by using *Latin Squares* design. This helps cut down the number of different ways the trials can be ordered. Each presentation of the trial order must have equal number of participants. For uneven number of trials the order effect cannot be completely eliminated. A Latin Squares that has five trials and where each trial comes before another two or three times can be seen in Table F.1. The different Relaxation Methods need to randomly be assigned to the five letters (Fisher and Yates, 1963).

A	B	C	D	E
B	C	E	A	D
C	E	D	B	A
D	A	B	E	C
E	D	A	C	B

Table F.1: Latin Squares order for five trials (Fisher and Yates, 1963, pp. 86).

When using the Latin Squares design, the five different Relaxation Methods were first randomly assigned to one of the letters in Table F.1. Since it is chosen to get twenty subject to complete the experiment, the five Latin Squares design is used four times. Table F.2 shows the order the 20 subjects receive. The subjects are then randomly assigned one of the numbers and given that order of Relaxation Methods during the experiment.

No.	Round 1	Round 2	Round 3	Round 4	Round 5
1	Biofeedback	Relaxing music	Meditation	Vibroacoustic	No music
2	Relaxing music	Meditation	No music	Biofeedback	Vibroacoustic
3	Meditation	No music	Vibroacoustic	Relaxing music	Biofeedback
4	Vibroacoustic	Biofeedback	Relaxing music	No music	Meditation
5	No music	Vibroacoustic	Biofeedback	Meditation	Relaxing music
6	Biofeedback	Relaxing music	Meditation	Vibroacoustic	No music
7	Relaxing music	Meditation	No music	Biofeedback	Vibroacoustic
8	Meditation	No music	Vibroacoustic	Relaxing music	Biofeedback
9	Vibroacoustic	Biofeedback	Relaxing music	No music	Meditation
10	No music	Vibroacoustic	Biofeedback	Meditation	Relaxing music
11	Biofeedback	Relaxing music	Meditation	Vibroacoustic	No music
12	Relaxing music	Meditation	No music	Biofeedback	Vibroacoustic
13	Meditation	No music	Vibroacoustic	Relaxing music	Biofeedback
14	Vibroacoustic	Biofeedback	Relaxing music	No music	Meditation
15	No music	Vibroacoustic	Biofeedback	Meditation	Relaxing music
16	Biofeedback	Relaxing music	Meditation	Vibroacoustic	No music
17	Relaxing music	Meditation	No music	Biofeedback	Vibroacoustic
18	Meditation	No music	Vibroacoustic	Relaxing music	Biofeedback
19	Vibroacoustic	Biofeedback	Relaxing music	No music	Meditation
20	No music	Vibroacoustic	Biofeedback	Meditation	Relaxing music

Table F.2: Order of the Relaxation Methods for the 20 subjects.

F.10 Schedule for the experiment

Table F.3 shows what time and day the different subjects completed the experiment. Each subject was booked for three hours even though the experiment lasted approximately two and half hours. The schedule also included a 30 minute break between the times. Sometimes when the subject and the facilitator were ready, the experiment began before the scheduled time. The first ten subjects were booked for the first ten times because, at the time, there was some uncertainty of whether or not it would be possible to complete all the 20 subjects since the time when The Interactive Chair was available was limited.

Times	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
9.00 to 12.00	Subject 5	Subject 10	Subject 6	Subject 7	Subject 16	Subject 20	Subject 13
12.30 to 15.30	Subject 2	Subject 4	Subject 9	Subject 8	Subject 11	Subject 19	Subject 12
16.00 to 19.00	Subject 1	Subject 3		Subject 18	Subject 15	Subject 17	Subject 14

Table F.3: The schedule used for running the experiment. It was run from Monday 4th April 2016 up to and including Sunday 10th April 2016.

F.11 Experiment equipment

During the experiment the following equipment was used:

- The Interactive Chair
- Computer No. 1 (Lenovo T440p ThinkPad)
- Computer No. 2 (Lenovo W510 ThinkPad)
- Computer No. 3 (Dell)
- Web camera (Logitech Carl Zeiss Tessar HD 1080p)
- Two external computer screens
- Two external mouses (one of those using wireless Bluetooth connection)
- External keyboard
- Small loudspeakers
- Shimmer3 GSR+ with additional pulse sensor http://pulsesensor.com/
- ABM B-Alert X10 and all the necessary materials
- The experiment room: at Fredrik Bajers Vej 7B, 9220 Aalborg. VR-room is soundproof and sound muffled.

For the placement and removal of the EEG Strips the following were used: measuring tape, alcohol swab, 9 foam pieces for each subject, synapse gel, and 2 mastoid sensors for each subject.

For measuring the EEG the model ABM B-Alert X10[5] is used with the small and medium Strips depending on the size of the subjects' head. For the GSR and HR a Shimmer3 GSR+ Unit[6] is used, where a pulsesensor is connected to measure HR. The equipment is connected through Bluetooth to a computer running iMotions' software iMotions 6.0[7] that collects the data. To measure the facial expressions iMotions FACET need a web camera. The temperature in the experiment room was measured and noted once for each round in the experiment, and the results can be found on the Attachment. This is done in the program that also run the two VAS questions and the backwards digit-span task. The purposes of the different computers are described below.

- Computer No. 1 has an extra computer screen, mouse, keyboard, loudspeakers and a web camera connected. This computer is running the program iMotions 6.0 and is connected to the internet to use Google Forms for the initial questionnaire and exit interview. For calibrating the EEG and answering the questionnaire the subjects use the extra computer screen, mouse, keyboard, and speakers. The web camera is placed in front of The Interactive Chair to record video (with sound) in order to measure the facial expressions.

[5] http://www.advancedbrainmonitoring.com/xseries/x10/
[6] http://www.shimmersensing.com/shop/shimmer3-wireless-gsr-sensor
[7] https://imotions.com/imotions-6-release/

- Computer No. 2 has an extra computer screen and mouse, and is connected to the loudspeakers in The Interactive Chair through Bluetooth. It used the program Abletone Live 9 Suite to generate the sound scape for the *Biofeedback*, and another program is used to run the VAS questions and the backwards digit-span task. The extra computer screen and mouse are placed in front of The Interactive Chair to show the subjects the VAS questions and the backwards digit-span task, where they use the mouse when answering the VAS questions. This computer also play the music for the other Relaxation Methods, where the volume is set to 100% for *Biofeedback*, *Relaxing music* and *Meditation*, and set to 60% for *Vibroacoustic*.
- Computer No. 3 runs the online mulitask game.

F.12 The program

The program was developed in Microsoft Visual Studio Express 2012 for Windows Desktop. The code can be found on the Attachment. The program has two windows, one the facilitator uses for beginning the VAS questions and the backwards digit-span task, and one that the subject sees during the experiment. These can be seen in Figure F.5 and Figure F.6. When starting up the program the facilitator's window will appear, called *Form1* in the program. There is a button that needs to be pressed in order to open the extra window that the subjects will be using, called *Form2* in the program.

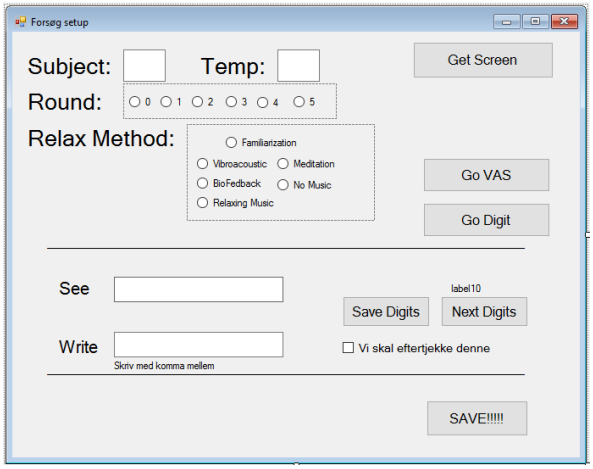

Figure F.5: Form1 that the facilitator uses.

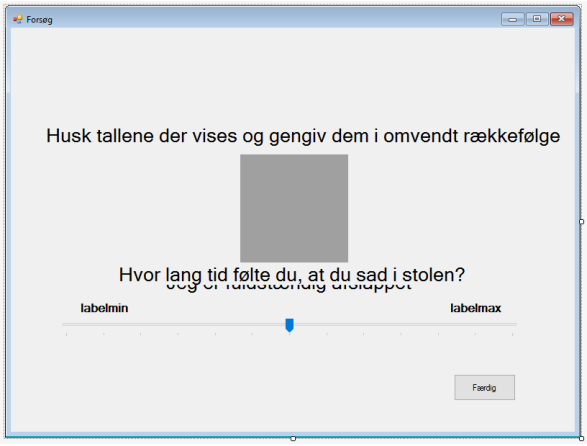

Figure F.6: Form2 that the subjects use.

Form2 is empty upon initializing. In Form1 the facilitator can input the subject's number, the temperature in the room, and check the round and Relaxation Method during the experiment. Form1 has two other buttons that activate the VAS questions and the backwards digit-span task. The VAS questions need to be completed first since the results will be saved when activating the backwards digit-span task. When performing the backwards digit-span task the facilitator needs to do three tings. When pressing the *Next* button the numbers will begin showing in Form2. When the numbers are done being showed, the subjects repeat the numbers,

where the facilitator will write the subjects' answers down. After that the facilitator has to press the *Save* button to save the subject's response and continue with the next order of numbers.

There is a big save button at the bottom which saves the results to a data file on the computer. In Figure F.7 an example of how the facilitator's screen looks during the experiment can be seen. Here it is Subject 14 that is completing the experiment, the temperature is 23 degrees during Round 5 while listening to *Meditation*.

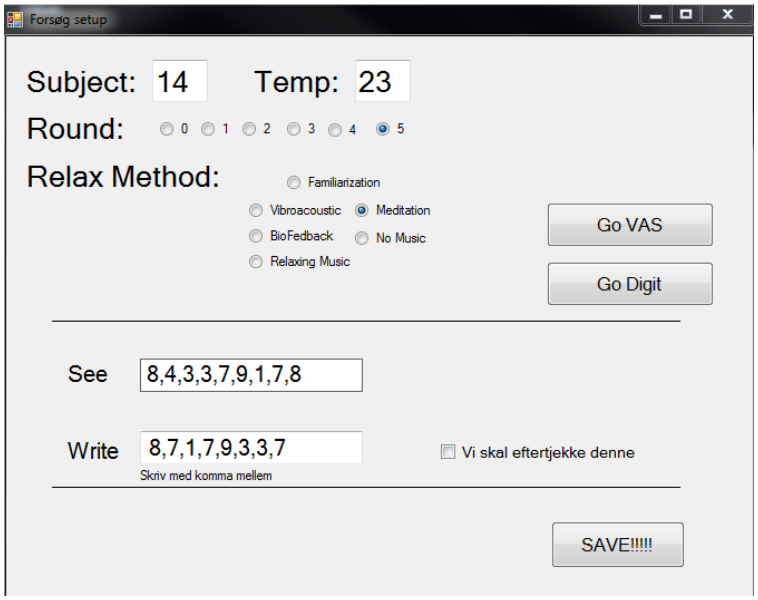

Figure F.7: The facilitator's screen during the experiment for Subject 14.

APPENDIX G

PILOT TESTS

Five pilot tests were run before the experiment to make sure that the setup worked and that it was possible to collect the wanted data. In Figure G.1 a time schedule over the different pilot tests can be seen. The Interactive Chair arrived in the evening of 29th March, and on the 30th March it was repaired after being damaged during a previous transport. Additionally some tests (Appendix H) about the sound pressure level and the vibration were made on 30th March and on the 11th April. The experiment was run from Monday the 4th to Sunday the 10th April. The Interactive Chair was sent back Tuesday 12th April.

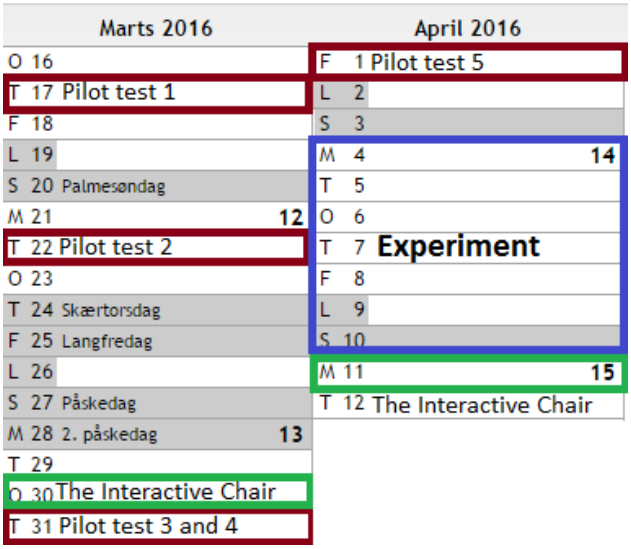

Figure G.1: Time schedule over the pilot tests (red), other tests (green) and the experiment (blue).

Pilot test 1

The purpose of pilot test 1 was to set up the GSR, HR and the EEG equipment and test it on a subject. The GSR, HR and EEG were applied and connected in iMotions. Hereafter the EEG was placed on the subject and an impedance check was executed. Afterwards the 9 minute benchmark was run.

The subject conducted two of the Relaxation Methods, *Relaxing music* (Adele with Hallo) and *Meditation*. The song in *Relaxing music* was played once and lasted 5 minutes and the *Meditation* was 10 minutes long. No data analysis was made, but it could be seen from the measurements that the GSR, HR and EEG data were collected. The test was conducted in a regular armchair with a loudspeaker standing on a table beside the chair, which can be seen in Figure G.2.

Figure G.2: Pilot test 1 setup where the subject sits in the armchair.

Pilot test 2

Since pilot test 1 only investigated how the EEG, GSR and HR could be connected to the iMotions program and collect data, the next pilot test was about investigating the possibilities when examining the data. Pilot test 2 was also about testing a setup closely resembling the intended experiment setup. The program that run the VAS and the backwards digit-span task was not finished at this point and was not tested. The test was run in the regular armchair used in pilot test 1, and therefore only included four Relaxation Methods.

The Four Relaxation Methods were performed for 10 minutes each (*Relaxing muisc* (Blue Foundation with Sweep), *No music*, *Meditation* and *Vibroacoustic*). An additional round was run in the end without music, where the purpose was to investigate what happened when e.g a blanked was giving to the subject. The pilot test took approximately 2 hours.

To measure the GSR, HR and EEG a project in iMotions was setup, however when exporting the data file from the program it was too big to handle in Microsoft Excel. This was caused by the big amount of data from the EEG, that have measured over 1.30 hour continuously. It was

chosen to separate the Relaxation Method rounds in different projects for the following tests, to get some "smaller" data files. This way it would also be possible to calculate an aggregation for the individual Relaxation Methods.

The GSR data measured in the different rounds can be seen in Figure G.3. The mean GSR and HR level for each Round were calculated, where a small difference could be seen between the Relaxation Methods. From the graphs in the iMotions program an overview of the EEG data was examined. From Figure G.3 it can be seen that the subject was interrupted in Round 5, where the GSR is higher. There was calculated one peak for *No music* and *Vibroacoustic* where there in the last round (No music*) was calculated 14 peaks.

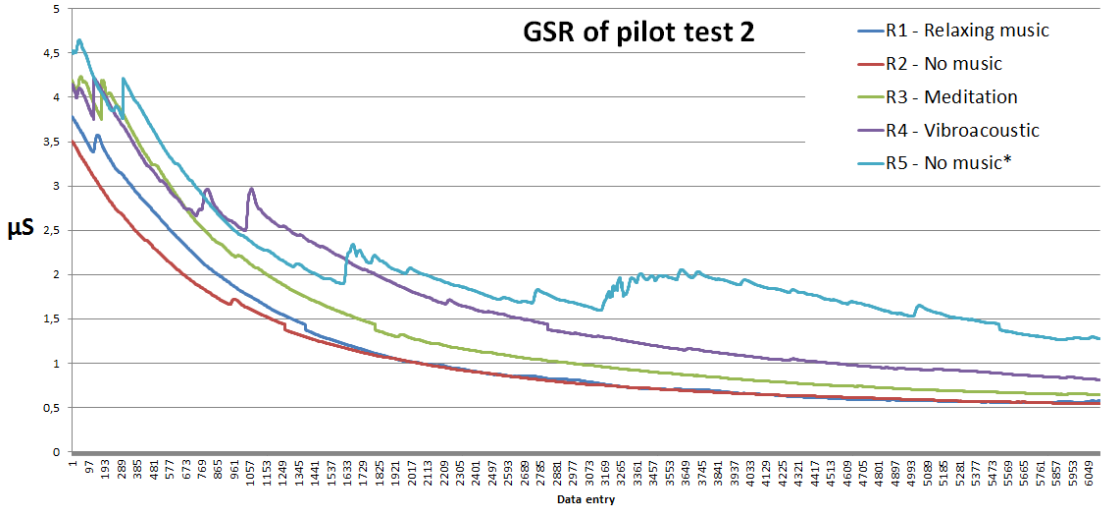

Figure G.3: GSR for the 5 rounds. The y-axis is the GSR in micro-Siemens (μS), and the x-axis is the different data entries during the 10 minutes. In Round 5 different small tests were made. In the first 2 minutes the subject's eyes were open, the next 2 minutes glasses were worn, and in the last 6 minutes the subject had her eyes closed and wore a blanket.

Pilot test 3

Pilot test 3 was performed in The Interactive Chair. Here the focus was on the *Biofeedback* and coordinating it with the other Relaxation Methods in The Interactive Chair where they were to be played form. Since *Biofeedback* play for different length of time depending on the subject sitting in The Interactive Chair (from 7 to 7.30 minute) it was chosen to play all the Relaxation Methods for 7 minutes. The pilot test contained of all the elements used in the experiment. The program that ran the VAS questions and the backwards digit-span task was finished and tested in the setup for the first time. The test took approximately three hours. No problems occurred regarding the GSR, HR or the EEG equipment. However due to technical problems the test was interrupted a few times.

Pilot test 4

Pilot test 4 was the first pilot test that ran without any interruptions. The purpose of this pilot test was to run through the entire experiment to test if everything worked as it should. Some small errors were discovered during the test and corrected afterwards. One thing the facilitator needs to check before the experiment, is to make sure that the song for *Relaxing music* is the correct one. This was not the case in this pilot test since two songs had the same title in Spotify. The GSR for the subject showed that the subject had the lowest GSR for *No music*, and that *Vibroacoustic* got the subject's GSR to raise again after it had been declining for some time. In Figure G.4 and Figure G.5 the EEG placement can be seen.

Figure G.4: Pilot test 4 where the subject gets the EEG placed.

Figure G.5: Pilot test 4 where the subject gets Synapses gel on.

Pilot test 5

It was chosen to shorten the multitask game from 5 minutes to 4 minutes for this pilot test. In pilot test 4 there was a problem with the backwards digit-span task, when showing the first three numbers, which happened again during this pilot test. It was not possible to discover why the problem occurred and it could therefore not be fixed. It was therefore chosen not to include the first two time numbers are shown (the two repetitions containing three numbers) when calculating the backwards digit-span task score. When examining the GSR the subject had the highest GSR for *Meditation* and the lowest GSR for *Biofeedback*. The subject had his head turned downwards during different Relaxation Methods, which resulted in the iMotions program not recognizing any facial expressions for this subject. Since the setup during this pilot test worked, it was the last pilot test conducted.

APPENDIX H

OTHER TESTS

H.1 Volume

When playing the different kinds of music for the Relaxation Methods in The Interactive Chair, it is wanted to know if the subjects are getting exposed to a loudness level that could cause hearing problems. This is done since the subjects will be listening to 7 minutes of music three times during the experiment from the loudspeakers in The Interactive Chair.

To begin with it was tried how loud the loudspeakers and the computer should play together to give a pleasant music experience. Here it was chosen to let the loudspeakers play at 20 presses on the plus volume button. It is not possible to see the rage of the loudspeakers in The Interactive Chair, so it was turned all the way down until no music was heard and then turned up by pressing the plus volume button 20 times. The computer's output volume was then set to 100%. This was in the beginning done for all the Relaxation Methods, but it was chosen to turn the computer down to 60% when playing *Vibroacoustic*, since it gave a lot of noise and was not pleasant to listen to. In order to make sure that the volume of the Relaxation Methods is within safe limits, it was decided to perform a loudness measurement test. The test was performed using an artificial head called MP3 Valdemar, where there was no indication that the subjects will get hearing problems sitting in The Interactive Chair, because the loudness was below the limit of listening to music 8 hours per day (Christensen, 2001).

H.2 Sound pressure level

One thing is that the subject are not getting hearings problems during the experiment, but it is interesting to examine a difference between the music playing in the different Relaxing Methods. Relaxing music is not included since the music pieces are not the same for each subject and played from different sources. A Hand-held Analyzer Type 2270 (Brüel & Kjær) was used to measure the sound pressure levels while placed between the loudspeakers in The Interactive Chair. The analyzer was setup to measure 7 minutes, and measure LAeq, LAF5.0, LAF50.0, and LAF95.0 with the assistance of Claus Vestergaard Skipper. A decription of the different measurements can be seen below (Brüel & Kjær, Manual):

- **LAeq**: An energy measurement that indicates how loud a continuous sound needs to be in order to have the same energy as the measured music.
- **LAF5.0**: A measure that indicates at what sound pressure level the music has been above 5% of the time. This then indicates the loudest sound pressure level in the music.
- **LAF50.0**: A measure that indicates at what sound pressure level the music has been above 50% of the time.
- **LAF95.0**: A measure that indicates at what sound pressure level the music has been above 95% of the time. This then indicates the lowest sound pressure level in the music.

In Table H.1 the results are shown, where it is possible to see that *Vibroacoustic* have the highest LAeq with 64.6 dB, followed by *Meditation* (56.4 dB), *Biofeedback* (48.9 dB), and *No music* (26.3 dB). The difference in the results could have an effect on how the subjects perceived the music during the Relaxation Methods. The purpose of the experiment is not to compare the music from the different Relaxation Methods clinically, and therefore not the music itself but the whole situation.

Relaxation Method	**LAeq**	**LAF5.0**	**LAF50.0**	**LAF95.0**
Biofeedback	48.9 dB	54.0 dB	46.1 dB	32.6 dB
Meditation	56.4 dB	63.9 dB	25.4 dB	24.4 dB
Vibroacoustic	64.6 dB	68.7 dB	63.2 dB	59.2 dB
No music	26.3 dB	30.2 dB	25.6 dB	25.0 dB

Table H.1: Measurements of the sound level in The Interactive Chair.

H.3 Vibration

A vibration test was made to investigate how much difference there is depending on the music played when sitting in The Interactive Chair. An accelerometer was placed on the outside of one of the loudspeakers in The Interactive Chair. The accelerometer was connected to an amplifier and then to a sound card that a computer could use to record the vibrations. The accelerometer was type L338, and the sound card can be seen in Figure H.1 with the settings used during the test. The test was assisted by Claus Vestergaard Skipper.

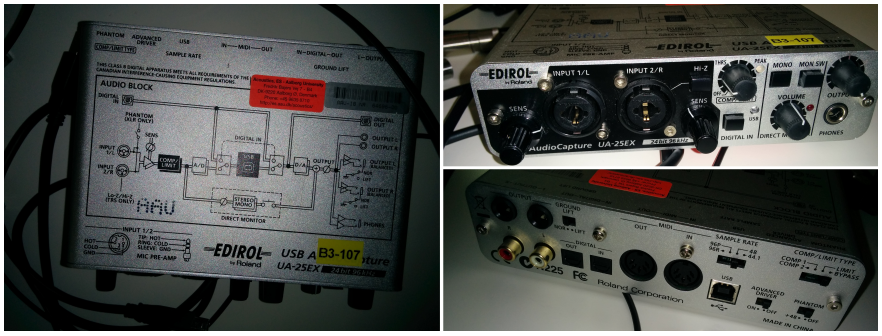

Figure H.1: The sound card that was used during the vibration test.

After measuring the vibrations, the recorded vibrations were analyzed using Audacity[1], where a *Wave Stats* plug-in[2] was used to analyze 30 seconds of each Relaxing Method. In Figure H.2 the measured sound files can be seen for each of the Relaxation Methods, and the results from the test can be seen in Table H.2. The *Relaxing music* used for the test was Enya with Only Time, and was included to get an estimate of the level the *Relaxing music* could be at. A person was sitting in The Interactive Chair during the measurements.

Relaxation Method	RMS
Biofeedback	-34.6 dBFS
Meditation	-36.1 dBFS
Relaxing music	-25.5 dBFS
Vibroacoustic	-26.6 dBFS
No music	-37.1 dBFS

Table H.2: The vibration measurements as RMS without being A-weighted.

No music has the lowest level at -37.1 dBFS, which makes sense since nothing was played through the loudspeakers. *Meditation* (-36.1 dBFS) and *Biofeedback* (-34.6 dBFS) follows as the Relaxation Methods with the least strong vibrations. The Relaxation Method with the highest level, and thereby the strongest vibrations, is *Vibroacoustic* (-26.6 dBFS). However depending on the songs played for *Relaxing music*, could this also have strong vibrations, where this song has measurements close to *Vibroacoustic*.

[1] http://www.audacityteam.org/
[2] http://forum.audacityteam.org/viewtopic.php?f=42&t=38134

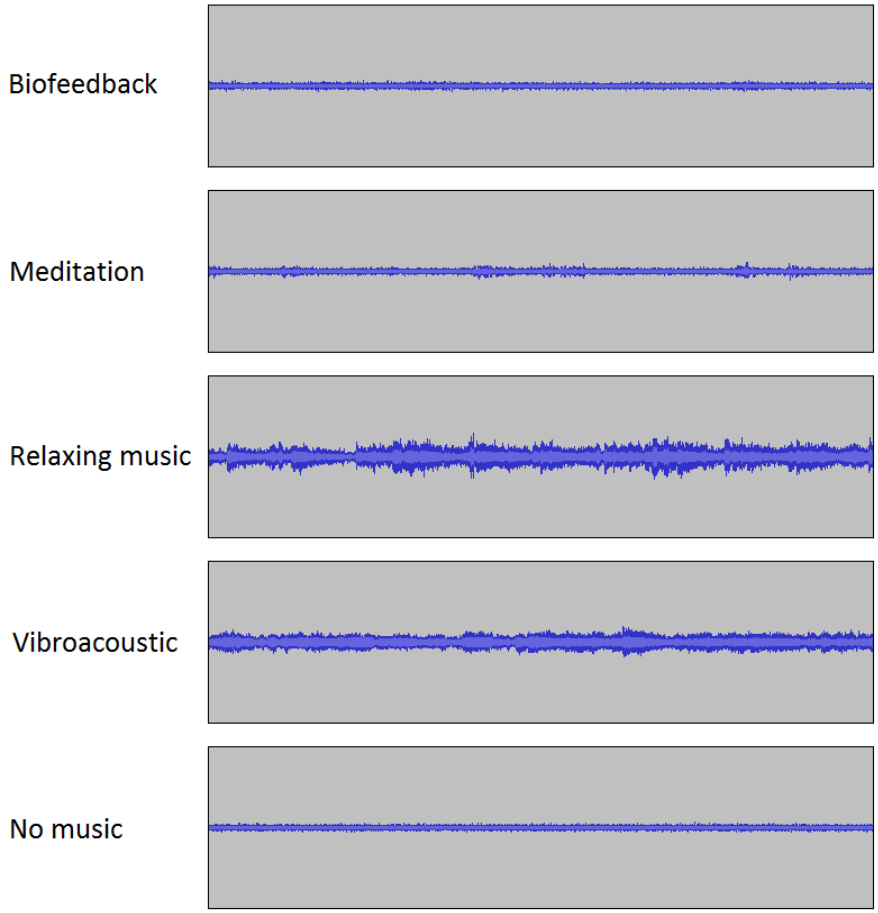

Figure H.2: The vibration measurements of the different Relaxation Methods.

APPENDIX I

ERRORS DURING THE EXPERIMENT

During the experiment different errors occurred. These are listed below in bullet points for the subjects where the errors occurred.

Generally the program that ran the backwards digit-span task had an error that sometimes affected the first two times the order containing three numbers were to be shown. The error resulted in only showing one or two numbers instead of three. This only happened when showing the three numbers, and as a consequence the result from these will not be used for any of the subjects.

When the backwards digit-span task is mentioned in the following bullet points, they will be denoted after how many numbers are shown and if it is the first or second time the that number is shown. E.g 4.2 means that there were shown four numbers, and it was the second time showing four numbers.

- **Subject 1**: The subject had a small fever, which can give higher GSR readings since he felt a bit sweaty and warm.
  When beginning the recording for Round 1 a text was shown in iMotions, however the context of the message was not remembered (it is assumed to be the same message as for Subject 9 in Figure I.2). The round was run and no more errors occurred and the recordings included the EEG brainstates which means is had access to the Benchmark .def file.
  The subject coughed multiply times during the experiment, where the results show that no peaks in the GSR occurred.
  The first four minutes of Round 2 with *Relaxing music*, the *Biofeedback* was played as well. This was first discovered after approximately four minutes, where *Biofeedback* was turned off. The subject said afterwards that he did not hear it before the time the facilitator heard it as well. Therefore it is chosen to keep and use the results from this round anyway.

- **Subject 2**: When beginning the recording for Round 1 in iMotions a text was showing, however the context of the message was not remembered (it is assumed to be the same

message as for Subject 9 in Figure I.2). The Round was run and no more errors curred and the recordings included the EEG brainstates which means is had access to the Benchmark .def file.
Before Round 2 (*Meditation*) the EEG equipment had to be restarted. This was done during the time the subject was playing the multitask game.
This subject had a different facilitator than the others. This facilitator had a cough, but only did it during the time the subject was playing the multitask game, and only during the backwards digit-span task before showing the next set of numbers.

- **Subject 4**: The benchmark of the EEG was run two times due to the error seen in Figure I.1.
  A text was shown when beginning the recording in iMotions for Round 1 regarding the Benchmark (it is assumed to be the same message as for Subject 9 in Figure I.2). The Round was run and no more errors curred and the recordings included the EEG brainstates which means is had access to the Benchmark .def file.

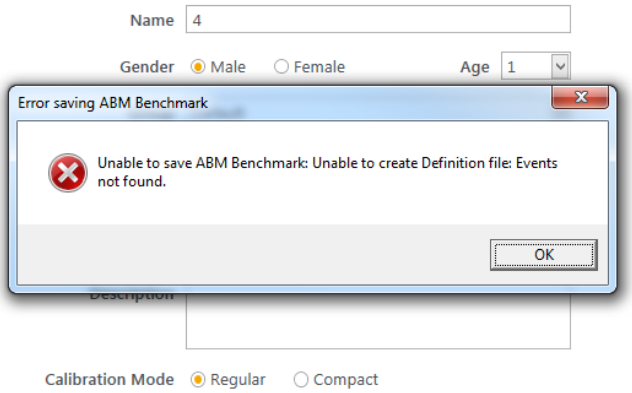

Figure I.1: The error shown after Subject 4 completed the Benchmark the first time.

- **Subject 6**: During *Relaxing music* the volume was purposefully turned down to 60% on the computer (it should have been at 100%) because the music otherwise was too loud. The music was played from Youtube.

- **Subject 7**: In Round 1, the subject dropped the mouse under The Interactive Chair before answering the VAS question on the computer screen. The facilitator helped and gave the subject the mouse again, to make sure the subject did not have to get up from The Interactive Chair.

- **Subject 8**: The impedance check failed, both the reference and the other strip placements. The EEG was restarted, and when this did not work, and the medium EEG strip was placed

on the subject instead. This did not help, and the small EEG was placed again. Every time the strips were replaced new mastoid electrodes were placed. In the end the impedance check was accepted without knowing what caused the error.
The facilitator coughed once during Round 2 when performing the backwards digit-span task 7.1.

- **Subject 9**: There were some problems with the EEG impedance check, both the reference and for the strip placements. The references were replaced and the EEG impedance check was thereafter approved.
  The subject mentioned that she got some headache from the blue screen during the benchmark calibration.
  In Round 1 a text was shown when beginning the recordings in iMotions for the round. The message can be seen in Figure I.2. The round was run without any problems, and the results included the EEG brainstates which means that the program had acces to the Benchmark .def file.
  When the subject got Round 4 (*Relaxing music*), the sound was only turned up to 60% because it had been turned down for the previous round (*Vibroacoustic*). The volume was turned up to 100% after approximately thirty seconds.

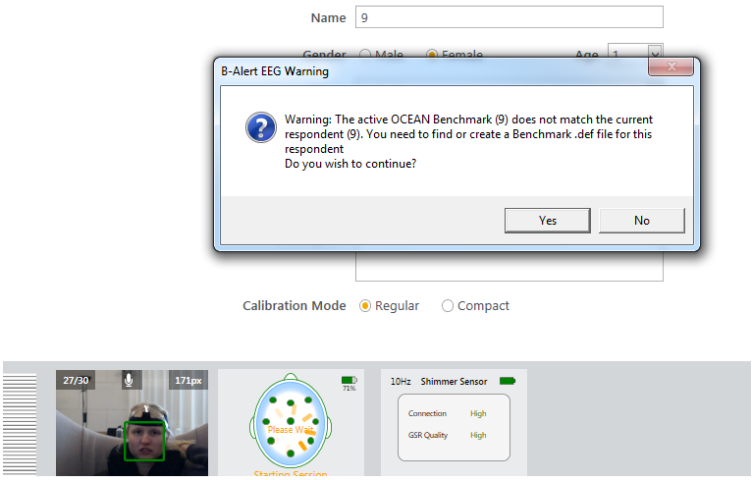

Figure I.2: The error that was shown in iMotions when beginning the recording for Round 1 for Subject 9.

- **Subject 10**: In Round 3 where the subject got *Biofeedback*, it did not start when the subject sat down. The subject was therefore asked to go to and play the multitask game again until the facilitator got *Biofeedback* working again. The subject played one more game and got 50 points (which took approximately one minute).

- **Subject 11**: The impedance check was accepted even though it had one orange electrode (placed on P3). During Round 1 with *Biofeedback* it did not start when the subject sat down. The subject was therefore asked to stand up and sit down twice before it would start.

- **Subject 12**: The subject stood up from The Interactive Chair after answering the R-states question in Round 3. He was instructed to keep sitting in The Interactive Chair in order to complete the backwards digit-span task.

- **Subject 13**: This subject also stood up from The Interactive Chair after answering the R-states questions in Round 3.
  In Round 4 (*Relaxing music*) the EEG was interrupted, and the EEG for the round was not measured. Figure I.3 shows the computer screen when the EEG was interrupt. After that round an error occurred which can be seen on Figure I.4, and the EEG equipment was restarted. During this the subject continued to play the multitask game while the problem was fixed.

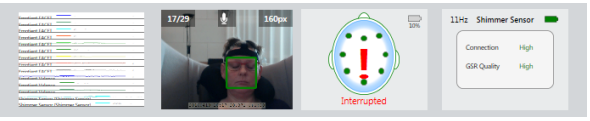

Figure I.3: The EEG was interrupted during Round 4 *Relaxing music* for Subject 13.

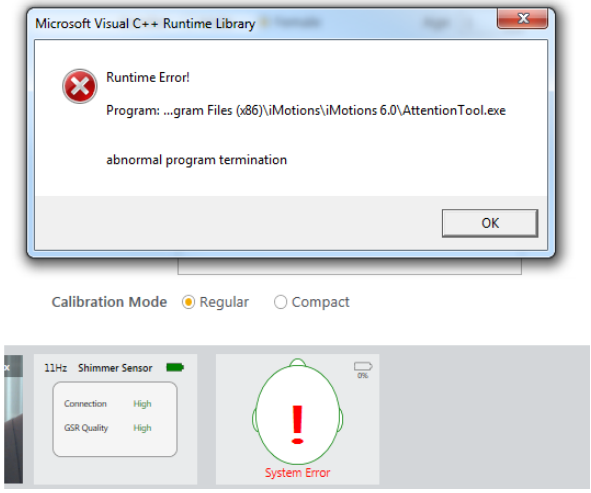

Figure I.4: The error message between Round 4 and Round 5 for Subject 13.

- **Subject 15**: The subject stood up from The Interactive Chair in Round 3 after answering the R-states question, and was instructed to keep sitting in The Interactive Chair in order to complete the backwards digit-span task.

- **Subject 17**: Between Round 1 and Round 2 the EEG equipment did not respond, and the subject was asked to play one round more of the multitask game.

- **Subject 18**: During Round 5 the subject coughed once during the backwards digit-span task 6.2.

- **Subject 19**: The subject mentioned after Round 2 (*Biofeedback*, and *Vibroacoustic* in Round 1) that she got a headache, and that she could feel the music in her teeth. The facilitator said that it was possible to turn down the music, but the subject said it was okay. After the music have been played in Round 3 (*Relaxing music*) she mentioned that her answers were affected by the bass in the music, which gave her a restless body. In the beginning of Round 5 she asked the facilitator to turn down the bass, however the round was *Meditation*, and was therefore not done.

In *Biofeedback* Round 2 the FACET baseline was not applied and must be taking unto account if looking at that data.

- **Subject 20**: When staring Round 2 the EEG equipment lost its connection and the round was interrupted. The subject was asked to play multitask game again, where she played 3 times for about 1.30 minutes in total. In the meantime the EEG equipment was restarted, and the round was restarted.
  In Round 2 and Round 3 the subject forgot that she was to complete the backwards digit-span task and began to rise from The Interactive Chair, but was instructed to keep sitting down.
  After Round 5 (*Relaxing music*) the subject mentioned that it was cheating since she knew how long the music number is (7.6 minutes).

I.1 Missing collected data

This section explain what have been done for the data with missing data entries for GSR, HR and EEG before the data is analyzed.

GSR

There were two subjects who had some missing data that was filled out by using an approximation. This was done by counting the number of missing data entries, and calculate a mean based on this number of data on each side of the missing data. The subjects that had missing data were Subject 1 during Round 4 with *Vibroacoustic* and Subject 10 during Round 4 with *Meditation*. Both subjects had 124 missing data entries.

HR

36 of the 100 rounds have missing data entries, and these will remain blank. This was done due to the fact that HR does not vary much, and the percentage of missing data is between 0.07% to 11.97% where half is below 1%, and only three times above 5%. These three were Subject 1 in Round 4 with *Vibroacoustic* (11.97%), Subject 8 in Round 3 with *Vibroacoustic* (7.92%), and Subject 10 in Round 4 with *Meditation* (9.62%). In Table I.1 the distribution of the 36 round with missing data can be seen. The rounds with missing entries are close to evenly distributed, where Round 1 has the lowest number. For Relaxation Methods it is *Vibroacoustic* that has the most amount of rounds with missing data. All the calculated percentage of missing data can be found on the Attachment.

	Missing rounds		**Missing rounds**
Round 1	5	Meditation	6
Round 2	7	Biofeedback	5
Round 3	7	Relaxing music	5
Round 4	9	Vibroacoustic	12
Round 5	8	No music	8

Table I.1: The amount of missing rounds for each Round and Relaxation Method for HR.

EEG

Only for Subject 13 during *Relaxing music* did an error occur that resulted in that no EEG was measured for either of the five metrics. Otherwise where was no missing data for High Engagement, Low Engagement, Distraction, and Drowsiness. However the data was sometimes not collected for Workload, where it was decided not to fill out the missing data. It was investigated how much of the data that was missing for each round for each subject. Only 39 of the 100 round were there 0% missing data. It could also be seen that Subject 5 during *No music* is missing 84% of the data and Subject 9 during all the rounds have over 50% missing (Round 1 *Vibroacoustic* 92%, Round 2 *Biofeedback* 93%, Round 3 *Relaxing music* 93%, Round 4 *No music* 52%, and Round 5 *Meditation* 87%). In order to get an overall Workload level that represents the Relaxation Methods, it was decided to exclude the rounds with higher than 20% missing data entries. However when closer inspecting the data it could be seen that Subject 1 during *Relaxing music* had 20.24% missing data and Subject 18 during *No music* had 20.71 % missing data. These two were approved to be used as well. In total there were 12 rounds that should be excluded from the 100. The distribution of the rounds with missing data for Round and Relaxation Method can be seen in Table I.2 including how many rounds have been excluded because the missing data exceeds 20% and the number with 0% missing. All the calculated percentage of missing data can be found on the Attachment.

	Missing rounds	**Excluded rounds**	**0% missing**		**Missing rounds**	**Excluded rounds**	**0% missing**
Round 1	11	2	7	Meditation	10	1	9
Round 2	9	2	9	Biofeedback	10	1	9
Round 3	11	2	7	Relaxing music	11	4	5
Round 4	7	4	9	Vibroacoustic	11	4	5
Round 5	11	2	7	No music	7	2	11

Table I.2: The amount of missing and excluded rounds for each Round and Relaxation Method for Workload. The number of rounds with 0% missing data is also shown.

APPENDIX J

INITIAL QUESTIONNAIRE

For the experiment twenty subjects participated. This section will go deeper into a description of the subjects based on their answers to the initial questionnaires. All the subjects answers to the initial questionnaire can be found on the Attachment, where this gives an overview.

In Table J.1 the subjects' age, gender, height and occupation can be seen. Subject 12 has reduced hearing on the left ear and have some light tinnitus. Subject 19 also answered that she has some slight hearing problems. The subjects were asked if they got some motor skills problem, that could affect the experiment. Here Subject 20 answered that she has *Højresidig radialisparese* which meant that the subject could not use the right hand much.

In the experiment there were 9 males and 11 females, the mean age was 31.35 (SD = 13.57), where fifteen subjects were under 27 years and five subjects over 50 years. The mean for the subjects' height was 174.3 (SD = 10.47), where the shortest subject is 160 cm and the tallest subject is 194 cm. From the twenty subjects, twelve subjects are student, four subjects have a job, two subjects are unemployed, and two subjects are not working anymore.

Information about the subjects

Table J.2 shows a summary of the subjects' answers from the initial questionnaire. It can be seen how long since the subjects' approximately had been sleeping from the time they entered the experiment. The time the subjects had slept are also shown, where the span is from 6 hours to 9 hours. If and what the subject had drunk and eaten before the experiment was noted down as well, including any medicine. These could help explain any large difference between the subjects' results. The subjects were also asked if they feel stressed in their everyday life, this question could help explain if the results of some of the subjects show that they do not get relaxed. It shows that twelve subjects do not feel stressed, five subjects answered to some degree

Subjects	**Age**	**Gender**	**Height**	**Occupation**
Subjects 1	25 years	Male	186 cm	Student, Radiographer 3rd semester
Subjects 2	22 years	Male	185 cm	System consultant
Subjects 3	24 years	Male	171 cm	Student, VGIS 10th semester
Subjects 4	25 years	Male	181 cm	Student, VGIS 10th semester
Subjects 5	25 years	Female	163 cm	Cand.it, job seeking
Subjects 6	26 years	Female	171 cm	Optician
Subjects 7	24 years	Female	162 cm	Student, Psychology
Subjects 8	23 years	Female	162 cm	Student, geography 6th semester
Subjects 9	22 years	Female	170 cm	Student, physiotherapist 4th semester
Subjects 10	26 years	Male	186 cm	Student, VGIS 10th semester
Subjects 11	62 years	Female	167 cm	Early retirement pensioner
Subjects 12	54 years	Male	185 cm	Job seeking (hedonist)
Subjects 13	52 years	Female	164 cm	Teacher
Subjects 14	23 years	Female	168 cm	Student, medicine 6th semester
Subjects 15	25 years	Male	189 cm	Student, medicine
Subjects 16	21 years	Female	160 cm	Student, law 4th semester
Subjects 17	26 years	Male	194 cm	Student, medialogy 6th semester
Subjects 18	21 years	Male	180 cm	Student, medialogy 2th semester
Subjects 19	51 years	Female	172 cm	Teacher
Subjects 20	50 years	Female	170 cm	Early retirement pensioner

Table J.1: Overview of the age, gender, height and occupation of the subjects.

(medium, normal, some times, or little), where three subjects answered yes (Subject 5, Subject 8, and Subject 20).

Five subjects had taking medicine the day of the experiment, Otrivin (nasal spray), one Ipren, one antihistamine, and one penicillin, this was Subject 1, Subject 12, Subject 13, Subject 20 respectively, where Subject 5 did not specify the type. None of the subjects smoked the day of the experiment.

Music

The subjects were asked if they had any music experience, where eleven subjects answered that they did not. The subjects that had music experience can be seen below along with their answers in Danish.

- **Subject 1**: "Meget lidt erfaring med guitar. Meget begynderstadie"
- **Subject 2**: "Arbejder med radio og har spillet lidt guitar for mange år siden"
- **Subject 3**: "Keyboard et par år (8-9 år siden)"

Subjects	**Hours since slept**	**Hours slept**	**Caffeine**	**Food** *hours since: what*	**Medicine**	**Feel stress**
Subjects 1	8.30	7	Cola zero	0.30 hour: Yogurt and cocio	Otrivin (nasal spray)	Medium
Subjects 2	5.10	6.5	Small cola	5 hours: Three buns	No	No
Subjects 3	8	7.5	Big coffee (3 hours ago)	0.30 hour: Bun with peanut butter	No	No
Subjects 4	5.30	8	Big coffee	0.15 hour: 3 rye bread, on bun	No	No
Subjects 5	1.40	7		1.15 hours: Oatmeal	Yes	Yes
Subjects 6	1.30	7.5		0.30 hour: Oatmeal	No	No
Subjects 7	2	8.5		Yogurt	No	No
Subjects 8	5.15	8.5		Bun with cheese	No	No
Subjects 9	5	7		0.15 hour: Sandwich	No	Yes
Subjects 10	2.20	7	Small coffee (5 min ago)	1 hour: Oatmeal	No	No
Subjects 11	5	8.5	One coffee	2 hours: Rice and vegetable	No	No
Subjects 12	2.30	6		Yogurt and banana	1 Ipren	Normal
Subjects 13	2.30	6	Small coffee	2 hours: Yogurt, oat bran, apple	1 Antihistamin (allergic)	No
Subjects 14	5.30	6	One coffee	Two rye bread with liver paste		Some times
Subjects 15	7.15	6	Two cups coffee	5 hours: Chili con carne	No	Some times
Subjects 16	2.30	8.5		1.30 hours: Two bun	No	Little
Subjects 17	9.30	6		3 hours: Rye bread		No
Subjects 18	9	7.30		1.30 hours: Sausage roll	No	No
Subjects 19	4.30	8	Yes a lot	1 hour: Lunch	No	No
Subjects 20	2.15	9	One coffee	1 hour: Smoothie	Penicillin	Yes

Table J.2: Overview of what the subjects ate, drank, if they took any medicine, how much they slept, and how stressed they felt before the experiment.

- **Subject 8**: "Bokfløjte"
- **Subject 9**: "Sang"
- **Subject 12**: "Ja handlet med musik i mange år"
- **Subject 14**: "Ja. Jeg har spillet guitar"
- **Subject 19**: "ja, snoezel og mit job"
- **Subject 20**: "Ja - uddannelses- og beskæftigelsesmæssigt; Spille instrument(er), omfattende amatørmusikdyrkning mm."

Meditation

From the answers to the initial questionnaire it can be seen that ten subjects have not tried to meditate before. The ten subjects that have tried it, are at different levels. Six of those subjects are categorized as being experienced with meditation or having meditation like experience. These subjects have a * after their subject number below. Their answers can be seen below in Danish.

- **Subject 1**: "Til Yoga en gang. Ikke særlig erfaring"
- **Subject 2**: "Ja, kun meget lidt"
- **Subject 5**: "Ja, er begynder"
- **Subject 7**: "Ja, ikke erfaren"
- **Subject 9***: "Har dyrket yoga i to år"
- **Subject 11***: "Ja - gennem flere år"
- **Subject 12***: "Ikke direkte meditere men tilsvarende"
- **Subject 13***: "Ja. I perioder gør jeg det hver dag. Har haft meditation inde i mit liv de sidste 15 år. Mediterer mest, når jeg oplever mig selv som stresset"
- **Subject 19***: "Ja, en del"
- **Subject 20***: "Ja, low-medium erfaring"

APPENDIX K

EXIT INTERVIEW

This section will consist of what the subjects generally thought about the experiment and what they thought about the different Relaxation Methods. The data containing all the subjects answers to the exit interview can be found on the Attachment. This therefore only includes summaries and relevant comments.

During the exit interview the subjects were asked which round (and thereby which Relaxation Method) they found most relaxing and which they liked the least. The answers from these questions are shown in Figure K.1 containing two pie charts. In the left it can be seen that *Relaxing music* (35%) and *Meditation* (40%) are the two methods the subjects felt they where most relaxed in. The Relaxation Methods that the fewest subjects preferred are *Biofeedback* (10%), *No music* (10%), and *Vibroacoustic* (5%).

From the right graph in Figure K.1 it can be seen that 0% thought that their own music was the least liked (*Relaxing music*). This is not a surprise since the subjects chose the song themselves. After that comes *Biofeedback* (16%) and *Meditation* (16%), where *No music* (31%) and *Vibroacoustic* (37%) are the least liked Relaxation Methods. During the experiment the subjects had difficulties separating *Biofeedback* and *Vibroacoustic* since they sounded similar. *Vibroacoustic* is not designed to The Interactive Chair and can explain why it gets the highest disliked. Subject 20 did not have a round she liked less than the others and is not taking into account in the graphs.

In Figure K.2 the answers are categorized depending on the order of the rounds instead of Relaxation Methods. It can be seen that only one subject chose Round 1 as the most relaxing where the other rounds have at least three subjects in each. When looking at the least liked round, it is Round 1 that is chosen most of time (32%). This can be because they forget the feeling they had in the first round or that they had trouble relaxing in the first round. This is also the reason for using Latin Squares design to counteract this effect. The questions are asked at the end of the experiment and the subjects could therefore have difficulties remembering all the relaxation Methods. This is the reason for asking the R-states questions after each Relaxation Method.

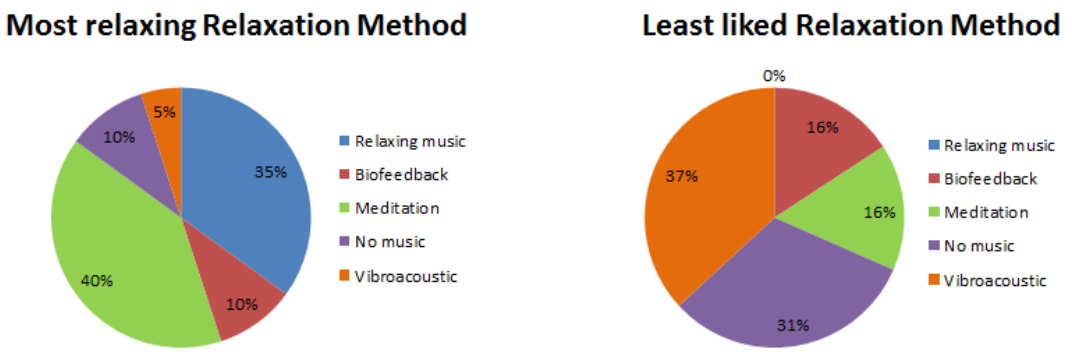

Figure K.1: The different Relaxation Methods the subjects felt most relaxed to and the one they liked the least.

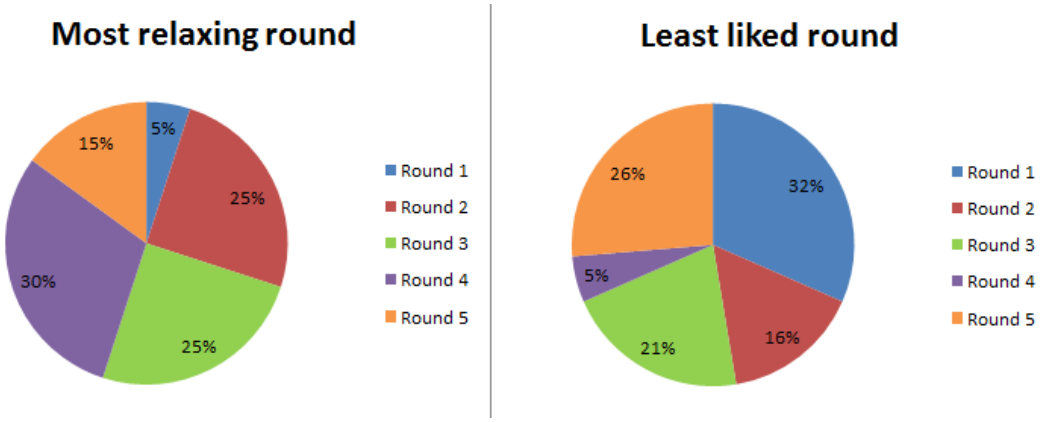

Figure K.2: The different rounds the subjects felt most relaxed in and the rounds they liked the least.

General comments

Two subjects mentioned in the exit interview that they were cold, a couple more mentioned it during the experiment. This could not have been caused by the room temperature, that was steady during the experiment, but could be that their body temperature fell since they were sitting down and did not move that much during the experiment. This is also the reason for why the subjects should perform the multitask game standing, in the hope that it would get the subjects blood flow going again between the rounds. This has unfortunately not helped all the subjects.

Subject 20 did unfortunately have an uncomfortable experience during the experiment, which was caused by the different tasks that she felt difficult to perform. After the experiment a talk with the subject was taken, where it was made clear that she would not directly be compared to the other subjects because it is known that people are different. That the subject felt uncomfortable can have affected the data from this subject. Below are some of the other comments that the subjects said during the exit interview.

- **Subject 4**: It is hard to relax when I just was working on my report before entering the

experiment, so it was hard not to think about that during the experiment.

- **Subject 5**: Exhausting that you have to sit in one specific way, which meant that it was hard to relax.
- **Subject 6**: I was cold after each time I played the multitask game. When I was sitting in The Interactive Chair I used the first half minute thinking that I was cold, hereafter I began to relax and forgot I was cold.
- **Subject 8**: Could not relax in my neck and the pillow did not help.
- **Subject 11**: Did probably use meditation techniques all the time I sat in The Interactive Chair.
- **Subject 12**: During the experiment the thoughts were flying around, and was trying to relax with a breathing exercise. He felt he had the same breathing throughout the experiment.
- **Subject 13**: Felt cold during the experiment.
- **Subject 16**: Got more and more relaxed, but not in Round 5 where there was no music.
- **Subject 17**: The comfort was the same all through.
- **Subject 20**: Did not like the first three rounds with *No music*, *Vibroacoustic* and *Biofeedback*. They where hard to do because I have to be familiar with the situation. I felt challenged, old and half stupid, when doing the different tasks. I am an other generation than you, and I was thinking on how I was thinking about the older generation when I was in your age.

The Interactive Chair

The subjects liked The Interactive Chair and the idea with loudspeakers implemented. Some of the subjects said it felt like sitting in their own bubble, where some of the subjects afterwards asked if the facilitator also could hear the music that was played. This give an indication that they felt isolated when sitting in The Interactive Chair and perhaps got an immersive experience. Two subjects mentioned that the vibrations some times interrupted the music experience. Three subjects said that they liked that The Interactive Chair vibrated.

Two subjects mentioned that there was not enough support to the back, and eight subjects mentioned that there was less neck and head support. Four subjects mentioned that some kind of footstool could be nice. Below some of the subjects' individual comments can be seen regarding The Interactive Chair:

- **Subject 2**: Some times the vibration of the sound interrupts the music experience.
- **Subject 5**: Think I can sit comfortable if I get free movement. The Interactive Chair did not fit my size, I could not touch the ground with my feet, which was a bit unpleasant.

- **Subject 6**: Need some support to my neck, could have been sitting better. When I use the U-pillow it did not help.
- **Subject 7**: I like that you can feel The Interactive Chair.
- **Subject 8**: Missing head support, maybe arm support when having the GSR on, I could not sit with my hands as I am used to. E.g place my hands between my legs. The Interactive Chair is soft and nice with so much space.
- **Subject 15**: Fine chair, good sound and bass. Due to my body structure I could maybe use some neck support, but did not think about it during the experiment.
- **Subject 18**: Not good for head support, did not sit natural as if I am sitting at home when relaxing. Would probably hang a bit more in the body. Did like that I could feel the sound, it gave some good movements in The Interactive Chair when there was deep sounds.
- **Subject 19**: The Interactive Chair gave a lot of bass during the rounds, which affected the music. I did not like that. The Interactive Chair was however comfortable.

Vibroacoustic

The comments about *Vibroacoustic* was generally that there was happening a lot of thing in the music and the vibrations in The Interactive Chair were intense. Two subjects mentioned it was stressing, and one mentioned it was annoying. The Relaxation Method with *Vibroacoustic* was not popular, seven subjects mentioned that they liked this round less than the others. One subject thought *Vibroacoustic* was the most relaxing, and one subject thought *Vibroacoustic* was the best but thought *Meditation* was the most relaxing. Below some of the comments about *Vibroacoustic* can be seen.

- **Subject 1**: In Round 4, where there was a some instrumental sounds, I got some strange pictures as if I was on drugs. The pictures were mixing together and gave some new pictures.
- **Subject 5**: I liked Round 2 with *Vibroacoustic*, it was the round where I was most relaxed. (The subject got *No music* in Round 1, and later said that it was Round 5 with *Relaxing music* that was the one she got most relax to.)
- **Subject 6**: Round 4 was powerful, but it was not bad.
- **Subject 9**: Did not like Round 1, when The Interactive Chair vibrated a lot, it did not make me relax. Felt like being on a savanna.
- **Subject 12**: There was a big difference in the musical impact, especially Round 4 with *Biofeedback* and particularly Round 5 with *Vibroacoustic* that had an annoying heavy bass.

- **Subject 13**: Round 3 was confusing in the start, but then I could feel it in the body. I should in the beginning of the round learn that it showed where my body was.

- **Subject 14**: In Round 1, there was a lot of sounds I should relate to, really intense. This was a bit stressing in the beginning, but not when I got familiar with it.

- **Subject 17**: Round 5 did stress me (*Vibroacoustic*).

- **Subject 19**: Could not remember that there was two different music pieces. They had the same music picture, when taking about *Vibroacoustic* and *Biofeedback*. But told that the two pieces gave her a feeling of being in a glass dome in the sea, it was relaxing and interesting.

The following two subjects felt that *Vibroacoustic* was the best and the most relaxing:

- **Subject 7**: Round 5 with *Vibroacoustic* was the best round. The most pleasant was one of the times where there were music.

- **Subject 16**: Round 4 with *Vibroacoustic* was the most relaxed. I came from Round 3 with *Meditation* where I was relaxed and then I came over to this round.

Seven subjects that preferred *Vibroacoustic* the least, and had the following reasons:

- **Subject 8**: Round 3 with *Vibroacoustic*. Began to be impatient, the music did not let me to think nice thoughts.

- **Subject 9**: Round 1 with *Vibroacoustic*.

- **Subject 12**: Round 5 with *Vibroacoustic*. The bass growled through the body, it was annoying, it was not possible to relax to the music though the music was okay.

- **Subject 13**: Round 3 with *Vibroacoustic*. It felt like the sound/vibration came all over in the body, if it had started in the legs and then was going up, it would be better.

- **Subject 15**: Round 2 with *Vibroacoustic*. The music was wild and not really harmonic and at the same time the music was complex so there was a lot of things to relate to, without a pattern.

- **Subject 17**: Round 5 with *Vibroacoustic*. There was some kind of noise that stressed me, to many sounds.

- **Subject 19**: Round 1 with *Vibroacoustic*. It was the one that was most fresh but also did have most bass.

No music

When performing *No music* in The Interactive Chair the subjects had trouble concentrating. They said that it was boring because nothing happened. Six subjects mentioned that they least liked the round with *No music*, two subjects thought that the round without music was the most relaxing. Some of the comments regarding *No music* can be seen below.

- **Subject 1**: In the last round, I was a really unrestful my thoughts were flying around.
- **Subject 4**: In Round 4 where there was *No music*, I got restless, I had the feeling of restlessness a bit before there was *No music*. Which probably also has an influence that I got more restless.
- **Subject 6**: In Round 5 it took longer to fall down, but I felt far away when the time was done.
- **Subject 10**: In Round 1, where there was *No music*, I could not relax, had a feeling that there came some music, which can do that I was a bit tense.
- **Subject 13**: Round 2, where there was *No music* was stressful. I was thinking about the task with the numbers I should go through afterwards. I have had stress and know it affects my memory.

The subjects that found *No music* the best and most relaxing, and their reasons:

- **Subject 12**: Round 3 was the best round, without music, where I felt relaxed.
- **Subject 19**: Round 4 without music, the bass interrupts me too much physical in my body in Round 1 with *Vibroacoustic* and Round 2 with *Biofeedback*. My own song did also have too much bass, otherwise it would probably be the round I would rate higher.

The subjects that preferred *No music* the least, and their reasons:

- **Subject 1**: Round 5 with *No music*. Could not stay calm, and did maybe compare the round with the other rounds. It felt like the time went slow, and sat there in a long time.
- **Subject 2**: Round 3 with *No music* or Round 5 with *Vibroacoustic*. The round without music made me think a lot on many things.
- **Subject 3**: Round 2 with *No music*. Sat and looked out in the air (the Danich "Stenede").
- **Subject 4**: Round 4 with *No music*. Hard to concentrate, restless and had been sitting in The Interactive Chair a long time at this point.
- **Subject 10**: Round 1 with *No music*. I maybe expected that there came some music.
- **Subject 16**: Round 5 with *No music*. There was *No music* which was boring.

Meditation

Some of the subjects had trouble concentrating during *Meditation*, where others thought it was good to be guided through the meditation. There were eight subjects that found *Meditation* the most relaxing, three subjects least liked *Meditation*. The following are some of the comments regarding *Meditation*.

- **Subject 3**: In Round 1 with the *Meditation*, I tried to follow the guide, but are not that good at things like that.
- **Subject 4**: During *Meditation* in Round 5. I was concentrating and the restless got smaller than it was in Round 4 with *No music*.
- **Subject 7**: Are not that happy for Round 2, with *Meditation*. Get the feeling that I am falling down, so will prefer to lie on the floor when meditating.
- **Subject 12**: Round 2, with the *Meditation*, was annoying with the voice which was frustrating.
- **Subject 14**: Round 5 with *Meditation* confused more than it benefited with that voice, at this point I just sat and waited for the time to finished.
- **Subject 18**: In Round 1 with *Meditation*, it was hard to relax because I should listen to the guide.

The subjects that found *Meditation* the best and/or most relaxing:

- **Subject 1**: Round 3 with *Meditation* was most relaxing. I was able to not think about other stuff and not be tense. The most of the time I felt like I was in some kind of trance where I felt more sleepy than awake.
- **Subject 2**: Round 2 with meditation or the one afterwards with some sound of waves. (The subject got *No music* in Round 3, so he was probably referring to *Biofeedback* that he got in Round 4 or *Vibroacoustic* that he got in Round 5).
- **Subject 6**: Round 3 with *Meditation* was most relaxing.
- **Subject 7**: Round 2 with *Meditation* was the most relaxing round but also most unpleasant. (She had before answered that she felt like falling during the *Meditation* round.)
- **Subject 8**: Round 1 with *Meditation* was good, this was the most relaxed of the all.
- **Subject 9**: Round 5 with *Meditation*.
- **Subject 10**: Round 4 with *Meditation* was most relaxing. I got guided to get my thoughts to another place. Where in the other rounds my thoughts were flying around.
- **Subject 11** Round 3 with *Meditation* was best. The guide was good.
- **Subject 16**: Round 3 with *Meditation* was best. The guide mentioned that I should focus on breathing, which did not happen when just listening to music.

- **Subject 17**: Round 2 with *Meditation*. The guiding was good, fine with the bells, they fit when my thoughts were wandering.

Three subjects preferred *Meditation* the least:

- **Subject 7**: Round 2 with *Meditation*.
- **Subject 14**: Round 5 with *Meditation*. Did not get relaxed.
- **Subject 18**: Round 1 with *Meditation*. It did not work, could not feel anything.

Biofeedback

The first set of bullet points are general comments about *Biofeedback*. There were two subjects that liked this Relaxation Method the best, and found it most relaxing. Three subjects liked this the least. The subjects had difficulties distinguishing between *Biofeedback* and *Vibroacoustic*, as seen in the bullet points as well.

- **Subject 4**: Round 1 with *Vibroacoustic* and Round 2 with *Biofeedback* was okay, there was a difference in the two rounds. In Round 2 (*Biofeedback*) I felt like I was part of the music, as if I was in a cave.
- **Subject 11**: Round 1 with *Biofeedback*, where there was a lot of deep bass, was annoying. It went into my body.
- **Subject 13**: Round 5 with *Biofeedback* was enormously relaxing.
- **Subject 14**: Round 1 with *Vibroacoustic* sounded a bit like Round 2 with *Biofeedback*, but it was not that stressing as in Round 2 and liked the music in this round better.

The two subjects that found *Biofeedback* the best and most relaxing:

- **Subject 14**: Round 2 with *Biofeedback*.
- **Subject 15**: Round 3 with *Biofeedback*. It is strange music, and I do not think the music was good, but it was the round I was most relaxed in.

The three subjects that preferred *Biofeedback* the least, and their reason:

- **Subject 5**: Round 3 with *Biofeedback*. Could feel I was cold which made it difficult to relax. The sound was not relaxing.
- **Subject 6**: Think it is Round 1 with *Biofeedback*, they were much alike.
- **Subject 11**: Round 1 with *Biofeedback*. I did not know what would happen.

Relaxing music

There was none of the subjects that found their own music choice as the round they liked the least. In the bullet points some of the comments the subjects mentioned during the exit interview can be seen.

- **Subject 4**: In Round 3 where I was listening to my own music, it was much easier to clear my thoughts. I know the music and know was is happening in the music, which is easy to relate to.
- **Subject 6**: In Round 2, with my own music, it was really nice, and felt a joy of recognition.
- **Subject 12**: Round 1 was well-known and I could relax, but not as much as I had expected. I am sitting and are tense.
- **Subject 14**: In Round 3 it was nice to try my own music this way. It felt like she was whispering in my ear and could feel the bass hit me in the back. When I am at home and listening to the song, I feel like it is a relaxed song, but I did not think the same here. It was more violent, there were more sounds I could feel in The Interactive Chair.

The subjects that found *Relaxing music* the best and/or most relaxing:

- **Subject 3**: Round 4 with my own music. It is a good number and it gets me down in gear, and as well happy.
- **Subject 4**: Round 3 with my own music was best and most relaxed. I knew what was happening in the music. Otherwise it is maybe Round 5 with *Meditation*, it is a small difference between these two. When sitting in The Interactive Chair I had a lot of thoughts, when listening to my own music I could focus on the rhythm in the song. During *Meditation* I was thinking about the respiration.
- **Subject 5**: Round 5 with my own music. It was most relaxing, I got the full experience of the potential of The Interactive Chair. It was like sitting in my own home and relax, felt at home.
- **Subject 8**: Round 4 with my own song was best. It is a good song and my thoughts were wandering to good things, not about things I need to do later on.
- **Subject 10**: Round 5 with my own music was best. I was able to not think about stuff that much, than in the other rounds.
- **Subject 11**: Round 2 with my own music was the most relaxing.
- **Subject 13**: Round 4 with my own music, but maybe it was too relaxing in the end, maybe I fell asleep.
- **Subject 18**: Round 4 with my own music. It is music I like to listening to and have chosen it on my own. It is the same music as I would have chosen at home, it is identifiable.
- **Subject 20**: Round 5 with my own music was most relaxing. The whole setup was awkward, and did not feel like I performed the best.

The subjects' own song choice

The subjects were asked why they feel that the song they brought to the experiment is relaxing. In the bullet points the subjects reasons can be seen, and in Appendix C.3 the songs the subject had chosen can be seen. General they chose the song because it is familiar and give them some good thoughts.

- **Subject 1**: Sounds good, have heard it so many times that I know the text, it is familiar.
- **Subject 2**: Like acoustic guitar, it gets me to relax.
- **Subject 3**: It has a down in gear tempo, the vocal are low.
- **Subject 4**: Have used the song to fall asleep to, otherwise I use it when I need to concentrate.
- **Subject 5**: It is music that makes me feel good. Quiet and relaxing pop/rock are the kind of music I get most relaxed to.
- **Subject 6**: It reminds me of some good memories.
- **Subject 7**: There are not any high tones, bass or noise that can disturb me.
- **Subject 8**: My brother use to play it on piano at home.
- **Subject 9**: I have heard the song through the last five yeas maybe. The song gives me some good memories when I am closing my eyes. It is also a good clear musical number with a good lyrics and vocal.
- **Subject 10**: The music have different levels of speed, the text is easy to understand, and I do not use my head to think about what they are saying, plus there is classic piano.
- **Subject 11**: Like to listen to water.
- **Subject 12**: It just works. The song helped me when I had a whiplash (the Danish "piskesmæld") to fall asleep. It is relaxing and like nature sounds. Mantra like.
- **Subject 13**: She sings slowly and the music is slow as well.
- **Subject 14**: Slow tempo, the background music is playing in a loop, the finger play on the guitar are the same all through the song.
- **Subject 15**: It is not boring, but at the same time not a lot is happening. It do that you need yourself to fill the rest out, and therefore do not have time to think about other tings.
- **Subject 16**: Because you can listening to it and know the music.
- **Subject 17**: Feel I get into a relaxing universe, feel save.
- **Subject 18**: Deep longs tones, it is possible to listen to it a long time without it getting to wild. Maybe a bit hypnotizing.

- **Subject 19**: Because you can hear the ground rhythm/heart beat instrumental, the vocal are only tones.
- **Subject 20**: Rhythmic moderate, there is a rhythm but it is not clear.

Backwards digit-span task

Many of the subjects gave some kind of indication that they did not find the backwards digit-span task easy. Some of the subjects mentioned the backwards digit-span task, and the comments are:

- **Subject 1**: To make it easier for myself, I converted the numbers to pictures and made a history. E.g 1 is a mast, 2 is a swan... I am not that trained in it, but I think it works better than just remembering normal.
- **Subject 4**: It is hard to start with the memory task, when you have just been relaxing with closed eyes.
- **Subject 9:** The memory was annoying, some of the thoughts I had during the relaxing time did come up and confused me. Especially with 7, 8 and 9 numbers. Would like that it was possible to skip the numbers when I know I can't remember the whole row.
- **Subject 13**: I had a system, tried to remember two or three numbers at the time, but even though I am trying to remember it in my head I forget it, probably because I have had stress.
- **Subject 19**: If it had been visual memory I would be better.

APPENDIX L

OVERVIEW OF THE DATA

The data included in the results are the measurements from iMotions for GSR, HR, and EEG divided between High Engagement, Low Engagement, Distraction, Drowsiness, and Workload. The subjective measurements are the VAS and R-states questions. Additional the a score for the backwards digit-span task has been calculated. On the Attachment all the ANOVAs and linear models used for the statistical analyses can be found along with the raw data sets.

L.1 Aggregated graphs for Relaxation Methods

In the iMotions program a mean can be calculated for the different Relaxation Methods. These *aggregated graphs* can give an overview of the difference between the Relaxation Methods. The figures to the left show the different Relaxation Methods' EEG measurements in the following order in the graphs: High Engagement, Low Engagement, Distraction, Drowsiness and Workload. The figures to the right show the different Relaxation Methods' HR, PPG, GSR and Peaks in this order.

In Figure L.1 and Figure L.2 the measurements from *Meditation* can be seen. In Figure L.3 and Figure L.4 the measurements from *Biofeedback* can be seen. In Figure L.5 and Figure L.6 the measurements from *Relaxing music* can be seen. In Figure L.7 and Figure L.8 the measurements from *Vibroacoustic* can be seen. In Figure L.9 and Figure L.10 the measurements from *No music* can be seen. The individual graphs for each subjects can be found on the Attachment.

Generally it can be seen that there is a lower level for High Engagement and Low Engagement compared to Distraction. It seems that none of the Relaxation Methods show any Drowsiness, and it does not look like these aggregated graphs for Workload can be used. For HR there does not seem to be a difference between the Relaxation Methods. The GSR level seems to decline for the Relaxation Methods, where some decline more than others. Based on the graphs it is also difficult to determine anything from the GSR peaks, where only *No music* seems to

have fewer peaks towards the end. Since there does not seem to be any patterns throughout the Relaxation Methods to divide the EEG after, the overall data will therefore be used.

Figure L.1: *Meditation* for EEG, High Engagement, Low Engagement, Distraction, Drowsiness and Workload.

Figure L.2: *Meditation* for HR, PPG, GSR and Peak.

Figure L.3: *Biofeedback* for EEG, High Engagement, Low Engagement, Distraction, Drowsiness and Workload.

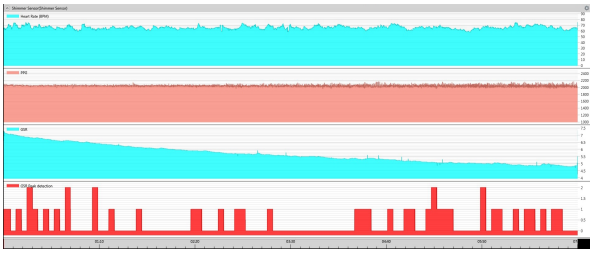

Figure L.4: *Biofeedback* for HR, PPG, GSR and Peak.

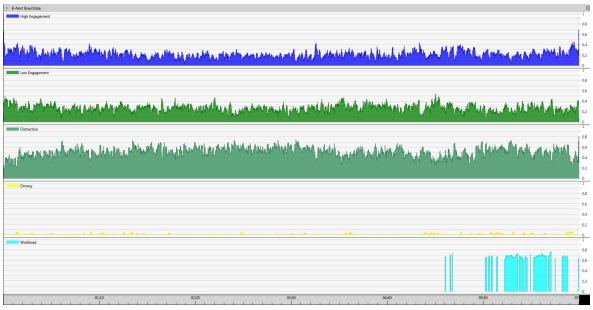

Figure L.5: *Relaxing music* for EEG, High Engagement, Low Engagement, Distraction, Drowsiness and Workload.

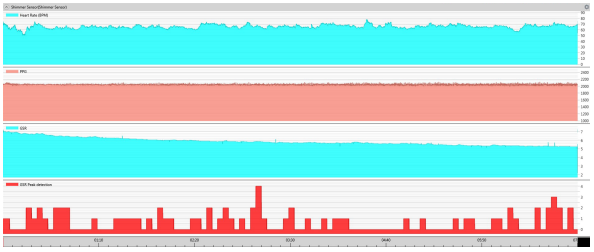

Figure L.6: *Relaxing music* for HR, PPG, GSR and Peak.

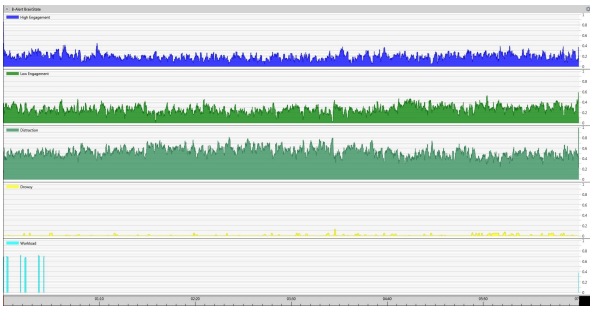

Figure L.7: *Vibroacoustic* for EEG, High Engagement, Low Engagement, Distraction, Drowsiness and Workload.

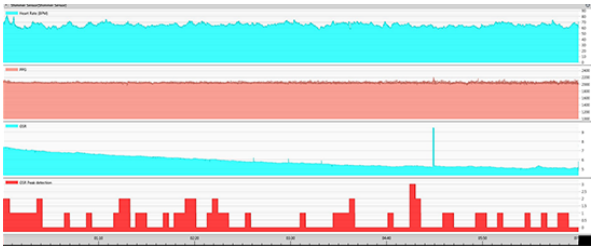

Figure L.8: *Vibroacoustic* for HR, PPG, GSR and Peak.

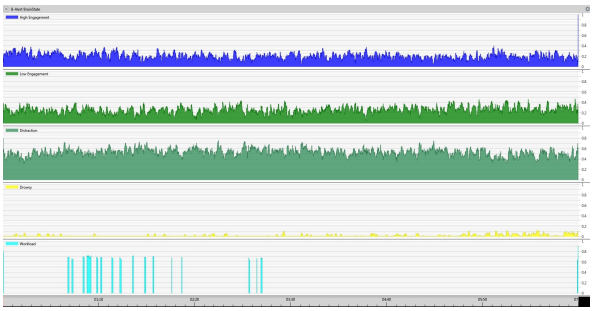

Figure L.9: *No music* for EEG, High Engagement, Low Engagement, Distraction, Drowsiness and Workload.

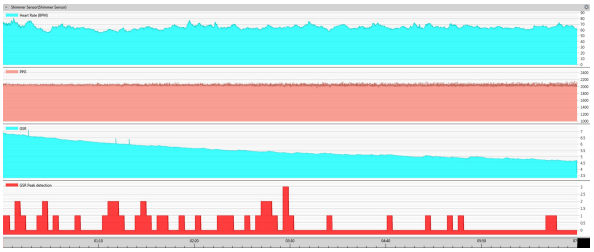

Figure L.10: *No music* for HR, PPG, GSR and Peak.

L.2 GSR

To get an overview of the collected GSR data, a histogram was made which can be seen in Figure L.11. In the histogram the frequency can be seen on the y-axes and are the amount of GSR data entries. The x-axes has the GSR value in micro-Siemens (μS). From the histogram it can be seen that most GSR measurements are from 1 μS up to 9 μS.

To examine the individual differences between the subjects a Plot of Means for each subject is made and can be seen in Figure L.12. Here it can be seen that Subject 2, Subject 5 and Subject 18 have the largest whiskers, which indicate that the GSR changed more for these subjects. It can also be seen that Subject 7, Subject 8, and Subject 15 have small whiskers, which indicate that these subjects' GSR have been almost the same during the experiment.

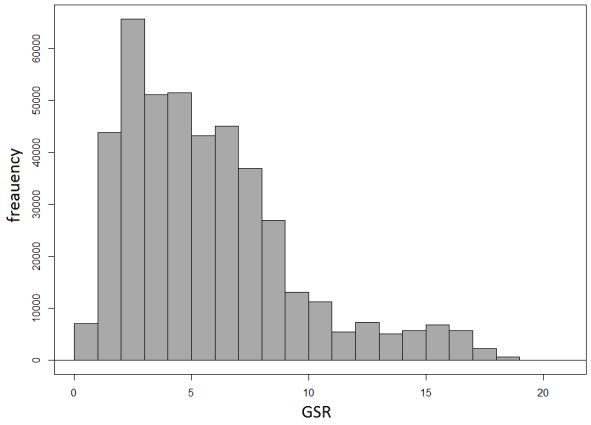

Figure L.11: Histogram based on GSR.

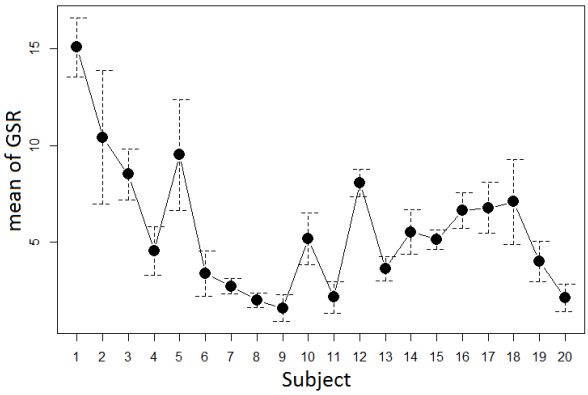

Figure L.12: Plot of Means for each subjects' GSR data entries (standard deviation).

Individual GSR graphs

In the following twenty figures (Figure L.13 to Figure L.32) the GSR data for each subject have been plotted divided between the Relaxation Methods. This is to show the difference between the subjects, and to see that some have a decreasing GSR through the rounds (e.g. Subject 2) where others do not (e.g. Subject 1).

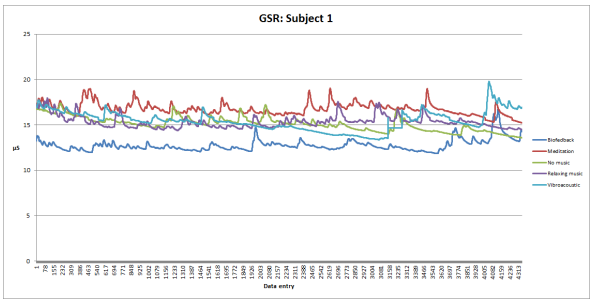

Figure L.13: GSR for Subject 1.

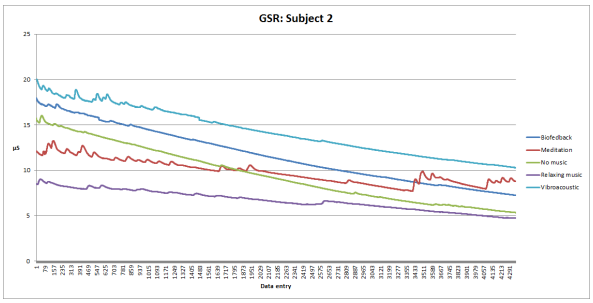

Figure L.14: GSR for Subject 2.

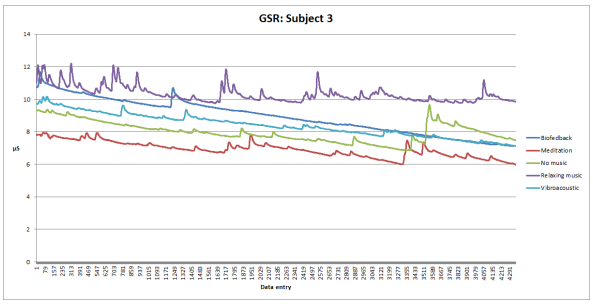

Figure L.15: GSR for Subject 3.

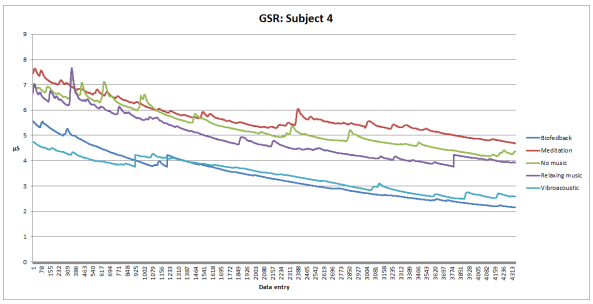

Figure L.16: GSR for Subject 4.

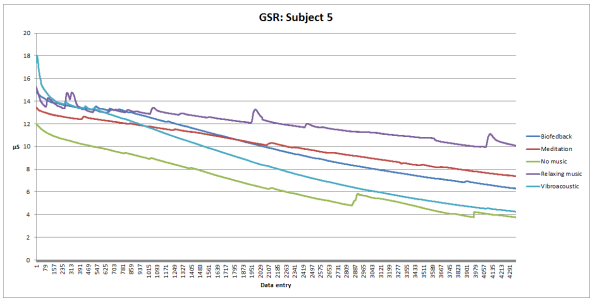

Figure L.17: GSR for Subject 5.

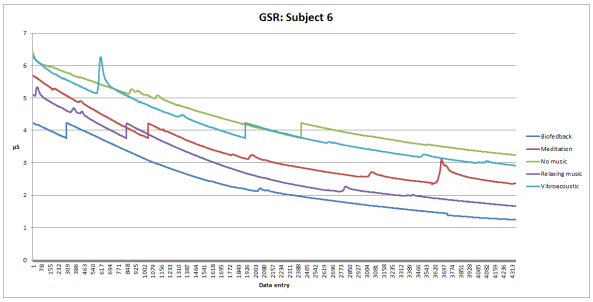

Figure L.18: GSR for Subject 6.

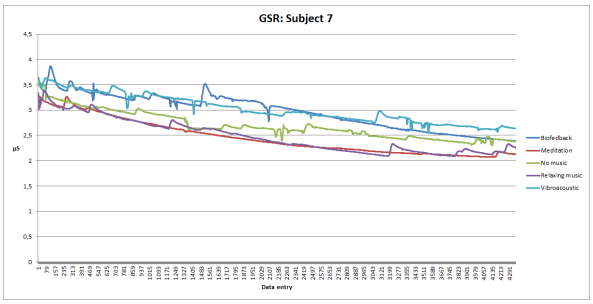

Figure L.19: GSR for Subject 7.

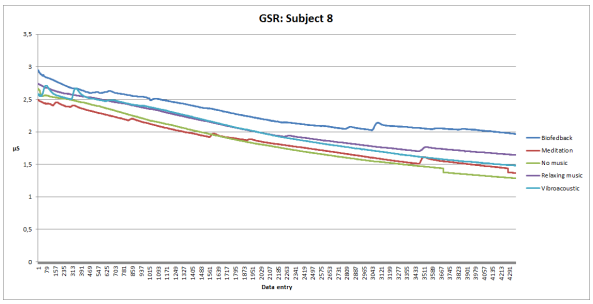

Figure L.20: GSR for Subject 8.

Subjects that looked like they had a decline

If examining the individual graphs for the subjects' GSR, it can be seen that some of the subjects have a decline where others do not. In Table L.1 the subjects are separated in two. A group that do not seems to have a decline and a group that seems to have a decline. The effect plots can

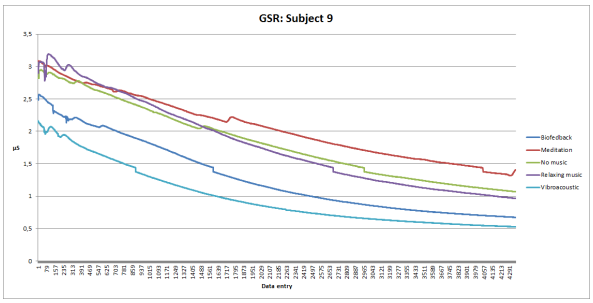

Figure L.21: GSR for Subject 9.

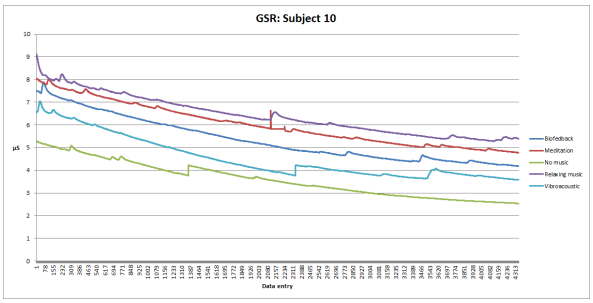

Figure L.22: GSR for Subject 10.

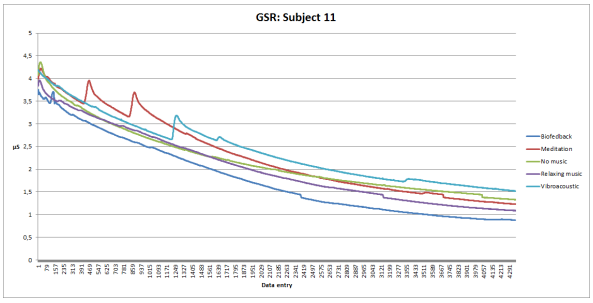

Figure L.23: GSR for Subject 11.

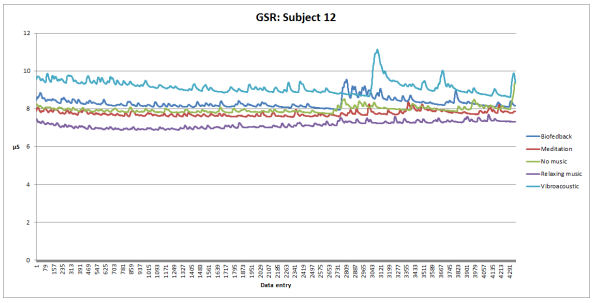

Figure L.24: GSR for Subject 12.

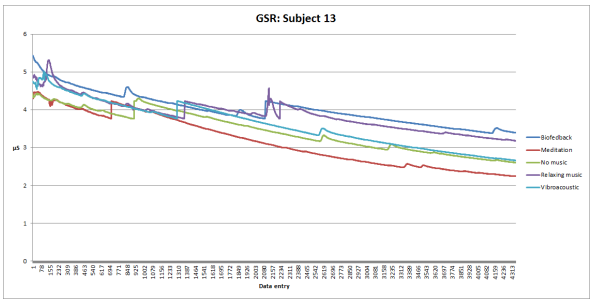

Figure L.25: GSR for Subject 13.

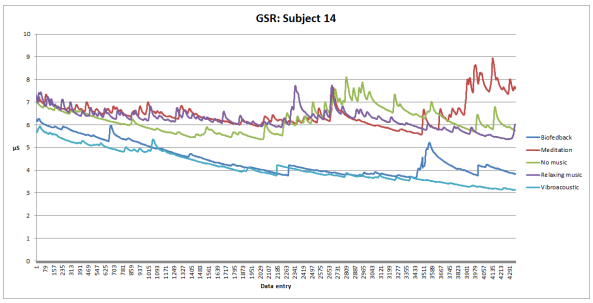

Figure L.26: GSR for Subject 14.

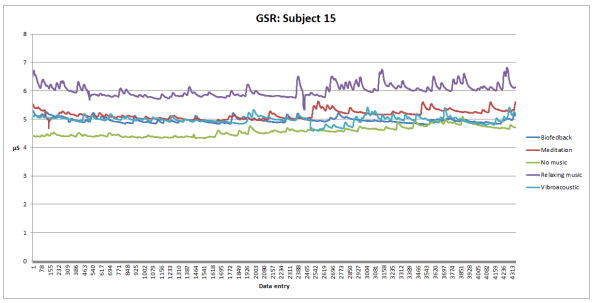

Figure L.27: GSR for Subject 15.

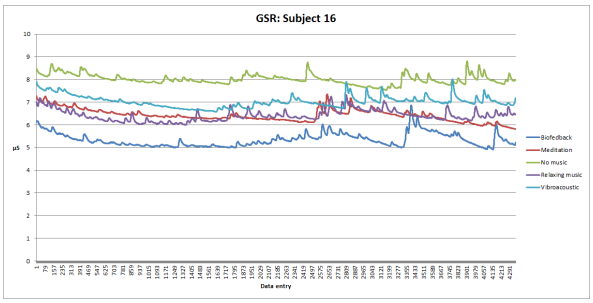

Figure L.28: GSR for Subject 16.

be seen in Figure L.33 based on a linear model that include Relaxation Methods, Round, and Subject as main effects. The results show, the same that can be seen in the effect plots, that there is not a significant difference between the Relaxation Methods and Rounds.

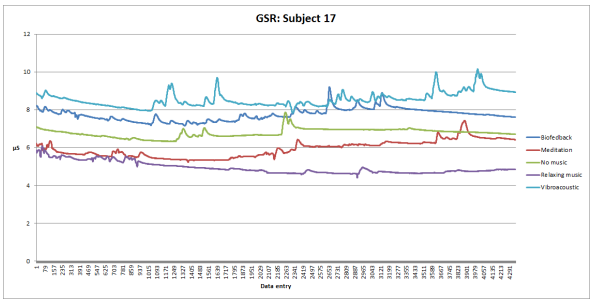

Figure L.29: GSR for Subject 17.

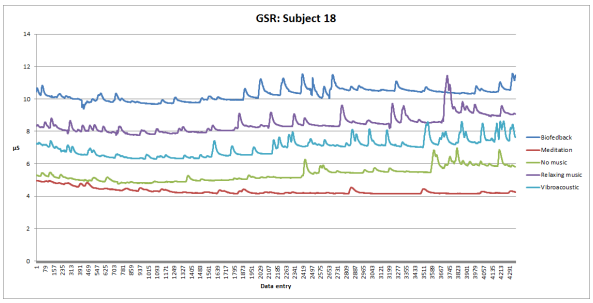

Figure L.30: GSR for Subject 18.

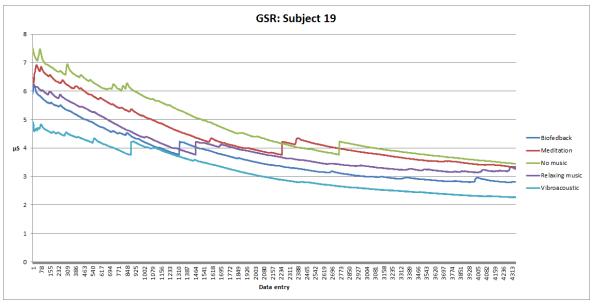

Figure L.31: GSR for Subject 19.

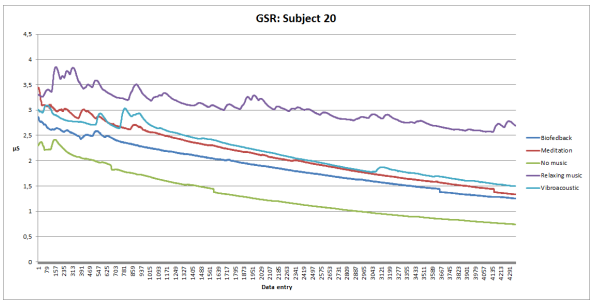

Figure L.32: GSR for Subject 20.

Even level	**Decline**	
Subject 1	Subject 2	Subject 9
Subject 12	Subject 3	Subject 10
Subject 14	Subject 4	Subject 11
Subject 15	Subject 5	Subject 13
Subject 16	Subject 6	Subject 19
Subject 17	Subject 7	Subject 20
Subject 18	Subject 8	

Table L.1: An evaluation of which subjects that have an even level of GSR and the subjects that have a declining GSR level through the Relaxation Methods.

Peaks

Figure L.34 shows six histograms for the different Relaxation Methods and the overall number of peaks that occurred. Here the frequency can be seen on the y-axes and the number of peaks on the x-axes. The overall is placed in the upper left corner of the figure. It can be seen that in 27 out of the 100 rounds the subjects did not have any peaks. One time in *Relaxing music* a subject had 19 peaks, this was Subject 20 in Round 5. The second largest number of peaks for one round is for *No music* where 12 peaks occurred (Subject 15, Round 1).

In Figure L.35 a Plot of Means for the peaks between the Relaxation Methods can be seen, and in Figure L.36 Plot of Means between the subjects can be seen. It looks like Subject 1 and Subject 2 did not have any peaks in any of their Relaxation Methods. *Relaxing music* has the larges mean, but that is due to Subject 20 with 19 peaks in that round, which also can be seen in

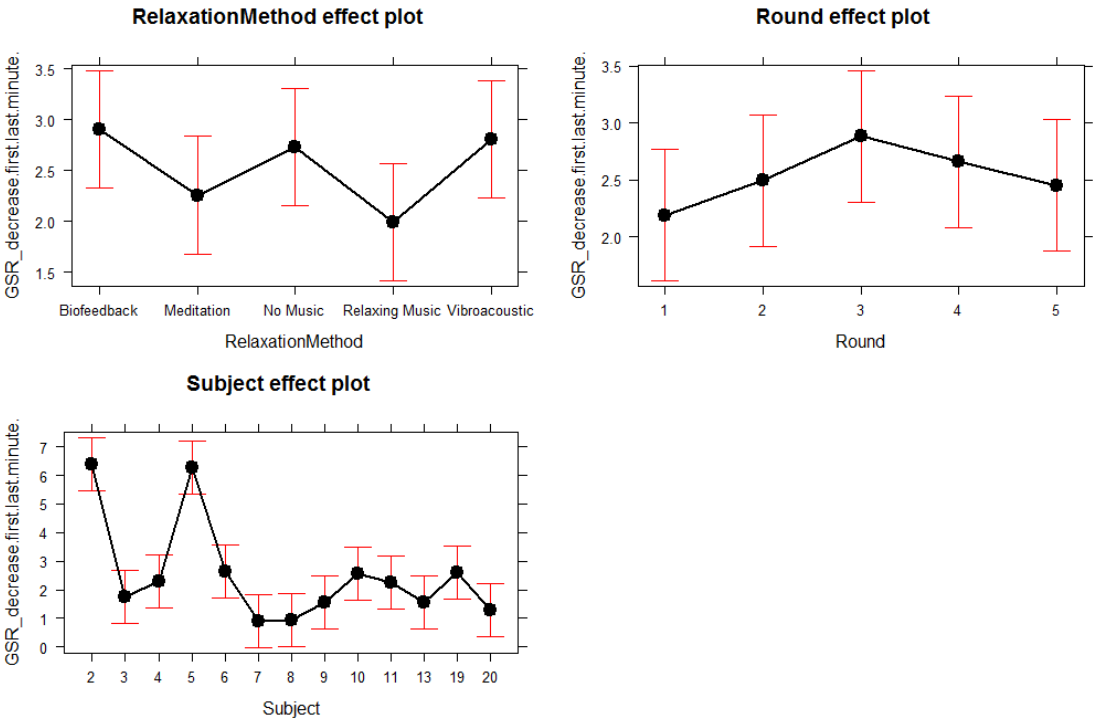

Figure L.33: Effect plots for a linear model including only the subject with a GSR decline.

the large confidence interval for both *Relaxing music* and Subject 20. Since all Relaxation Methods' confidence intervals overlap it could be expected not to discover any difference between them, which was also what the statistical analysis showed.

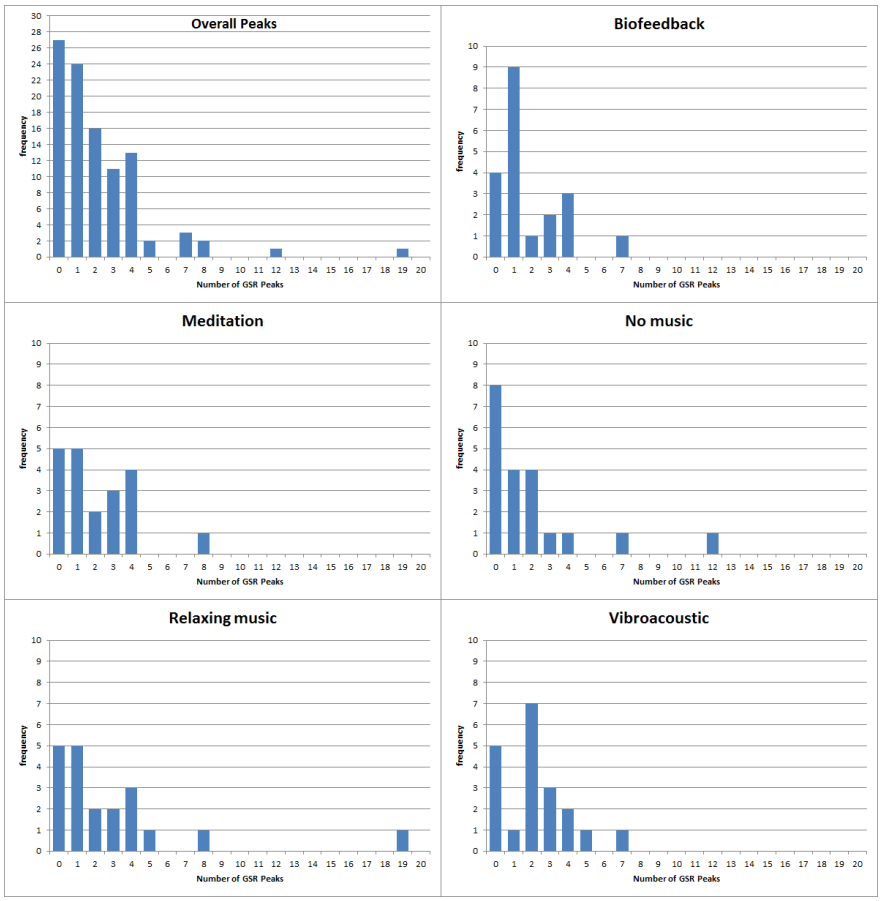

Figure L.34: Histograms for the overall GSR peaks and for each Relaxation Method.

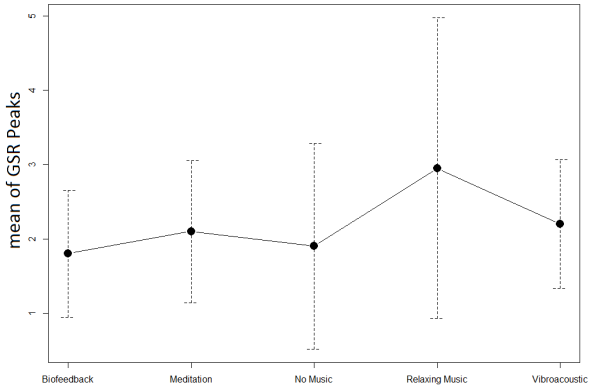

Figure L.35: Plot of Means for peak between the Relaxation Methods (0.95 confidence interval).

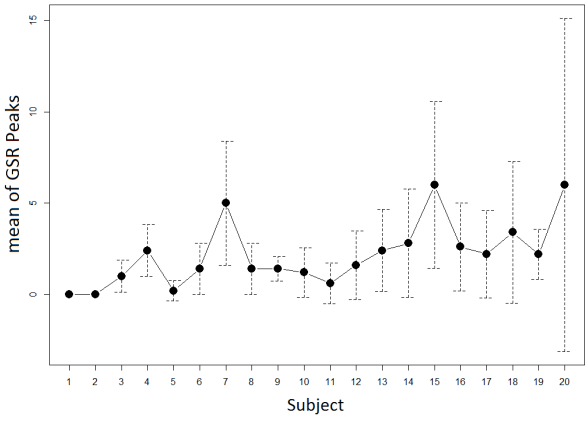

Figure L.36: Plot of Means for peak between the subjects (0.95 confidence interval).

L.3 HR

To get an overview of the collected HR data, a histogram was made and can be seen in Figure L.37. In the histogram the frequency can be seen up at the y-axes and the x-axes are the HR values in BPM (beats per minute). From the histogram it can be seen that the HR entries are from 50 BPM up to 70 BPM, and there are not much data over 100 BPM. There seem to be a few data entries with a HR around 150 BPM and 200 BPM. These are assumed to be errors in the collected data, however when analyzing using the overall dataset the few with a large value will not affect the results.

To examine the individual subjects a Plot of Means for each subject is made, and can be seen in Figure L.38. Here it can be seen that Subject 7, Subject 8, Subject 13, and Subject 20 have the largest whiskers, which indicate that their HR varied through the experiment.

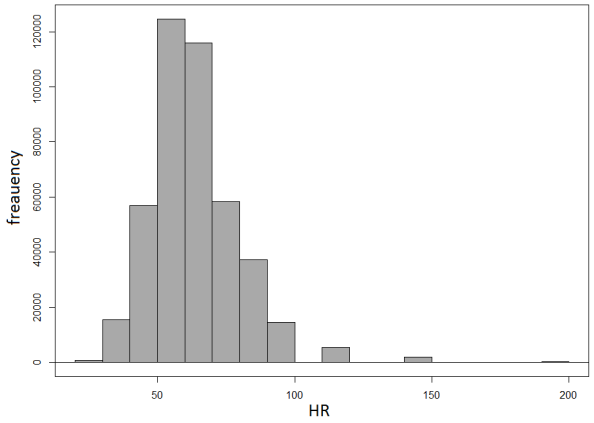

Figure L.37: A histogram over all the collected HR data entries regardless of Relaxation Method.

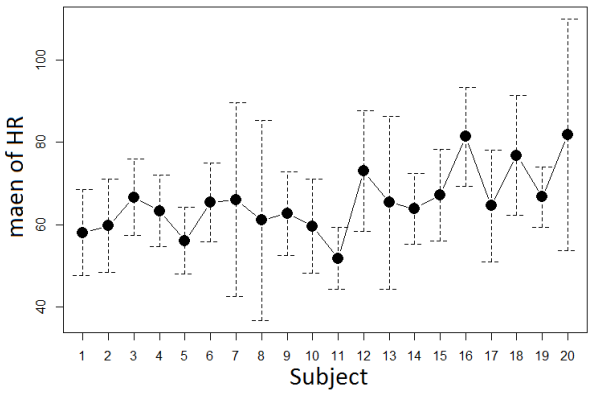

Figure L.38: Plot of Means for each subjects' collected HR data entries (standard deviation).

L.4 High Engagement (EEG)

A histogram is made for High Engagement and can be seen in Figure L.39 divided between the Relaxation Methods. It looks like the values either lie close to 0 or to 1. Figure L.40 shows the Plot of Means between the subjects, where Subject 19 has the highest mean value.

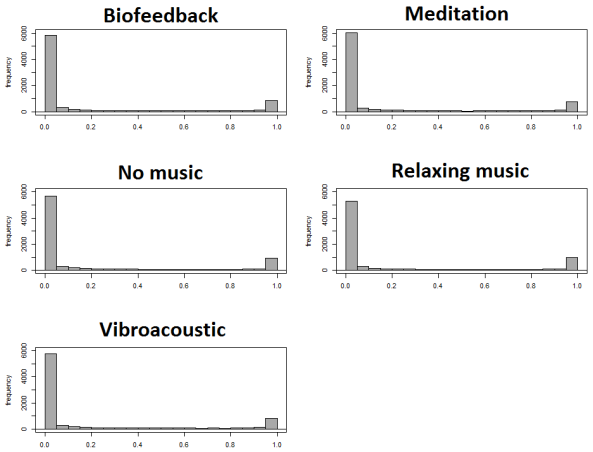

Figure L.39: Histogram for High Engagement between the Relaxation Methods.

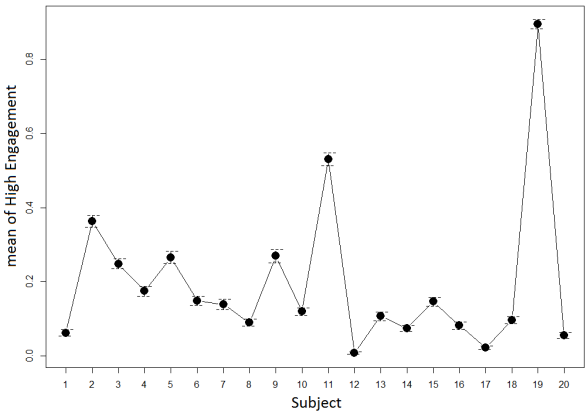

Figure L.40: Plot of Means for High Engagement between the subjects (0.95 confidence interval).

L.5 Low Engagement (EEG)

A histogram is made for Low Engagement and can be seen in Figure L.41 divided between the Relaxation Methods. It looks like the values either lie close to 0 or to 1. Figure L.40 shows the Plot of Means between the subjects, where the subjects' mean vary a lot between them.

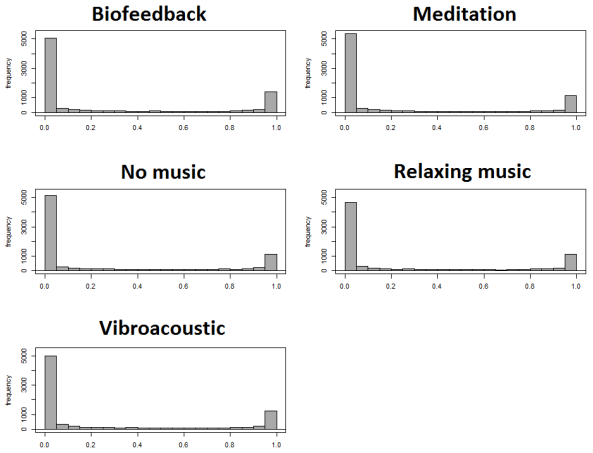

Figure L.41: Histogram for Low Engagement between the Relaxation Methods.

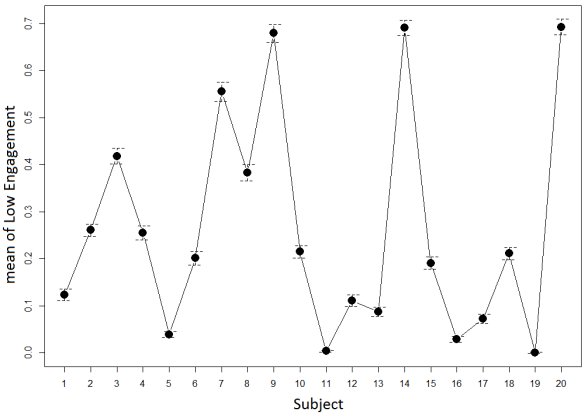

Figure L.42: Plot of Means for Low Engagement between the subjects (0.95 confidence interval).

L.6 Distraction (EEG)

A histogram is made for Distraction and can be seen in Figure L.43 divided between the Relaxation Methods. It looks like the values either lie close to 0 or to 1. Figure L.44 shows the Plot of Means between the subjects, where the subjects' mean vary a lot between them.

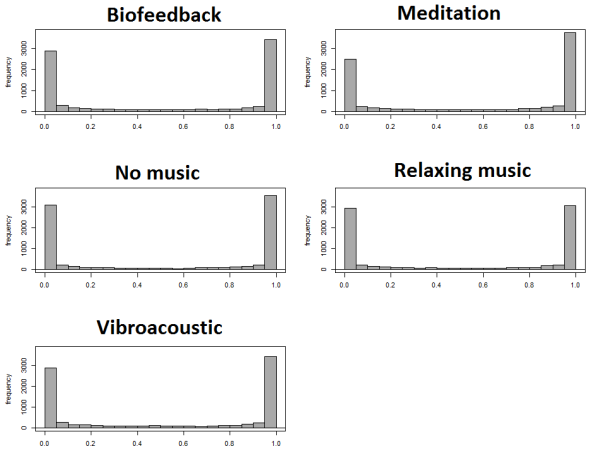

Figure L.43: Histogram for Distraction between the Relaxation Methods.

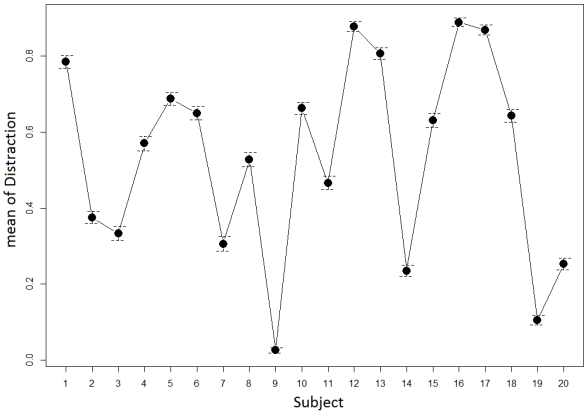

Figure L.44: Plot of Means for Distraction between the subjects (0.95 confidence interval).

L.7 Drowsiness (EEG)

A histogram is made for Drowsiness and can be seen in Figure L.45 divided between the Relaxation Methods. It looks like the values lie close to 0. Figure L.46 shows the Plot of Means between the subjects, where the subjects' mean do not vary a lot between them, and many have a value close to 0.

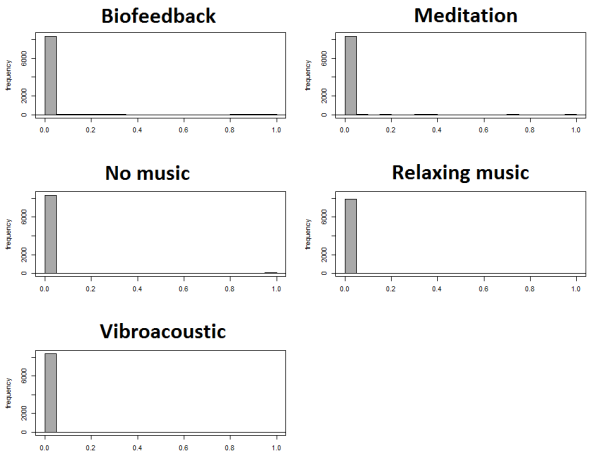

Figure L.45: Histogram for Drowsiness between the Relaxation Methods.

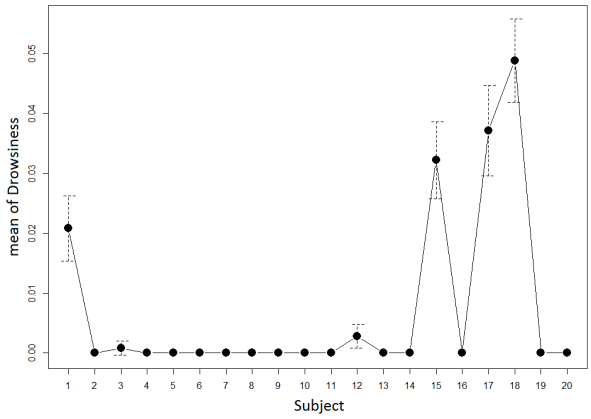

Figure L.46: Plot of Means for Drowsiness between the subjects (0.95 confidence interval).

L.8 Workload (EEG)

A histogram is made for Workload can be seen in Figure L.47 divided between the Relaxation Methods, that looks normal distributed however slightly skewed.Figure L.48 shows the Plot of Means between the subjects, where the subjects' mean vary a lot between them. Subject 9 is missing since all the rounds had a high number of missing data.

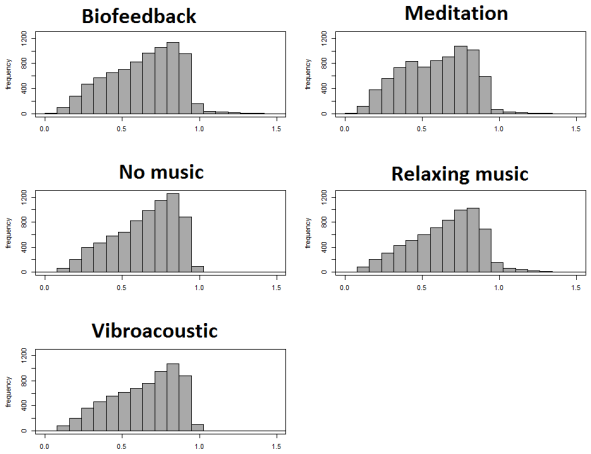

Figure L.47: Histogram for Workload between the Relaxation Methods.

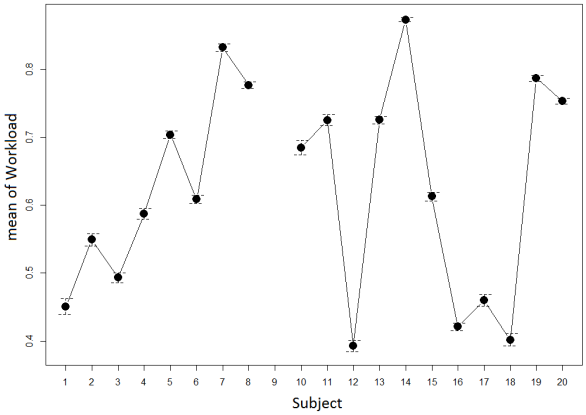

Figure L.48: Plot of Means for Workload between the subjects (0.95 confidence interval).

L.9 VAS

The asked VAS questions were:

- **VASQ1**: Jeg er fuldstændig afslappet (enig – uenig)
- **VASQ2**: Hvor lang tid følte du, at du sat i stolen (0 min – 15 min)

In Figure L.49 and Figure L.50 the histograms for the two questions divided between the different Relaxation Methods can be seen. In Figure L.49 it can be seen that the majority of answered have a positive value, however *Meditation* and *Vibroacoustic* have one data point close to -100. In Figure L.50 it can be seen that the answers are closer to 0 and negative. In both figures it looks like the answers could be normal distributed.

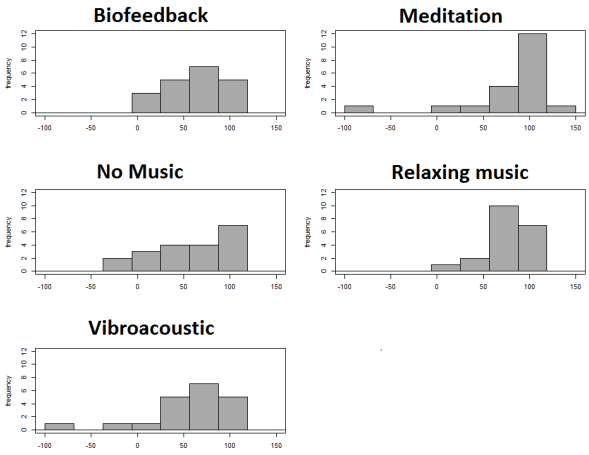

Figure L.49: Histogram for VASQ1 divided between Relaxation Methods.

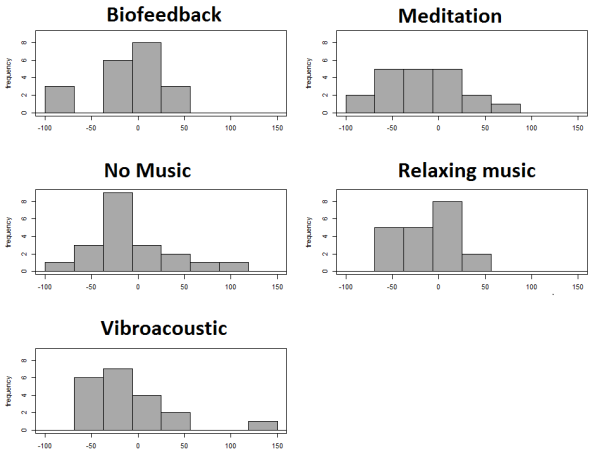

Figure L.50: Histogram for VASQ2 divided between Relaxation Methods.

In Figure L.51 and Figure L.52 the overall boxplot for the two VAS questions can be seen. In Figure L.51 for VASQ1 it can be seen that the subjects overall felt relaxed during the experiment because of the positive responses with only the 5 outliers below 0. In Figure L.52 for VASQ2 it can be seen that the subject did feel that they sat in The Interactive Chair closer to 0 minutes than 15 minutes, where only the 2 outliers answered close to 15 minutes.

Plot of Means have been made for the two VAS questions, and can be seen in Figure L.53 and Figure L.54. For VASQ1 it can be seen that *Meditation* and *Relaxing music* have a higher mean than *Biofeedback*, *No music* and *Vibroacoustic*. However their confidence intervals overlap and it is therefore not possible to see any difference in Relaxation Methods for VASQ1. The mean for VASQ2 divided between the different Relaxation Methods do not vary much, and since the confidence intervals overlap there is a small likelihood that any difference between the Relaxation Methods for VASQ2 can be found. This is also what the results from the statistical analyses for both VASQ1 and VASQ2 showed.

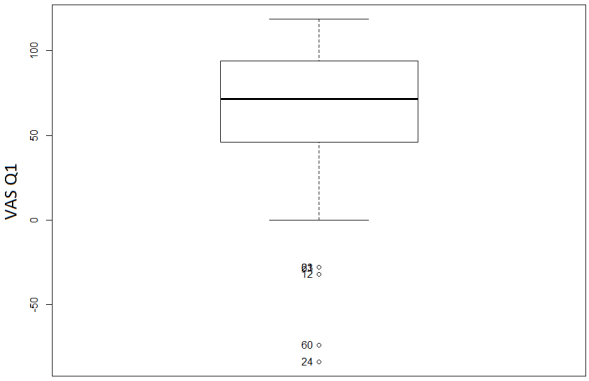

Figure L.51: Boxplot for VASQ1 (5 outliers).

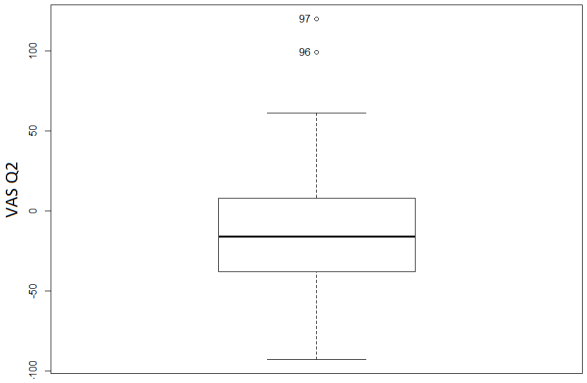

Figure L.52: Boxplot for VASQ2 (2 outliers).

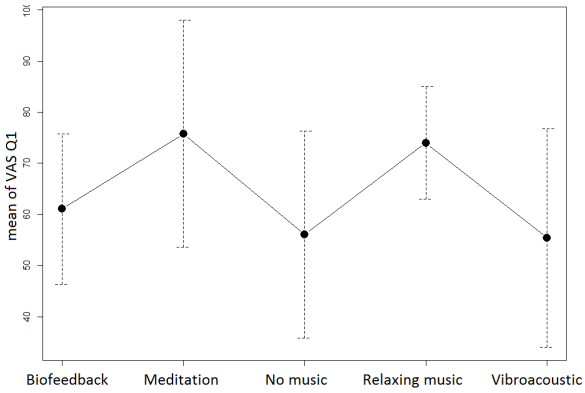

Figure L.53: Plot of Means for the different Relaxation Methods for VASQ1 (0.95 confidence interval).

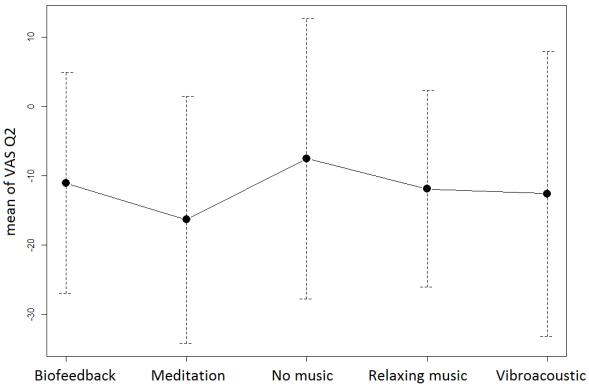

Figure L.54: Plot of Means for the different Relaxation Methods for VASQ2 (0.95 confidence interval).

L.10 R-states

The subjects answered eleven questions on a Likert scale from 1 to 5 regarding their R-states. There is a R-states scores for each subject's five rounds, which makes 100 in total.

A boxplot over the answers can be seen in Figure L.55 for the total scores calculated as a mean of the eleven questions. Additionally a histogram has been made for the R-states scores which can be seen in Figure L.56. From the boxplot in Figure L.55 it can be seen that the median is a bit over 3, which also can be seen in the histogram in Figure L.56 that looks to be normally distributed.

A histogram for each Relaxation Methods can be seen in Figure L.57 where is seems like *Meditation* and *Relaxing music* have more scores closer to five. A Plot of means for the R-states score for each subject can be seen in Figure L.58. Based in the Plot of Means it can be seen that there are two subjects where their answers vary more than the others, these are Subject 5 and Subject 12. Opposite is Subject 11 who seems to have answered 5 all the time to all the questions.

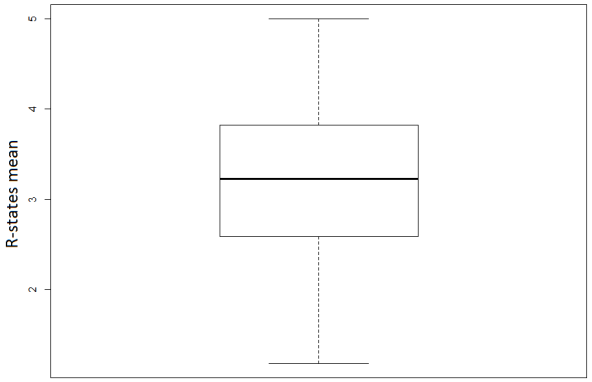

Figure L.55: Boxplot for the R-states scores.

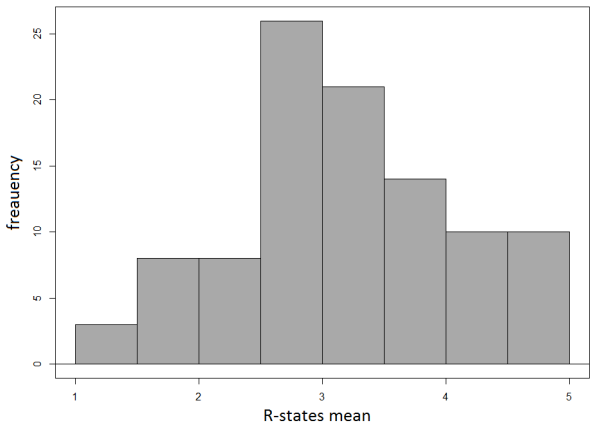

Figure L.56: Histogram for the R-states scores.

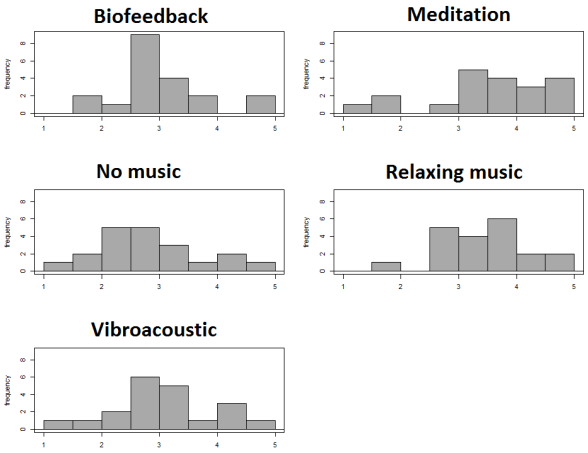

Figure L.57: Histogram for the R-states scores divided between Relaxation Methods.

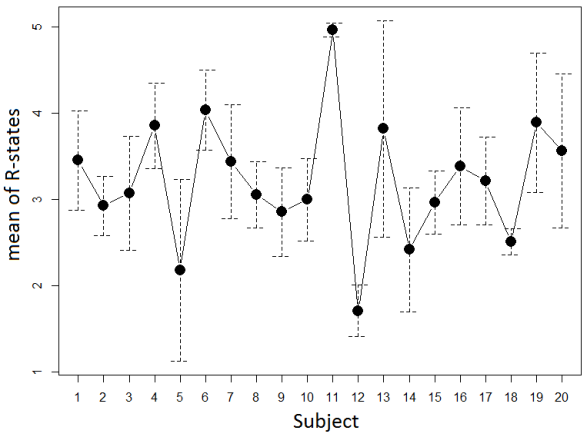

Figure L.58: Plot of Means over the R-states for the different subjects (standard deviation).

Individual questions

The different questions are discussed individually below where the difference between the Relaxation Methods is based on the effect plots from a linear model including Relaxation Method and Subject as main effect.

- **Question 1**: I felt **FAR AWAY FROM MY CARES** and the **TROUBLES AROUND ME**.
  Here *Relaxing music* and *Meditation* are higher than *No music*. This could indicate that the subjects felt the same about *Meditation* and *Relaxing music* even though there is a difference between them for for GSR and Workload measurements.

- **Question 2**: My **MUSCLES felt RELAXED**, loose, limp, warm and heavy.
  No significant difference for Relaxation Method was found which could indicate that the subjects felt that their body was relaxed the same way each time since they were sitting in the same chair the whole time.

- **Question 3**: My **BREATHING was RELAXED**, slow, even, and easy.
  Surprisingly no significantly difference for *Meditation* or *Biofeedback* since these should make the subject focus on their breathing. However perhaps the subjects did not feel that the breathing was connected to being relaxed but instead as something they were demanded to be focusing on.

- **Question 4**: I felt **AT EASE, AT PEACE**, refreshed.
  Relaxing music and *Meditation* have significantly higher score than *No music*. This could indicate that they did not enjoy sitting in The Interactive Chair to *No music*.

- **Question 5**: I felt **FOCUSED**.
  Meditation has the highest score and is significantly higher than *No music* and *Vibroacoustic*. This was also as expected since the *Meditation* was about keeping focus on one's breathing and train this focus.

- **Question 6**: Things seemed **CLEAR**, vivid, intense.
  There was no significant difference between the Relaxation Methods. The subjects could have difficulty understanding this question, and connecting the words clear and intense because they could have different meaning when translating to Danish (e.g. the Danish "Klar" and "Intensiv").

- **Question 7**: I felt **CENTERED**, absorbed, grounded.
  Here there was not a significant difference between the Relaxation Methods. The subjects sat in the same chair throughout the experiment, and their feelings could therefore be the same during the whole experiment.

- **Question 8**: My mind was **QUIET**, still, few thoughts.
  A reason that *Relaxing music* and *Meditation* have a significantly higher score from the three reaming Relaxation Methods could be because the *Meditation* was about keeping thoughts from wandering, and *Relaxing music* was a song known to the subject that they could just sit and focus on.

- **Question 9**: I felt **ACCEPTING** of what I can't have or change.
  Here *Relaxing music* with the highest score is significantly different from *Vibroacoustic* with the lowest score. This could be because the vibrations from *Vibroacoustic* makes their body unrestful and fidgety, and when their body is not calm it makes it more difficult to just accept things as they are. Subject 4 mentioned in the exit interview that the questions were difficult to understand and interpret, especially Q9.

- **Question 10**: I felt **HAPPY, OPTIMISTIC, TRUSTING**.
  Since there was no significant difference between the Relaxation Methods, could this mean that the subjects were feeling the same amount of happy, optimistic and trusting throughout the experiment.

- **Question 11**: I had deeper feelings (**AWE/WONDER, REVERENT/PRAYERFUL**).
  There is a significantly difference between *Relaxing music* and *No music* with the highest and lowest score respectively. A reason for this could be that during the subjects' own

song they could connect with the song and have different feelings regarding the song, where they could begin to think about more everyday tings during *No music*.

L.11 Backward digit-span task (BDST)

For the backward digit-span task there will be examined:

- BDST-O: Where all the numbers are correct and in the correct order.
- BDST-N: Where all the numbers are correct but regardless of the order.

To look at the results a boxplot is made for both BDST-O and BDST-N and can be seen in Figure L.59 and Figure L.60 respectively. Here it can be seen for Figure L.59, that the 50% of the results are between six and eight correct. It can be seen for BDST-N in Figure L.60 that the boxplot is more spread out, between six and nine.

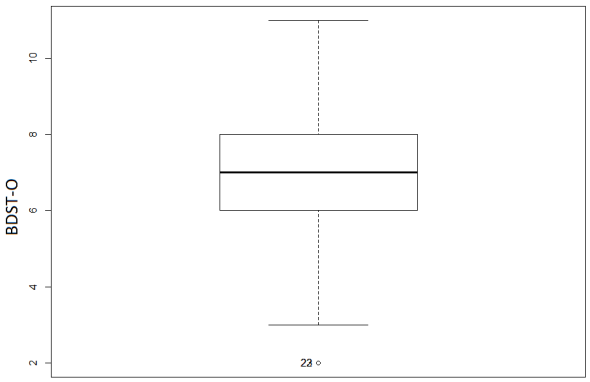

Figure L.59: Boxplot for BDST-O (2 outliers).

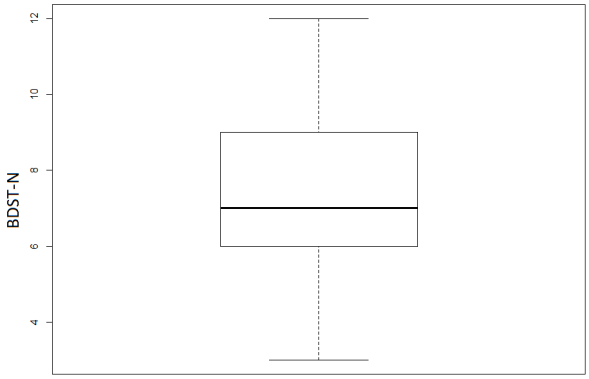

Figure L.60: Boxplot for BDST-N (0 outliers).

To examine how the subjects performed for the different rounds histograms are made for the overall and for the different Relaxation Methods, for both BDST-O and BDST-N in Figure L.61 and Figure L.62. For BDST-O in Figure L.61 it can be seen that the subjects most times answered six of the twelve orders correct. This histogram also resembles a normal distribution. For BDST-N in Figure L.62 it is nine correct that happens the most. For BDST-O *Biofeedback* and *Vibroacoustic* are the only Relaxation Methods where a subject only answered two out of the twelve correct in the correct order. Only one time did a subject get all the twelve correct for BDST-N, and this was after *Vibroacoustic*.

To get a better overview over the difference between the Relaxation Methods a Plot of Means is made for both BDST-O and BDST-N. This can be seen in Figure L.63 for BDST-O and Figure L.64 for BDST-N. Here it can be seen that there probably is not any significance between the Relaxation Methods for either BDST-O or BDST-N because the confidence intervals overlap for all of them.

To examine how the individual subjects scored, a Plot of Means were made both for BDST-O in Figure L.65 and for BDST-N in Figure L.66. Here it can be seen that Subject 5 is placed much

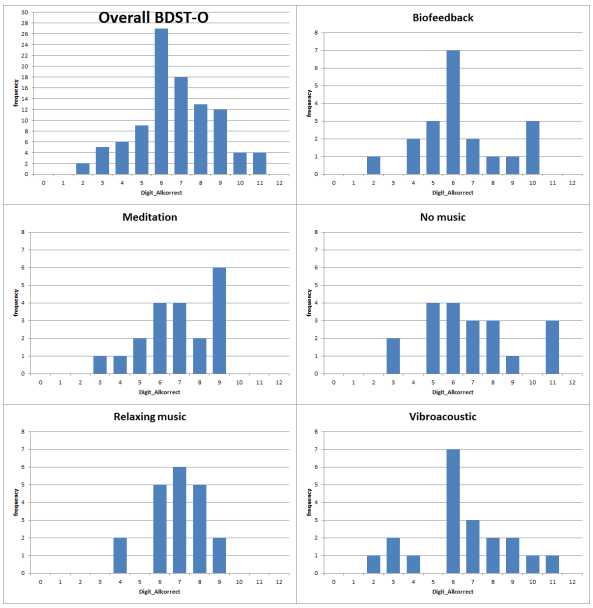

Figure L.61: Histograms for BDST-O for all the results and divided between Relaxation Methods.

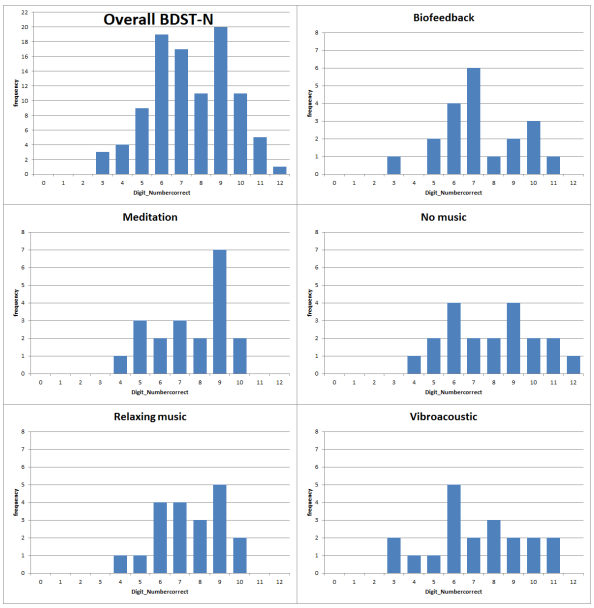

Figure L.62: Histogram for BDST-N for all the results and divided between Relaxation Methods.

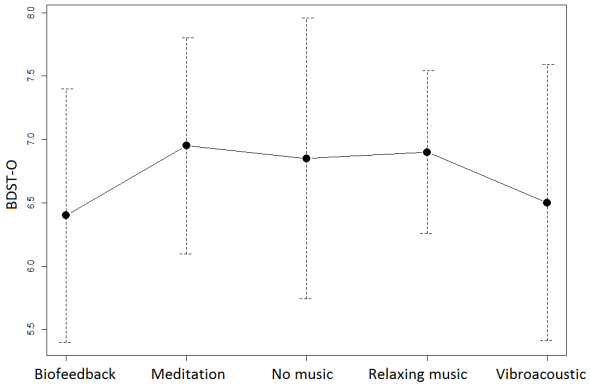

Figure L.63: Plot of Means between the Relaxation Methods for BDST-O (0.95 confidence interval).

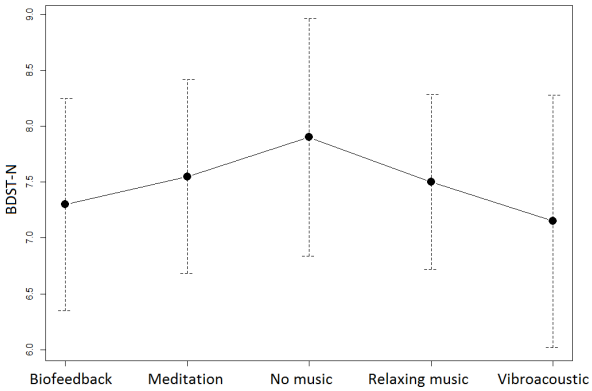

Figure L.64: Plot of Means between the Relaxation Methods for BDST-N (0.95 confidence interval).

lower than the other subjects. This subjects scores for each round and both BDST-O and BDST-N can be seen in Table L.2. From this it does not look like only one score results in the low mean, and the subject's results will therefore still be included in the analyses.

L.12 Facial expressions

During the experiment it was noted that the program could not detect the facial expression of some subjects all the time. This was manly due to the subjects' head position, where some

Round	BDST-O	BDST-N
Round 1	3	5
Round 2	2	3
Round 3	2	3
Round 4	3	5
Round 5	4	5

Table L.2: The results for Subject 5 for BDST-O and BDST-N.

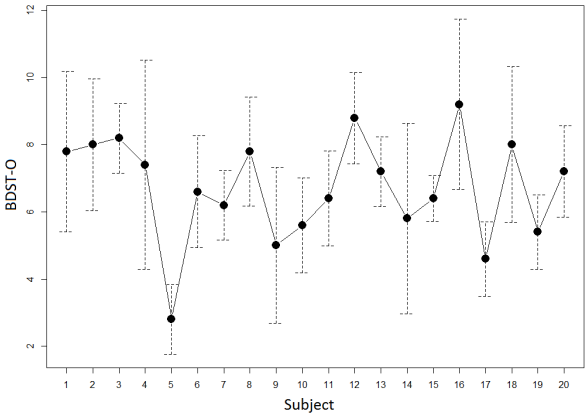

Figure L.65: Plot of Means between the individual subjects for BDST-O (0.95 confidence interval).

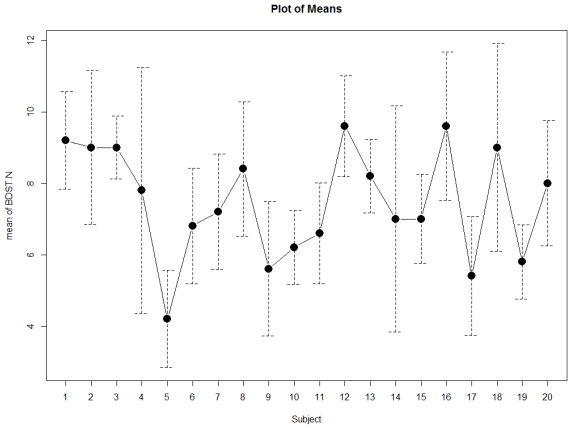

Figure L.66: Plot of Means between the individual subjects for BDST-N (0.95 confidence interval).

bent their head forwards or backwards, presumably in order to get a more relaxing position. This resulted in the subjects' face not being captured in the video. An example of the different head positions that the subjects had can be seen in Figure L.67, all taken during the *Biofeedback* round.

When examining a sample it can be seen that the subjects primarily had a neutral facial expression. This can also be seen in the bottom third graph in Figure L.68 where the evidence for Neutral is 2, meaning that the facial expression is 100 times more likely to be categorized as Neutral compared to the neutral state from the baseline (iMotions FACET, Website). In Figure L.68 it is also possible to examine the other nine facial expressions that the iMotions program can detect. These are from the top *Joy*, *Anger*, *Surprise*, *Fear*, *Contempt*, *Disgust*, *Sadness*, *Confusion*, and *Frustration*. The individual graphs for each subjects facial expressions can be found on the Attachment both for the Relaxation Method and for when the subjects are sitting in The Interactive Chair afterwards.

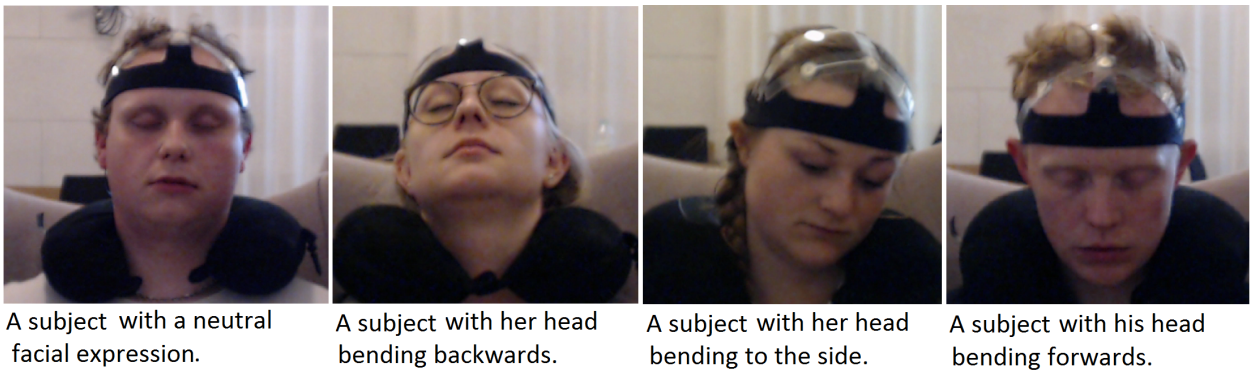

Figure L.67: Some of the head positions during the experiment.

L.13 Factors for subjects

Based on the subjects' answers to the initial questionnaire, they are divided into factors for the subjects and will be used for further analysis regarding the subjects. The following shows the factors, and which categories they are separated in.

- **Age**: Fifteen subjects under 30 years and five subjects over 30 years.
- **Gender**: Eleven females and nine males.
- **Caffeine**: Eleven subjects said "yes" and nine subjects said "no".
- **Medicine**: Five subjects said "yes" and fifteen subjects said "no".
- **Feel stressed**: Three subjects said "yes", five said "sometimes", and twelve said "no".
- **Meditation experience**: Ten subjects did not have any, four has a little, and six are experienced at meditating.
- **Time of day**: Seven subjects performed the experiment in the morning, seven subjects during midday, and six in the afternoon.

These factors will be examined during the analyses of the results in order to determine if some of the factors have an influence on the results. In Table L.3 the overview of which subjects are divided into the different categorize can be seen. For Meditation experience, the six subjects categorized as experienced, five of those are also over 30 years, and five are also female. When analyzing the factors, it needs to be kept in mind that there can be an overlap between some of the categories for the factors.

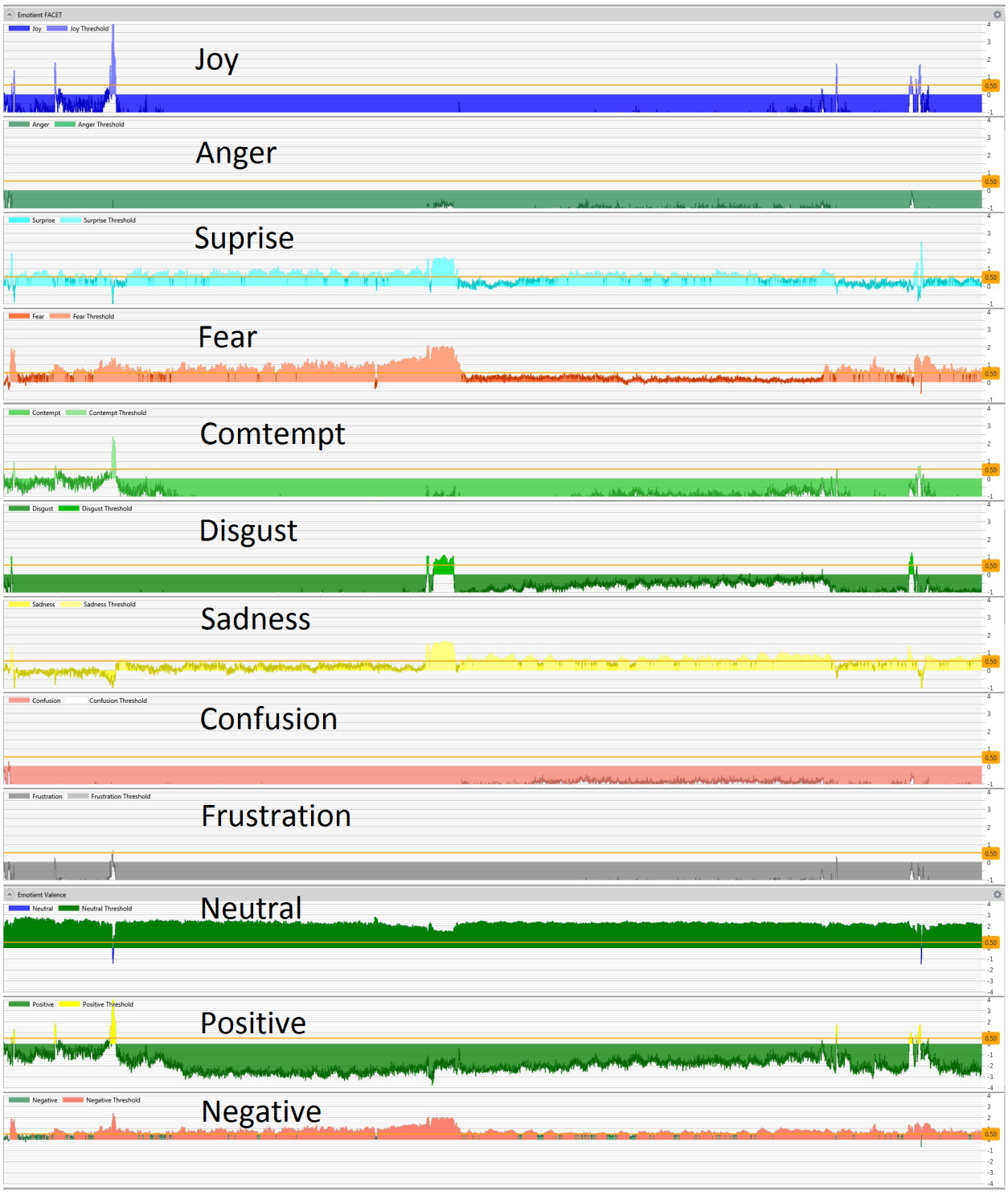

Figure L.68: The iMotions graphs for facial expressions for Subject 1 during *Biofeedback*.

Subjects	Age	Gender	Caffeine	Medicine	Feel stressed	Meditation experience	Time of day
Subject 1	Under 30	Male	Yes	Yes	Sometimes	A little	Afternoon
Subject 2	Under 30	Male	Yes	No	No	A little	Midday
Subject 3	Under 30	Male	Yes	No	No	None	Afternoon
Subject 4	Under 30	Male	Yes	No	No	None	Midday
Subject 5	Under 30	Female	No	Yes	Yes	A little	Morning
Subject 6	Under 30	Female	No	No	No	None	Morning
Subject 7	Under 30	Female	No	No	No	A little	Morning
Subject 8	Under 30	Female	No	No	No	None	Midday
Subject 9	Under 30	Female	No	No	Yes	Experienced	Midday
Subject 10	Under 30	Male	Yes	No	No	None	Morning
Subject 11	Over 30	Female	Yes	No	No	Experienced	Midday
Subject 12	Over 30	Male	No	Yes	Sometimes	Experienced	Midday
Subject 13	Over 30	Female	Yes	Yes	No	Experienced	Morning
Subject 14	Under 30	Female	Yes	No	Sometimes	None	Afternoon
Subject 15	Under 30	Male	Yes	No	Sometimes	None	Afternoon
Subject 16	Under 30	Female	No	No	Sometimes	None	Morning
Subject 17	Under 30	Male	No	No	No	None	Afternoon
Subject 18	Under 30	Male	No	No	No	None	Afternoon
Subject 19	Over 30	Female	Yes	No	No	Experienced	Midday
Subject 20	Over 30	Female	Yes	Yes	Yes	Experienced	Morning

Table L.3: Overview of the factors for each subject.

L.14 Additional factors

In Table L.4 an overview of the factors that are significant based on the ANOVA from the linear model below can be seen. These are the factors regarding the subjects that can be seen in Appendix L.13. The table shows the significant codes for the p-value. When performing the analyses, the factors that were not significant were removed until only the significant factors remain. It is based on that last linear model that the significant codes from the ANOVA are from.

Linear model: [GSR|HR|EEG|VAS|R-states|BDST] ~ Relaxation Method + Round + Meditation experience + Age + Gender + Caffeine + Medicine + Feel stressed + Time of day

Dependent variable	Relaxation Method	Round	Meditation experience	Age	Gender	Caffeine	Medicine	Feel stressed	Time of day
Overall GSR	***	***	***	***	***	***	***	***	***
GSR Decline			***			***		***	***
GSR Range			***			**		**	
GSR Peaks									
Overall HR	***	***	***	***	***	***	***	***	***
HR Decline			***						
HR Range							**	**	
VASQ1									
VASQ2									
R-States	*				***	***		***	
BDST-O		*						***	
BDST-N								***	
High Engagement	***	***	***	***	***	***	***	***	***
High Engagement threshold 0.25			***	*		**	***		
High Engagement threshold 0.50			***	**		*	***		
High Engagement threshold 0.75			***	***			***		
High Engagement under 0.1			***	*		***	***	*	
Low Engagement	***	***	***	***	***	***	***	***	***
Low Engagement threshold 0.25									
Low Engagement threshold 0.50					*				
Low Engagement threshold 0.75					*				
Low Engagement under 0.1				**		*			
Distraction	***	***	***	***	***	***	***	***	***
Distraction threshold 0.25			**		**	***	***	***	**
Distraction threshold 0.50			**		**	***	***	***	*
Distraction threshold 0.75			*		**	***	***	***	*
Distraction under 0.1			**		**	**	***	***	*
Drowsiness	***	***	***	***	***	***	***	***	***
Drowsiness threshold 0.25					**	***			***
Drowsiness threshold 0.50			**		**	***	***	***	*
Drowsiness threshold 0.75					*	**			***
Drowsiness under 0.1						***			***
Workload	***	***	***		***	***		***	***
Number of significants	8	8	19	11	17	22	16	19	16

Table L.4: Results from the ANOVA based on the linear model with Relaxation Method, Round, Meditation experience, Age, Gender, Caffeine, Medicine, Feel stressed, and Time of day as main effects. The boxes with color are the factors that have significant influence on the variable. These also include the significant codes, and the last row show how many time the factor is significant.

APPENDIX M

ATTACHMENT OVERVIEW

The following is the content of the Attachment.

1. **iMotions graphs**: The folder include all the graphs from iMotions. The graphs are separated in six folders, where five folders consist of the graphs for GSR, HR, and EEG for each of the five Relaxation Methods. The last folder consists of all the facial expression graphs. The graphs are named after the Relaxation Method, then a parenthesis with a number indicating the subject, and lastly either R for round or A for the time after performing the Relaxation Method. E.g. "Biofeedback (1) - A" means the measurements for Subject 1 after performing Biofeedback.

2. **Pilot**: The folder consists of the raw data and calculations for pilot test 2, pilot test 3, pilot test 4, and pilot test 5.

3. **Program code**: The folder consists of the program code used for the VAS questions and the backward digit-span task.

4. **Raw data**: The folder consists of the raw data from the iMotions program regarding the GSR, HR, and EEG. The raw data from the initial questionnaire and exit interview is also included as a excel document.

5. **Results**: The folder consists of all the excel files used for calculating and analyzing the data.

6. **Sounds**: The folder include the recorded *Biofeedback* music and 30 seconds of the music used for *Vibroacoustic*.

7. **Mail Permission to use SRSI3 (M-Tracker 7a.brief)**: The PDF is the mail correspondence with Jonathan C. Smith regarding permission to use M-Tracker 7a.brief.

8. **Note document** The PDF consists of extra material used during the project. Most of this is considered notes and have not been thoroughly corrected for grammar mistakes and the like.
9. **Pilot document**: The PDF consists of a thorough description of the five pilot tests.
10. **Report 16gr1081**: A digital version of the report.
11. **Result document**: The PDF consists of all the statistical analyses made for this project.

BIBLIOGRAPHY

Lene Bak, Anne Sophie Madsen, Bettina Henrichsen, and Søren Troldborg. *Danskernes Kulturvaner 2012*. Kulturministeriet, 2012. ISBN 978-87-7960-140-6. URL http://kum.dk/uploads/tx_templavoila/endelig_danskernes_kulturvaner_pdfa.pdf.

Ilias Bergstrom, Sofia Seinfeld, Jorge Arroyo-Palacios, Mel Slater, and Maria V. Sanchez-Vives. Using music as a signal for biofeedback. *International Journal of Psychophysiology*, 2013.

Marc G. Berman, John Jonides, and Stephen Kaplan. The cognitive benefits of interacting with nature. *Psychological Science*, 19(12), 2008.

Lars Ole Bonde. *Musik og menneske: Introduktion til musikpsykologi*. Samfundslitteratur, 1 edition, 2011. ISBN 978-87-593-1400-5.

Philip C. Boswell and Edward J. Murray. Effects of meditation on psychological and physiological measures of anxiety. *Journal of Consulting and Clinical Psychology*, 47(3):606–607, 1979.

Rafael A. Calvo, Sidney K. D'mello, Jonathan Gratch, and Arvid Kappas. *The Oxford Handbook of Affective Computing*. Oxford University Press, 2015. ISBN 978-0-19-994223-7.

Jiyoung Cha. Television use in the 21st century: An exploration of television and social television use in a multiplatform environment. *First Monday*, 21(2), 2016.

Flemming Christensen. *Binaural Technique with special emphasis on recording and playback*. PhD thesis, Aalborg University, 2001.

Mihaly Csikszentmihalyi. *Flow and the Foundations of Positive Psychology: The Collected Works of Mihaly Csikszentmihalyi*. Springer, 2014.

Andy Field and Graham Hole. *How to Design and Report Experiments*. SAGE, 2003.

Ronal A. Fisher and Frank Yates. *Statistical Tables: For Biological, Agricultural and Medical Research*. Oliver & Boyd, 6 edition, 1963.

Nicky Hayes. *Foundations of Psychology*. South-Western Cengage Learning, 3rd edition, 2000. ISBN 978-1-86152-589-5.

Jon Kabat-Zinn. *Full Catastrophe Living: How to cope with stress, pain and illness using mindfulness meditation*. Piatkus Books Ltd, 2004. ISBN 978-0-7499-1585-8.

Geoffrey W. Melville, Dennis Chang, Ben Colagiuri, Paul W. Marshall, and Birinder S. Cheema. Fifteen minutes of chair-based yoga postures or guided meditation performed in the office can elicit a relaxation response. *Evidence-Based Complementary and Alternative Medicine*, 2012. Article ID 501986.

Brian C. J. Moore. *An Introduction to the Psychology of Hearing*. BRILL, 6th edition, 2003.

Arijit Sinharay, Debatri Chatterjee, and Aniruddha Sinha. Evaluation of different onscreen keyboard layouts using eeg signals. *IEEE International Conference on Systems, Man, and Cybernetics*, 2013.

Jonathan C. Smith. The new psychology of relaxation and renewal. *Biofeedback*, 35:85–89, 2007.

E. Mark Stern. *Psychotherapy and the Broed Patient*. The Hawort Press, Inc., 1987.

Yi-Yuan Tang, Yinghua Ma, Junhong Wang, Yaxin Fan, Shigang Feng, Qilin Lu, Qingbao Yu, Danni Sui, Mary K. Rothbart, Ming Fan, and Michael I. Posner. Short-term meditation training improves attention and self-regulation. *PNAS*, 104(43), 2007.

Yi-Yuan Tang, Yinghua Ma, Yaxin Fan, Hongbo Feng, Junhong Wang, Shigang Feng, Qilin Lu, Bing Hu, Yao Lin, Jian Li, Ye Zhang, Yan Wang, Li Zhou, and Ming Fan. Central and autonomic nervous system interaction is altered by short-term meditation. *PNAS*, 106(22), 2009.

Shirley Telles, Bhat Ramachandra Raghavendra, Kalkuni Visweswaraiah Naveen, Nandi Krishnamurthy Manjunath, Sanjay Kumar, and Pailoor Subramanya. Changes in autonomic variables following two meditative states described in yoga texts. *The Journal of Alternative and Complementary Medicine*, 19(1), 2013.

Jay Vidyarthi, Bernhard E. Riecke, and Diane Gromala. Sonic cradle: Designing for an immersive experience of meditation by connecting respiration to music. *DIS 2012 - In the Wild*, 2012.

Heidi Wenk-Sormaz. Meditation can reduce habitual responding. *Alternative Therapies in Health and Medicine*, pages 42–58, 2005.

Krista West. *Biofeedback*. Chelsea House Publishers, an imprint of Infobase Publishing, 2007. Series Editor: Eric H. Chudler, Ph.D.

Christopher D. Wickens, Justin G. Hollands, Simon Banbury, and Raja Parasuraman. *Engineering Psychology and Human Performance*. Pearson, 4th edition, 2013.

Tony Wigram and Cheryl Dileo. *Music vibration and health*. Jeffrey Bookse, 1997.

Shao-Wei Xuea, Yi-Yuan Tang, Rongxiang Tang, and Michael I. Posner. Short-term meditation induces changes in brain resting eeg theta networks. *Brain and Cognition*, 87:1–6, 2014.

ADDITIONAL BIBLIOGRAPHY

Advanced Brain Monitoring, Internal Material. A PowerPoint regarding the B-Alert EEG and and metrics overview was sent from Advanced Brain Monitoring support.

B-Alert, Manual. B-Alert with AcqKnowledge Quick Guide: Benchmark Acquisition and Cognitive States Analysis. Distributed by BIOPAC Systems, Inc. and Manufactured by Advanced Brain Monitoring, Inc. 2016. https://www.biopac.com/wp-content/uploads/b-alert-with-acqknowledge-quick-guide.pdf (20-05-2016).

B-Alert X10, Manual. B-Alert X10 Setup Manual, by BIOPAC. Number D0010-9 Rev 3.5 BIOPAC. https://www.biopac.com/wp-content/uploads/b-alert-x10-setup.pdf (20-05-2016).

Bang & Olufsen, Internal material. Information about The Interactive Chair and its function was given by Bang & Olufsen confidentially.

Brüel & Kjær, Manual. Technical Documentation: Hand-held Analyzers Types 2250 and 2270. 2011, User Manual.

Hjerteforeningen, Website. Fakta om kondition og puls. https://www.hjerteforeningen.dk/files/Motion/Faktaark_om_konditioin_og_puls.pdf (20-05-2016).

iMotions, Website. Biometric Research Platform. https://imotions.com/ (20-05-2016).

iMotions Data, Website. How to Export Raw Data. https://help.imotions.com/hc/en-us/articles/202970572-How-to-Export-Raw-Data (20-05-2016). A login to iMotions is required in order to access the link.

iMotions EEG, Website. What is EEG (electroencephalography) and how does it work? 2016. https://imotions.com/blog/what-is-eeg/ (20-05-2016).

iMotions FACET, Website. Emotient FACET module: Quick Guide. https://help.imotions.com/hc/en-us/articles/203001451-Emotient-FACET-module-Quick-Guide (24-05-2016). A login to iMotions is required in order to access the link.

iMotions GSR, Guide. GSR The Definitive Guide, Everything you need to know to push your insights into emotional behavior. 2015. https://imotions.com/wp-content/uploads/Guides/iMotions_Guide_GSR_2015.pdf (20-05-2016).

iMotions GSR peaks, Website. iMotions' GSR peak detection, binarization and aggregation. https://help.imotions.com/hc/en-us/articles/205167392-iMotions-GSR-peak-dete

ction-binarization-and-aggregation (20-05-2016). A login to iMotions is required in order to access the link.

iMotions Shimmer3 GSR, Website. Shimmer3 GSR. https://imotions.com/portfolio-item/shimmer-gsr/ (20-05-2016).

Jonathan C. Smith, M-TRACKER 7a.brief. M-TRACKER 7a.brief. http://blogs.roosevelt.edu/jsmith/files/2016/04/M-TRACKER-7a-brief1.pdf (31-05-2016).

Jonathan C. Smith, SRSI3. Smith Relaxation States Inventory 3. http://www.lulu.com/shop/jonathan-c-smith-phd/smith-relaxation-states-inventory-3/ebook/product-21751108.html (20-05-2016).

Necker Cube, Website. Figure. https://nevalalee.files.wordpress.com/2014/12/necker.jpg

Raymond De Young, Website. Testing Mental Vitality. http://www.snre.umich.edu/eplab/intranet/demo_dac_tasks.html (20-05-2016).

Rikke Østergaard, Website. Mentaltræning. http://erhvervssociologen.dk/mentaltraening/ (20-05-2016).

Shimmer, Website. Shimmer3 GSR And Optical Pulse Sensor Set For 2014 Release. http://www.shimmersensing.com/news/shimmer3-gsr-and-optical-pulse-sensor-set-for-2014-release (20-05-2016).

Stephen W. Porges, Website. Body Perception Questionnaire. http://stephenporges.com/index.php/publicationss/21-body-perception-questionnaires (30-05-2016).

Vibroacoustuc.org - Harmonize Your Life with Sound, Website. Vibrational Resonant Frequencies for Vibroacoustic Sound Tables, Loungers, Sound Chairs and other Vibroacoustic Devices. http://goo.gl/YJlbQv (20-05-2016).