Loss of Control

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Bachelor Thesis Artificial Intelligence

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Abstract

Loss of Control (LoC) is a low amount of percieved control over a feedback system. In this thesis is investigated what the neurophysiological correlate of LoC is. Expected is LoC involves two processes: workload and stress. During a well-controlled task we wanted to investigate whether the workload and stress increases more during a condition when a participant recieves wrong feedback (LoC) than correct feedback. Workload was measured with EEG and questionnaires, stress was measured with Skin Conductance (SCL), heart rate and subjective measures (questionnaires, performance measures). Participants watched a sequence of visually presented letters and indicated whether or not the current letter was the same letter and the same color as the one (n instances) before. There were 3 conditions: an easy (1-back), an difficult (2-back) and a easy task with LoC (1-back with LoC). SCL increased during the LoC, but increased more during the 2-back task when comparing with the 1-back task. Heart rate also increased during these conditions but not significant. The questionnaires supported these results, as participants felt more stressed and they had to put more effort in the 1-back task with LoC but more in the 2-back task. The performance of the participants decreased more during the LoC than the 2-back when comparing with the 1-back. The LoC has less effect than a more difficult task.

Contents

Chapter 1

Introduction

1.1 Control

The feeling of being in control appears to have far-reaching consequences for our mental health. Plante and Rodin (1990) showed that increasing the sense of control among eldery men and women made them happier, increased their alertness and lowered their morality rate, over a period of 18 months by 50% (Peterson, 1999; Plante & Rodin, 1990). The increased control came from simple changes to their lifes, for example allowing them to decide what to eat, and determining how the furniture should be arranged. Apparently the feeling of being in control involves:

- to be able to make a decision
- to experience the results of that decision

While interacting with our surroundings, people (mostly unconsiously) try to control the outcome of their actions. For example, while driving a car we are using the steering wheel to maintain or adjust our course. We feel 'in control' of the car because we assume that (in the future) we are able to steer it as we like. An interesting question is how we acquired that feeling. As already stated before, the perceived results of our actions (sometimes called feedback) is an extremely important aspect gaining the feeling of control. Turning the steering wheel results in an immediate change of course, implicitly giving us the impression we caused that action and strengthens our feeling of being in control.

There are, however, two important assumptions related to control. First of all the feeling of control is based on the perception and interpretation of experiences and implied causality: it was *me* that changed the direction of the car, since every time I turn the steering wheel, it changes course. Secondly, somehow we silently assume that our actions are repeatable and will have the same feedback in the future. Anyone who experienced driving a car on an unexpected slippery and icy road knows that this assumption does not always hold. The moment that we lose control, that is: realize that our actions do not have the expected feedback anymore, is usually described as an unpleasant experience. In some cases it may cause panic and render the person uncapable of performing simple (life-saving) tasks. In other less critical situations it may cause stress and frustration.

Loss of Control

In other words; control is the amount of percieved control over a feedback system (Zander & Jatzev, 2012). In the situation described in the section before the feedback system is the steering wheel and the direction of the car is the feedback. The moment a driver has a small amount of feedback or no feedback anymore (when the car is not responding when you steer) it is called Loss of Control (LoC). LoC can be very stressfull for a person and it can increase the mental workload of the task the person has to perform for retrieving their control. A couple of studies about LoC are described below.

Reuderink, Poel, and Nijholt (2011) already investigated whether Loss of Control is of influence on an online Brain Computer Interface (BCI) task. The participants played a game of Pacman with keyboard arrows, where during the LoC the keys were ignored in 15% of the time. To investigate the influence of LoC on the BCI performance, they trained classifiers from the normal condition and compared the performance on unseen normal blocks and unseen LoC blocks. The BCI performed differently on a LoC state and a normal state. What they did not expect was that the performance of the BCI became better. The authors mentioned they expected with a change of situation the performance still would decrease; so the BCI would still perform worse when people lost control. Their experiment showed that Loss of Control influences the performance of a BCI task. To be able for the BCI to detect the Loss of Control so the BCI can anticipate and can change the behaviour would be a solution for this.

Changing the behavior and anticipating on the Loss of Control is called context awareness (Zander & Jatzev, 2012). In a BCI context awareness can make sure the BCI can handle mistakes or situations that normally go wrong. Zander and Jatzev (2012) investigated the context awareness related to the perceived Loss of Control during an user's state. During an experiment they had a RLR (rotation-left-right) paradigm. The users had to play a game where they had to turn one object in the same way of the example object. It depended on the color of the object how many degrees it turned (red: 90°, yellow: 60° and green: 30°). During LoC the colors and the number of degrees did not match. Their experiment demonstrated that context awareness could beneficially be implemented in and combined with a BCI system. Additional information can be accessed by physiological data, such as EOG, EEG, SCL and human gaze and aids the context awareness in a system.

When a users state is changed, a Brain Computer Interface will react differently than the user actually wants. In some situations this may be undesirable for the user. In a situation where it can be life threatening the BCI can alert the user. When driving a car and the user gets drowsy a BCI can intervene (Hung et al., 2010). In a situation a user loses control a BCI can be used as an auto-pilot. A BCI can stop the car when driving a car towards a cliff due to a loss of control.

It has been demonstrated that Loss of Control is associated with an increase of workload (Zander, n.d.). Workload is high when task demands are close to full mental capacity (Kantowitz, 1988). A high workload can be detected with an ERS in the theta at Fz and an RDS in the alpha band at Pz. In the experiment of (Zander, n.d.) they found during the RLR paradigm the participants had a significantly greater event related synchronization in the LoC condition than in the full control condition at 5,5 Hz. At Pz, they observed an event related desynchronization at 11,5 Hz during the LoC condition compared with full control. During an situation you lose control you get stressed (Storm et al., 2002). Because you want to do the task correct, but you get feedback that you are doing it wrong, you get stressed.

In this thesis I will explore whether or not LoC involves this two processes: cognitive workload and stress.

1.2 Cognitive workload and stress

Cognitive workload

A higher cognitive workload will decrease our attention (Lavie, 2005) and creates Loss of Control. Attention consists of three components: explicit attention, susidiary awareness and shared attention (Oakley, 2009). The first two components of attention consist of secondary components, see Figure 1.1. Control belongs to explicit attention. With explicit attention you will recognize the objects you see. Control is particularly critical in theories of working memories and planning. With attention we can filter unimportant objects of the important objects.

Control of attention often entails shifting to different elements in working memory, or attending to an entirely new set of elements in working memory as they match the sensory store (Oakley, 2009). Our attention narrows as cognitive workload increases and we have less

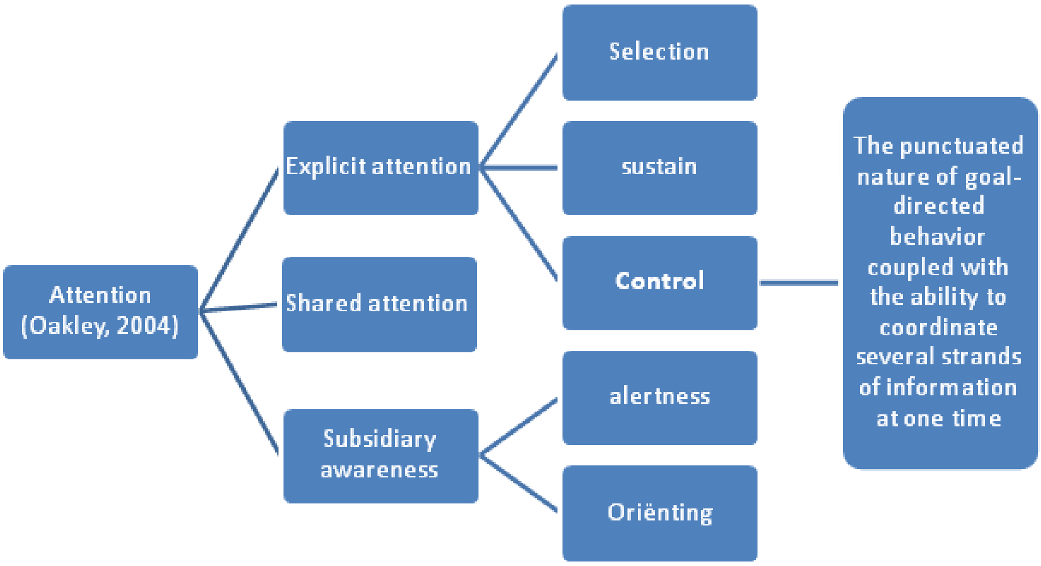

Figure 1.1: The components of attention by Oakley, 2009. Control is one of them.

control over our actions (Von Hippel & Gonsalkorale, 2005). During the Loss of Control when driving on a slippery road, the cognitive workload increases because you have to understand why the car does not respond, how the situation is changed since you went another direction (is this direction dangerous, do I cause danger to others) and you may know or wish you knew how you get the car in control. This situation gives you a lot to progress in a limited time.

Stress

Stress is a physical response to events that make you feel threatened. When you sense danger, whether it is real or imagined, the body's defenses kick into high gear in a rapid, automatic process known as the fight-or-flight reaction, also known as the stress response. The stress response helps you rise to meet challenges. The stress response helps your body to get into a state in which dangerous challenges can be dealt with. When driving the car, you might get stressed when the car does not go into the direction you wanted and you have to solve it before it goes wrong.

How to measure workload and stress

Performance measures like work pace and accuracy can be useful indicators of workload in some cases, but usually it is undesirable to wait until performance is overtly decreased. Another way to measure workload is through subjective rating scales like the NASA TLX, SWAT (Nygren, 1991) and RSME (Zijlstra, 1993). A range of variables has been examinded over the years (Kalsbeek & Ettema, 1963), such as heart rate, different types of heart rate variability, pupil size, eye blink frequency and duration, saccade and fixation related measures, electrodermal measures, respiration, blood pressure, chemical measures, EMG and neurophysiological variables derived from EEG. (Brouwer et al., 2012) showed the neurophysiological variable to be an 'winning' variable that can effectively be used to determine workload. The fight-flight response of stress helps you stay focused, energetic and alert, your heart rate increases, you begin to sweat more, blood pressure increases, there is more oxygen in our blood, muscles tighten and your digestion is at a low level. In several studies the heart rate and sweat responds is been used to measure stress e.g. (Storm et al., 2002). When an user is stressed the heart rate and skin conductance become higher. Brouwer et al. (2013) showed that Skin Conductance can be a better way to show whether a user is stressed as opposed to measuring heart rate.

1.3 Research aim

My research question is whether it is possible to find a neuro physiological correlate of Loss of Control and whether it is possible to make a distinction between Loss of Control and a no Loss of Control. I expect LoC consists of two processes: cognitive workload and stress. I am interested whether a LoC ensures the cognitive workload and stress get higher when compared with a no LoC. EEG signals are recorded for determining the workload and heart rate with Skin Conductance for determining stress. As mentioned before in a situation a user loses control a BCI can be used as an auto-pilot, but besides this social relevance we can also add the EEG and physiological correlates in a combined model, so this would be a potential valuable test case for multimodal classification. During the LoC we have clear expectation the EEG and physiological correlates make their specific contribution allow this a good combination.

In this study the n-back task is used to manipulate cognitive workload (Moore, Keogh, & Eccleston, 2009). In the n-back task participants view successively presented letters. For each letter they have to decide whether or not it is the same as the one presented n letters before. By increasing n memory load can be increased without having an effect on visual input and type of motor output. These factors can act as confounding variables that impede the interpretation of results of previous studies on correlates of workload (Brouwer et al., 2012). The n-back task is a typical task to increase the workload. In this experiment different colors are added to the letters. Only when the color and the letter is the same, it is a target. During the Loss of Control condition frequently the wrong feedback is given to participants. By adding the colors the difficulty of the task increases so that the participants hopefully do not notice the wrong feedback given in de LoC condition.

A bonus is expected to make the emotional aspect higher, participants receive more money when doing the task better. In the LoC condition their performance gets lower and they receive a lower bonus so the participants find it worse they are not in control.

During the rest of this thesis will be explained whether it is possible to find a neurophysiological correlate of Loss of Control and whether it is possible to make a distinction between Loss of Control and not Loss of Control. In the next chapter I will explain how my experiment was set up and how I analysed the data. In chapter 3 I will explain what the results are and lastly I will give an answer on the research question whether it is possible to find a neurophysiological correlate.

Chapter 2

Experiment

As mentioned earlier, we have the following research questions:

1. Is it possible to find a neurophysiological aspect of loss of control?

2. Can we find a distinction between loss of control and not loss of control?

In this section the experiment is described. With our mental task experiment is tested whether work load is increased when the wrong feedback is given. GSR signals, heart rate and EEG signals were measured and the participants had to fill in questionnaires.

2.1 Methods

2.1.1 Participants

A total of 23 participants were tested in this experiment. Their ages varied between 19 and 60 years. All of the participants were right handed and did not have any neurological disorders or vision problems like color blindness or problems why they cannot perform a task on a computer, like RSI.

2.1.2 Apparatus

A standard colour monitor is used to display the task to the participant. The distance between the participant and monitor was 50 cm. A numeric keyboard is used, connected to the monitor displaying the task. The '1' and '2' number keys are used to indicate whether a letter is a target or a non-target. Which of the keys indicate target or non-targets was counterbalanced between participants. Next to the monitor a laptop was kept for filling the questionnaires after a condition. The participants could get the laptop themselves. Across all trials the volume settings on the speakers and computer were kept constant and the light turned off. The participants were able to get the laptop itself and fill in the surveys. The EEG data is collected using the Biosemi ActiveTwo amplifier., a 32-channel active-headcap with electrodes. In figure 2.1 the layout of the cap is shown. Eye-Movements of participants were measured with EOG, placed under the left eye, above the left eye, left of the left eye and next to the right eye. Galvanic Skin Response was measured with the BioSemi passive electrodes. The electrodes of the GSR were placed on the fingertips of the index and middle finger of the left hand. The electrodes to measure heart rate (electrodes 5-6) were placed on the right collar bone and the left floating rib.

Questionnaires

Two different questionnaires were used during the experiment. During the experiment a Visual Analogue scale (VAS) is used to measure stress and workload (Davey, 2007). Scales consisted of 10-cm horizontal lines, anchored on the left by the words 'not at all stressed' and on the right by 'extremely stressed' and 'not at all strenuous' on the left and 'extremely strenuous'

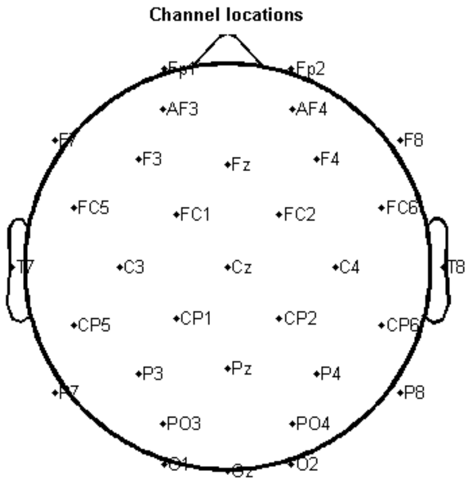

Figure 2.1: Layout of the EEG cap (32 channel cap plus 2 reference electrodes: CMS and DRL). Figure retrieved from (Delorme & Makeig, 2004)

on the right. The participants were asked to move the curser to mark the line how they felt in the beginning and the end of each trial. Before the experiment the Dutch version of the NEO-5 Factor Inventory (Hoekstra, Ormel, & de Fruyt, 2003), which is the short version of the Revised NEO Personality Inventory ("revneo", n.d.), was used. The Revised NEO Personality Inventory is a psychological personality inventory, a 240 items measure of the big five personality traits: Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness to Experience. Besides these traits this inventory also measures 6 facets per trait. The short version contains 60 items, and only measures the traits. Items consist of statements like "I do not worry" in the neuroticism subscale, which have to be judged following five points likert scales ranging from "totally agree" (1) to "totally disagree"(5). Higher scores indicated higher levels of each dimension. This questionnaire can be used for future research as during this research the answers are not analysed.

2.1.3 Task

The participants got the instructions to do an 1-back and a 2-back task. During this n-back task the participants viewed a sequence of colored letters presented on a screen. They had to decide for each letter whether it is a target or not. In the 1-back condition, a letter is a target when it is the same character and color as the letter before. In the 2-back condition, a letter is a target when it is the same character and color as two letters before (see for an example figure 2.2). Their performance was linked with a bonus, when they did the task better, their bonus increased.

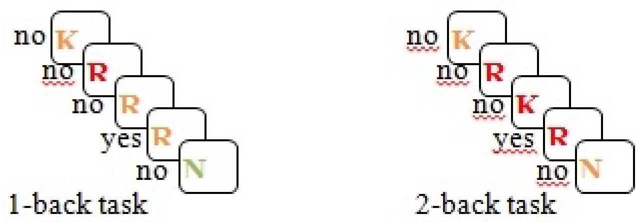

Figure 2.2: Example of the 1-back task and the 2-back task with modifications. In the left figure is the second orange letter a target. In the right figure the second red r is a target.

Participants were informed with a high tone when they made a correct decision whether the letter is a target or not. They heard a low tone when they made a mistake. During the

LoC condition we frequently gave the wrong feedback by letting the participants hear a low tone when they answered correctly and a high tone when they answered wrong. This wrong feedback is only given in 30% of the cases the participants made a correct decision whether a letter is a target or not.

After each block the participants were asked to fill in the questionnaire how they liked the condition. In this questionnaire the participants can give their opinion how difficult the task was and how stressful the task was. At the end of the experiment another questionnaire is filled in, with the questions if the feedback of the two conditions were correct.

2.1.4 Experimental design

The experiment is a within subject design, consisting of three conditions (the order is randomized and counterbalanced). 3 different conditions were used: LoC/1-back, 2-back and 1-back/LoC. The conditions were combined in multiple ways: LoC/1-back, 1-back/LoC and 2-back; 1-back/LoC, LoC/1-back and 2-back; 2-back, LoC/1-back and 1-back/LoC and 2-back, 1-back/LoC and LoC/1-back (condition A,B,C and D). See table 2.1 for an overview.

A	LoC/1-back	1-back/LoC	2-back
B	1-back/LoC	LoC/1-back	2-back
C	2-back	LoC/1-back	1-back/LoC
D	2-back	1-back/LoC	LoC/1-back

Table 2.1: Conditions table, note the 1-back without LoC and 1-back with LoC were combined during the experiment in one block of 4 minutes.

We combined the 1-back and 1-back with LoC condition into one block so the participants would not recognize when the Loss of Control began. The duration of each block was 4 minutes. The duration of the LoC was 2 minutes and also of the 1-back without LoC, combined it was 4 minutes. During 4 sessions every block is repeated for 2 times. In one condition 48 letters are shown, with 16 targets. The blocks were randomly assigned with the Latin Square method, such that each condition is in each session. Before each session we showed a cross on the screen the participants could fixate on.

Stimuli

The letters in the n-back task have different colors. Four different colors were used (red, blue, green, black) and were presented on light grey background. The letters were random selected from the English consonants, where 33% is a target. The letters were presented for 500 ms followed by 2000 ms where the letters were replaced with a fixation cross.

2.1.5 Procedure

The procedure can be found in Appendix 5.2, table 5.1 on page 26. Before entering the lab the participants were explained about the procedure. Afterwards the participants read and signed an consent form, and fill out the Big Five Inventory on the laptop. They had to finish four different conditions. The 1-back and the 2-back were being practiced until the task was clear. The participants were told they would receive a bonus when performing well. Afterwards electrodes were attached. The participants were asked to avoid movement and use the breaks between the sessions to move. After completing a condition the participants were asked to fill in a questionnaire on the laptop (See Appendix 5.3 for questionnaire). On the laptops screen was shown which condition the participant was going to do. Each condition is done twice. During the task itself when the participant answered whether the letter is a target or not, a tone is given as feedback so the participant knows whether they did answer correct. When performing well on the 1-back task the participants received 5 euros bonus, performing well on both the 1-back task and the 2-back task but not really good they received 10 euros and performing well on both tasks the participants received 15 euros.

2.2 Analysis

To find the neuro physiological correlate of LoC, the different conditions of the 1-back task and the 1-back task with LoC and the differences between the 1-back and the 2-back are compared.

Expected is that workload increases during LoC, the difference in EEG between 1-back and the LoC condition is expected to be greater than the difference between 1-back and 2-back without LoC. The same for stress, stress is expected to increase during LoC. Stress is measured with heart rate and Skin Conductance. As Brouwer, van Wouwe, Muhl, van Erp, and Toet (2013) showed Skin Conductance is a better stress measure than heart rate, I expect a greater difference between the conditions in the Skin Conductance data than the heart rate data. In the EEG data the alpha waves are expected to be lower during LoC than during no LoC, see figure 2.3.

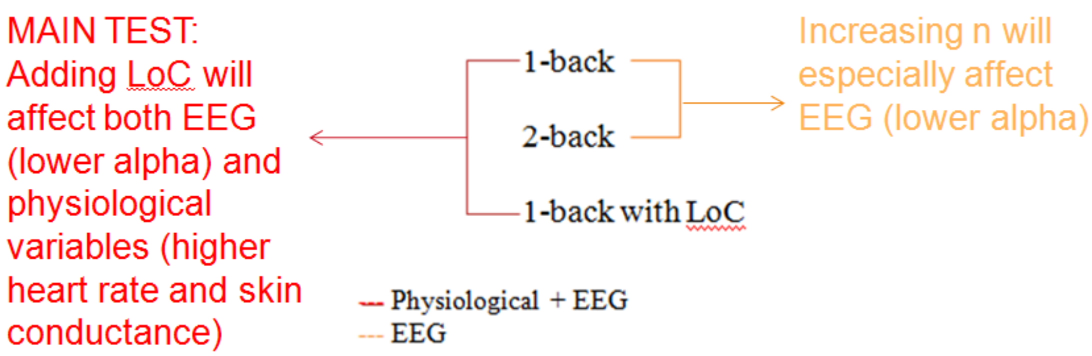

Figure 2.3: Expected is the Loss of Control increases heart rate and skin conductance and decreases the alpha waves when comparing with no Loss of Control. A higher workload is expected only to decrease the alpha waves.

We also check with a questionnaire whether the participants found the 1-back with Loss of Control more stressful and strenuous than the 1-back and the 2-back.

2.2.1 Signal processing

The data is processed and analyzed using EEGlab, a toolbox in Matlab (Delorme & Makeig, 2004). First of all, artifacts and noisy channels were manually removed from the data. Furthermore a notch filter of 50 Hz was used to filter out any electrical signals produced by the 50 Hz alternating current electricity . Next a highpass filter was used of 0.5 Hz and a lowpass filter of 8-Hz was used. On the GSR data a lowpass filter of 3 Hz was used. For the GSR data the averages of the GSRchannel per each condition and each participants were calculated. For each condition and each participant, we then determined the heart rate, determined how many heart beats there were during the complete condition and divided those by the duration in minutes of the condition. The peak detection algorithm of the toolbox was used.

2.2.2 Statistical analysis

For each dependent variable (heart rate, skin conductance), a paired t-test was performed on the data from the difference between the 2-back and 1-back condition and the difference between the LoC condition and the 1-back condition. We chose an alpha level of 0.05. The analysis of the EEG electrodes was skipped due to limitations of this thesis.

2.2.3 Questionnaires analysis

To see whether the LoC condition was more stressful and strenuous we used paired-samples t-tests. A t-test was done with the difference between the 2-back and 1-back condition and the difference between the LoC condition and the 1-back condition.

Chapter 3

Results

In this section the results are explained. In table 3.1 all the results are captured. During the rest of this section these results are explained in more detail.

	Heart rate	SCL	Performance	Subjective workload	Subjective stress
A: Δ LoC 1-back	Not significant	Significant	Significant	Significant	Significant
B: Δ 1-back 2-back	Significant	Significant	Significant	Significant	Significant
Δ A B	Not significant	Significant	Significant	Not significant	Not significant

Table 3.1: All the results for Δ Loss of Control and No Loss of Control are captured in this table. The ΔA B is significant, but the SCL is higher during the 2-back condition than the other two condition, so the SCL is lower during the LoC than during the 2-back.

3.1 Subjective workload

Perceived mental effort as measured by VAS, increased with mental load and the wrong feedback as expected, with average scores of 35,42,44 for the 1-back, 1-back with LoC and the 2-back conditions respectively (paired t-test 1-back and 1-back with LoC, t(3,421), $p<0.01$, paired t-test 2-back and 1-back, t(-4,419, $p<0{,}01$)). The difference between 1-back and 1-back with LoC and the difference between 2-back and 1-back was lower as expected, though not significant (paired t-test, t(1,050), p=0.3). Percieved mental stress measured by VAS also increased with mental load and the wrong feedback as expected, with average scores of 38,32,39 for the 1-bac, 1-back with LoC and the 2-back conditions respectively (paired t-test 1-back and 1-back with LoC, t(3,421), $p<0.01$, paired t-test 2-back and 1-back, t(-4,419, $p<0{,}01$)). The difference between 1-back and 1-back with LoC and the difference between 2-back and 1-back was lower as expected, though not significant (paired t-test, t(0.740), p=0.467). See Figure 3.1 and for more details see Figure 3.2.

3.2 Performance measures n-back

Performance decreased during the Loss of Control as expected and was higher than 2-back and 1-back as expected (Paired t-test, t(2.94, $p<0.01$). The performance was during the 1-back task highest and during the Loss of Control lowest.

3.3 Subjective belief

During the experiment most participants reacted to the wrong feedback and started to become frustruated and started slamming on the keyboard. Every participant noticed the wrong feed-

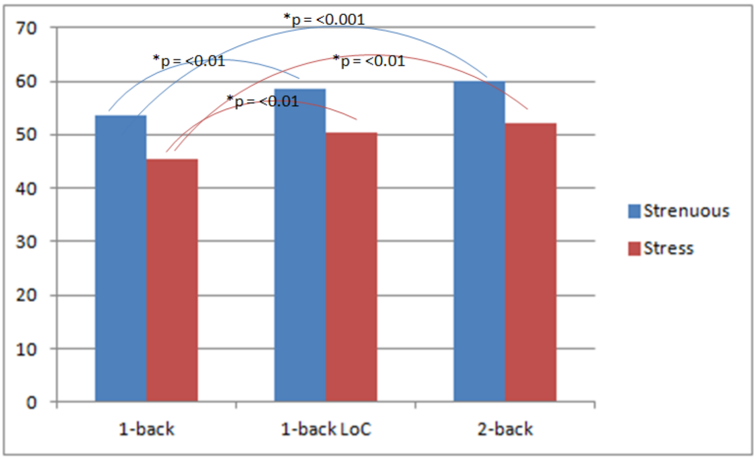

Figure 3.1: In this Figure the results of the questionnaires are shown. Loss of Control differs significantly from 1-back and 1-back differs significantly from 2-back during both questions (How stressful is this condition/How strenuous is this condition?). Only the difference between workload and Loss of Control is not significant in both conditions (p=0.305 for strenuous and p=0.467 for stress).

Strenuous		Mean	Std Dev.	t	df	Sig.
	1-back - 1back with LoC	-6,2	8,8	-3,421	22	0,002
	1back - 2back	-8,1	8,8	-4,419	22	0
	(2back - 1back) - (1back - LoC)	-2,2	9,8	-1,05	22	0,305
Stress						
	1back - 1back with LoC	-5,9	9,2	-3,095	22	0,005
	1back - 2back	-6,8	10	-3,243	22	0,004
	(2back - 1back) - (1back - LoC)	-1,7	10,7	-0,74	22	0,467

Figure 3.2: In this Figure the results of the questionnaires are shown. Loss of Control differs significantly from 1-back and 1-back differs significantly from 2-back during both questions (How stressful is this condition/How strenuous is this condition?). Only the difference between workload and Loss of Control is not significant in both conditions (p=0.305 for strenuous and p=0.467 for stress).

back in the 1-back with LoC condition, 8 participants thought the feedback was also wrong in the 2-back condition.

3.4 Physiological variables

Note that the data for subject 3 is skipped due to incomplete data.

3.4.1 Heart rate

Figure 3.3 shows the average heart rate for each of the three conditions. Heart rate was higher for higher workload as expected (Paired t-test, t(-3,7), p <0.01) and was higher for LoC compared to no LoC, but not significant (Paired t-test, t(-2,54), p=0.11). No results were found when comparing the difference between the lower and higher workload and the difference between no LoC and LoC. When comparing Interbeat interval(IBI) the same trend is seen.

3.4.2 Skin Conductance Level (SCL)

Figure 3.4 shows the average SCL for each of the three conditions. SCL was higher for LoC compared to no LoC (Paired t-test, t(2,4), p=0.02) and higher for higher workload as expected

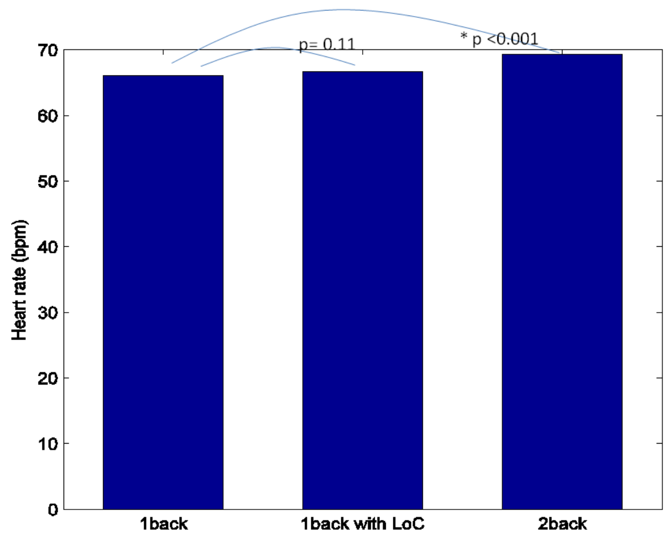

Figure 3.3: In this graph the average heart rate during one condition is shown. The 1-back was not significant different than the Loss of Control (p=0.11) and the 2-back was significant different than the 1-back (p<0.001). Same results were found when comparing Interbeat interval (IBI).

(Paired t-test, t(-2,6), p =0.02). A significant result was found when comparing the difference between the lower and higher workload and the difference between no LoC and LoC (Paired t-test, t(-2,6), p = 0.022), but this result the SCL in low workload vs high workload was higher than the SCL in no LoC vs LoC.

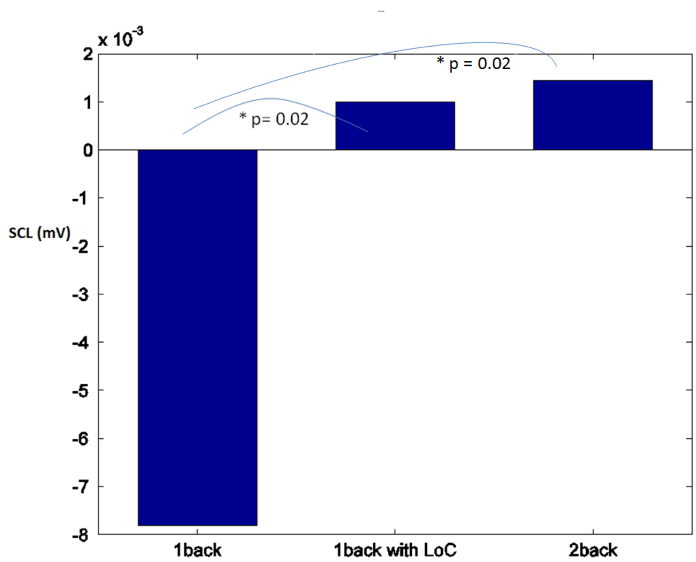

Figure 3.4: In this graph the average SCL is shown. The results of the 1-back were significant different than Loss of Control (p=0.02) and 2-back was significant different than 1-back , besides that (p=0.022). When comparing the difference between the lower and higher workload and the difference between no LoC and LoC significant results were found (p=0.022), but the SCL in low vs high workload is higher than the SCL in no LoC vs LoC.

Chapter 4

Discussion

In this thesis is examined whether a neuro physiological correlate of Loss of Control could be found. Expected was that Loss of Control involves workload and stress. First a task to increase workload was considered and modified. The n-back task is a well controlled task to increase workload. Colors were added to the letters and wrong feedback brought the user in a Loss of Control state, a bonus was added to increase the stress component of the participants. During the experiment 23 participants were tested.

Behavioral measures confirmed participants got more stressed and had to put more effort in the task during the Loss of Control when workload was the same: with an increase in Loss of Control, subjective workload increased and task performance decreased. Only the subjective workload increased more during high workload. During a higher workload the participants experienced the task more stressfull and strenuous. The task performance decreased more during the Loss of Control condition than during a high workload.

Skin Conductance increased with Loss of Control. Heart rate did increase during Loss of ontrol, but it was not significant. In this experiment the increase of heart rate and Skin Conductance during Loss of Control with the same workload is probably caused by stress since participants reported they were more stressed during Loss of Control. Brouwer et al. (2013) mentioned Skin Conductance is a more reliable factor for measuring stress, that explaines why Skin Conductance increased significant and heart rate not. It is interesting participants' SCL and heart rate still went up during the LoC condition thought they did know the feedback was wrong. This is still expected, during the LoC condition participants wanted to do more their best because they heared they did it wrong, and the stress increased so the heart rate increased (Reuderink et al., 2011).

The behavioral measures and the physiological measures do imply the same; there is a difference in LoC and no LoC but only when the workload is the same, during a higher workload these measures differ more than during LoC and no LoC.

During the experiment some participants got really frustrated. They smashed on the keyboard and repeately sighed. So even thought they noticed the wrong feedback, still became aggretated because of it. Frustration may cause that participants' physiological measures increased. The participants reported the workload increased during the experiment in a Loss of Control state. It may also cause participants had negative emotions against the training stimuli (Rozell & III, 2000) and can reduce a persons belief in his or her ability to do well in task (Briggs, Burford, & Dracup, 1998). When a persons belief in his or her ability to do well in a task is reduces, it can seem like the workload is increased. An addition to this experiment can measure whether frustration is also part of LoC, during this addition can facial expressions be measured for frustrating of participants and whether the participants belief to do well in the task is reduced or still motivated.

Thought I had limited time for examine the EEG data. The alpha band of Loss of Control can be compared with no Loss of Control. Analyzing this data may make it possible to see whether Loss of Control also increases the workload.

When disregarding the last session there was a significant increase of heart rate between

1-back without Loss of Control and 1-back with Loss of Control. It is possible participants noticed the Loss of Control and got used to the wrong feedback. It would be interesting to only look at the data during the first session when participants were less aware of the Loss of Control.

4.1 Conclusion

This experiment did not find physiological correlates, measured by skin conductance level and heart rate, of Loss of Control. We found the skin conductance level (SCL) and the heart rate only increased in situations when the workload is the same, but SCL and heart rate increased less than during a higher workload. This also means we cannot find a distinction between LoC and no LoC.

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Chapter 5

Appendix

5.1 Handleiding BioSemi

Protocol fysiologie

Vooraf: plakkertjes op elektroden

Accu eraf halen, aan de stroom hangen en de volle accu eraan hangen. Let op!! Accu moet altijd in volle toestand bewaard worden. (Zie voor meer info handleiding blz 17)

Meet hoofdomtrek om kapje te bepalen, maten staan in de kapjes

Voor alle losse elektroden geldt:

- Richt ze handig ivm wegleiden draadjes en plak de draadjes vast met plakband om ze te ontlasten (ze moeten niet slingeren maar let ook op voldoende bewegingsvrijheid). Alle kabeltjes gaan uiteindelijk over linkerschouder van proefpersoon naar de amplifier.
- Vooraf stickertjes plakken. Direct voor het electroden plakken vullen met gel en stickerbeschermlaagje eraf halen. Let op bij het plakken dat je de electrode en niet het versterkertje (met het ronde labeltje) op de juiste plek plakt.
- Plak electroden extra vast met stukje plakband, behalve de electrode onder het oog.
- Pak electroden vast aan casing als je ze loshaalt (connectie met draad is kwetsbaar)

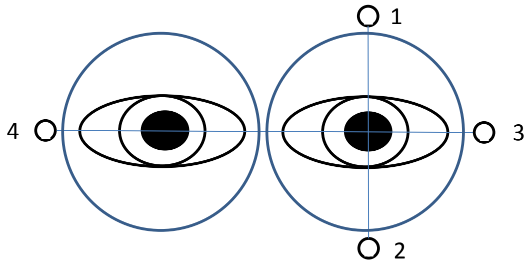
Skin conductance - ronde passieve-electroden :

- Deze als eerste plakken ivm relatief lange adaptatietijd
- Laat proefpersoon handen wassen met zeep en drogen
- Vul met speciale gel (wordt nog bezorgd – tot zo lang de EEG gel)
- Plak met huidplakband op vingertoppen van linker wijs en middelvinger

EOG – electr 1-4:

- Plaksites schoonmaken met alcohol (proefpersoon ogen dicht wegens damp)

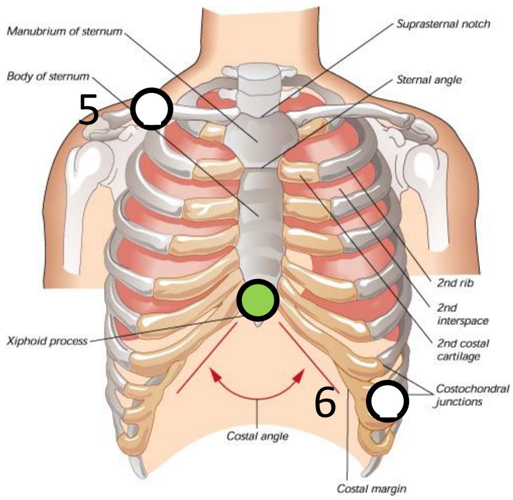
- Plakschema zie onder. Laat de proefpersoon recht vooruit kijken en plak de electroden netjes tegenover elkaar recht onder/boven/naast pupil net buiten derand



van de oogkas (en boven wenkbrauw)

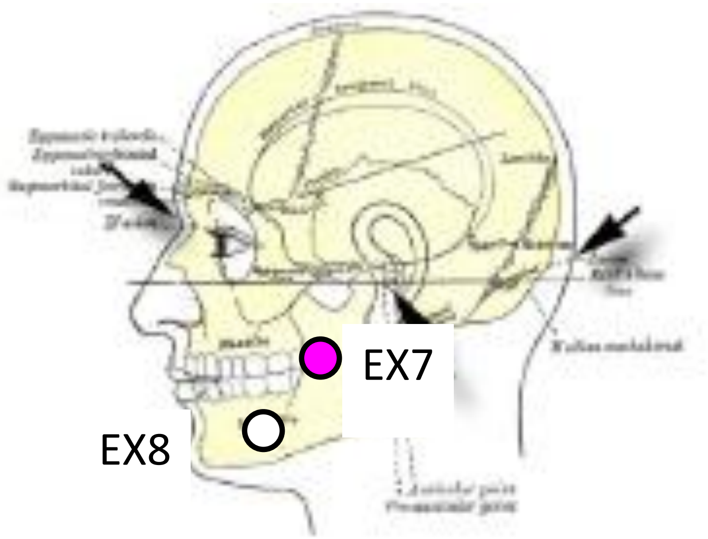
ECG – electr 5-6:

- Plaksites schoonmaken met alcohol
- Electr 5 op sleutel been, electr 6 rond zwevende rib (hart zit er tussen in)



Gaap EMG – electr 7-8:

- Electr 7 bovenop kin, electr 8 eronder. Denk eraan dat er onder de kin ook nog een strap van het kapje komt.



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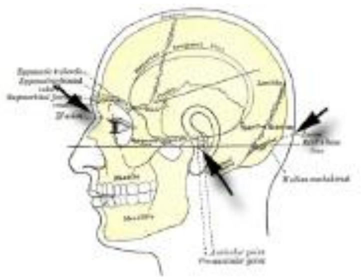
Ademhalingband:

- Plastic dingetje vooraan rond onderzijde sternum (groene stip in plaatje hierboven).
- In principe over de kleding maar als de proefpersoon een hele dikke trui heeft onder de trui (nooit direct op de huid).

EEG:

- Positioneer kapje.
- Bevestig kinstrap.
- Verschuif kapje zodat Cz op het midden van nasion (kuiltje precies tussen ogen) naar inion (knobbel op achterhoofd) en tussen beide oren. Meet met meetlint netjes over de elctrodengaten.
- Kijk goed aan voor en achterkant of ie niet gedraaid zit



- Spuit aan achterkant vullen met gel.
- Vul de electroden gaten. Doel is een kolommetje van huid naar electroden. Wiebel eerst het haar weg, spuit gel in terwijl je met spuit naar boven gaat. Als proefpersoon gel voelt is het zeker goed.
- Plug de electroden in.

Proefpersoon in auto, alles op juiste plek inpluggen:

- EEG boven op, 1^e ingang (let op stekkerorientatie!)
- Losse electroden vooraan bij juiste nummers.

Check signalen voor offset. Als er een probleem is: vul gel bij, wiebel nog eens haar weg.

Schoonmaken:

- Was electroden meteen na gebruik met warm water. Geen zeep of borsteltje gebruiken (soft brush alleen als echt noodzakelijk), laat ze niet in water staan, air-dry de electroden weg van direct zonlicht en/of papieren doekjes, vermijd contact met metaal. Let op dat de stekkertjes niet nat worden!
- Kapje wassen met milde zeep (afwasmiddel bv) en water, plat drogen, geen warmte gebruken om drogen te versnellen.

Misschien nog handig uit inleiding:

- LED indicators (blz 14)

5.2 Procedure

5.3 Questionnaire

Hoofdsectie

EEG Onderzoek

1. Proefpersoonnummer:

2. U bent:

- ○ man
- ○ vrouw

3. Wat is uw leeftijd? .... jaar

4. Wat is uw hoogst afgeronde opleiding?

- ○ Lagere school
- ○ VMBO
- ○ MBO
- ○ HAVO
- ○ VWO
- ○ HBO
- ○ WO
- ○ Anders ...

5. Drinkt u koffie ? (drinkt u altijd coffeine vrij dan aub "nee" antwoorden)

- ○ ja ➡ Ga verder met vraag 7.
- ○ nee

6. hoeveel kopjes koffie drinkt u gemiddeld per dag of per week?

7. Heeft u de afgelopen 3 uur koffie gedronken?

- ○ ja
- ○ nee

8. Drinkt u normaal koffie rond deze tijd van de dag?

- ○ ja
- ○ nee

We beginnen nu eerst met een oefensessie. De proefleider zal deze opstarten.

Na deze oefensessie en het bevestigen van de elektroden beginnen we nu met sessie 1. De proefleider zal deze opstarten. We beginnen met een **1−back** taak. Deze duurt 4 minuten lang.

Na de 1back taak moet u deze vragenlijst invullen. We vragen u een seintje te geven wanneer u klaar bent.

9. **Hoe moeilijk vond u de opdracht?**
   (Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

   0 = Heel makkelijk
   100 = zeer moeilijk

10. **Hoe stressvol vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Totaal niet stressvol
100 = Zeer stressvol

11. **Had u het gevoel dat de opdracht stressvoller werd naarmate de opdracht vorderde?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Absoluut niet
100 = Heel sterk

12. **Hoe denkt u dat de opdracht ging?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Heel goed
100 = Zeer slecht

13. **In hoeverre moest u zich concentreren om de opdracht uit te voeren?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Helemaal geen concentratie nodig
100 = Heel veel concentratie nodig

14. **Had u het gevoel dat de opdracht na meer letters beter ging?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Het begin ging veel beter
100 = Het einde ging veel beter

U bent nu klaar met de vragenlijst. Geef door aan de proefleider dat we de volgende taak kunnen starten. Dit wordt de **2back** taak. Deze duurt ook 4 minuten lang.

Na deze 2back taak moet u deze vragenlijst invullen.

15. **Hoe moeilijk vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Heel makkelijk
100 = zeer moeilijk

16. **Hoe stressvol vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Totaal niet stressvol
100 = Zeer stressvol

17. **Had u het gevoel dat de opdracht stressvoller werd naarmate de opdracht vorderde?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Absoluut niet
100 = Heel sterk

18. **Hoe denkt u dat de opdracht ging?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Heel goed
100 = Zeer slecht

19. **In hoeverre moest u zich concentreren om de opdracht uit te voeren?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Helemaal geen concentratie nodig
100 = Heel veel concentratie nodig

20. **Had u het gevoel dat de opdracht na meer letters beter ging?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Het begin ging veel beter
100 = Het einde ging veel beter

U bent nu klaar met de vragenlijst. Geef door aan de proefleider dat we de volgende taak kunnen starten. Dit wordt de **1back** taak. Deze duurt ook 4 minuten lang.

Deze vragenlijst invullen na deze 1back taak

21. **Hoe moeilijk vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Heel makkelijk
100 = zeer moeilijk

22. **Hoe stressvol vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Totaal niet stressvol
100 = Zeer stressvol

23. **Had u het gevoel dat de opdracht stressvoller werd naarmate de opdracht vorderde?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Absoluut niet
100 = Heel sterk

24. **Hoe denkt u dat de opdracht ging?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Heel goed
100 = Zeer slecht

25. **In hoeverre moest u zich concentreren om de opdracht uit te voeren?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Helemaal geen concentratie nodig
100 = Heel veel concentratie nodig

26. **Had u het gevoel dat de opdracht na meer letters beter ging?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Het begin ging veel beter
100 = Het einde ging veel beter

U bent nu klaar met de vragenlijst. We beginnen nu met een nieuwe sessie. Geef door aan de proefleider dat we de volgende taak kunnen starten. Dit wordt de **2back** taak. Deze duurt ook 4 minuten lang.

De vragenlijst invullen.

27. **Hoe moeilijk vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).
0 = Heel makkelijk
100 = zeer moeilijk

28. **Hoe stressvol vond u de opdracht?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Totaal niet stressvol
100 = Zeer stressvol

29. **Had u het gevoel dat de opdracht stressvoller werd naarmate de opdracht vorderde?**
(Plaats het schuifje op de plaats die zo goed mogelijk met uw oordeel overeenkomt).

0 = Absoluut niet
100 = Heel sterk

30. **Hoe denkt u dat de opdracht ging?**

Procedure	Time (min)
Entering lab	4
The procedure is explained	2
Participants sign informed consent form	1
Fill in the NEO Personality inventory	10
Testing 1-back with the participants	2
Testing 2-back with the participants	8
Attaching the electrodes	20
Session 1.1	4
Fill in questions	3
Session 1.2	4
Fill in questions	2
Session 1.3	4
Fill in questions	2
Session 2.1	4
Fill in questions	2
Session 2.2	4
Fill in questions	2
Session 2.3	4
Fill in questions	2
Session 3.1	4
Fill in questions	2
Session 3.2	4
Fill in questions	2
Session 3.3	4
Fill in questions	2
Session 4.1	4
Fill in questions	2
Session 4.2	4
Fill in questions	2
Session 4.3	4
Fill in questions	6
Detaching the electrodes	10
Total	128

Table 5.1: Procedure table