A user self-reported emotion feedback system

Bachelor Thesis for Creative Technology by

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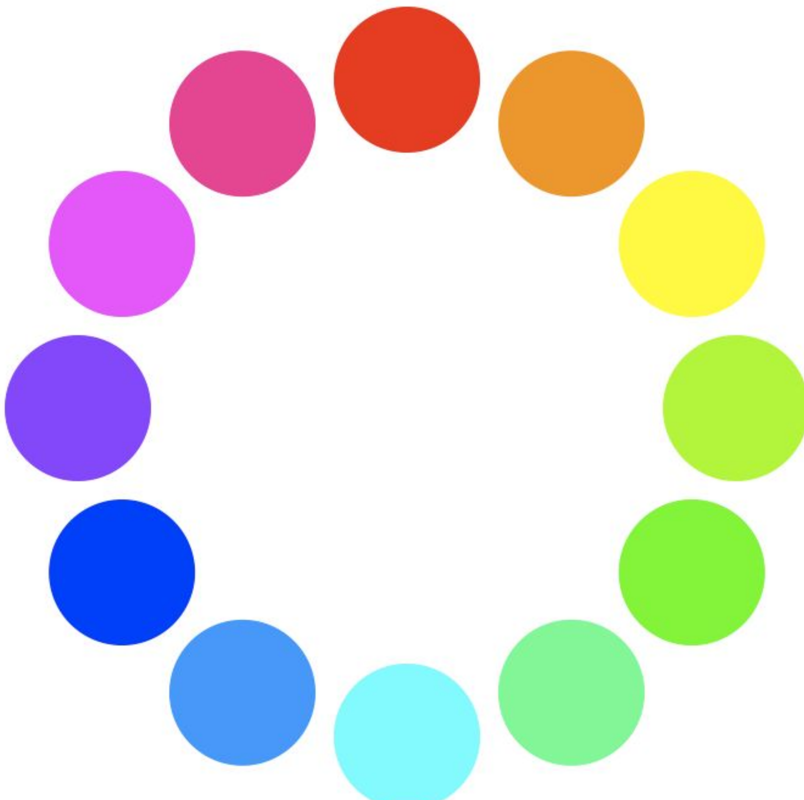

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Abstract

The Escalade, a prototype wearable with various sensors, shows great implementations for a mood-sensing method. Mood-sensing is important since it contains vital information useful in many professions and applications generating self-awareness, regarding communication, improving treatments in the therapeutic industry and optimising the caregiver-patient relationship to help promote general well being.

One promising way to develop a mood-sensing method is a combination of the Escalade and machine learning. For making use of machine learning, you need a labelled dataset. A combination of physiological sensor data and mood labels to train an AI agent is achievable.

Acquiring a mood label is challenging, since collecting spontaneous emotions and self-reported emotions are hard. The user should also be willing to give this self-reported emotion. The focus of this thesis is how to design an engaging mood experience self-sampling system and how to implement this in a prototype. To do so a combination of background research, state of the art research and many design techniques are used. This with a focus on hallway usability tests and user tests. Following from this a prototype is built and evaluated.

The evaluation stated that however, the sample size is small, the prototype meets most requirements and is ready for implementation of artificial intelligence. Implemented can be some additional requirements can be implemented in future work.

Acknowledgements

There are several people I would like to thank for helping me with this project.

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1. Introduction

Emotions have a vital role in everyday life of people. Goertzel (2004) described emotions as mental states that are not formed through free will and causing physiological changes in the body. This consists of internal feelings, thoughts and internal processes, and external physical expressions. The person experiencing these emotions may not be aware of the felt emotions, for example due to lack of self knowledge. People use emotions by making decisions, solving problems, communicating, negotiating, and being able to adapt to unpredictable environments.

Therefore, mood recognition is important since it contains vital information useful in many professions and applications generating self-awareness, regarding communication, improving treatments in the therapeutic industry and optimising the caregiver-patient relationship to help promote general well being. Also, mood recognition can improve the ability to cope with emotions of yourself and others. Emotional Intelligence (EQ) is an important skill to deal with social and personal problems. Mood recognition has become an important subject in human-machine interaction.

Common ways of developing a mood recognition method are by analyzing textual content, facial expressions, speech, body movement and gestures, and lastly physiological changes. While most methods record after effects, research has shown physiological changes in the body can help identifying concerns at an early stage before they become more serious (Neidlinger, 2018). Our goal is to find the precursor, monitor this in the moment, and create a map for the future.

1.1 Problem statement

One promising way to develop a mood-sensing method is a combination of physiological changes and machine learning. However, for making use of machine learning, you need a labelled dataset as stated by Troung (Appendix C). Training an AI agent by only sensor data from physiological sensors is difficult. A combination of physiological sensor data and a mood labels to train an AI agent is achievable. Acquiring such a dataset is challenging, since collecting spontaneous emotions and self-reported emotions is hard. When you ask someone about a felt emotion, they start thinking causing inauthentic information. Besides, the user should be willing to give this self-reported emotion.

1.2 Goal

The overarching objective is to build a mood recognition system that automatically detects emotions, by making use of machine learning. Within this mood recognition system, an algorithm will learn the emotions of the wearer by making use of supervised learning. Supervised learning includes an algorithm learning from, in this case, physiological sensor data and an emotion label. Therefore the goal of this thesis is to collect mood labels in the form of a

user self-reported emotion feedback system. This feedback system should collect spontaneous emotions with a focus on keeping users motivated and interested.
Ideally, the label is obtained by asking users for self-reported mood samples at the moment after a change happens in the obtained biosignals. Other options are at random moments or at a set time.

1.3 Research questions

The main research question of this thesis is how to design an engaging user self sampled mood feedback system system.
In support of the main research question sub-research questions are distinguished:

- What is the best technique to ask for mood feedback from the user?
- In relation to the to be used technique, what is the best location for the to design self sampled mood feedback system?
- How to ask for mood feedback from the user?
- How to make the user be willing to give mood feedback?
- And lastly, how to put the findings into a prototype.

1.4 Report outline

This thesis is separated in eight chapters. Chapter one, which is ending here, is focussing on introducing the problem, goal and research questions.
Chapter two will include a background research on various topics together with state of the art research on the main research question and sub-research question. Chapter three describes the used techniques within this thesis. Chapter four described the ideation phase. Chapter five describes the specification phase. The realisation of the prototype is described in chapter six. Afterwards, in chapter seven, this prototype is evaluated. This bachelor thesis ends with a conclusion and recommendation in chapter eight.

2. State of the Art

2.1 Background research

2.1.1 Quantified self movement

Mood recognition is important since it contains vital information useful in many professions and applications regarding communication, generating self-awareness, improving treatments in the therapeutic industry and optimising the caregiver-patient relationship to help promote general well being. This importance is also noticed by people outside these professions, resulting in the quantified self movement.

Quantified self is a movement that tries to use technology to log data on aspects of a person's daily life. According to Wolf and Kelly (2007) (as cited in de Groot et al., 2018) a trend, named quantified self, on personal data logging started. Wolf and Kelly organise gatherings regarding this subjects. Also, according to Wolf and Kelly (2018) people collect data concerning food consumption, air quality, mood, EDA (skin conductivity) as proximity for arousal, blood pulses, and mental or physical performance. Quantified self according to Wolf is "self-knowledge through self-tracking with technology." Thus, quantified self gives people self-knowledge. In short, a trend on personal data logging started and will provide people with self-knowledge by making use of technology.
People are taking their health into their own hands by collecting data about themselves. Firstly, according to de Groot et al. (2018) more and more people are self-tracking what they do daily, mainly because this can give insight and can help them improve making decisions. Also, self-tracking on a big scale can lead to a movement from the knowledge of groups to the knowledge of the individual. This movement can cause huge changes in the healthcare industry regarding personalised health and personalised medication.
In addition, According to Erwin Blom (as cited in de Groot et al., 2018) quantified self reminds of the things said about the internet before its hype started. Quantified self could be the next big thing concerning revolutionary technological changes with a social impact. Owing to this, quantified self devices will cause big changes in the healthcare industry and will lead to revolutionary technological changes with a social impact.

2.1.2 Company Sensoree

According to the quantified self trend devices helping users to log data about themselves in any way are booming. Companies like Sensoree are adapting to this.

The initial goal of Sensoree was to provide a real-time interface to keep people in their bodies and to avoid switching to analyzing mind mode. But there is valuable information to be gained when logging, especially when asking meaningful questions of the data. It is especially beneficial for caregivers to have the information to predict reoccurrences. (Neidlinger, 2018) Sensoree's focus is therapeutic biomedia. Therapeutic biomedia uses physiological data, also named biodata, sensed by physiological sensors, also named biosensors, and visualises this data by making use of visual, auditory, or tactile (technological haptic) displays in textiles. Tangible displays creates instant biofeedback for the wearer and their surroundings but also serves as an external communication tool. Therapeutic biomedia is a combination of gamification, healthcare and fashion, as seen in Figure 1 (Neidlinger, 2016). Sensoree believes therapeutic biomedia is the future of healthcare and therefore does research and building designs promoting extimacy.

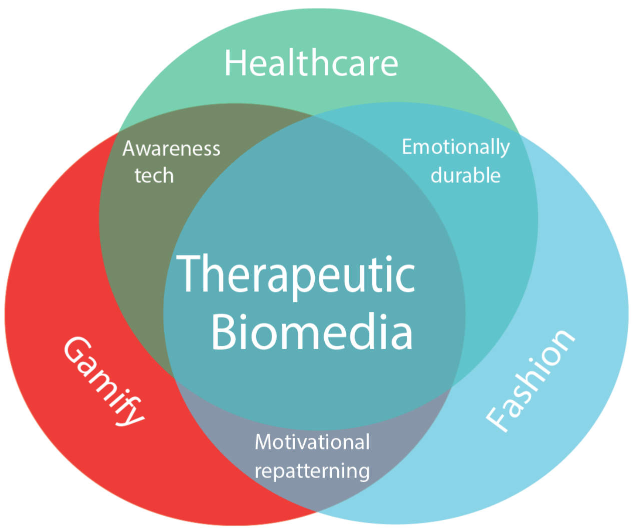

Figure 1: Therapeutic biomedia diagram (Neidlinger, 2016)

Extimacy means externalised intimacy. According to Sensoree (2016), extimacy is promoted by devices that show how you feel on the inside. Intimacy means a private atmosphere, keeping your emotions to yourself, in contrast, extimacy means showing your emotions to others. Therefore, extimacy is a result of therapeutic biomedia.
Sensoree believes therapeutic biomedia is the future of healthcare and therefore doing research and building designs promoting extimacy. Extimacy gives a voice to people who find communicating how they feel difficult. It also provides awareness with tangible biofeedback. This awareness could help improving someone's EQ. Extimacy can help people with PTSD, Alzheimer's and dementia. Next to this paediatrics can be made easier.
According to Neidlinger (2018), the 1-10 scale to determine pain of patients is limited and can enhanced by making use of extimacy. Where the 1-10 scale is limited because when you ask someone about their emotional state this person starts thinking causing inauthentic information. While extimacy provides a real time, low latency read of someone's feelings. (Neidlinger, 2018) Therapeutic biomedia is perfect for the patient-caregiver relationship. The caregiver can predict discomfort and note optimal moods, this gives great new implementations.

2.1.3 Physiological sensor data in relation to emotion

According to many researchers, emotional states can be measured by biosignals. First of all Healey and Picard (2005) researched analysing physiological data to determine drivers' stress levels. They recorded ECG (electrocardiography), EDA, EMG (electromyography to measure muscle activity) and breathing of 24 drivers. Their results showed that EDA and ECG mostly correlated with the drivers' stress level.

Secondly, a similar research from Zhai and Barreto (2006) is a stress detection system based on monitoring physiological signals. Four signals have been monitored: EDA, blood volume pulse, pupil diameter and skin temperature. The collected data is analyzed to differentiate valence and arousal levels in computer users. In their research, the pupil diameter had the most significance to the stress level of the user.

Thirdly, research by Sierra et al. (2011) is also about a stress detection system based on physiological signals. In this research, EDA and ECG were used to monitor physiological data. Specific designed psychological experiments by Sierra et al. are used in the research to build a database for training and testing the system. The system is based on fuzzy logic. It described the behaviour of someone under stress regarding EDA and ECG.

Furthermore, research by Kim and André (2008) describes an automatic emotion recognition system using audio data. Data Collection took place over multiple subjects over multiple weeks using a musical induction method. Four biosensors were used to measure four biosignals: ECG, EDA, EMG and breathing to measure arousal levels.

Additionally, research on emotion recognition making use of audio data is executed by Takahashi (2009) and focuses on multi-modal bio-potential signals. ECG by making use of a pulse sensor clip and EDA were measured to distinguish between three emotions. Positive emotion (relax and pleasure), negative emotion (stressful and un-pleasure) and normal.

And, Maaoui et al. (2009) used five biosignals: ECG by making use of a pulse sensor clip, EMG, EDA, skin temperature and breathing. They made use of the International affective picture system to extract target emotions from the participants. They made use of the Fisher linear discriminant and supporting vector machine method to classify emotional states.

Lastly, research by Yang and Cho (2008) used an accelerometer and physiological sensors on an armband to recognise the activity of the user. Bayesian networks are used for continuous biodata analysis. However the above-described researchers vary in success regarding accuracy, all used biosignals gave some insight in emotion recognition. Therefore, combining multiple sensors is promising recording accuracy of mood detection. In conclusion, the accelerometer, breath sensing, ECG, EDA, EMG, pupil diameter and skin temperature give promising results for research on mood detection.

Detecting mood from biodata can be done by making databases, analysing data and using machine learning. First of all, research from Zhai and Barreto (2006) analysed the collected data to differentiate valence and arousal levels in computer users. Secondly, the research by Sierra et al. (2011) used specific designed psychological experiments to build a database for training and testing the system. The abstract of Sierra et al.'s paper described that the system is based on fuzzy logic. Thirdly, Maaoui et al. (2009) used the Fisher linear discriminant and supporting vector machine method to classify emotional states. Lastly, research by Yand and Chao (2008) used Bayesian networks for continuous biodata analysis. However, the above-described studies vary in success regarding accuracy, their used way of subtracting mood from biodata gives insight into how to do so. More research on combinations of various methods will give new insights. In short, methods for subtracting mood from biodata are making databases, analysing data and using machine learning.

2.1.4 The Escalade

The Escalade is a prototype wearable with various sensors, combined for further research. The Escalade's name is based on the Cadillac Escalade, their biggest SUV with the most options and sensors. The Escalades basic idea was to put as many as possible sensors in one design, to be able to see which combinations of sensors gave the best read of emotional data. Figure 2 shows the Escalade, a band with integrated sensors, casing with all major electronics and a power adaptor (Harmsen, 2017). To conclude, the Escalade is a prototype wearable with various sensors combined for further research on moods.

Figure 2: The complete Escalade sensor system, including the strap, the sensor and the EDA electrodes and wires. (E. Harmsen, 2017)

The Escalade is a combination of many sensors. The base is a Polar H7 chest strap with an integrated heartbeat sensor. This strap is updated with a stretch breath sensor thus capturing the breathing frequency and secures the electronic housing of the other sensors in a 3d printed housing. The Escalade prototype consists out of the following components;

The data and controlling components are:

- PJRC Teensy 3.2 microcontroller;
- SparkFun microSD Transflash Breakout;
- and a HC-05 Bluetooth module.

For sensing the Escalade makes use of the following:

- Bitalino (r)evolution Electrocardiography (ECG) block;
- Bitalino (r)evolution Electrodermal Activity (EDA) block;

- DIY Conductive rubber stretch sensor interface circuit;
- and GY-85 9DOF IMU Sensor module.

Power supply is done by:

- Lithium Ion Polymer Battery - 3.7v 1200mAh;
- And the Bitalino (r)eHC-05 Bluetooth module.volution Power Management (PWR) Block.

Other support components are:

- Polar Soft Strap;
- Conductive Rubber Cord Stretch Sensor;
- H124SG Covidien electrodes;
- and Electrode cables.

(Harmsen, 2017)

2.1.5 Emotions

Definition of basic emotions

The debate of the definition of basic emotions contains two groups. On the one hand, according to Ekman (1992), basic emotions are triggered by the brain with the goal of survival. He distinguished between these emotions with facial or other expressions, without knowing what the person is experiencing. Additionally, Plutchik (2001) states that basic emotions evolved because of the reason that our ancestors had to deal with ecological changes. They are the fundamental base of our emotion system. They happen universal, automatic and extremely fast. Basic emotions trigger high survival behaviour. His theory is that complex emotions are a blend of basic emotions and cognition. On the other hand, from a constructionists perspective, Feldman-Barrett (2006) states in his research that biological and psychological ingredients form emotions: core affects (valence and arousal) and conceptual knowledge. Emotions do not have specific locations in the brain. The reason for this debate is different ways of doing research focussing on various aspects of emotions. In conclusion, the definition of a basic emotion varies among researchers and is depending on the direction one is doing research. In this research, the constructionist perspective of basic emotions fits best since valence and arousal are proper variables for sampling. Also, it is a complete description.

Emotion models

Researchers developed different models of emotions. Examples are in lists, circumplex and three-dimensional models. First of all, according to Ekman (1992) in the 'List of Basic Emotions', basic emotions are anger, disgust, fear, happiness, sadness and surprise. The experiment by Ekman describes a situation presented to an individual and asks the same individual afterwards to choose a facial expression that best fit. He also asked the individuals to identify shown pictures of facial expressions. The chosen individuals are from different cultures making the research cross-cultural.

Secondly, Russell's (1980) developed a circumplex model (a two-dimensional circular space) as seen in Figure 3. The x-axis represents arousal, and the y-axis represents valence. High valence means that an event is positive and low valence means an adverse event. High arousal means one is in a state of alertness and low arousal means the opposite. The origin represents a neutral valence and a medium level of arousal. Russell's circumplex model is used to test words that indicate emotions, facial expressions, and moods.

Thirdly, Plutchik (2001) identified eight basic emotions in an excessive emotion model: anger, disgust, fear, joy, sadness and surprise, trust and anticipation. His circumplex and three dimensional model in figure 4 is, however not cross-cultural, way more excessive as Ekman's. Plutchik's model shows the basic, mild and intense emotions concerning each other and also primary dyad’s.

Lastly, the PANA (positive activation and negative activation) model by Watson et al. (1988) describes that positive and negative effects are different systems in the brain. In the PANA model is based on two basic behavioural systems the Positive Activation (PA) and Negative Activation (NA). Positive activation links to terms of activation and excitement on one end and dull and sluggish on the other hand. Negative Activation links to terms as distress and nervous on one side and calm and relaxed on the other. These two behavioural systems are put on two axes to define the location of moods within the plot.

Thus, variations and differences of the described emotion models depend on the focus, age and kind of research. In conclusion, there is no such thing as the ideal model.

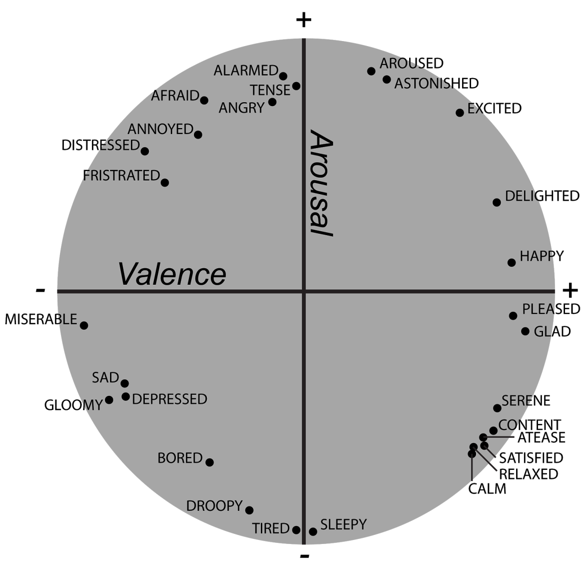

Figure 3. Placement of self reported affective states in relation to valence and arousal. Based on russell circumplex model of arousal and valence.

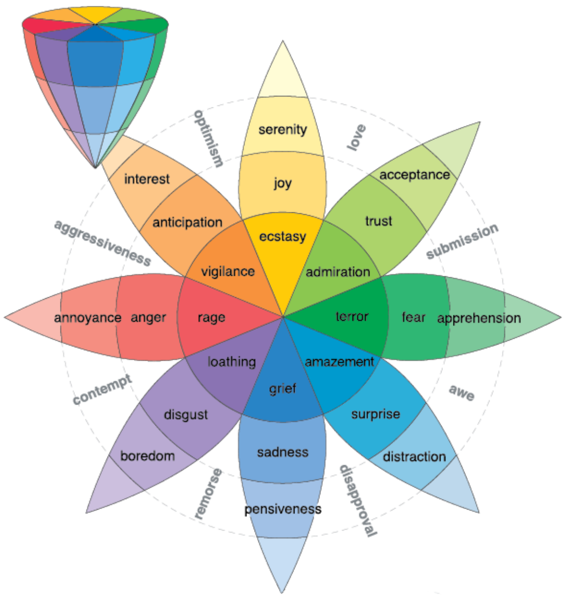

Figure 4. three dimensional circumplex model representing the mild, basic and intense emotions. (R. H. Plutchik, 2001, p 349)

2.1.8 EQ

EQ is the level of someone's ability to understand other people. Described by Akers and Porter (2016) there are five major categories of EQ skills: self-awareness, self-regulation, motivation, empathy and social skills. These five categories will briefly be explained.
First of all, self-awareness is the ability to recognise emotions at the moment they happen. Evaluating your own emotions is required, so you can manage these. This is so called emotional awareness. Another self awareness element is self-confidence: knowing your worth and capabilities. Self awareness is where mood recognition can help. If one is able to recognise and adapt to its own emotions, EQ could rise.
Secondly, self-regulation is all about changing the time and intensity of an emotion. Emotions occur whenever and one does not have much control over this. But there are techniques like meditation that can make the intensity of emotions less harmful.
Thirdly, motivation is the product of clear goals and a positive attitude towards the work that needs to be done. Changing negative thought and rephrase them into positive thought will help one to achieve goals. Another important category is empathy, this is the ability to recognise how other people feel. If you understand the others feelings, you can adapt to those. You can change the signals about your own feelings towards them and in this way benefit.
And lastly, social skills like influence, communication, leadership, building bonds, etcetera.
How well you succeed in daily life depends mostly on EQ. To be able to gain a high EQ one first needs to deal with himself, afterwards the ability to deal with other people can be expanded. EQ exists out of 5 categories and focuses mostly on understand yourself so you can understand and cooperate with others.

Mood recognition could improve one's EQ. This improvement might be achieved due to the fact that someone becomes aware of its emotional state. According to Chamorro-Premuzic in 2013 it is possible to improve your EQ, however inner EQ is hard to train. Effective EQ-coaching's basic is giving good feedback. The most promising EQ-coaching techniques focus on cognitive behavioral therapy and psychological flexibility. Mood recognition could help these coaching techniques become better because feedback on emotions is made easier by extimacy. In conclusion, being actively aware of your emotions and reviewing those could work as a coaching mechanism, raising self-awareness and self-regulation.

2.1.7 Market trends wearable technology

However this topic might be out of the scope of this thesis, it is form a creative technology perspective helpful to have insight into the market a follow up product might be part of. Therefore some research on the wearable technology market and its investment possibilities is done.

The wearable technology market is currently a hot topic in the technology industry because it seems big and booming. Big technology companies do many forecasts on this market. First of all, according to Llamas et al. (2017), there will be an increase of wearable devices until 2021. The total shipment of all wearable devices will rise to 560 million in 2021, and the wearable technology market will grow 16.9% every year. Secondly, Garnet (as cited in Lomas, 2017) estimates that the sales of smartwatches will increase to 81 million devices a year by 2021. Thirdly, IDTechEx (as cited in i-scoop, 2015) stated in 2016 that the wearable technology market would grow 23% yearly to moreover 100 billion devices by 2023 and 150 billion devices by 2026. Lastly, according to González (2017), the wearable technology market will grow in value from 10 billion (2017) to 17 billion in 2021. Therefore, the wearable technology market is a great opportunity. In conclusion, many companies expect a rise in market and sales growth regarding wearable technology.

All wearable devices will increase their number of sold units over the next years. Figure 5 shows sell forecasts of wearable devices by Garnet (as cited in Lomas, 2017). According to this graph respectively body-worn cameras, head-mounted displays and smart watches will grow most in the next three years. In 2021 Bluetooth Headsets will be the market leader in the wearable market. However, the sales growth forecast is quite low. Respectively, Body-worn cameras, head-mounted displays and smartwatches sales will grow most in the next three years. The growth of Wristbands and other fitness monitors are 31% and 4,5% from 2018 to 2021, together they form 13,9% of the wearable market in 2021 according to Gartner's forecast. Although the growth of wristbands and other fitness monitors lack behind on growth in the period 2018 to 2021 and their total market percentage is only 13,9% in 2021, these wearables' are still promising investments. This sub-market is still innovating, and it seems like the early adopters start to discover these devices. For this reason, designing and producing an excellent device can create much revenue. Especially before the general public massively start using these devices. In short, wristbands and other fitness monitor devices are promising investments according to Gartner's forecast on the wearable device market.

Wearable device	Sell forecast 2018	Sell forecast 2021	Sell growth percentage in period 2018-2021	Percentage of total wearable market in 2021
Smartwatch	48,2M	80,96M	68,2%	16,0%
Head-mounted display	28,28M	67,17M	137,5%	13,3%
Body-worn camera	1,59M	5,62M	190,6%	1,1%
Bluetooth Headset	168M	206M	21,7%	40,8%
Wristband	48,84M	63,86M	**31,0%**	**12,7%**
Sports Watch	21,65M	22,3M	3,0%	4,4%
Other Fitness monitor	59,03M	58,73M	**4,5%**	**1,2%**
TOTAL	347,59M	504,65M		

Figure 5: Overview sales wearable devices forecast 2018 to 2021 with growth percentage and percentage of total market. Based on forecast graph by Gartner. (Lomas, N., 2017)

22.1.8 Color Psychology

Colours are very common in our daily life, but not much research has been conducted regarding the influences of colours. Firstly, according to Elliot and Maier (cited in Cherry, 2018) "Surprisingly, little theoretical or empirical work has been conducted to date on color's influence on psychological functioning, and the work that has been done has been driven mostly by practical concerns, not scientific rigor." Secondary, according to Cherry (2018) color psychology has become hot topic in marketing, art, design and many other areas. Much evidence in this field is anecdotal at best, but important discoveries and observations by researchers and experts have been made. Therefor, color psychology is an important field with not much evidence.

Some colours have universal perceptions, others are somewhat subjective. According to Cherry (2018), colors in the red color spectrum area are warm colors, including red, orange, and yellow. They evoke emotions ranging from feelings of warmth and comfort to feelings of anger and hostility. Colors in the blue color spectrum area are known as cool colors, including blue, purple, and green. These colors are often described as calm, but can also be representative of feelings like sadness or indifference. According to Johnson (2018) colours represent different meanings in different cultures. He also states that according to researchers in the united states colors have more or less the same meaning in western culture. In conclusion, colors have different meanings in different cultures, but most western cultures share the same meaning for each color.

First of all, the color black represents authority and power. But it is also used as a symbol of menace or evil. Secondly, white symbolises innocence and purity within western culture. Thirdly, red which is the most intense color regarding emotions, stimulates heartbeat and breathing, but can also be seen as the color of love, but also anger. Pink however is more romantic and tranquilizes. In addition, blue is peaceful, representing calmness or serenity. Tranquil blue causes the body to produce calming chemicals. However green is also peaceful, the color has a more calming effecst. It represents good luck, health and jealousy. Dark green implies masculine, conservativity and implies wealth. Next, the color yellow, the optimistic color. It is attention grabbing and cheering. Orange calls to mind feelings of excitement, enthusiasm, and warmth. Warmth makes it mostly different from yellow. Purple stands for luxury, wealth and sophistication, but also femininity and romance. It is often seen as a royal colour. Lastly, brown stands for the color of earth and is reliable, but could also be sad and wishful (Johnson, 2018; Cherry, 2018).

2.2 State of the art

The primary research question of this thesis is how to design an engaging user self sampled mood feedback system. Many researchers have worked in the field of mood experience sampling. Also the other sub-research questions are explored.

2.2.1 Questionnaire-based mood self-sampling techniques

A standard way of asking for self-sampled mood experience feedback is by the use of questionnaires. Some relevant questionnaires principles are described below.

POMS

The first described questionnaire method is the profiles of mood states (POMS) by McNair et al. (1971). POMS is a 65 items rating scale. This scale forms a total mood index, a positive mood index and five indexes of negative mood. The five indexes of negative mood are Tension/Anxiety, Depression/Dejection, Anger/Hostility, Fatigue/Inertia and Confusion/Bewilderment. Respondents use a unipolar 5-star scale starting from not at all to the extreme. The respondents can rate extend to which they experienced 65 affect states in the past week, an hour or right now. Examples of the used affect states are: angry, energetic, weary, confused, etcetera as seen in Figure 6.

Other researchers make made variations on the POMS questionnaire. For example, the profiles of mood states 2 (POMS2) by Heuchert and McNair (2012) adds an extra index: Friendliness. POMS 2-Y focuses on people in the age range from 13 to 17 years old. Also, there are shorter versions of POMS.

In general, POMS is a suitable measurement method to sample moods experiences because it captures a range of different negative moods and also positive moods. However, for the positive moods, the vigor subscale is used. The vigor subscale contains items like lively, energetic, cheerful, pull of pep, carefree, etcetera. This vigor subscale is only measuring higher activation positive mood and not lower activation positive mood.

Abbreviated POMS (Revised Version)

Name: ______________________________ Date:

Below is a list of words that describe feelings people have. Please **CIRCLE THE NUMBER THAT BEST DESCRIBES HOW YOU FEEL RIGHT NOW**.

	Not At All	A Little	Moderately	Quite a lot	Extremely
Tense	0	1	2	3	4
Angry	0	1	2	3	4
Worn Out	0	1	2	3	4
Unhappy	0	1	2	3	4
Proud	0	1	2	3	4
Lively	0	1	2	3	4
Confused	0	1	2	3	4
Sad	0	1	2	3	4
Active	0	1	2	3	4
On-edge	0	1	2	3	4
Grouchy	0	1	2	3	4
Ashamed	0	1	2	3	4
Energetic	0	1	2	3	4
Hopeless	0	1	2	3	4
Uneasy	0	1	2	3	4
Restless	0	1	2	3	4
Unable to concentrate	0	1	2	3	4
Fatigued	0	1	2	3	4
Competent	0	1	2	3	4
Annoyed	0	1	2	3	4
Discouraged	0	1	2	3	4
Resentful	0	1	2	3	4
Nervous	0	1	2	3	4
Miserable	0	1	2	3	4

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Figure 6. Abbreviated POMS Questionnaire. (R. Grove & H. Prapavessis,1993)

PANAS

Another mood experience sampling technique is the Positive and Negative Affect Schedule (PANAS) questionnaire by Watson et al. (1988). The PANAS questionnaire, as seen in Figure 8, is a scale consisting out of 20 item to measure positive affect (PA) and negative affect (NA). Figure 7 illustrates what item PA or NA is measured. Twenty emotions have to be rated on a scale from one (=very slightly) to five (=very much). Just like at POMS, also PANAS has variations, so does exist for example a 10-item PANAS, containing instead of 10 items for PA and 10 NA, only five items for PA and five items for NA (Mackinnon et al., 1999). According to validation studies; these questionnaires show great validation. (Crawford & Henry, 2004)

The PANAS questionnaire and its other versions are popular within the field of mood experience sampling, but low activation feeling like calmness, happiness or sadness are not captured. The PANAS-X by Watson & Clark (1994), partly solves this problem. However, instead of 20 items, 60 items are captured to measure more low activation feelings as well a broader spectrum of PA and NA. Therefore PANAS-X is more time consuming than the regular PANAS questionnaire.

	PA (positive affect)	**NA** (negative affect)
Item	Attentive, interested, alert, enthusiastic, excited, inspired, proud, determined, strong, and active	Distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, and jittery

Figure 7: Watson and Clark’s 20 item distribution over PA and NA in PANAS.

PANAS Questionnaire
This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way right now, that is, at the present moment *OR* indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)**

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

__________ 1. Interested	__________ 11. Irritable
__________ 2. Distressed	__________ 12. Alert
__________ 3. Excited	__________ 13. Ashamed
__________ 4. Upset	__________ 14. Inspired
__________ 5. Strong	__________ 15. Nervous
__________ 6. Guilty	__________ 16. Determined
__________ 7. Scared	__________ 17. Attentive
__________ 8. Hostile	__________ 18. Jittery
__________ 9. Enthusiastic	__________ 19. Active
__________ 10. Proud	__________ 20. Afraid

Figure 8: PANAS Questionnaire. (L Jeana & Magyar-Moe, 1988, p 52)

2.2.2 Visual-based mood self-sampling techniques

SAM

The self-assessment manikin (SAM) by Margaret and Lang (1994), as seen in Figure 9, is a statistically proven useful sampling mechanism perfect for quickly assessing the pleasure, arousal and dominance associated with the person’s emotional reaction to an event. SAM is in close relation to the Russell circumplex model as described in the background research. It is a useful and not time-consuming method to measure mood, however SAM is quite spacious and hard for digital representation on smaller screens.

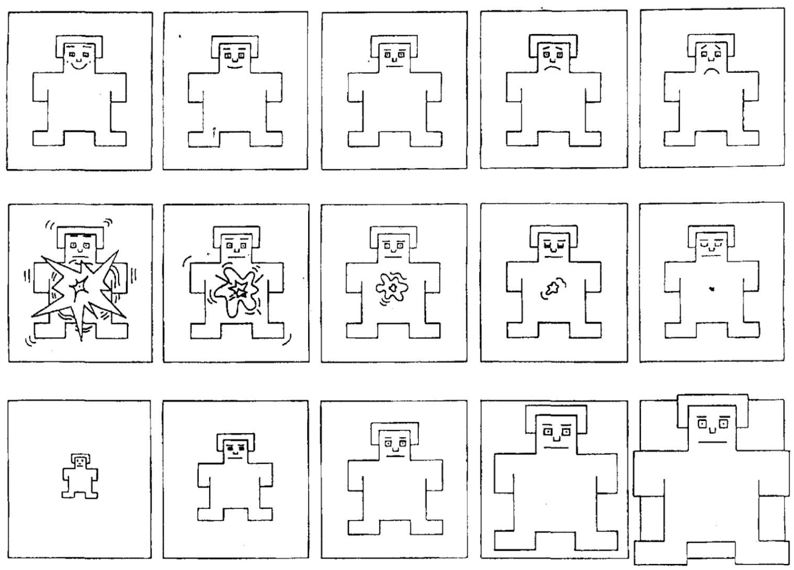


Figure 9. Self-Assessment Manikin (SAM), top panel rates the affective dimensions, middle panel arousal and the bottom panel rates dominance. (M. M. Bradley and P. J. Lang, 1994, p 51)

Affective Slider

In addition, the affective slider is another user self-mapped mood feedback measurement technique developed by Betella and Verschure (2016), as seen in Figure 10. The Affective Slider is a combination of SAM and the circumplex Russell model. The Affective Slider is a digitalised self-report mood tool, and it consists two sliders which makes it possible to give feedback on pleasure and mood quickly. The statistical research stated the Affective Slider is as useful as SAM, following time-consuming statistical testing.

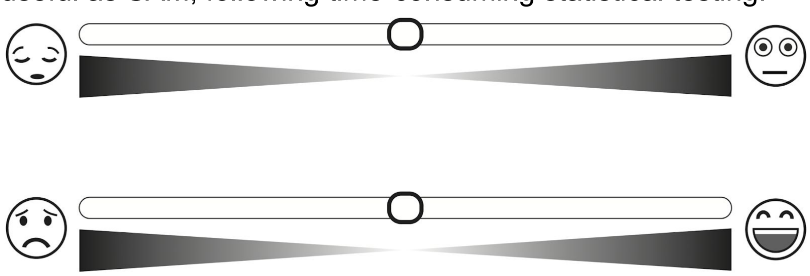


Figure 10. The Affective Slider. The top slider reports arousal and the bottom lider reports pleasure. (A. Betella and P. F. M. J. Verschure, 2016)

VAS

The 16-item Bond-Lader visual analogue scale (VAS) as seen in Figure 11 makes use of the comparison between 16 bipolar scales that measure four different concepts of mood: mental sedation or intellectual impairment, physical sedation or bodily impairment, tranquilization or calming effects and other types of feelings or attitudes. (Pipingas et al., 2013). For example, these scales have on the one side calm and exited on the other. The lines are 10cm long, in Figure 11 illustrated by the light blue line. The participant marks the degree of, in Figure x represented as a dark blue dot, agreement between the adjectives based on their current state. So this agreement can be visualised along the 10cm scale (Bond & Lader, 1974). From this mark, a score is conducted, which is the distance from the negative anchor to the mark of the participant.

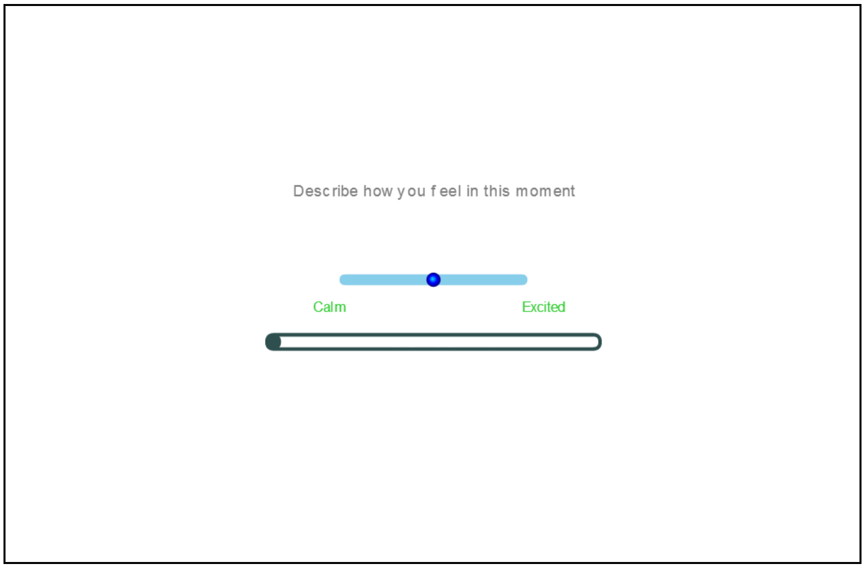


Figure 11: A VAS bipolar scale, showing one of the 16 items. (Bond, 2015)

2.2.3 Ways to ask for mood feedback

Many researchers worked on how to ask for mood feedback. Findings from multiple studies are described.

Mood diaries

Mood diary methods are ways to ask for mood feedback; it is an interval contingent sampling technique. It involves completing a diary or a survey, after a certain amount of time. For example daily in the evening before going to bed. Questions about the experience of the participant are answered. Subjects regarding food, mood and any experience are addressed.

A typical daily diary study duration is from one to three weeks. After two to four weeks the quality of the data collects decline, possibly due to participants. (Stone et al., 1991). Daily diaries are popular because they make administration of emotions easy. Primarily when the surveys are collected through internet implementations. Popularity is also caused by the fact that these diaries are a form of low-frequency sampling and have the option to include many items. According to Parkinson et al. (1995) are end-of-day diaries and hourly diaries close to each other in correspondence. Noë et al. (2017) researched the differences between current or daily mood diaries. The outcome of the research is that both current and daily feedback can be used to map mood. Daily feedback is preferred when it is essential that the survey has high compliance, however it is less accurate. Current surveys are more accurate but sometimes not executed because the user is not always able to comply.

An example of a daily diary study is the daily phone diary (DPD). It is a study of religious/spiritual behaviour frequently rely on self-reported questionnaire data. Self-reported question data is susceptible to bias. DPD is developed to minimise bias in reporting activities and behaviour over a full day. The study is cross-sectional with 126 parents containing children with cystic fibrosis. Focussing on the validity of the DPD on religious/spiritual behaviours. To determine the odds of improved mood during religious/spiritual activities longitudinal models were used. Convergent validity is found. Participants had increased odds of improving mood during religious/spiritual activities compared to non-religious/non-spiritual activities. Associations with gender and religious have been found. In conclusion, the DPD is a valid tool for studying religious/spiritual activities. (Szcześniak et al, 2016).

Experience sampling method

Experience sampling can be used to ask for mood feedback; it is a signal contingent sampling method. It involves more frequent reports than daily diaries and uses signalling in their natural setting. Participants are signalled randomly from six to ten times a day, between 6 to 10 times per day, usually over the course of several days to weeks. Participants respond, following this signal, in the form of feedback. Although the number of items in experience sampling usually is small, accurate feedback can be conducted by collecting items and link them over time to display changes (Csikszentmihalyi & Larson, 1987).

Event sampling

Event sampling can be used to collect mood feedback; this refers to data collected by the participant following an event. For example the research Lowe and Fisher (1983) on obese female college students using food and mood self-monitoring (FMSM) form. Obese female college students recorded their food intake and mood using just before eating.

Sensor Sampling

Sensor sampling is a real-time method using sensors to sample moods and other psychological states over time. Sensors are used to measure activities and physiological measures. These sensors, however, are used to indicate when mood feedback needs to be given by the participant.

In continuous sensor sampling, activities and physiological measures are recorded continuously over a designated time period. According to Rachuri et al. (2011) data from continuous recording from physiological sensors is used in relation to self-reports of experiences. Similarly, adaptive sensor sampling lowers the sampling rate to save energy, reduce memory use and processing power.

2.2.4 Engaging design

Any product nowadays needs to be engaging to be pleasant to use. Engagement is accomplished by for example persuasive technology and, currently a hot topic, gamification. Persuasive technology is designed technology with a focus on changing behaviours of the users making use of persuasion and social influence, however not through coercion. In which coercion is a forceful or threatening way to make someone perform a target behaviour (Fogg, 2002). Also, in 2012 Huotari and Hamari defined gamification as follows: ‘A process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation.' Gamification only works when correctly designed. Just the fact that something is a game does not make it engaging. According to Fogg and Huotari, persuasive technology and gamification are both focussing on the user aspect of the product, putting the user in the centre of the design process will cause better and more engaging design. However, some constraints and critical points will be taken into account. In short, persuasive technology and gamification could make the product more engaging, but only if executed correctly.

There are different ways of adapting persuasive technology into a design, focussing on different aspects. To begin with, a well-known method is to make use choice architecture. Firstly, Thaler and Sunstein (2009) state: "A good system of choice architecture helps people to improve their ability to map and hence to select options that will make them better off." They listed six so-called NUDGES: iNcentives, Understanding mappings, Defaults, Give feedback, Expect error and Structure complex choices. Secondly, another way of adapting persuasive technology into a design is the Fogg Behaviour Model (FBM), as seen in Figure 12. Fogg (2009) stated that his model is the product of three factors: motivation, ability and triggers. The assets of the FBM model include a sufficient motivation, the ability to perform the behaviour and be triggered to do such behaviour. These assets should occur at the same time otherwise the person that should perform the desired behaviour will not succeed doing this. Three types of triggers exist according to BJ Fogg in 2009: signals, spark and facilitators. Thus, since incentive of the NUDGES model is in close relation to motivation in the FBM model, both describe ways of adapting persuasive technology into a design are overlapping. Both ways are focussing on different aspects of design with the user as a central focus point. In short, using both NUDGES and FBM give the aimed user self-reported emotion feedback system useful design input to improve engagement.

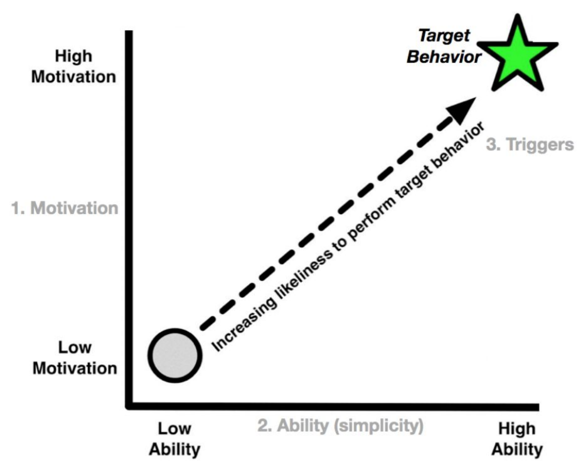


Figure 12: *A Behavior Model for Persuasive Design.* (B.J. Fogg., 2009)

Gamification is an excellent way to create more user value to the design, but only if executed correctly. An example of a positive influence of gamification is the recent study by van Berkel et al. (2017) about gamification in the Experience Sampling Method (ESM) for human sensing. Their ESM described: users were asked to submit a word submission about particular locations and rate other users' submissions. Van Berkel et al. developed two versions of the same ESM

application. One ESM version has strong gamification elements, and the other version does not. In total 24 participants took part in the user study. The results of this research are fascinating. A definite positive outcome of the study is that the leaderboard and score functions benefit the motivation and effectiveness of the participants. An example of negative influence within the same study is when the participants are facing a time challenge; causing negative impacts on motivation and effectiveness of participants.
The outcome of this study gives insight into the effectiveness of gamification, not facts. According to the study, more additional research needs to be done to make clear statements about the findings.

2.2.5 Conclusion

The research question how to design an engaging mood experience self-sampling system is explored. Some of the sub-research questions have been partly answered.
First of all the question what the best technique is to ask for mood feedback is partly answered by some studies. Researchers developed questionnaire based mood self-sampling techniques as well visual based mood self-sampling techniques. Since the mood experience self-sampling system preferably is not time-consuming for participants, the Affective Slider and SAM are interesting and could be possibly used as a technique to ask for mood feedback from the user. More research on what is the best technique to ask for mood feedback need to be conducted.
Secondly, the ideal location for a user self sampled mood feedback system will need more research since no studies are found regarding this.
Thirdly, the way the system should ask for mood feedback from the user is answered and explored. Possibilities include mood diaries, the experience sampling method, event sampling and sensor sampling. Where experience sampling method and sensor sampling is most interesting to implement.
Lastly, the question how to keep users motivated and interested to give feedback will be answered by making use of persuasive technology techniques. These techniques, including NUDGES and FBM, can help to guide the designer into the right direction regarding keeping the user interested and not annoyed. Gamification can help to keep users motivated, however, this statement needs more testing to be valid.
In conclusion, researchers did find answers to parts of the research question, however, in my knowledge an existing answer to the main research question in this form is unanswered. Therefore I can state the graduation project is novel.

3. Methods and techniques

This chapter mentions the different methods and techniques used in this thesis. Motivated is the use of the particular methods or technique.

The used methods and techniques are well known, especially within the scope of this thesis. Therefore more detailed descriptions of every used technique or method are given in Appendix J.

The project starts with the ideation phase. In which the possibilities and nieces of mood sensing are explored, to narrow down to a product concept. The ideation phase started with an individual brainstorm, meetings with Kristin Neidlinger and an expert meeting with Troung. These activities together with the background research and state of the art research are the base for iPACT and the user perspective scenarios. All the previous information is used to make design choices which result in the first iteration of requirements.
First design ideas are described and tested in a hallway usability test to determine what the best technique to ask for mood feedback is. Also in combination with this technique, the ideal location following the user is researched. Conclusions from the usability test result in the second iteration of requirements.

The specification phase will take a closer look at the functionalities of the creative idea, which is a result of the ideation phase. First, a FICS description is written to describe the functionalities and user interactions with the system; afterwards established is a brainstorm on the implementation of the 8-wheel representation into a physical form. To make the user willing to give emotion feedback and to find an appropriate way to ask for feedback persuasive technology techniques, the NUDGES and the FBM model, are used. Afterwards, a second hallways usability test will test these implementations. Results from this usability test are implemented into the third iteration of requirements together with findings from more research into colour psychology and a questionnaire regarding the use of emojis. Next, described is a more detailed overview of the functionalities of the system, by making using of functional system architecture procedures.

Creation of the prototype takes place during the realisation phase. First designed are the wristband hardware, software and its casing. Afterwards, established is the serial communication between both the wristband and the Escalade. When both devices can communicate, adjustments to the original Escalade software are conducted to be able to generate a timestamp and save the mood feedback together with the physiological data on the SD card.

The evaluation phase includes a functional test and a user test. The functionality test will be performed by the researcher, to check if the developed prototype meets the desired requirements. Due to time constraints, performed will be a simplified user test procedure. Described is the user test procedures results, resulting in conclusions. Lastly, given is a last iteration of requirements, usable for future work.

In conclusion and recommendation, discussed and answered are the research questions. Resulting in recommendations for future work.

4. Ideation

The goal of the ideation phase is to explore the possibilities and nieces of mood sensing. To be able to narrow down to a product concept.

4.1 Mood sensing project direction

4.1.1 Mind Map

At the start of the ideation phase, a mind map is conducted to get a broader view of the total mood sensing concept. Appendix A includes this mind map. In this first mind map, some niches are distinguished: sensing, use of sensors, reading sensors, testing and reading of emotions in certain situations and design related subjects. These design related subjects include casing, creating a symbiosis between user and device, improve communication between people etcetera. Based on these niches background research is conducted.

4.1.2 Brainstorm

Afterwards, a brainstorm and several meetings with Neidlinger are conducted to determine a direction for the graduation project. Appendix B shows an ideation map regarding the mood-sensing project. Illustrated are three directions for the project: technology, processing and giving meaning to the data. Technology is partly conducted by the Escalade, while for processing new ideas need to be generated to make the data from the Escalade useful. Give meaning to the data is could be represented by an artificial intelligence agent. The primary outcome of this brainstorm session is the use of a self-sampling method that will link to the data. This way a machine learning agent can give meaning to the sensor data.

4.1.3 Expert meeting

During the expert meeting, an expert provides feedback. The expert, in this case Truong, gives an advisable project direction to be able to integrate AI into the project. Troung is closely related to the project as the critical observer. During the meeting directions and ideas are discussed starting with the use of AI. First, discussed is the difference between machine learning and supervised learning. Truong stated that an AI agent, using supervised learning ideally uses a mood label to learn from physiological sensor data. Generating such label is an exciting focus point for the project. Unsupervised learning is less likely to succeed, therefore generating a mood label is essential. Therefore the focus of this thesis will be to generating a valuable dataset of physiological data and a mood label to train an AI agent. Implemented are techniques on how to ask for feedback, when to ask for feedback and how to keep people willing to give feedback. Regarding the usability tests, they should include the interface, but at the end test with the final prototype, the goal should be to test the system when someone wears the interface in combination with the Escalade. So the combination of both devices can be tested. Appendix C includes an encryption of the meeting.

4.2 iPACT

In this section, the system will be explained using the iPACT method. iPACT will be used to describe the system through the eyes of the user. For this section of the report the aimed mood recognition system is used; however this thesis will focus on the mood sampling. Information from the state of the art research, background research, mindmap, meetings with Neidlinger and expert meeting with Troung is used to form the iPACT.

Intention
The system aims to collect self-generated mood feedback from the user. Encourage the user to perform the target behaviour, to eventually be able to detect moods in combination with the biomedical sensor data and machine learning.

People
Kara (24) is suffering from PTSD (post-traumatic stress disorder) just as many other people suffering from this disorder her physical and emotional reactions are changing (Mayo Clinic Staff, 2017). PTSD is affecting herself and others around her.

Carlos (78) is a proud senior man who just moved into a retirement home. He feels like he lost his pride since he is not able to take care of himself anymore. Other residents and staff of the retirement home noticed Carlos is being passive aggressive, sad and prefers to be alone. His caregivers are worries for him and themselves since he shows tantrums.

Jack (28) has a low EQ. He has a lack of empathy, has many arguments and has a hard time maintaining friendships. Jack is worried about his personal growth since EQ is vital to succeed in life. However, Jack is interested in technology from an early age.

Julia (59) is visiting the hospital quite often, she is rheumatic and feels much pain. Doctors ask her to fill in 1-10 scales regarding her pain. Julia herself feels like she is at level 10 pain, her doctors are in doubt if she is, but don't want to underestimate her feelings.

Activities
The aimed mood recognition system will be worn by people during their daily life activities to be able to track mood changes over time and detect mood swings to be able to draw conclusions that can be used in for example therapies, improving the caregiver-patient relationship, improving pain treatments in the hospital and improving EQ.

Context
Users will wear the system in any environment. Later the generated data is used in stable environments like consulting rooms or retirement homes.

Technology
The system will make use of the Escalade, a digitalisation of a mood sampling technique, an SD card to store the data and an algorithm saving the data.

4.3 User perspective scenarios

Use scenarios are created using the described personas in Section 4.2. The use scenarios will provide more insight into the use of a mood recognition system.

First of all, Kara, who is suffering from PTSD. Is showing differences in her physical and emotional changed. Kara decided to seek professional help. A psychologist offers her to improve her treatment by using a mood recognition system. A mood recognition system could help her understanding these changes and in combination with a treatment form psychologist or psychiatrist. She accepts the offer and wears the device so it can learn from her emotions. At first, she thought it was a bit funny to walk around with such device especially since it is asking for much feedback. However, with enough encouragement from her psychologist and knowing she will benefit from the device in a later stage of her treatment she continues using the device.

Secondly, Carlos, a proud senior man who just moved into a retirement home causing the feeling of losing his pride. He hates not being able to take care of himself anymore, he is angry at everyone, but mostly himself. He feels lonely and left behind and therefore gets moody when caregivers give him daily care. When a caregiver offered him to use a mood recognition system, he refuses. Even after another attempt when a researcher explained to him that the caregivers could, by making use of the system, learn about him and his feelings to make his last days more pleasurable. Improving their relationship (Neidlinger, 2018). After a while, Carlos accepts the invitation to use the mood recognition system. Out of misery and boredom, he is willing to try. At first, his thoughts were sceptical, how can such system learn how he feels and giving feedback was somehow unclear.

Thirdly, Jack who is suffering from many social issues because of a lack of EQ decided to look for a treatment. His EQ-coach advises him to wear a mood recognition system to improve cognitive behavioural therapy and psychological flexibility. The mood recognition system helps the coaching techniques become better because feedback on emotions is made more accessible and more insightful. Especially self-awareness could be improved using this technique. Since Jack is encouraged to improve his EQ and his life he is more than willing to try this new tool. He has an affection for technology and enjoys the fact that this technology could help him solve his issues.

Lastly, Julia who is in a lot of constant pain is asked to use the mood recognition system. She feels misunderstood since doctors unpurposely showed their doubts about her pain feedback on the 1-10 scale. The doctors offer Julia to use a mood recognition system so they can learn from her felt emotions to determine her pain levels. They told her not to accelerate her moods. She expected pain to be one of the moods that can be filled in, but surprisingly this was not on the feedback system. Since Julia wants to prove the doctors wrong about her feelings regarding pain she is determined to give feedback. Since the doctors told her overestimating her feelings will result in less valuable data she will do her best to give accurate feedback. The feedback method does not include pain, which is helpful. At first, she was sceptical, how can such system learn how he feels and giving feedback was somehow unclear. After a while she obtained less interest in giving feedback, causing her not to give feedback anymore at all. Her doctors, however, encouraged her again to give proper feedback due to improving her treatment. The thing she wants of most due to her pain.

4.4 Design choices

Two scenarios are possible for a user self-reported emotion feedback system. The first scenario is a mood recognition system that includes a self-reported emotion feedback system. In the first period of training, labels are formed by the self-reported emotion feedback system to generate mood labels. Ath the end of the training period the self-reported emotion feedback system is removed from the system. Since machine learning can detect moods. The second scenario is a mood recognition system with a permanent self-reported emotion feedback system integrated. This scenario might be more realistic since it is hard for machine learning to distinguish emotions in different individuals since for every person physiological signals are different for every emotion. Therefore the self-reported emotion feedback system should be seen as a part of the end product.

Research on the use of biosensors in Section 2.1.3 gives insight on the use of sensors and processing of data. Many researchers have explored options regarding the processing of biodata into moods. The outcome of this literature: methods for subtracting mood from biodata are making databases, analysing data and using machine learning. Combining multiple biosensors is promising according to the accuracy of mood detection. The Escalade is combining many sensors and therefore is a promising tool to measure biosignals. Therefore the Escalade is used. Using the Escalade for supervised learning includes an algorithm learning from, in this case, physiological sensor data and an emotion label will make it possible for an algorithm to perform supervised learning.

To be able to collect mood labels in the form of a user self-reported emotion research on mood models is conducted in the background research. Discussed are the ‘List of Basic Emotions’ by Ekman (1992), the circumplex model (a two-dimensional circular space) by Russell’s (1980), Eight basic emotions in an excessive emotion model by Plutchik (2001) and the PANA (positive activation and negative activation) model by Watson et al. (1988). All described in Section 2.1.5. These models are in close relation to many mood sampling methods and can be used to generate new sampling techniques, illustrated in Section 4.6.

A standard way of asking for self-sampled mood experience feedback is by the use of questionnaire-based sampling techniques; many researchers worked on such projects indicating its importance. First of all the profiles of mood states (POMS) by McNair et al. (1971), secondly the positive and Negative Affect Schedule (PANAS) questionnaire by Watson et al. (1988). Described in Section 2.2.1.

In conclusion, the use of questionnaires like PANAS and POMS shows proper validation, but the use of these questionnaires is more or less time consuming regarding the version of the questionnaire. Since the user is will probably be asked for feedback multiple times a day a not time-consuming method is preferred, like most visual based sampling techniques.
Section 2.2.2 describes and illustrates the self-assessment manikin (SAM) by Margaret and Lang (1994), the Affective Slider developed by Betella and Verschure (2016) and the 16-item Bond-Lader visual analogue scale (VAS) by Pipingas et al. (2013). SAM and the affective Slider are not time-consuming and show great validation according to the researches, using one of these techniques to generate a mood label described in Section 4.6.

Many researchers worked on how to ask for mood feedback. Findings from these researchers are essential because designing a mood experience self-sampling system needs to ask users for feedback. The first option described in Section 2.2.3 is interval contingent sampling techniques like mood diaries, once a day questions about that particular day are asked. Secondly, a signal contingent sampling method, using signalling in a natural setting for the user to ask for more frequent reports. Thirdly, event sampling refers to data collected by the participant following an event. Lastly, Sensor sampling is a real-time method using sensors to sample moods and other psychological states over time.

As a conclusion from the expert meeting and due to time constraints decided is to use a contingent sampling method, since that way it is possible to generate a dataset including moods at different set times. After implementation of AI, the ideal way to ask for feedback would be sensor sampling. The AI agent can, when being most uncertain about the user's mood state ask for mood feedback to expand knowledge.

The sub research question how to make users willing to give mood feedback is by making use of engaging design, making use of persuasive technology and gamification. There are different ways of adapting persuasive technology into a design, focussing on different aspects. Both the NUDGES and FBM model, which are related, can improve the mood feedback system. Both techniques will be used to improve the system at a later stage of the design.

Besides, the use of gamification, as discussed in 2.2.4 is not advised since the study by van Berkel et al. (2017) about gamification in the Experience Sampling Method (ESM) for human sensing has no definite conclusions regarding the use of gamification for sampling methods. Since the study stated that gamification needs more research, results of this study are only an indication.

In conclusion, implementing a leaderboard with other users, which are not there yet, is not an option at this stage of the design. Secondly adding a time challenge, which could decrease the time between the felt emotion and the sampling of that particular emotion, is out of the discussion because of their adverse effect on the participants' effectiveness and motivation.

4.5 Requirements first iteration

The project direction together with the state of the art, background research and iPACT are used to form the following requirements according to MoSCoW method.

Must

- Make use of the Escalade to generate physiological data;
- Generate a mood label to make supervised learning possible;
- Use a mood model or a mood sampling technique to generate mood feedback to form a mood label;
- Ask the user for self-reporting mood feedback;
- Make the user fill in their mood by themselves;
- Save this mood feedback;
- Give the user an indication of when to give mood feedback;
- Be wearable and easily accessible.

Should

- Save the mood feedback in a database together with the physiological sensor data;
- Give feedback to the user, makes visible what the user will give as an input;
- Make the user willing to give feedback by making use of persuasive technology;
- The sampling technique must be understandable for people with less knowledge of technology;
- Be understandable by users of all ages.

Could

- Make the random mood feedback more valuable (avoid many neutral states in samples);
- Stimulate the users to give better feedback.

Won't

- Include AI to determine the moment when the system is most uncertain about the user's mood;
- Avoid generation of biased samples by users, due to the fact when someone asks someone about their mood, their thinking causes inauthentic feedback;
- Use peaks in physiological sensor data as an indication to ask for mood feedback;
- Implement gamification to make use of peer pressure to make people give more feedback;

4.6 First Ideas

4.2.1 Self-sampling techniques

During the background research phase, explored is research regarding mood models and mood self-sampling techniques. Four sampling techniques are favourable. The first sampling technique is a six-slice wheel with emotions: anger, disgust, fear, happiness, sadness, tender and surprise as seen in the left interface of Figure 13. For the user, this model is rather easy and intuitive for the user. They select how they feel, and the selectable emotions are simple.

Figure 13: a six-slice wheel representation with 6 basic emotions and emoji representations.

The second self-sampling technique is a representation of the Plutchik model discussed in the background research. Plutchik distinguished between eight emotions and their intensity, as well as the ability to form more complex moods. Figure 14 gives a aight wheel representation of the Plutchik model; left is the start situation, right is filled in a situation in which the user is going to give an important presentation. The sampling technique works as an inside going wheel when the user presses a slice the emotion goes one level up. By pressing one time, the user selects the mild emotion. By pressing two times, the user selects a basic emotion. Moreover, an intense emotion is elected by the user by pressing three times. Also, the user can select two different emotions to form complex emotions.

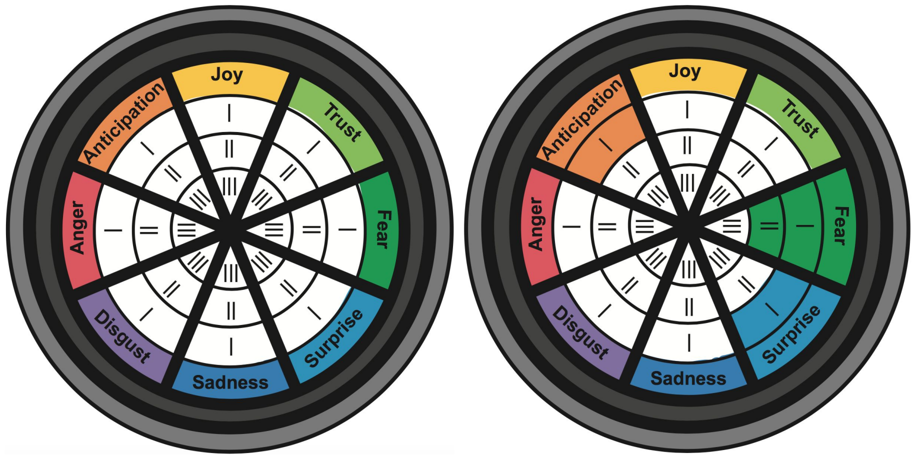


Figure 14: an eight-slice wheel representation making use of the Plutchik circumplex.

A third self-sampling technique is simply making use of SAM as described in visual-based mood self-sampling techniques. This technique is statistically proven effective to sample mood. In Figure 15 an adjusted version of SAM is illustrated. The user can swipe left or right to be able to select the representing state they are in.

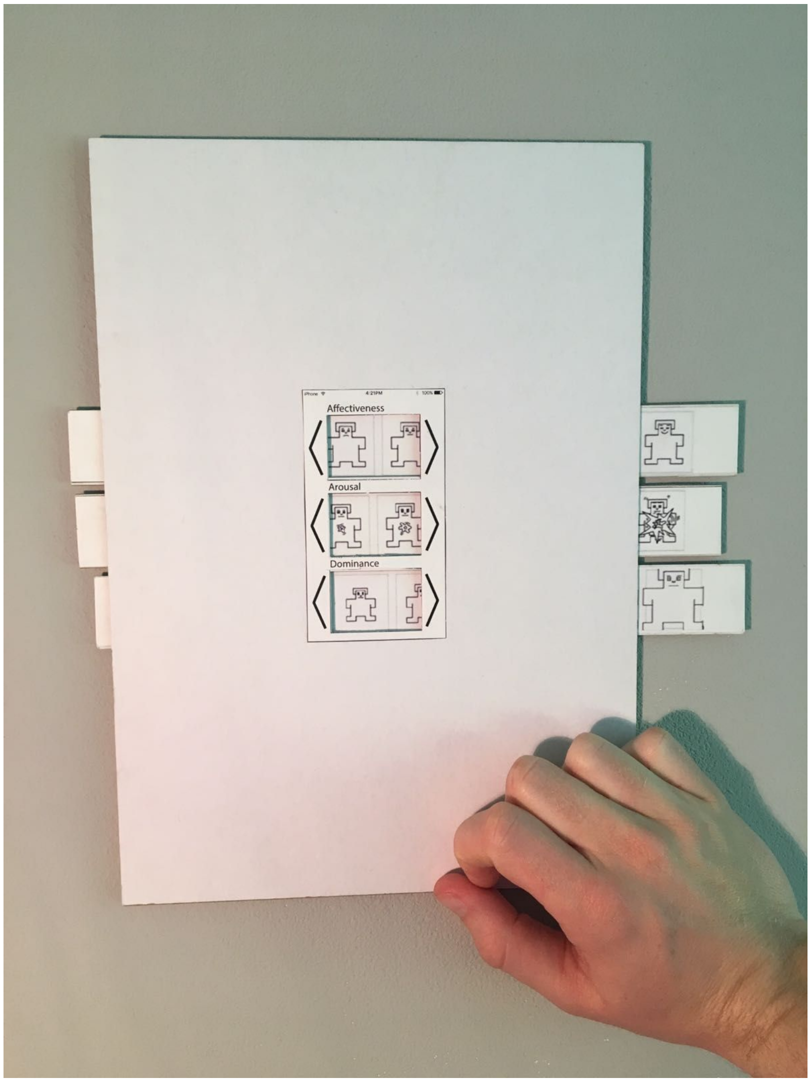


Figure 15: SAM swipeselection self-sampling technique.

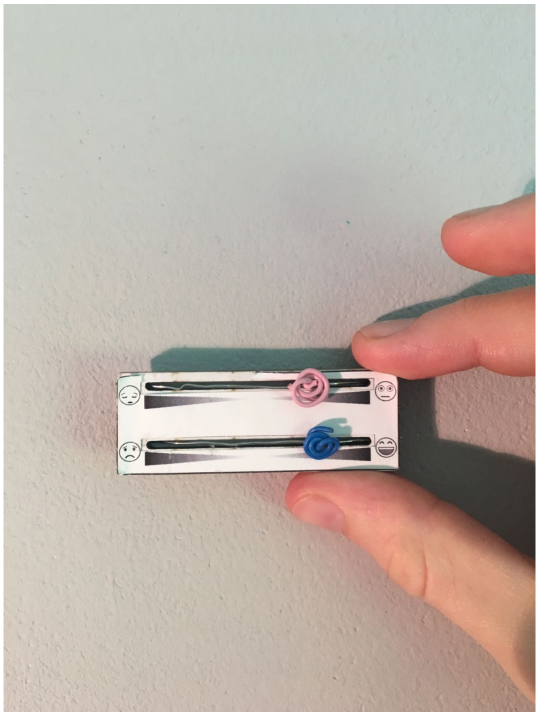


Figure 16: Valance and Arousal slider sampling technique.

4.2.2 Self-sampling locations

The above described self-sampling techniques will be located in a device on the user's body. Favourable is easy access, intuitive and some more technical and practical aspects. Important is that giving mood feedback is not time intensive.

The first location, as illustrated in Figure 17, would be to place the device on the Escalade, making it easy to implement technically. Some constraints about the user raising their shirt to be able to give feedback will cause issues.

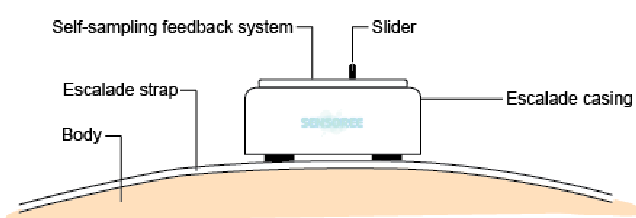


Figure 17: Self-sampling feedback system directly on the Escalade.

A second location, as illustrated in Figure 18, is to place it on the wearers clothing. The device will be connected to the escalade by magnets, getting rid of the constraint of the user raising their shirt to give feedback. The user can take off the device to fill it in and then put it back in place using the magnets. At the same time, everyone can now see that the user is wearing the escalade device and also the self-sampling feedback system now needs wireless connectivity as well a power source.

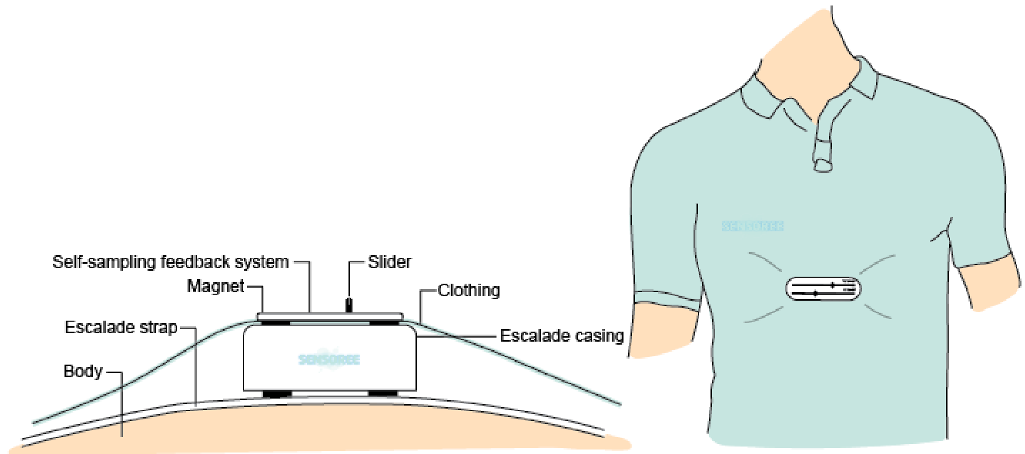


Figure 18: Self-sampling feedback system on the Escalade with magnets.

Additionally, a key hanger could be used to give mood feedback. However it is also not in direct connection to the Escalade, and it needs power supply etcetera to be able to work, it is more discreet and maybe even more accessible. Figures 19 and 20 illustrate this keychain design.

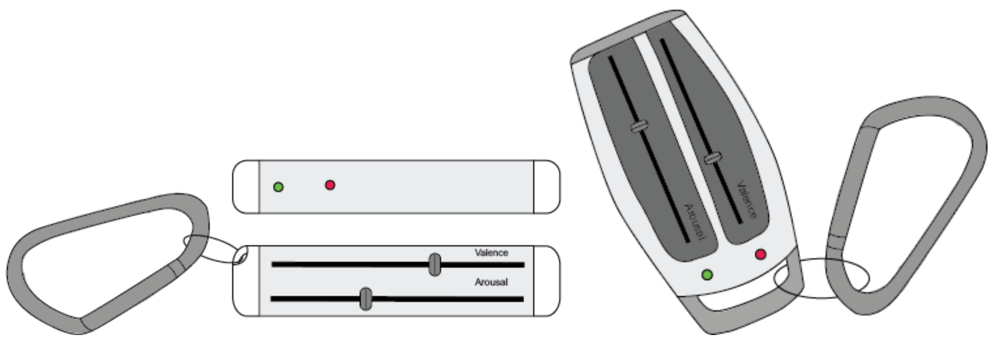


Figure 19: valance and arousal slider keychains

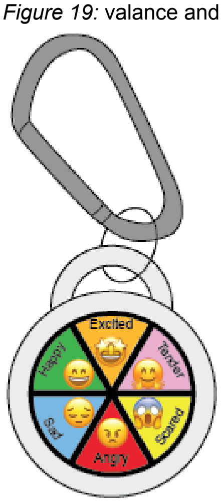


Figure 20: 6 slice circular mood selection keychain

Another possible location is to make a wristband feedback device as seen in Figure 21 is a wristband. Figure 21 shows such implementation with sliders. A wristband is a rather good option because it is easily accessible and in the worst case, a cable connection to the Escalade is possible.

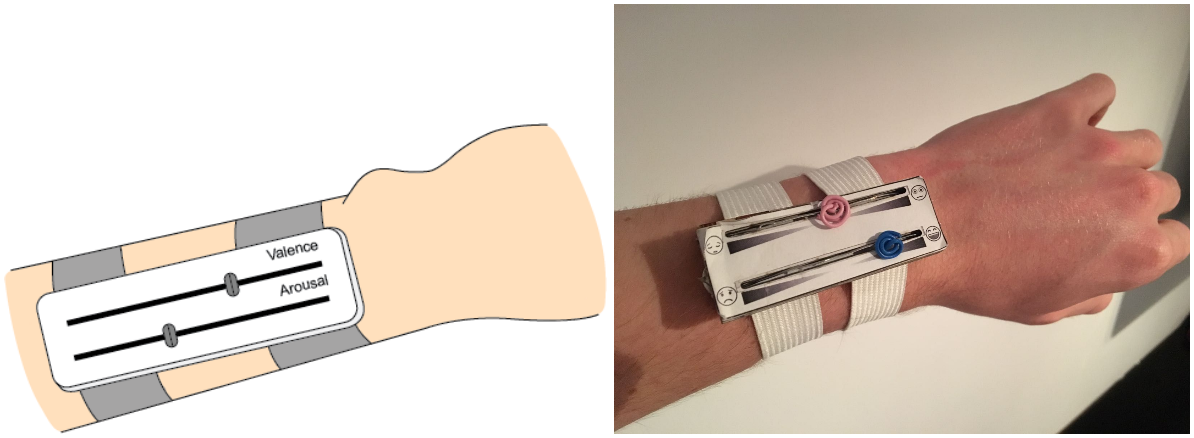


Figure 21: valance and arousal slider wristband, illustration left, real life paper prototype version right.

Lastly, a smartwatch interface is an option to give self-sampling mood feedback as seen in Figure 22. The user will select emotions to give feedback. Gamification options for later stages of the design make this option interesting, but the fact that it is hard to connect a Teensy microprocessor to an Android smartwatch makes this option less desirable.

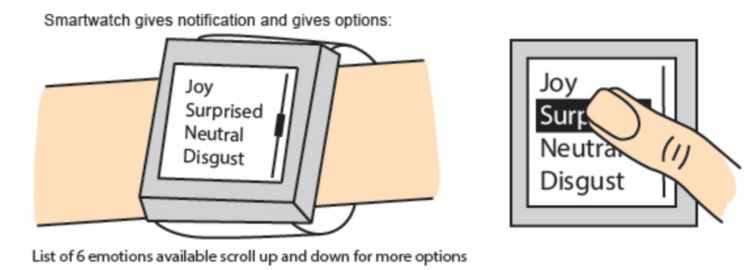


Figure 22: first idea of mood sampling personal input system

4.2.3 Own judgement on ideas

In Figure 17 a personal indication of the design assets regarding self-sampling techniques is rated. “+1” means that the design has an extra focus on this aspect. “0” means neutral and “-1” means less useful on that particular aspect.

From this quick rating scheme in Figure 23, rating different sampling techniques, both the six-wheel representation with emoji’s and the eight wheel representation are favourable. Moreover, according to Figure 24, rating different sampling locations, a wristband and smartwatch are preferred.
Hallway usability testing in combination with expert testing will make a final decision regarding both design choices.

Sampling method	sliders	Plutchik model representation	6 slice wheel with emotions	SAM swype

Statistically correct	+1	-1	-1	+1
Complexity of moods	0	+1	-1	0
Intuitivity	0	0	+1	0
Implementation options	+1	+1	+1	-1
Ease of use	0	0	+1	-1
Avoid neutral mood states	-1	+1	+1	-1
TOTAL	1	2	2	-2

Figure 23: personal indication of the design assets regarding self-sampling techniques.

Self sampling location	On Escalade (Magnets)	On Escalade	Wristband	Key hanger	Smartwatch
Discrete (not obvious seeable for others that one is using the design)	-1	+1	+1	0	+1
Accessibility	-1	+1	+1	+1	+1
Intuitivity	0	0	+1	+1	+1
Engagement	0	0	0	0	+1
Connection to escalade components	0	+1	+1	+1	-1
TOTAL	-2	3	4	3	3

Figure 24: personal indication of the design assets regarding self-sampling locations.

4.7 First usability test

To distinguish more clearly between both the self-sampling technique and self-sampling location hallway usability testing will take place. Sampling will take place from random people passing by in a hallway. The sample will not be perfect due to the time constraints and difficulty to find people willing to participate. To make sure the findings will not be biased also some more experienced users/researchers are asked to participate.

4.7.1 Script hallway usability test

The hallway usability test contains paper models representing the above described self-sampling techniques and self-sampling locations. The hallway usability test is put together as follows. People from preferably from different ages and education level are asked to participate in a short feedback session of 15 minutes. The sample will include experts as well as regular end users to give as much as possible insight into a sample of 20 people. As seen in Appendix E.1 the session starts with a short introduction video introduce the participant to the project. The footage is from a self-conducted interview with Neidlinger. Figure 25 shows a screenshot of this video. Afterwards, explained and presented are the different sampling techniques. The user will fill in the first part of the questionnaire and help is provided if needed. Afterwards, illustrated are the sampling locations with small models of the valence and arousal slider. The researcher explains that all sampling techniques are placeable on all the locations. The questionnaire ends with a grid asking for the favourable sampling technique on the favourable location. In Appendix E.2 a script of the co-design actions is provided.

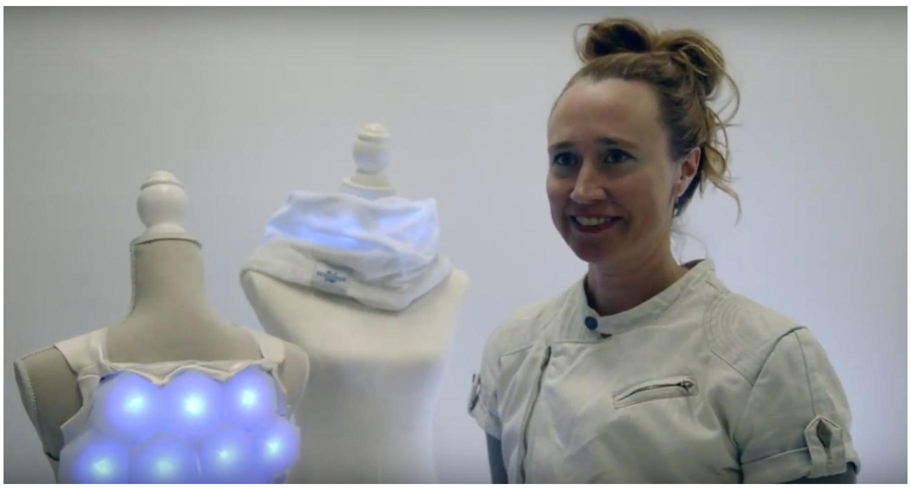


Figure 25: Screenshot interview Kristin Neidlinger.

4.7.2 Results open questions and extra feedback

Appendix E.3 contains the extra feedback notes form. For every participant, extra notes regarding the design options are written down if necessary while explaining the different options to them. Also, discussed below are the answers to the open questions.

In general, respondents said about the sampling techniques that SAM is unclear, the used images to represent valence, arousal and dominance are unintuitive. The valence and arousal sliders are unclear at first. Also, the top slider (arousal) is less clear than the bottom slider. (valance) Indicating the smileys next to the sliders need replacement.
Next, the six-slice wheel representation is clear and intuitive, the used smileys are likeable, but it lacks options according to some users, making the eight-slice wheel representation the better option.
The eight-slice wheel representation gives more options regarding mood but might be not clear for everyone at the start. Most respondents stated that this option is their favourite because it gives the most accurate representation of their mood. However, it takes a bit more time to fill in than the other representation. The accuracy makes up for the downside of the design.

Regarding the sampling locations, the respondents said that making a device on the Escalade is impractical because the users have to raise their shirts to be able to give feedback. Making it necessary to walk to a toilet every time you need to give feedback. The magnet version with a feedback system above the shirt lacks privacy, and it is easy to lose the feedback device.
The smartwatch app, smartphone app are mostly discrete since most people already have these devices.
The favourite location according to the extra feedback and open questions are the wristband, the key hanger and on the Escalade, because they are all easily reached and (partly) discrete.

4.7.3 Results questionnaire

20 respondent took place in the hallway usability testing procedure (n=20). In Appendix E.4 the results of the open questions of the questionnaire are illustrated in graphs. Regarding the sampling techniques, the 8-slice wheel representation is most favourite among the respondent. 75% said this representation is most accurate to their mood experiences. On a scale from 1 to 10, the eight-slice wheel representation scored a mean of 7,65 regarding clearness/intuitively. While SAM only scored a mean of 5,8, the six-slice wheel representation scored a mean of 8,75, and the valence and arousal slider scored a mean of 6,2. Besides 75% of the respondents stated that the eight-slice wheel representation is their favourite technique to self-map their moods, however, the general opinion is that this sampling technique is not the fastest. 45% of the respondent stated the valence and arousal slider is the fastest.
The 20 respondents stated, on a scale from 1 to 5, a mean of 4,05 regarding the preference of privacy. The most discreet locations are under the shirt on the Escalade and the smartwatch app (which shares the same location as the wristband). Regarding the easiest to access locations, the wristband and the key hanger are most easy according to the respondents. Together they from 100% of the respondents' votes. This is possible because the questionnaire allowed multiple answers to this question. According to the first respondent, multiple options regarding this question need to be selectable. He stated it is hard to pick one location. After correction, 64% of respondents preferred the wristband location or the key hanger. The smartwatch app is easiest accessible according to 19% of the respondents. The question of what sampling technique users personally prefer got two primary responses. The wristband formed 35% of the respondent's preference, the key hanger 30% and the smartwatch app 20%. According to the last question, the most preferred 8-wheel representation first best on a wristband.

4.7.4 Conclusion hallway usability test

According to the usability test respondents, the eight-slice wheel representation is most preferred. It has the most options, is most accurate and favourite regarding the respondents of the usability testing procedure. The questionnaire, the open questions and extra feedback form stated that the eight-slice wheel representation is favourite. This sampling technique takes more time, which is a small downside to this sampling technique.

Conclusions on the locations are somewhat tricky to draw. The eight-slice wheel representation fits best on the wristband according to the respondents. Most respondents preferred the wristband.

4.8 Requirements second iteration

4.8.1 Conclusion to determine changes in requirements

According to own judgement on various subjects from statistical correctness, the complexity of the filled in mood feedback, intuitively of the sampling technique, implementation options into sampling locations, ease of use and the avoidance of neutral states both the six-slice wheel representation with emoji's and the eight-slice wheel representation are favourable. Most respondents stated that the eight-slice wheel representation is their favourite because it gives the most accurate representation of their mood. 75% of the respondents stated that the eight-slice wheel representation is their favourite technique to self-map their moods. However, the general opinion is that this sampling technique is not the fastest. The implementation of emojis can improve the clearness and intuitively of the eight-slice wheel representation. Users find the representation with smileys more intuitive.

According to own judgement on various topics like secrecy, accessibility, intuitively, engagement, gamification possibilities, and connectivity to components of the Escalade, not one location is favourable. Dropped is the escalade location with magnets.
Since the user finds secrecy important, this should be implemented in the design as much as possible.
The conclusion from both the own judgement and the usability test is that the use wristband location in combination with the 8-slice wheel representation is ideal.

4.8.2 Requirements

The project direction together with state of the art research, background research and iPACT, own judgement and hallway usability test are used to form the following requirements according to MoSCoW method. Requirements written in bold are conclusions from the own judgement together with the hallway usability test described above.

Must

- Make use of the Escalade to generate physiological data;
- **Use the 8-wheel representation to generate** a mood label to make supervised learning possible;
- Ask the user for self-reporting mood feedback;
- Make the user fill in their mood by themselves;
- Save this mood feedback in a database;
- Give the user an indication of when to give mood feedback;
- **Be wearable and easily accessible by making use of a wristband.**

Should

- Save the mood feedback in a database together with the physiological sensor data;
- Give feedback to the user, makes visible what the user will give as an input;
- Make the user willing to give feedback by making use of persuasive technology;
- The sampling technique must be understandable for people with less knowledge of technology;
- Be understandable by users of all ages and education level;
- **Should be (partly) discrete to use in case of location;**

Could

- Make the random mood feedback more valuable (avoid many neutral states in samples);
- Stimulate the users to give better feedback.

Won't

- Include AI to determine the moment when the system is most uncertain about the user's mood;
- Avoid generation of biased samples by users, due to the fact when you ask someone about their mood, their thinking causes inauthentic feedback;
- Use peaks in physiological sensor data as an indication to ask for mood feedback.
- Implement gamification to make use of peer pressure to make people give more feedback;

5. Specification

The specification phase will take a closer look at the functionalities of the creative idea, which is a result of the ideation phase.

5.1 FICS

In this section, the system will be explained using the FICS method. FICS described the system through the eyes of the designer.

Functions and events:
The primary function of the system is to generate a mood label by asking the user to fill in the 8-slice wheel representation questionnaire. Additional the system should show the user feedback on mood. The mood feedback needs to be saved in a database together with the sensor data generated by the Escalade.

Interaction and usability issues:
The mood feedback system is wearable for the user and is in connection with the Escalade. The system asks the user to give feedback by a signal, gives feedback to the user regarding what they filled in and has an option to save the data.

Content and structure:
The mood feedback system will save the data on an SD card together with sensor data from the Escalade sensors by making use of an algorithm.

Style and aesthetics:
The system is supposed to feel solid and needs to look white, in line with the Sensoree design vision.

5.2 Brainstorm

Appendix D shows a brainstorm exploring the implementation options for the eight-slice wheel representation. Explored are some niches like the indication of different mood level. These could be represented by blinking, light intensity or the amount of LEDs illuminated. Participants preferred the eight-slice wheel representation. However, the six-slice wheel representation with emoji's is more evident according to the questionnaire results. Therefore the use of emojis and colours representing moods should be explored. Additionally, buttons, capacitive sensing or a slider mechanism, can represent the sampling technique. Lastly, some form of persuasive technology needs to be implemented to grab the user's attention. To do so NUDGES and the FBM model could be implemented.

5.3 Persuasive technology techniques

5.3.1 NUDGES

However the mood feedback system should be easy to be understood by a big variation of users, it is helpful to take a look at the NUDGES theory by Thaler and Sunstein (2009) and implement it into the design.

Incentives:
The importance of the product to the user would be the generated information affect the user's life. As described in Section 4.3 users would be affected positively by making use of a mood detection system to improve their therapies, better patient-caregiver relationships and the option to raise self-awareness to improve EQ. To be explained by a researcher, doctor, psychologist, caregiver or coach. Both parties will benefit, cause improvement of therapies, patient-caregiver relationships and improved methods of EQ will lower costs of treatment, care to provide costs, etcetera.

Understanding mappings:
The system is quite excessive regarding possible options. Distinguished are eight emotions with for each emotion three levels of intensity. Mild, basic and intense. For some users, this might be too excessive but providing a direct feedback iteration to show what intensity of mood is selected can fix this issue.

Defaults:
The users tend to take the option with the least effort, which in this system would be to ignore the system asking for feedback. In some cases the user is not able to give feedback, the system should respect that. The system should give an extra signal ask for feedback. However, when the user does not reply to the second signal, the system should stop asking for feedback to respect the user.

Give feedback:
According to Wood (2014), it is important to give feedback to the user. The accuracy of the feedback will improve whenever the user can see what they filled in before they save their feedback.

Expect error:
Since the user is not going through many steps, errors are not expected to happen. However, a researcher, doctor, psychologist, caregiver or coach should instruct the user how to use the device.

Structure complex choices:

The structure in the complexity of choices is following the Plutchik wheel of emotions. Combinations of emotions and their intensity will result in so called dyad's. Dyads are combinations of emotions. So is the combination of fear and surprise the mood: Awe. (Plutchik, 2001) Awe is according to Sensoree an interesting emotion, measuring and visualising this emotion is one of the company's interests (Neidlinger, 2018).

5.3.2 Fogg Behaviour Model (FBM)

The Fogg Behaviour Model can give some insight towards the design of the mood feedback system. The FBM includes motivation, the ability to perform the desired behaviour and be triggered to do such behaviour.

Motivation:
The motivation is similar to the described incentives in Section 5.3.1.

Desired behaviour:
The desired behaviour from the user is to give mood feedback by making use of a mood feedback system in the form of the eight-slice wheel representation. The to perform behaviour is rather simple and achievable by anyone.

Triggers:
Since the user has a high ability to perform the target behaviour, but possibly lacks motivation as a trigger the so-called spark should be used (Fogg, 2009). The spark encourages users by combining a motivator with a simple call for action. Fogg distinguishes between multiple motivators. A strong motivator is according to Fogg social rejection. The feedback device making noise and producing light can annoy or irritate people in the surroundings of the user. This annoyance by others can motivate the user to give mood feedback to avoid social rejection. Probably a bit controversial since users want the design to be discrete, but promising affective. Also, since the system needs to warn the user to give feedback, a way to ask the user for feedback is already implemented.

5.4 Mood level indication

According to the Brainstorm in Section 5.2, three techniques could be used to indicate the selected mood level. The first technique would be to use blinking to represent the intensity of a mood. Blinking faster means more intense. Since we are using for people, who possibly have epilepsy, this technique is dangerous. However, only 3% of people who have Epilepsy are sensitive for fast blinking light, risking a seizure is out of the discussion (Sirven, 2013).
Using a set of three LEDs for every mood would make the design unnecessary big. An interface with so many LEDs is only possible in combination with capacitive sensing or a slider interface. To determine what selection option is best will be researched in the usability test.

5.5 Second usability test

From the first hallway test, most favoured is the eight-slice wheel representation. The second hallway testing fill focus on implementing this self-sampling technique in a physical form regarding the electronics to be used, additionally the question if adding smileys to the eight-slice wheel representation would be preferred is researched. Also, options regarding selecting the moods will to be mentioned, conducted are three possible options: buttons, capacitive sensing area's and a slider on the side as seen in Figure 26. Figure 27 shows two interface options, one with and one without emojis representing moods.
Additionally, a combination of light and sound, as being described in Section 5.3.2 is researched to be attention-grabbing enough. Lastly, this usability test includes if the illumination level of LED's gives a proper indication of the selected emotion.

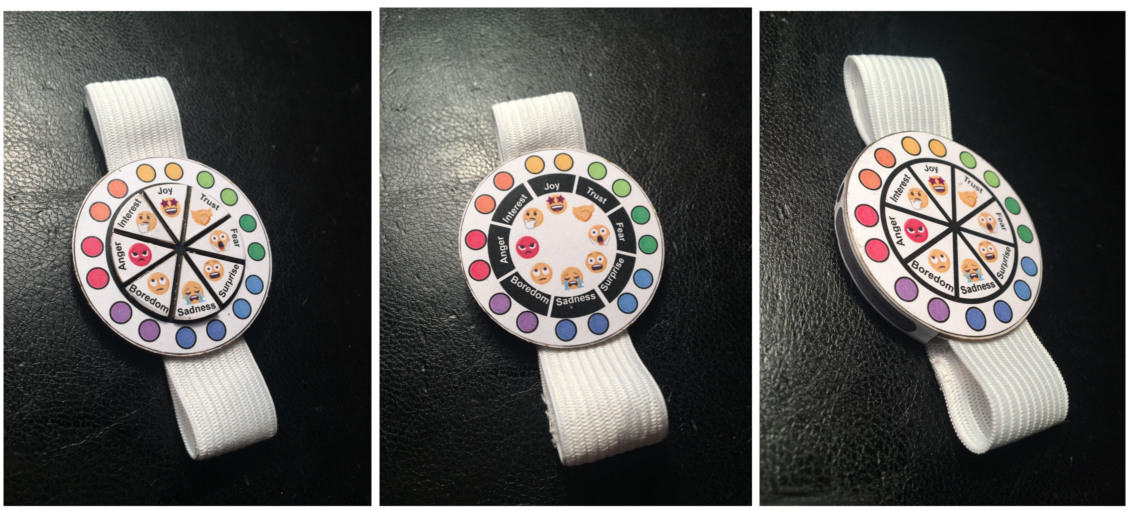


Figure 26: Interface with buttons, interface with capacitive sensing, interface with slider.

Figure 27: Interface with smileys and an interface without emoji's.

5.5.1 Script hallway usability test

First of all the participant is introduced to usability test by a small introduction text on the first page. Additional questions can be asked by the participant if necessary. An self made animations video, as seen in Figure 28, in the questionnaire is used to illustrate the mood selection interface for buttons and capacitive sensing, together with the notification animation, more clearly. After completing the video the participant is asked to fill in the first part of the questionnaire. The questionnaire can be found in Appendix F.1.
Afterwards, the researcher will explain and illustrate the three interface options by making use of paper prototypes as illustrated in Figure 26. The researcher will explain that these paper prototypes are representing wristbands, in case this might not have been clear. Also, presented is an animation video, as seen in Figure 29. To clarify the particular option. The user is asked to fill in the next part of the questionnaire.
Afterwards, the researcher will place two interfaces on each arm of the participant. On the one arm an interface with emoji's and on the other arm an interface without emojis. The user is asked to fill in their preference in the questionnaire.
Lastly, the researcher will show all options, with and without emojis and with all selection options.

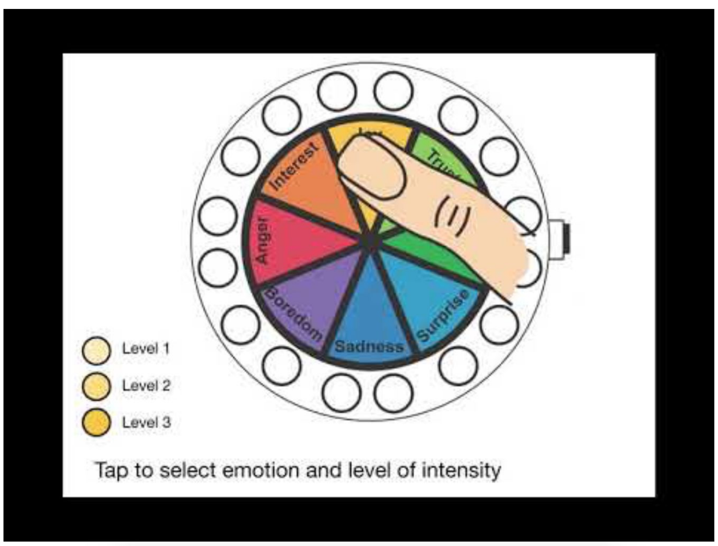


Figure 28: Screenshot video illustrating the buttons and capacitive sensing selection method.

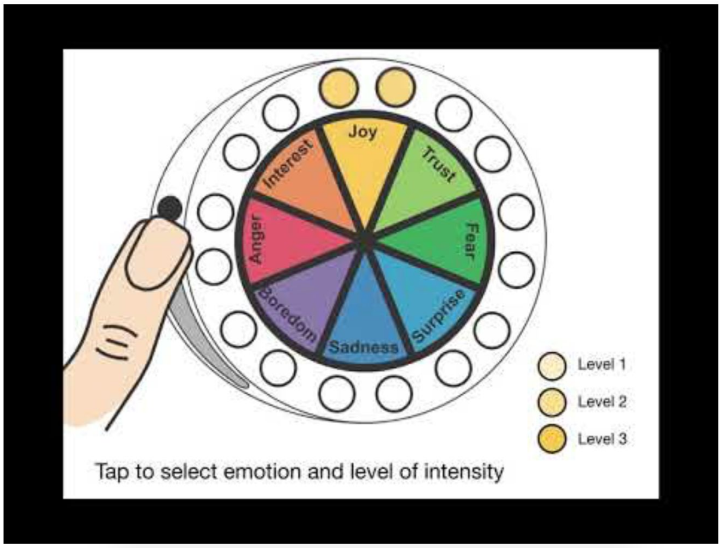


Figure 29: Screenshot video illustrating the slider selection method

5.5.2 Results questionnaire

12 respondent took place in the hallway usability testing procedure (n=12). In Appendix F.3 the results of the open questions of the questionnaire are illustrated in graphs.

Regarding the question of the used way to ask for feedback, a combination of light and sound grabs attention. The user is asked to fill in a 1 to 5 scale to determine the intensity grabbing attention. The used method scored 4,167 which indicated the used method, a combination of light and sound, is adequate to grab the user and its surroundings. Making the used spark effective.

Since in Section 5.4 the level indication of the intensity of the LED's was favourable, user preference is tested to determine if the idea works. According to a 1 to 5 scale in which five means the method is effectively showing the selected mood level. The technique scored 3,91, indicating the used technique is sufficient.

The next question asks for the participants' opinion about three selection methods to select moods in the eight-slice wheel representation. 83,3% of the respondents preferred a button interface because buttons give click feedback and the fact that pressing multiple times reflects the intensity of an experienced mood. For example, when one is angry pressing multiple times is intuitively reflection to a more intense feeling of anger. The slider is stated to be too time-consuming.

Afterwards, presented is a question regarding the use of emojis. 66,7% of the respondents prefer the emoji representation. The emojis are more illustrative and make the moods more clear. However, emojis might be childish for some users and are less visually pleasing. Also, participants stated some smileys do not truly reflect the moods.

5.5.3 Conclusion usability test

The usability test indicates that the use of light and sounds is efficient to grab the users attention. Also using the intensity of the LED's as a way to indicate the intensity level of the selected mood is sufficient. Moreover, the respondents prefer buttons to select moods. Lastly, emojis can represent moods. However, the combination of emojis and colours would please more respondents of the usability test. Additionally, the emoji’s should be made more visually pleasing and less childish.

5.6 Representation of emotions

5.6.1 colours representing emotion

Section 2.1.8 includes research on colour psychology. The eight-slice wheel representation includes the moods: anger, boredom, fear, joy, sadness and surprise, trust and interest.

According to the background research the colour red, a warm colour, could evoke feelings like anger. Therefore it can be used to represent the anger in the feedback system. The colour blue can be a representative of feelings like sadness and indifference. Indifference, meaning a lack of interest, is the opposite of interest, which is in this representation surprise. Therefore blue can also represent the mood of surprise. The colour green is peaceful and calming; therefore it can be used to represent trust. However, darker green implies masculinity, conservative and wealth. This in is close relation to things people are attached to, dependant on a fearful stigma implies to it. The colour black is a better representation of fear since it implies evil. But LED's cant show black. Therefore dark green will be used to represent fear. Yellow is the optimistic colour, perfect to represent joy. Purple stands for sophistication which according to some people can be boring. Especially for adventure seekers, therefore purple can be used to represent boredom. However, argumentation is not bonding. Lastly, the colour orange implies excitement and enthusiasm, feelings associated with interest. Therefore orange can represent interest. Again as being said by Elliot and Maier (as cited in Cherry, 2018), not much scientific research has been done on the use and representation of colour. Using colour is therefore open of own interpretation.

5.6.2 Emojis representing emotion

Emojis have different meanings according to everyone. To be able to link emoji to the used emotions in the eight-slice wheel representation a questionnaire is built and sent to family and friends to define what emotion is represented by what emoji. The used questionnaire can be found in Appendix G.1. and made use of the smiley matrix in Figure 30. The questionnaire has 21 respondent (n=12). In Appendix G.2 the results of the open questions of the questionnaire are illustrated in graphs.

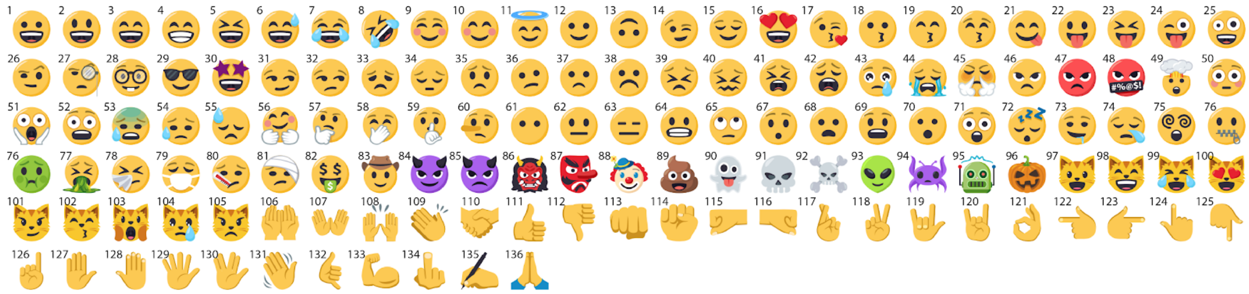


Figure 30: smiley matrix with numbers used in the emoji emotion questionnaire.

According to the results, option 3 in Figure 30 mostly represents joy. 47,5% of the respondents preferred this option. Option 7 represents fear. However only 33,3% of the respondents preferred this option, no other option collected a percentage close to 33,3%. Option 14 best represents surprise, according to 66,7% of the respondents. 42,9% of the respondents said option 9 is best representing sadness. 52,4% of the respondents stated option 32 is best represents boredom. Anger should be represented by option 48 according to 57,1% of the respondents. Option 110 is on a scale of 1 to 5 only scoring 2.71 on representing trust. While 30% of the respondents explicitly choose option 56 to be best representing of trust. Option 57 is on a scale from 1 to 5 only scoring 2,43 on representing interest. While 33,3% of the respondents explicitly choose option 56 to be best representing of trust.

5.5 Design choices

According to the questionnaire results, buttons are favourable, and the light intensity representing the intensity of the selected mood is sufficient. Due to the outcome of the questionnaire the mood level representation with 3 LEDs for each mood is dropped. So an interface with buttons and LEDs which make use of light intensity to show the mood level is preferred.
Since, according to the usability test, the combination of light and sound is sufficiently attention-grabbing, this method to ask for feedback needs to be implemented.
Additionally, as an outcome of the usability test, the use of colour and emoji's is preferred to please as many users as possible. From background research on colours representing emotions and an additional questionnaire about emojis, drawn are the following conclusions:

- **Anger:** will be represented by the colour red and emoji option 48.
- **Boredom:** will be represented by the colour purple and emoji option 32.
- **Fear:** will be represented by the colour dark green and emoji option 7.
- **Joy:** will be represented by the colour yellow and emoji option 3.
- **Sadness:** will be represented by the colour dark blue and emoji option 9.
- **Surprise:** will be represented by the colour blue and emoji option 14.
- **Trust:** will be represented by the colour green and emoji option 56.
- **Interest:** will be represented by the colour orange and emoji option 57.

5.6 Requirements third iteration

The project direction together with the state of the art, background research and iPACT, own judgement and hallway usability tests are used to form the following requirements according to MoSCoW method. Requirements written in bold are conclusions from the own judgement together with the hallway usability test described above.

Must

- Make use of the Escalade to generate physiological data;
- Use the 8-wheel representation, **represent every emotion with colour and an emoji**, to generate a mood label to make supervised learning possible;
- Ask the user for self-reporting mood feedback, **by making use of a combination of light and sound;**
- **Give feedback to the user, the intensity of the selected mood should be represented by the illumination intensity of the LEDs (more illumination represents a more intense emotion);**
- Make the user fill in their mood by themselves;
- Save this mood feedback in a database;
- Give the user an indication of when to give mood feedback;
- **Be wearable and easily accessible by making use of a wristband.**

Should

- Save the mood feedback in a database together with the physiological sensor data;
- Give feedback to the user, makes visible what the user will give as an input;
- Make the user willing to give feedback by making use of persuasive technology;
- The sampling technique must be understandable for people with less knowledge of technology;
- Be understandable by users of all ages and education level;
- Should be (partly) discrete to use in case of location;
- **Make use of a spark as a trigger as described in Fogg (2009);**

Won't

- Include AI to determine the moment when the system is most uncertain about the user's mood;
- Avoid generation of biased samples by users, due to the fact when you ask someone about their mood, their thinking causes inauthentic feedback;
- Use peaks in physiological sensor data as an indication to ask for mood feedback.
- Implement gamification to make use of peer pressure to make people give more feedback;

5.7 Functional system architecture/dataflow

Based on the requirement list in Section 5.6 a functional system architecture is put together. The architecture of the to design system is described in two levels. Level 0 is a simplified overview of the system, and level 1 gives a more detailed overview of the system.

5.7.1 Level 0

The level 0 architecture gives an overview of the complete system. Figure 31 illustrates the level 0 architecture.

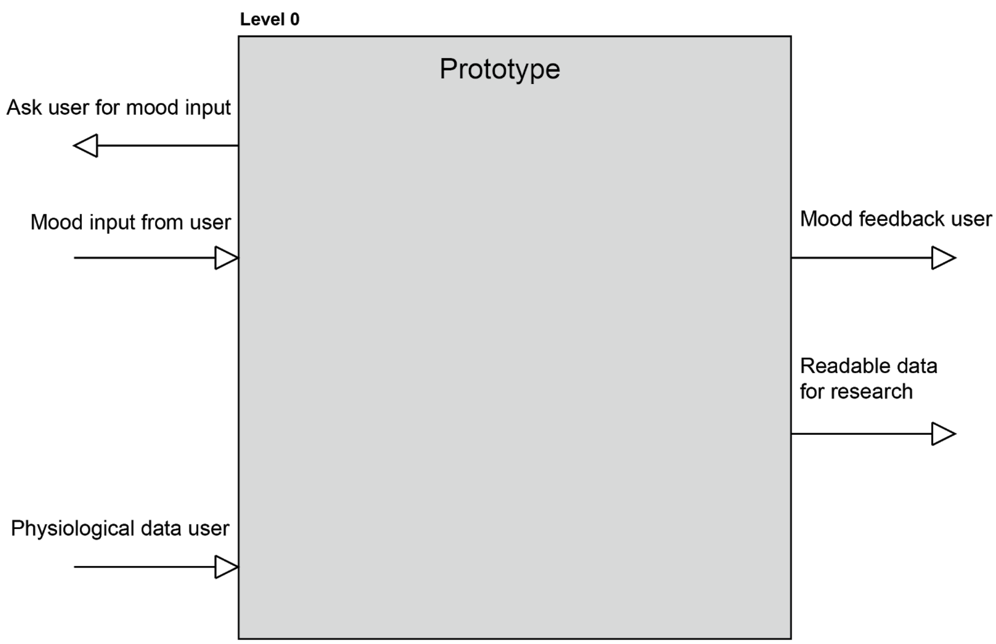


Figure 31: Level 0 architecture.

Level 0 consists of two inputs, the mood input from the user and the physiological data. The mood data is the mood the user will fill in by making use of the eight-slice wheel representation, and the physiological data includes heart rate, skin conductance, breathing rate, and angular velocity.
Also, three outputs are distinguished, first of all, one output flow is asking the user for mood input, the other one gives direct feedback regarding the moods filled in by the user. The generated data by the prototype is the last output and should be readable for further research.

5.7.2 Level 1

Level 1 is created to explain further what is happening inside the prototype. Figure 31 illustrates level 1.

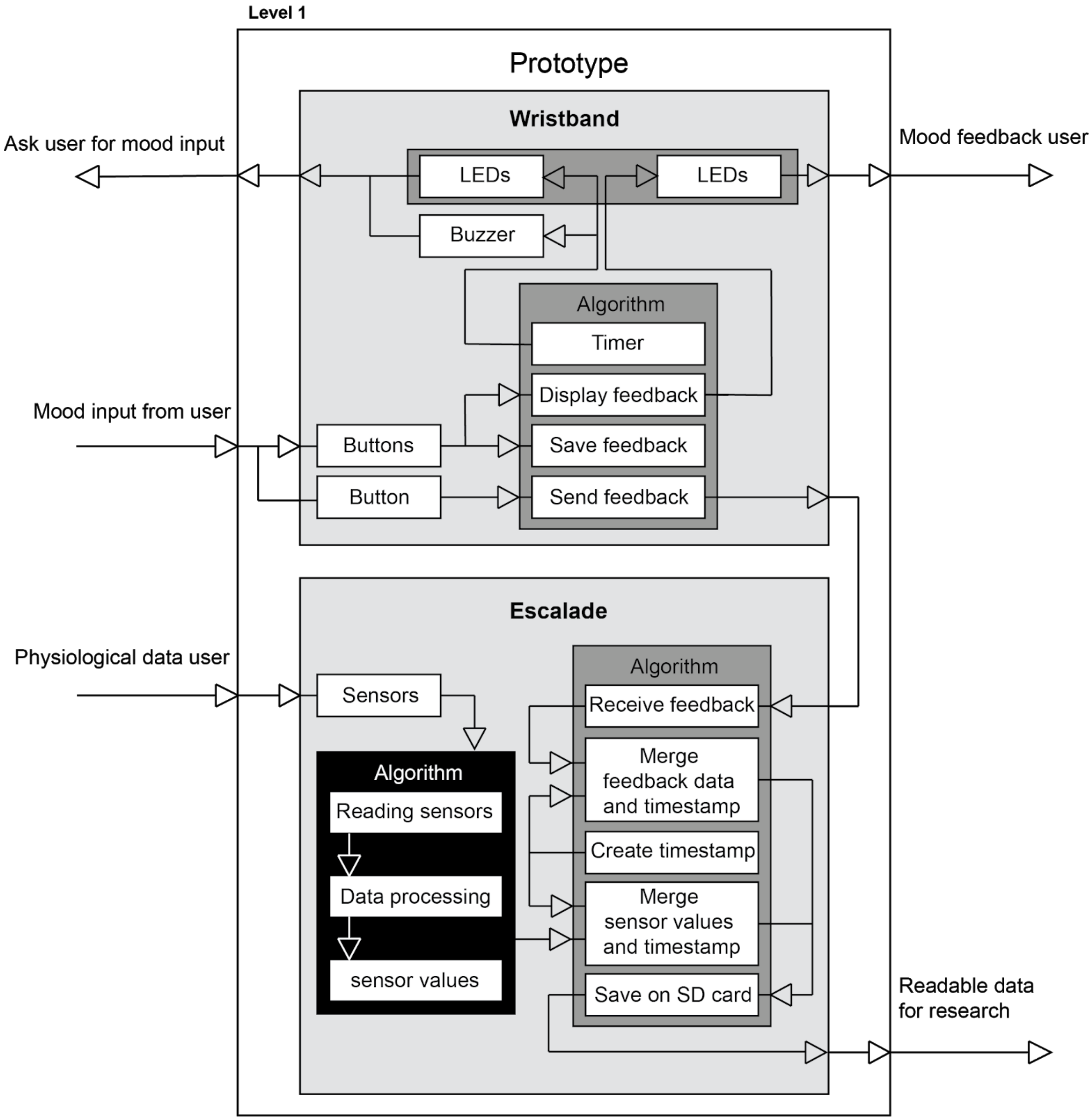


Figure 32: Level 1 architecture.

The architecture shows the data flow within the to be designed prototype. First of all the prototype will include a timer function (within the algorithm), that will generate a request for feedback every 15 to 20 minutes. Three to four times an hour is set to be the feedback frequency. However, more research is desired to determine the ideal feedback frequency.

The request for feedback generated by the algorithm will make the buzzer make noise and LEDs blink in a circular direction to grab the users attention. Afterwards, the user will give feedback by pressing the buttons. The algorithm will show the presses buttons by illuminating the LEDs connected to the selected mood. Illumination of the LEDs indicates the intensity of the mood. At the same time, temporarily saved are the mood states. When the user is okay with the selected mood state, the enter button can be used to send the mood state to the Escalade.

Due to time constraints, serial communication between the wristband and the Escalade is used to send mood feedback. The Escalade, as designed by Harmsen (2017) measures physiological signals by making use of physiological sensors. The black box represents a simplified version of the Escalade within the level 1 architecture. Adjustments to its original algorithm will enable the use of a timestamp and make it possible to save the mood data in the same file on an SD card. The timestamp enables the researchers to determine at what time a day the felt emotion is mapped by the user. The wristband sends mood feedback to the Escalade, which will be received and read by the algorithm. The current timestamp, the physiological data and the wristband data are merged.

6. Realisation

The realisation phase focuses on the implementation of previous findings in a prototype.

6.1 Programming language

For the creation of the prototype, used is an Arduino prototyping base. Using this base is considered most practical since the Escalade, which is part of the final prototype is built using this prototyping environment. This environment consists of Arduino Boards and Arduino IDE, which can be used to design and upload algorithms to the boards. The boards is a Teensy 3.2 since it is much more compact and powerful than the original Arduino Uno board.

6.2 Wristband

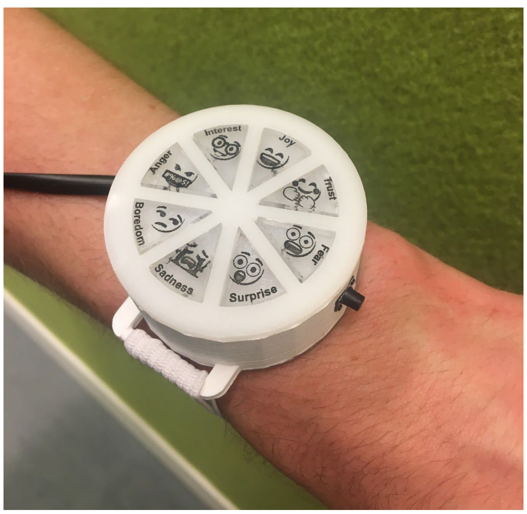


Figure 33: Wristband prototype

First first the wristband prototype, as seen in Figure 33, is designed, including hardware, software and casing. The designed software of the wristband is accessible in appendix H. Figure 33 illustrates the electrical circuit of the wristband part of the prototype. The wristbands consist out of the following components:

- A round protoboard;
- NeoPixel Ring with 16 RGB LEDs;
- Nine mini push buttons;
- PJRC Teensy 3.2 microcontroller;
- Wires;
- Piezo buzzer;
- 3D printed casing;
- Buttons cut and engraved with a laser cutter.

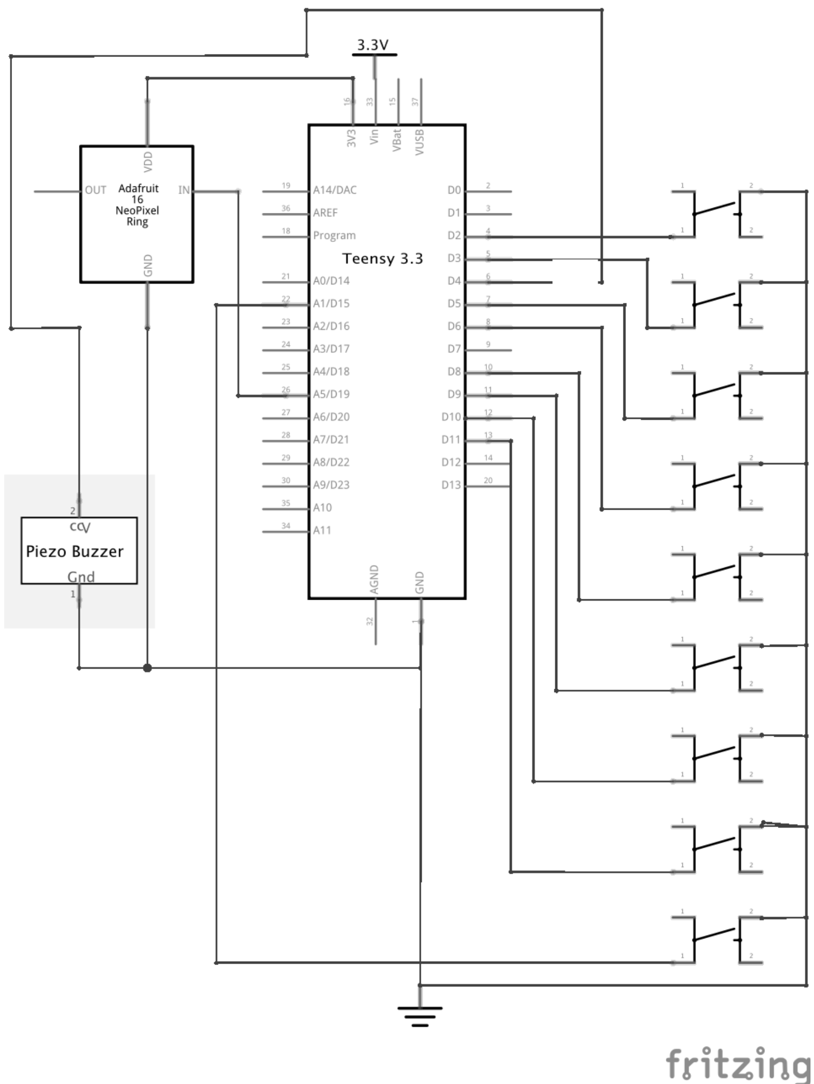


Figure 33: Electrical circuit wristband

The wristbands casing will be a combination of plexiglass, 3D printed plastic and elastic strap band.

One of the requirements in Section 5.6 is the use of colour and emoji to represent mood. The use of plexiglass enables the LEDs to shine through the casing, giving the prototype a smooth finish. Additionally, engraved are simplified versions of emojis in the plexiglass buttons. According to the usability test in Section 5.5 the used emojis could be seen as childish. Using simplified colourless versions of the used smileys in the questionnaire might be seen as less childish.

Figure 34 shows the laser cut files. The top left file is the transparent engraved with emojis buttons. The top left will be the bottom plate of the casing. Additionally, the bottom left will be the white bottom side of the buttons. Lastly, the bottom right illustrates the top plate of the casing.

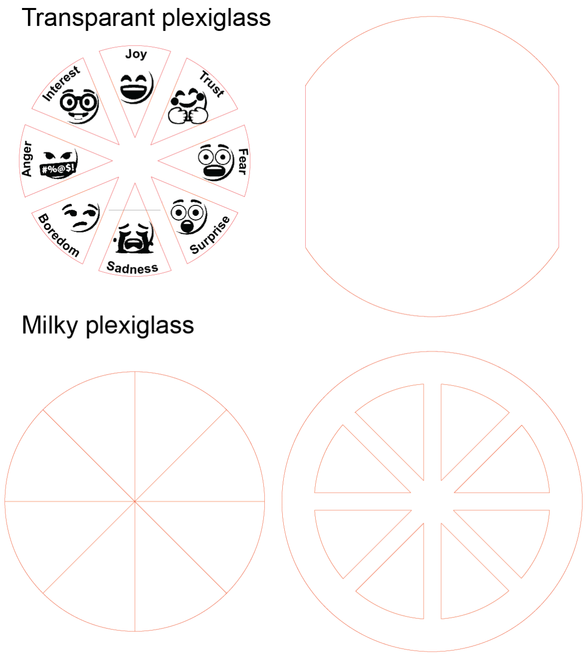


Figure 34: Plastic laser-cut shapes

The 3D printed casing is designed to keep electronics safe and out of reach of the user. Figure 35 shows the 3D printed model in which the top and bottom plate, the buttons, and the electronic circuit is placed.

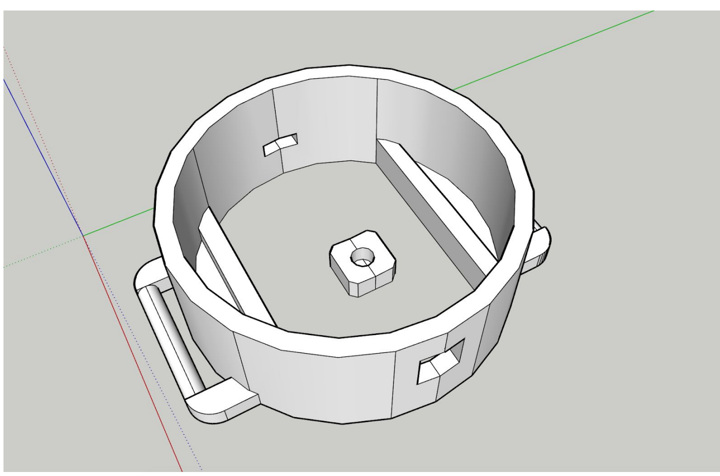


Figure 35: 3D print model casing wristband.

6.3 Update Escalade

Like said before, established is, due to time constraints, serial communication between the wristband and the Escalade. A wireless connection would take more time to establish. Additionally, the wristband would need a power supply, making the wristband bigger and therefore less wearable. Using a serial communication enables using the same battery as power source, located in the Escalade.

The original Escalade software and original circuit as described by Harmsen (2017) is updated. Figure 36 shows the updated combined circuit of the original escalade and the wristband device. The two wires that form the connection between both devices represent the serial communication. In Appendix H.4 a bigger version of the schematics of Figure 36.

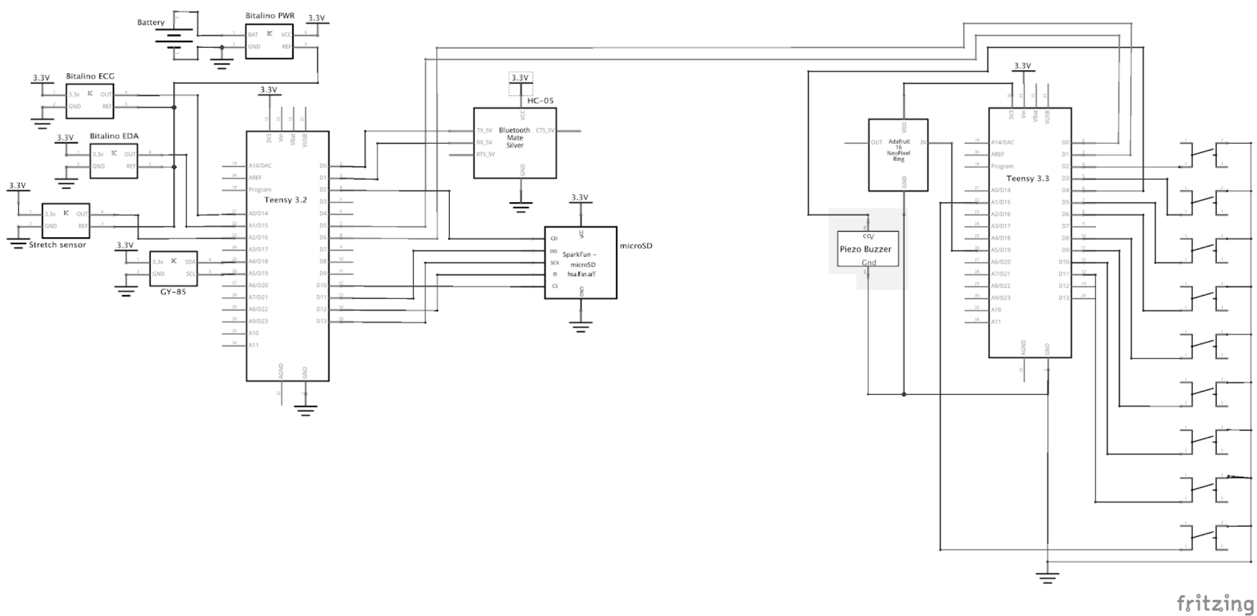


Figure 36: Prototype circuit

6.3 Software

According to the system architecture in Section 5.7.2 software is created. The wristbands software is accessible in Appendix H.1 and includes all functionalities described in the top part of the system architecture. The Escalades software, as created by Harmsen (2017), is updated. The updated version is accessible in Appendix H.2.

6.4 Bluetooth protocol for mac

To be able to start and stop the Escalade from measuring physiological data used is a Bluetooth protocol. Due to the fact when one measures biomedical data on someone, no connection with the power net should be there. Due to safety reasons (Harmsen, 2017). In Appendix H.3 a description for Mac users to be able to connect and instruct the Escalade to do measurements.

6.5 Generated data

The prototype saves the generated physiological data together with the mood feedback, as seen in Figure 37. Figure 38 illustrates the generated timestamp of the samples.

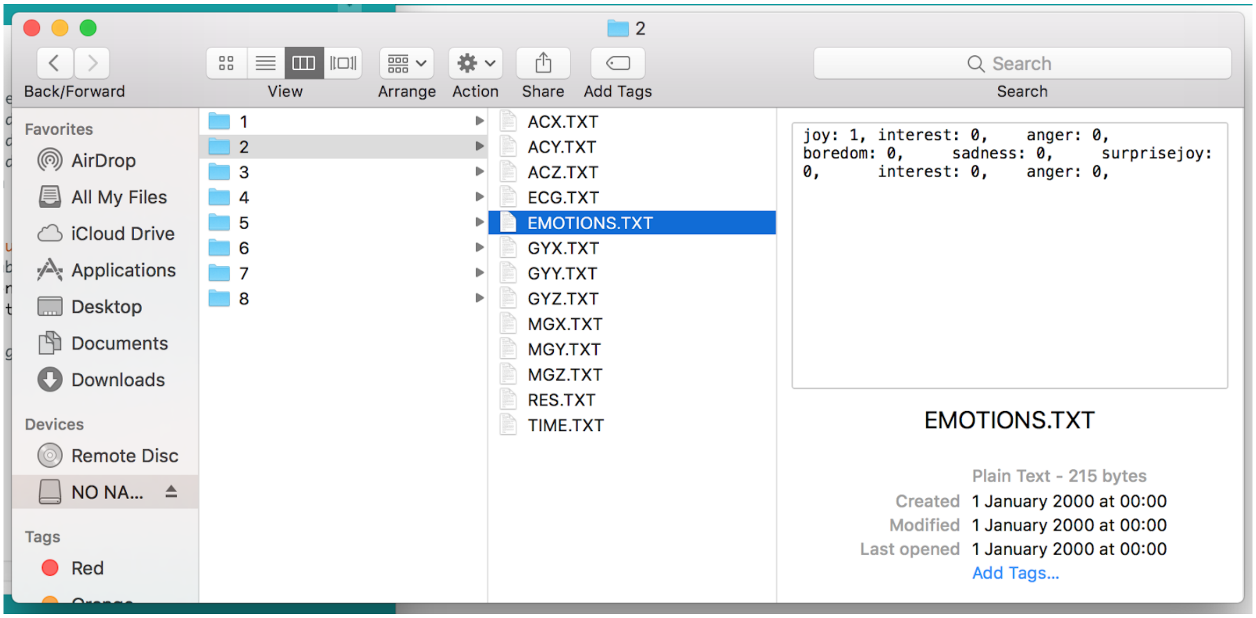


Figure 37: SD card .txt file showing an EMOTIONS file together with sensor data.

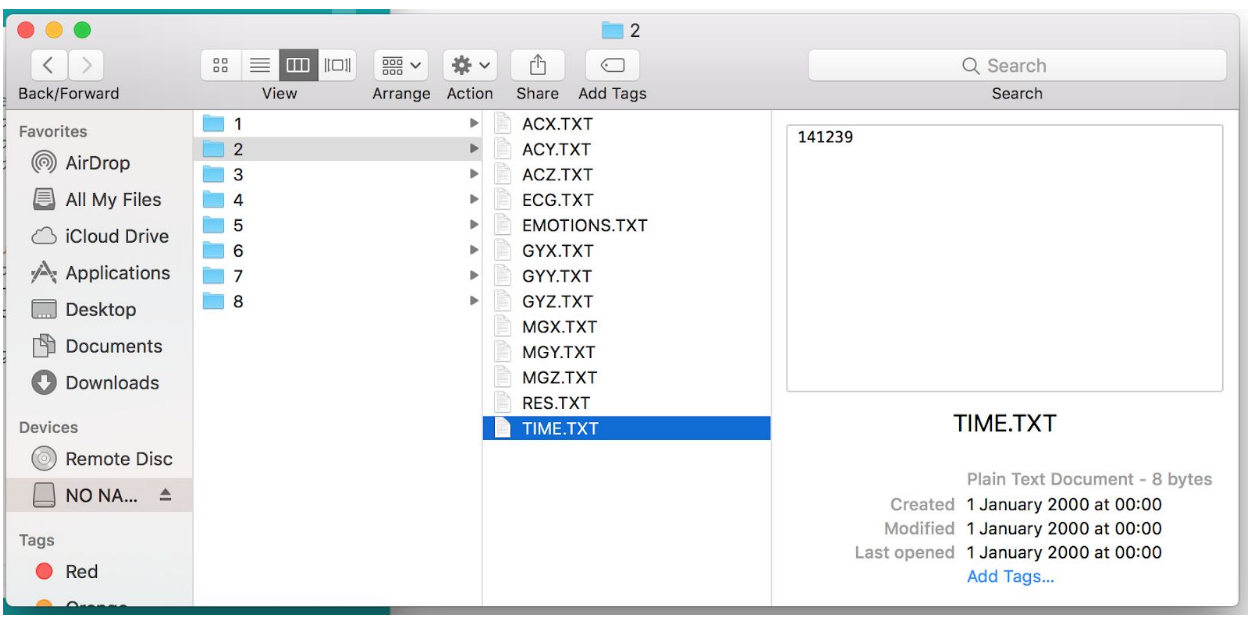


Figure 38: SD card .txt file showing a timestamp file together with sensor data.

7. Evaluation

In this chapter, the test performed with the prototype developed in the realisation phase, are described, and drawn are conclusions from this test.

7.1 functional test

Before the user test can take place, performed is a functional test. The functional test will assure the prototype meets most of its requirements. The prototype needs t meet all “Must have” requirements. Preferred is that the prototype also meets most of its “Should have” and “Could have” requirements. In Figure 36 all requirements are listed, and for each requirement, determined is if the prototype has met this requirement. Most of the “Must Have” requirements and some of the “Should Have” requirements are checked off. The user test will focus on some “Should Have” requirements as well the general view of the prototype by possible users.

#	Requirement	Checked off
Must have		
1	Make use of the Escalade to generate physiological data.	x
2	Use the 8-wheel representation, represent every emotion with colour and an emoji, to generate a mood label to make supervised learning possible.	x
3	Ask the user for self-reporting mood feedback, by making use of a combination of light and sound.	x
4	Give feedback to the user, the intensity of the selected mood should be represented by the illumination intensity of the LEDs (more illumination represents a more intense emotion).	x
5	Make the user fill in their mood by themselves.	x
6	Save this mood feedback in a database.	x
7	Give the user an indication of when to give mood feedback.	Needs testing
8	Be wearable and easily accessible by making use of a wristband.	Needs testing
Should have		

11	Save the mood feedback in a database together with the physiological sensor data.	x
12	Make the user be willing to give feedback by making use of persuasive technology.	Needs testing
13	The sampling technique must be understandable for people with less knowledge of technology.	Not sure
14	Be understandable by users of all ages and education level.	Not sure
15	Should be (partly) discrete to use in case of location.	Needs testing
16	Make use of a spark as a trigger as described in Fogg (2009).	Needs testing
Could have		
18	Make the random mood feedback more valuable (avoid many neutral states in samples).	Needs testing
19	Stimulate the users to give better feedback.	

Figure 36: Functional test checklist

7.2 User test

7.2.1 user test description

First of all the participant is introduced to the project. Additionally, the interview with Kristin Neidlinger is presented to the participant to illustrate the project more clearly. Afterwards how to use the device is illustrated to the participant. If the user would still like to take part in the study, the user is asked to fill in the consent form.

The user will wear the device for a minimum of 3 hours and will be interviewed in a semi-structured style to be able to address all subjects but also leave enough space for new subjects during the interview. In Appendix I more details of the user test script, the consent form and the interview subjects in question form are accessible. Due to time constraints and the fact that a participant will wear the device for a few hours, only two participants will take place in the user test.

7.2.2 user test interview result

The interviews after the user address predefined subjects as seen in Appendix I.3. The focus of these subjects is the user’s perspective on using the prototype.

According to two respondents, the system is efficiently providing the user with a signal to indicate when to give mood feedback. The sounds remind the user to do something, where the LEDs indicate what to do. Only sound would not be efficient since people have many sounds from other sources, for example, notifications from a smartphone. After hearing a sound, the user is reminded by the LEDs to give mood feedback.

However, the system is easy to use and straightforward, the respondents both advised to keep explaining how to fill in mood feedback to all users. Since without the introduction the device could be misinterpreted. The respondents stated that with a short introduction people of all ages and education level should be able to use the device.

Both respondents recognised that the used colours and emojis represent the emotions presented on the device. They also stated that the option of a neutral mood state would be an easy choice and that, probably out of laziness, they would use this option. Therefore not using a neutral mood state as one of the options will force the user to think more about their felt emotion, possibly generating self-awareness. One of the respondents even changed her behaviour during the user test according to the mood feedback she put into the device. The participant stated: 'When I filled in a level 3 boredom, I realised a change during that activity was desired. I asked people to help me out and later I found myself willing to fill in surprise. Without this device, I would not have decided to ask for help.'

Asking for three to four feedback moments on an average day is sufficient according to the respondents. However when a day consists out of more interesting, or less interesting, events the sample rate could be, respectively, more or less. The time to fill in mood feedback is 30 seconds to maximum two minutes. According to the respondents, sufficient and not time-consuming.

The device should become less visible underneath clothing and preferably should be less big on both the wristband and chest location.

The respondents also stated that the device is not annoying to people in their surroundings, however, people are interested in the device. The respondents do not feel social pressure to fill in the mood feedback.

The emotions on the device are strong and intense. This is not unanimous stated as insufficient, but switching to a more subtle emotion could make it easier to select an emotion. One of the respondents stated to not feel very strong emotions as a person. Therefore selecting an irritated button three times would easier represent anger than anger representing irritation when filled in two times.

Lastly, both respondents stated that the use of this device for everyday use would not apply to them. They are both not familiar with the ‘Quantified Self’ movement. Using this device on request of a doctor or psychologist to improve a treatment would give sufficient motivation for the user.

7.3 Discussion

However, the sample is small due to time constraints, from the generated qualitative data the following discussion points are distinguished. The prototype includes some positive and negative factors.

The first positive factor is the device being able to make a user change behaviour during the test period, resulting in some form of self-awareness. The way of asking for feedback, a combination of sound and light is stated to be sufficient for both users. Indicated is that the device is usable for people of all ages and education level. Lastly, the time it takes to fill in the questionnaire is sufficient the number of mood feedback request is stated right for regular day use.

Some negative factors include, first of all, the form factor to be too noticeable and big. The system is wearable, but desired are improvements according to wearability. The social pressure to give mood feedback due to the annoyance of people nearby by the system is not working as a strategy to make the user give mood feedback. Additionally, the emotions are quite intense and therefore hard to fill in for some users. Both respondents recognised that the used colours and emojis represent the moods. Lastly, emojis will always represent different emotions for everyone.

7.4 Conclusion

Overall the prototype is meeting most of the requirements. Both participants were overall positive about the prototype and saw the use of it as beneficial within medical treatment. Taking a look at the downsides of the prototype insists the following considerations:

- The form factor needs an update to be more compact and therefore be less visible. A PCB design can fix this since rapid prototyping is always bulky.
- The Fogg Behaviour Model as applied in the prototype needs a new applying.
- The emoji's need more research to represent the emotions correctly or should be adjustable by the user to personal preference.
- Moreover, the emotions are intense and sometimes hard to fill in. Represented on the feedback device should be more subtle emotions. A device showing weak, basic and intense emotions regarding selection would give an outcome.

7.5 Requirements fourth iteration

The functional test and user test together form the base the fourth requirements according to MoSCoW method. Requirements written in bold are additional requirements following from the evaluation phase. Met are the green requirements following the user test. The red requirements are not met following from the user test. The bold requirements are outcomes of the user test.

Must

- Make use of the Escalade to generate physiological data;
- Use the 8-wheel representation, represent every emotion with colour and an emoji, to generate a mood label to make supervised learning possible;
- Ask the user for self-reporting mood feedback, by making use of a combination of light and sound;

- Give feedback to the user, the intensity of the selected mood should be represented by the illumination intensity of the LEDs (more illumination represents a more intense emotion);
- Make the user fill in their mood by themselves;
- Save this mood feedback in a database;
- Give the user an indication of when to give mood feedback;
- Be wearable and easily accessible by making use of a wristband;

Should

- **Show weak, basic and intense written out to make it easier for the user to give mood feedback (instead of just the basic emotion);**
- **Emoji adjustable to users preference or be better-representing emotions;**
- **Both the Escalade and the wristband need to become smaller to improve wearability and discretion;**
- Save the mood feedback in a database together with the physiological sensor data;
- Give feedback to the user, makes visible what the user will give as an input;
- Make the user willing to give feedback by making use of persuasive technology;
- The sampling technique must be understandable for people with less knowledge of technology;
- Be understandable by users of all ages and education level;
- Should be (partly) discrete to use in case of location;
- Make use of a spark as a trigger as described in Fogg (2009);
- **Successfully use the Fogg Behaviour Model to make the user give mood feedback.**

Won't

- Include AI to determine the moment when the system is most uncertain about the user's mood;
- Avoid generation of biased samples by users, due to the fact when you ask someone about their mood, their thinking causes inauthentic feedback;
- Use peaks in physiological sensor data as an indication to ask for mood feedback.
- Implement gamification to make use of peer pressure to make people give more feedback;

8. Conclusion and recommendation

To conclude this Graduation Project the research questions will be discussed once again as well as the answers given within this project. Furthermore, discussed is the possible future work regarding the created prototype.

8.1 Conclusion

The focus of this Bachelor thesis is “how the design of an engaging mood experience self-sampling system.” To do this background research on various subjects was conducted together with state of the art research. In close relation to this, determined is the project direction by making use of a mind map, brainstorm and expert meeting. Designing an engaging mood experience self-sampling system includes research, many design techniques with a focus on hallway usability tests to determine what the user would prefer most.

In support of the main research question, explored is the sub-research question determining the best technique to ask the user for mood feedback. Using a hallway usability test and own judgement determined is the ideal technique. The six-slice wheel representation with emoji’s and the eight-wheel wheel representation are favourable. Most respondents stated that the eight-wheel wheel representation is their favourite because it gives the most accurate representation of their mood. 75% of the respondents stated that the eight-wheel wheel representation is their favourite technique to self-map their moods. However, the general opinion is that this sampling technique is not the fastest. To improve the clearness and intuitivity of the eight-slice wheel representation implemented is the use of smileys.

In close relation to the used technique, the best location for a self-sampled mood feedback system is chosen using own judgement and a usability test. The eight-slice wheel representation fits best on the wristband according to the respondents. Most respondents preferred the wristband. Therefore the 8-slice wheel representation will be located on a wristband.

Another sub-research question includes the way to ask the user for mood feedback. The background research includes many techniques to ask the user for mood feedback including interval contingent sampling, signal contingent sampling, event sampling and sensor sampling. As a conclusion from the expert meeting and due to time constraints decided is to use a contingent sampling method, since that way it is possible to generate a dataset including moods at different set times. After implementation of AI, the ideal way to ask for feedback would be sensor sampling. The AI agent can, when being most uncertain about the wearer's mood state ask for mood feedback to expand knowledge about the user's mood state.

Lastly, explored is a technique to make the user willing to give mood feedback. According to background research making use of persuasive technology, techniques would give a solution. However, implementing this into a prototype has been partly successful. Implementing the FBM model is stated inefficient by the user test. The NUDGES model, however, seems to be working, since the participants in the user test stated that the use in therapeutic treatments would make them willing to use the device. The device outside of therapeutic treatments, however, is stated unlikely motivational.

The implementation of the findings of the research questions into a prototype is proven successful by the functionality test together with the user test. As a result of the realisation phase, built is a prototype meeting most requirements.

8.2 Recommendations

he prototype conducted for this thesis is working and meets most of the requirements. Met are all the “Must have” requirements. However, according to the user test, some new requirements need implementation:

- Show weak, basic and intense written out to make it easier for the user to give mood feedback (instead of just the basic emotion);
- Emoji adjustable to users preference or be better-representing emotions;
- Both the Escalade and the wristband need to become smaller to improve wearability and discretion;
- Successfully use the Fogg Behaviour Model to make the user give mood feedback.

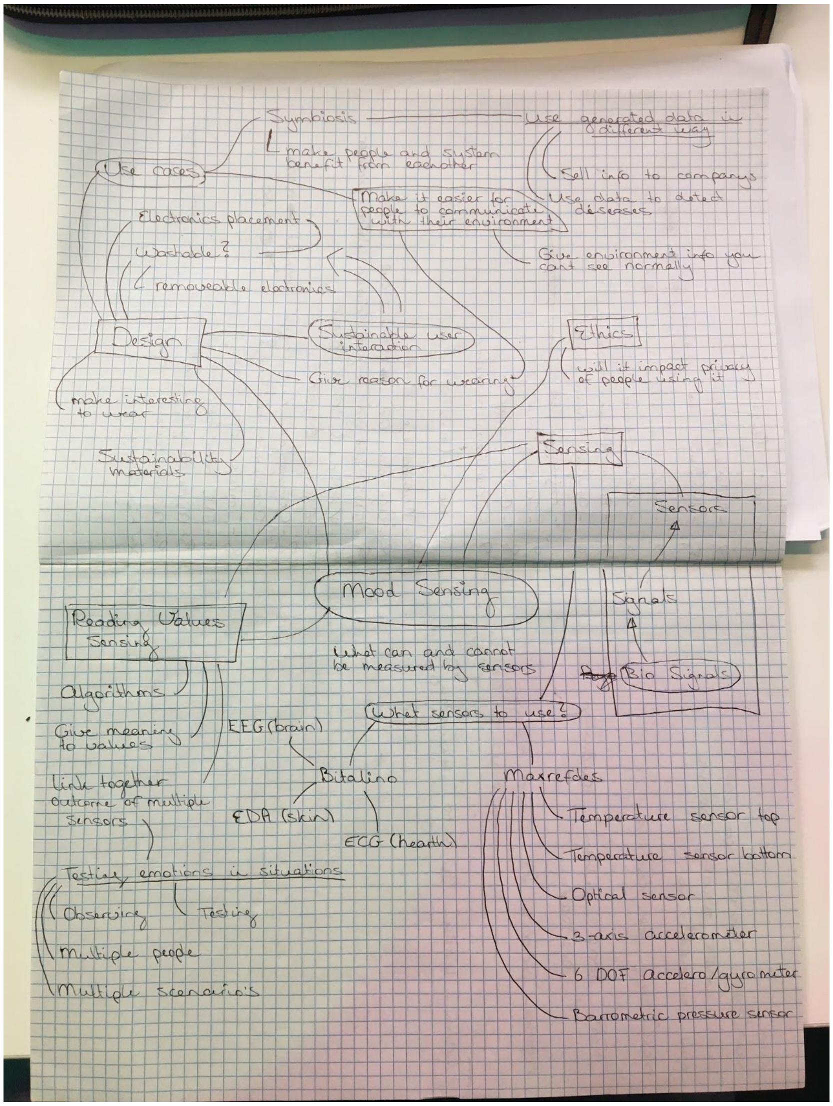
Please note the user test consists of with only two participants. More participants will lead to more insights towards a better design. Therefore the last requirements should be seen as indications. Strongly advised is to conduct more user tests to determine a better requirement iteration.

However, some new requirements need implementation the designed prototype is ready for the implementation of AI. Which is the next step for the project.

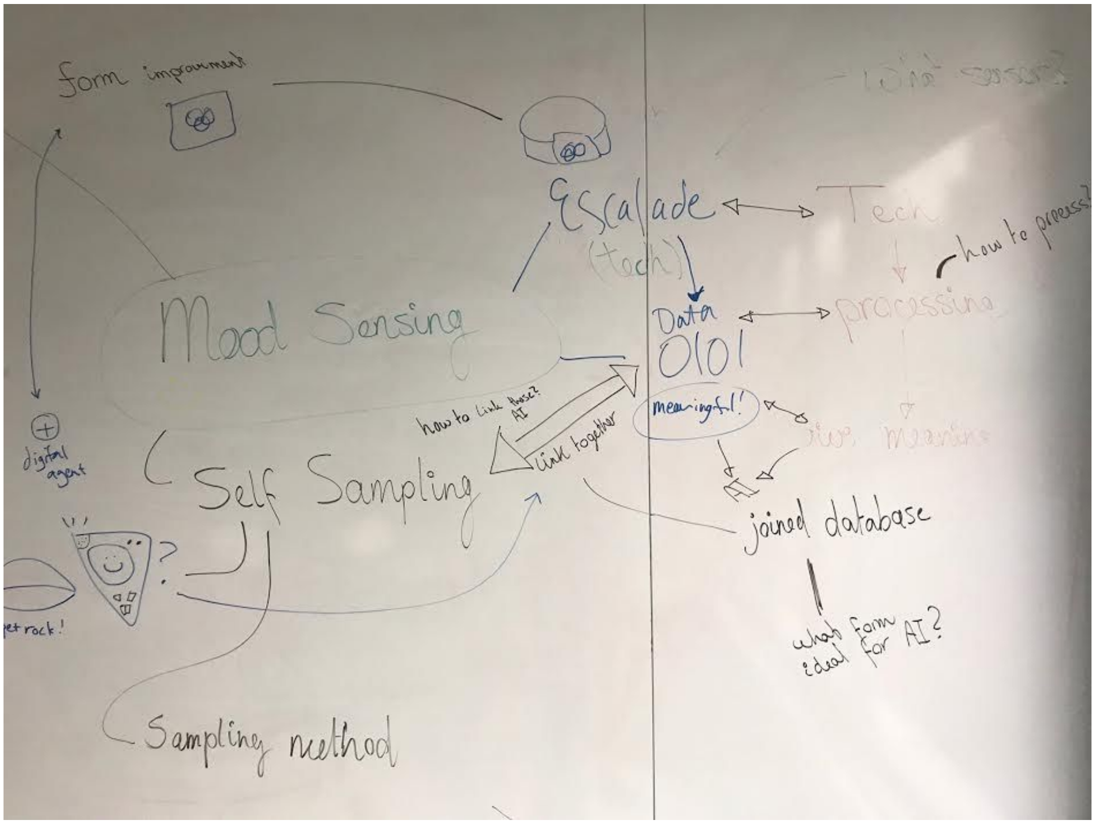
Additionally, research regarding the feedback device as a stand-alone prototype can be conducted to determine whether it could be successfully used to improve EQ.

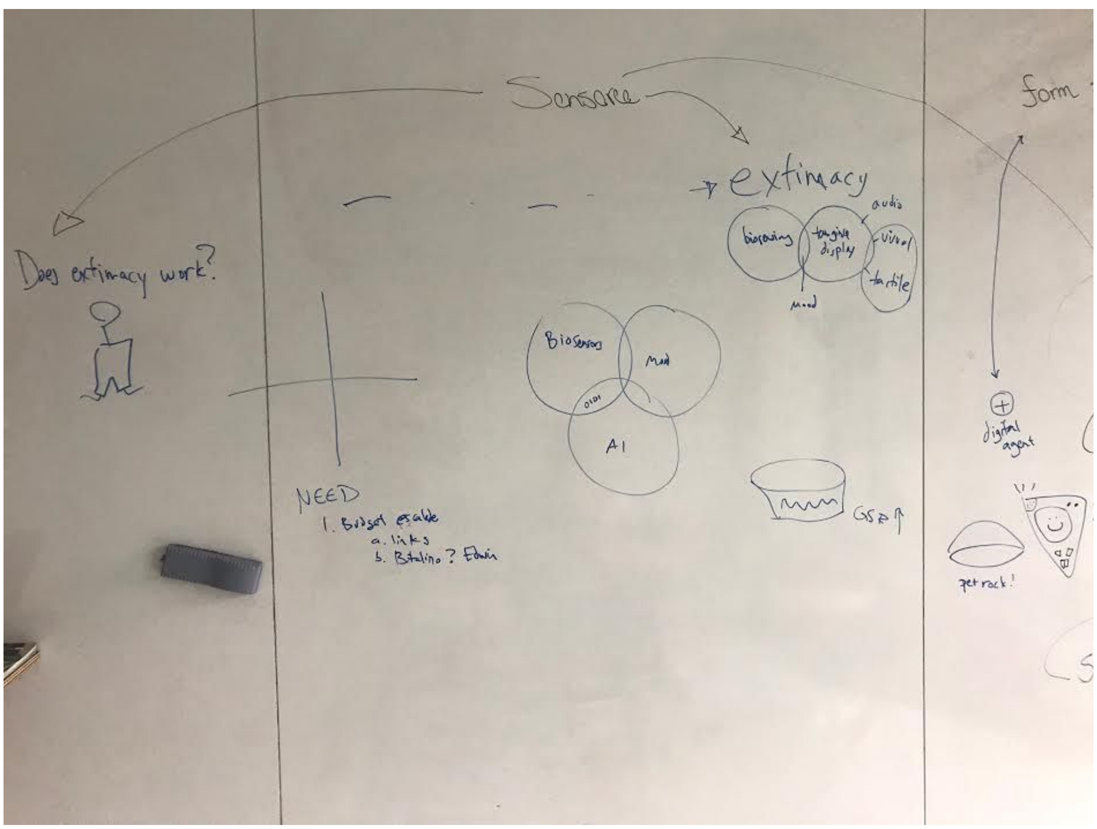
Appendix

A. Mind Map



B. Brainstorm


form improvement
Escalade
(tech)
Tech
how to process?
processing
Mood Sensing
Data
0101
meaningful!
how to link these? AI
link together
Self Sampling
digital agent
joined database
what form ideal for AI?
pet rock!
Sampling method


Sensore
extimacy
audio
biosensing
tangible display
visual
tactile
mood
Does extimacy work?
Biosensors
Mood
0101
AI
NEED
1. Budget escalade
a. links
b. Bitalino? Edwin
GSR ↑
form
digital agent
pet rock!

C. Expert meeting Troung

Please note the recording started late in the conversation. And the description below is a wrap up.	
Brouwer:	Volgens mij heb ik hem.
Truong:	Lukt dat zo?
Brouwer:	Volgensmij wel.
Truong:	Staat hij aan? Dus jij zegt het overkoepelende doel is het automatisch herkennen van emoties.En hoe doe je dat? Doormiddel van AI techniek. Wat heeft een AI techniek nodig om automatisch emoties te herkennen.
Brouwer:	Ja.
Truong:	Dat heet supervised learning/ machine learning.
Brouwer:	Wat is het verschil tussen die twee?

Truong: Supervised learning betekent dat een machine learning algoritme leert van data, in dit geval fysiologische data, en een mood label.

Brouwer: En dat label voegen wij toe.

Truong: Precies, dat is dus die dataset die machine learning nodig heeft om te leren. “Supervised.”
Unsupervised leren is ook mogelijk, dan is het label er niet, en moet het algoritme zelf ontdekken wat clusters zijn. Het is dan zelflerend.

Brouwer: Dat is dan veel moeilijker toch?

Truong: Veel moeilijker inderdaad.

Brouwer: Dus meestal is het doel dan ook supervised learning.

Truong: Er is in ons geval een emotion label en er is data. Regel met data: hardslag, skin conductance, etc. uit de Escalade. Die dataset is heel waardevol omdat daar modellen mee getraind kunnen worden. Momenteel is dat er niet voor de Escalade. Dat is de kern.

Brouwer: Je verwoordt het zo erg mooi. Voorheen had ik het ook zo in mijn hoofd, maar ik kon het niet zo uitleggen.

Truong: Ik kon merken dat je het idee hebt, maar het kwam er niet helemaal uit.

--- Distraction to a not interesting subject within the conversation ---

Truong: Het verkrijgen van het label, en is het zelf reported toch?

Brouwer: Ja.

Truong: Dus mensen vullen zelf hun emoties in.

Brouwer: Ja.

Truong: Waarom is dat zo relevant?

Brouwer: Omdat we het label nodig hebben, AI kan anders niet op een haalbare, gemakkelijke manier de connecties leggen.
Het nadeel is van self labeling dat als je gebruikers vraagt om feedback dat

	de gebruiker dan nadenkt over de gevoelde emotie en dat er dan biased samples ontstaan. Het is dan dus niet meer wat het écht was.
Truong:	Dat is een probleem, wat hetzelfde is als hier, dus dat los jij niet op.
Brouwer:	Hoe kan ik dat oplossen zou dus ook een vraag kunnen zijn.
Truong:	Je hoeft niet alles op te lossen, dat is niet haalbaar. Een ding is dus dat mensen het moeilijk kunnen vinden om op een schaalverdeling hun emoties in te vullen. Maar nogmaals, ik denk niet dat jij dat binnen de gezette tijd gaat oplossen.
Brouwer:	Nee oke, dat is inderdaad waarschijnlijk niet haalbaar.
Truong:	Een ander probleem is, als we die mood data willen verzamelen, hoe vaak moet dit ingevuld worden? Hoe vaak vragen we aan de mensen om iets in te vullen? “self report”
Brouwer:	Ik heb hier onderzoek naar gedaan, bijvoorbeeld naar Mood Diaries, een “interval contingent sampling technique”. De gebruiker word elke dag op een vaste tijd naar feedback gevraagd. Maar ook “signal contingent sampling method” waar in random om feedback word gevraagd. Persoonlijk leek het mij handiger als om het op het moment zelf te doen wanneer de gebruiker de mood voelt. Het is dan meer significant omdat ze het direct op dat moment voelden. Als je een maal per dag zou vragen is het minder precies op welk moment die emotie gevoeld werd.
Truong:	Oke.
Brouwer:	Bijvoorbeeld twee uur geleden voelde ik mij goed. Is minder kloppend met de werkelijkheid dan: twee minuten geleden voelde ik mij goed. Het nadeel is dus als je vaker voor feedback gaat vragen dan krijg je dus dat mensen minder feedback gaan geven. De kans dat zij er zat van worden en niet invullen is dan groter.
Truong:	Waarom?
Brouwer:	De kans dat de gebruikers niet reageren is minder erg, omdat je beter kunt hebben dat ze een aantal keer overslaan dan minder accurate feedback aan het eind van de dag. Dat was duidelijk tijdens het vooronderzoek.
Truong:	Dat is jouw focus: de ‘user experience sampling.’

	Hoe, wanneer? Hoe hun interesse vasthouden?
Brouwer:	In het vooronderzoek heb ik nar “Gamification” gekeken in relatie tot experience sampling, omdat dit het meest in de buurt kwam van mood sampling. Experiences in een restaurant, een plein, een openbare ruimte, etc. Hieruit kwam dat niet goed vastgesteld kon worden dat dit eigenlijk werkte omdat de testgroep te klein was. Daarnaast één onderzoek geen sterke basis voor conclusies.
Truong:	Ja.
Brouwer:	Als voorbeeld zou een simpel puntensysteem zou hier een uitkomst kunnen zijn. Als je mood feedback geeft met meer diepgang krijg je meer punten. Zo zou je de testgroep kunnen stimuleren om meer feedback te geven net zoals in dat experience sampling onderzoek.
Truong:	Dat zou kunnen, maar moet wel specifieker. Maar het is dus gebaseerd op sociale druk.
Brouwer:	Groepsdruk.
Truong:	Dat gebruik je dan om mensen te motiveren.
Brouwer:	De tellart fishtank doet dat ook, die motiveert mensen op kantoor om gezondere keuzes te maken. Alle werknemers worden gerepresenteerd met een vis, als de werknemer meer afstanden aflegt ziet de vis er mooier en beter uit.
Truong:	Fishtank? Dat komt uit de persuasive hoek denk ik?
Brouwer:	Ja.
Truong:	Zo ver moet je denk ik niet gaan. De vraag is een beetje: wat kwam er uit de state of the art onderzoek? Op het moment dat mensen een emotie voelen moeten ze dat aangeven zeg je eigenlijk.
Brouwer:	Het zou heel mooi zijn als dat lukt, maar om zover te komen is waarschijnlijk niet mogelijk.
Truong:	Dan heb je eigenlijk al emotie herkenning nodig.

Brouwer:	Een systeem wat inschat hoe de gebruiker zich voelt en dan om feedback vraagt, indien het systeem het fout heeft vraagt kan de gebruiker het corrigeren. Op een gegeven moment wanneer de AI agent meer leert heeft zal het systeem het vaker goed hebben.
Truong:	Dat is ook een idee. Maar dan heb je al wel al die AI nodig! Zo ver ga je niet komen.
Brouwer:	Dat idee kan ik wel uitschrijven?
Truong:	Als je het niet gaat doen, moet je het niet uitschrijven, anders wordt het verwarrend.
Brouwer:	Dat is het denk ik nu al…
Truong:	Hou de focus op “user mood sampling.” Bij deze afgebakend. De uitdaging is om de waardevolle dataset te genereren. Ik zie het zo voor mij: Iemand draagt de escalade de hele dag.
Brouwer:	Ja.
Truong: Dat	We moeten ook labels hebben. Hoe generen we de labels? Hoe vaak? Etc. is al een hele uitdaging. Een van de manieren is: als de gebruiker een emotie voelt, dan geeft hij meteen feedback. Hoe krijg je die persoon zo ver dat hij dat doet?
Brouwer:	Dat zou kunne met persuasive technology en/of gamification.
Truong:	Dat is erg lastig, je kunt zeggen van nou hier is de Escalade, geef feedback wanneer je een bepaalde emotie voelt. Dat gaat de gebruiker niet onthouden, heeft daar geen zin in, etc.
Brouwer:	Daarvoor dus die persuasive technology, daarin heb ik gekeken naar technieken waarop je dat zou kunnen doen, met voorbeelden.
Truong:	Hoe kun je de gebruiker overtuigen.
Brouwer:	Dat is erg lastig, en moeilijk om te integreren. Instrueren op een manier waarop de gebruiker het begrijpt, een signaal waarna ze feedback gaan geven en dus het ‘target behaviour’ kunnen gaan performen. In dit geval dus feedback geven.

Truong:	We zijn op zoek naar een ‘experience sampling methode’ die we kunnen gebruiken om een dataset te generen. Het beste is om de persoon op het moment dat de persoon een emotie heeft deze meteen te laten invullen. Dat gaat niet lukken, want daarvoor moet AI al aanwezig zijn.
Brouwer:	Random sampling zou dan dus kunnen.
Truong:	Random, om of het uur, of iets dergelijks.
Brouwer:	Eigenlijk is ideaal gezien, wanneer het systeem het meest onduidelijk is over de emotie die de gebruiker heeft, feedback het meest bruikbaar. Dan moet die AI er ook al zijn. Dus een random functie is daarom voor nu beter.
Truong: mij	Nadeel van de random functie is dat er veel onbruikbare info zal zijn. Ik voel neutraal, ik voel niks. De gebruiker meer dan alleen neutraal laten invullen.
Brouwer:	Wat als we de feedback aan een piek hangen.
Truong:	Daar zat ik ook net aan te denken.
Brouwer:	Hier heb ik ook naar gekeken in het vooronderzoek.
Truong:	Dat zou eventueel een goed idee zijn.
Brouwer:	Moeten we dan de sensoren gebruiken van de Escalade om even de piek te t racken met een algoritme.
Truong:	Dan moet je ‘even’ zo’n algoritme bedenken. Denkende aan dat iedereen een andere baseline heeft etc. Wat het wel lastig maakt.
Brouwer: natuurlijk	Ik zou dit wel kunnen uitwerken, maar als ik niet zo ver kom, geeft dat onduidelijkheid.
Truong:	Je moet wel iets testen, dus als je niet zo ver komt moet je het niet uitwerken.
Brouwer:	Ik wou eigenlijk beginnen met hallway usability tests om verschillende ideeën om mood te sampelen te evalueren. Dan de beste optie kiezen om verder uit te werken.

Truong: Wat wil je precies gaan testen bij die usability tests?

Brouwer: Of het werkt, fijn is, logisch, niet veel tijd in beslag neemt, intuïtief, etc.

Truong: Dat is een goede start, maar ik zou meer testen dan alleen een interface.

Brouwer: Als ik aan het eind nou iemand laat lopen met de Escalade en de ontworpen interface?

Truong: En dan bijvoorbeeld vragen stellen of de gebruiker het fijn vond om met de Escalade rond te lopen, anders heb je alleen een interface geëvalueerd.

Brouwer: Dat is denk ik te weinig.

Truong: Ja, maar als je die twee doet dan zou je al een eind komen. Je zou dat eerste als in een app kunnen maken.

Brouwer: Welke app?

Truong: De app die jij gaat maken?

Brouwer: Ow zo, ik weet nog niet of het een app gaat worden. Omdat ik eerst wil kijken wat uit die usability test gaat komen en daarnaast heb ik nog nooit een app ontwikkeld. Het lijkt mij ook moeilijk om een app te laten communiceren met een arduino based interface.

Truong: Hoe wil je die user mood sampling doen?

Brouwer: Gesprekken met Edwin (project supervisor) gingen in de richting van een armbandje met Arduino interface die de moods sampled.
Ik dacht zelf een smartwatch interface, maar dat kan lastig zijn.

Truong: Dat kan.

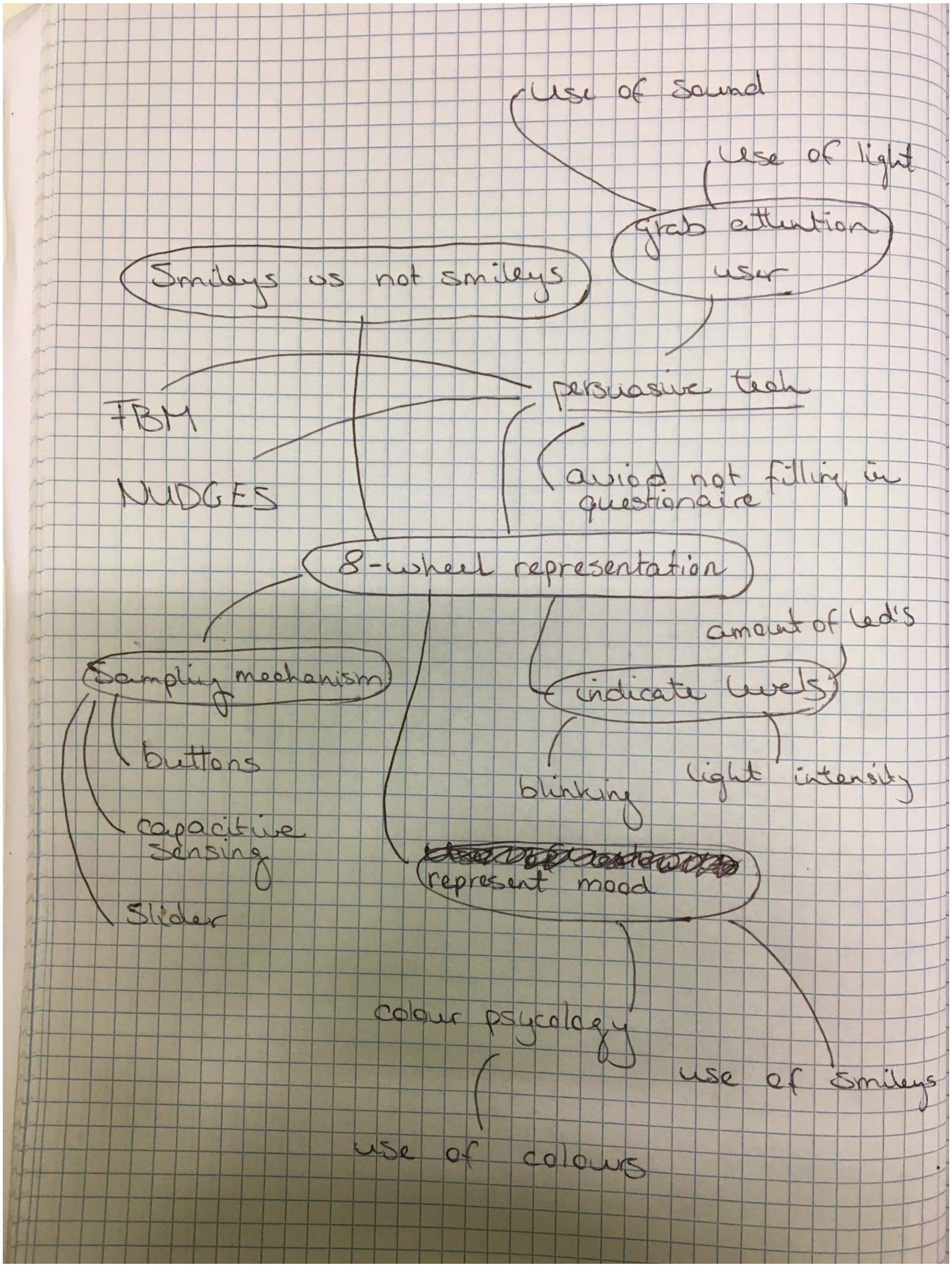
Brouwer: In verband met de tijd etc.

Truong: Het moet dus goed afgebakend worden, dit zou je met Edwin moeten bespreken.

Brouwer: Wat als ik de mensen de experience wel geef op het eind, maar de Escalade nog niet gelinked is met het feedback systeem?

Truong:	Dat moet wel goed gecommuniceerd worden met alle partijen zodat iedereen weet waar ze aan toe zijn. Zodat de verwachtingen niet te hoog zijn.
Brouwer:	Ik denk dat de verwachtingen al best hoog zijn.
Truong:	Dat moet je dus goed communiceren, wat je van plan bent om te doen etc.
Brouwer:	Ik wil er uiteraard zo veel mogelijk uit halen, maar het moet wel haalbaar zijn in het gezetten timeframe.
Truong:	Iedereen heeft denk ik al verwachtingen en ideeën over wat je gaat doen, ik dacht dus je een app gaat maken. Kristen en Edwin hebben waarschijnlijk ook ideeën verwachtingen. Dus communiceer dat goed.
Brouwer:	Smartwatch, armband, zijn richtingen die kunnen.
Truong:	Dat is een begin, jij hoeft ook echt niet alles op te lossen!
Brouwer:	Stel ik maak zo'n armband, dan zou je dat ook later alsnog kunnen omzetten in een smartwatch app interface.
Truong:	Ja! Je moet in ieder geval bij een prototype komen. Geen geheel product. Maar wat precies ga je dan testen blijft dan de vraag. Ik moet nu alleen wel weg zie ik net.
Brouwer:	Bedankt in ieder geval voor je tijd!
Truong:	Je weet best wel wat het doel is, je hebt heel veel dingen erbij gehaald.
Brouwer:	Dat is toch ook de bedoeling van deze fase in het project? En dan ga je focussen.
Truong:	Het moet wel duidelijk zijn wat die focus precies is. Dat op papier krijgen.

D. Brainstorm



E. First usability test

E.1 Questionnaire

Self Reported emotion feedback

This form exist of two parts. Part one is about sampling techniques and will be instructed. Part two is about the location of the sampling technique on the body.

* Required

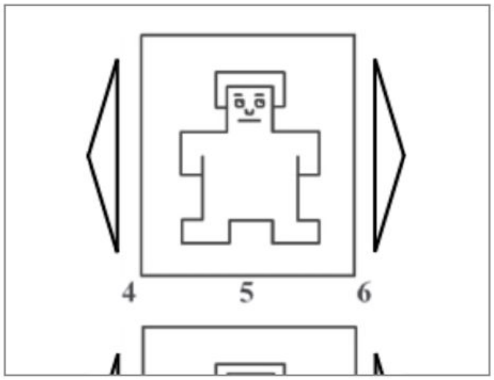
Interview Kristin

http://youtube.com/watch?v=QFtEiP6T3b8

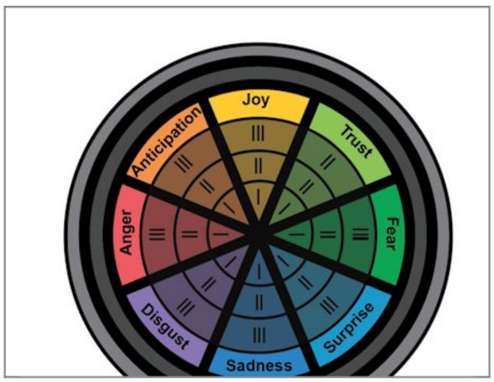
Self-sampling techniques

The 4 sampling techniques: valance and arousal sliders, 8-wheel representation, 6-wheel representation and Self-assessment manikin will now be illustrated.

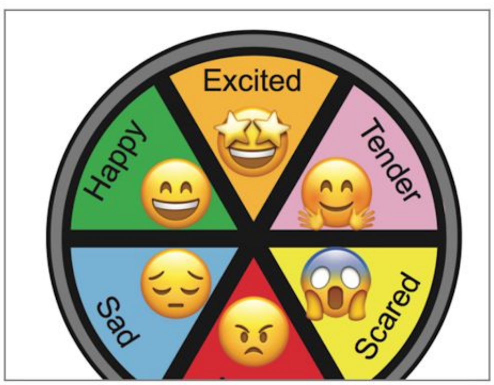
1. **What self-sampling technique is most accurate to the moods you experience?** *
   Check all that apply.



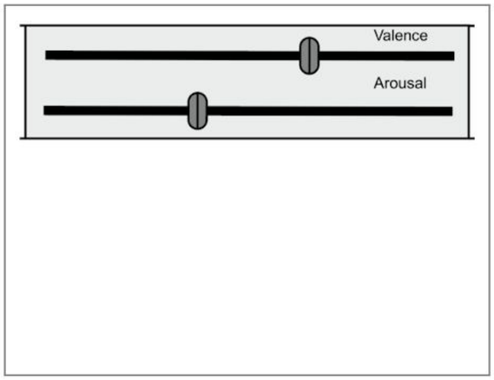
☐ Self-assessment manikin (SAM)



☐ 8-wheel representation



☐ 6-wheel smiley representation



☐ Valance and arousal sliders

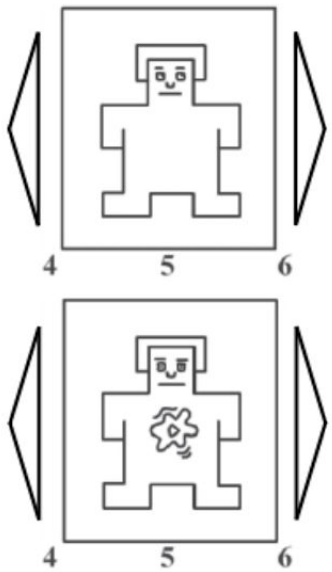
☐ Other: ______

2. **Is it clear/intuitive how to use the 8-wheel representation?**

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not intuitive	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Clear how to use

3. **Is it clear/intuitive how to use the self-assessment manikin (SAM)?**



Mark only one oval.

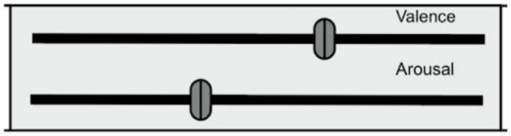
	1	2	3	4	5	6	7	8	9	10	
Not intuitive	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Clear how to use

4. **Is it clear/intuitive how to use the 6-wheel smiley representation?**

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not intuitive	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Clear how to use

5. **Is it clear/intuitive how to use the valance and arousal sliders?**

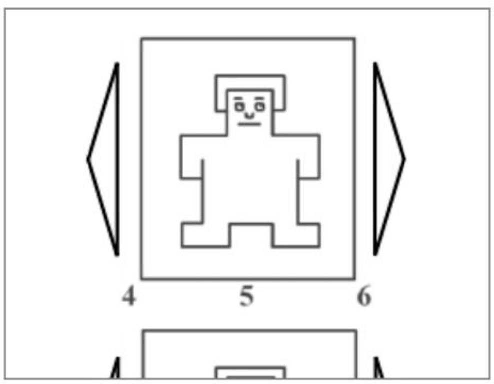


Mark only one oval.

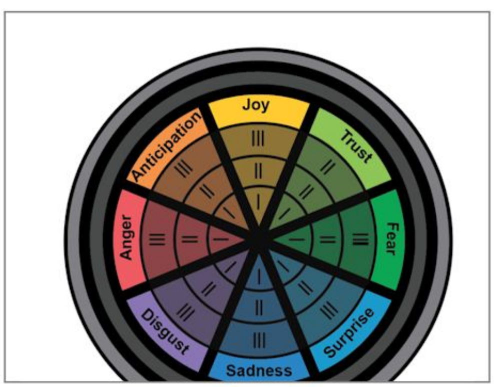
	1	2	3	4	5	6	7	8	9	10	
Not intuitive	○	○	○	○	○	○	○	○	○	○	Clear how to use

6. **What sampling technique is fastest according to you?** *

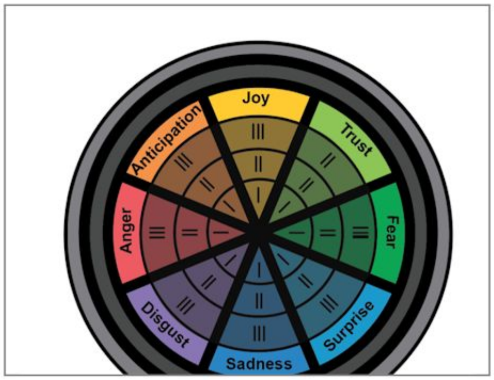
Check all that apply.



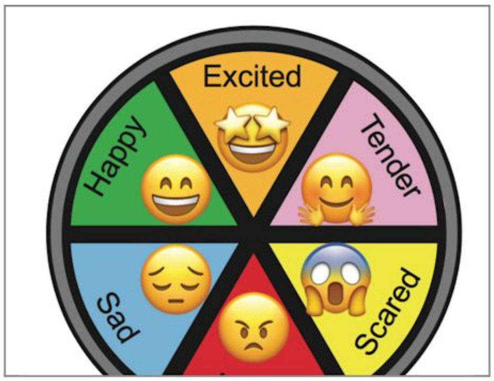
☐ Self-assessment manikin (SAM)



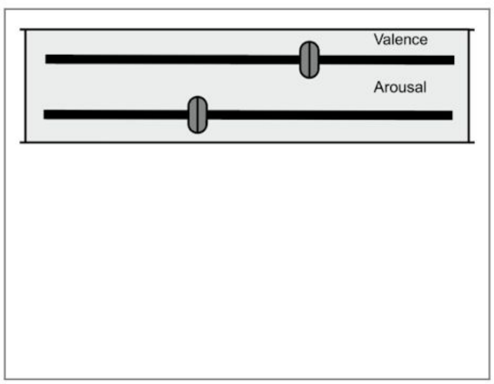
☐ 8-wheel representation



- [ ] 8-wheel representation



- [ ] 6-wheel smiley representation



- [ ] Valance and arousal sliders
- [ ] Other:

8. **Why do you prefer the above selected self-sampling technique most?** *

STOP!

Self-sampling locations

The 5 sampling locations: on the escalade with magnets (above shirt), on Escalade (under shirt), a wristband, a key hanger and a Smartwatch will now be illustrated.

9. **Do you want privacy when using a mood tracking system?**
Mark only one oval.

	1	2	3	4	5	
Not important	⬭	⬭	⬭	⬭	⬭	Important

10. **What self-sampling technique location is most discreet according to you?**
Check all that apply.

- ☐ on chest with magnets (above shirt)
- ☐ on chest (under shirt)
- ☐ Wristband
- ☐ Key hanger
- ☐ Smartwatch app
- ☐ Smartphone app
- ☐ Other: ____________________

11. **What self-sampling technique location is easiest to access?**
Check all that apply.

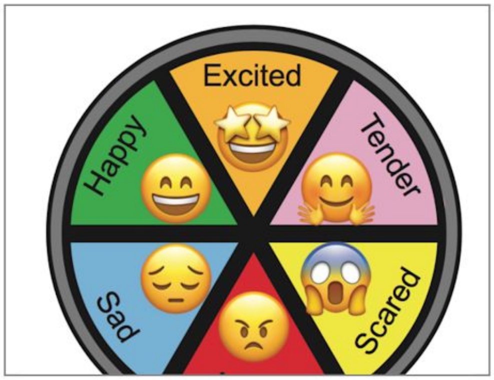
- ☐ on the Escalade with magnets (above shirt)
- ☐ on the Escalade (under shirt)
- ☐ Wristband
- ☐ Key hanger
- ☐ Smartwatch app
- ☐ Smartphone app
- ☐ Other: ____________________

12. **What self-sampling technique location do you personally prefer?**
Check all that apply.

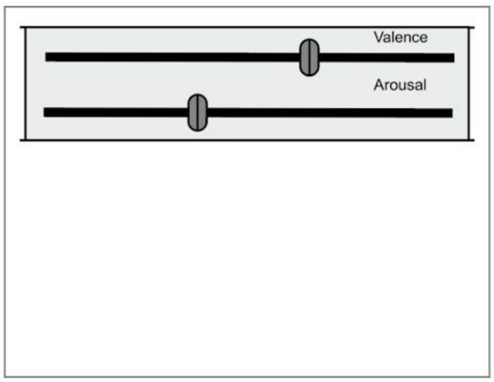
- ☐ on the Escalade with magnets (above shirt)
- ☐ on the Escalade (under shirt)
- ☐ Wristband
- ☐ Key hanger
- ☐ Smartwatch app
- ☐ Smartphone app
- ☐ Other: ____________________

13. **Why do you prefer the above selected self-sampling location most?**

____



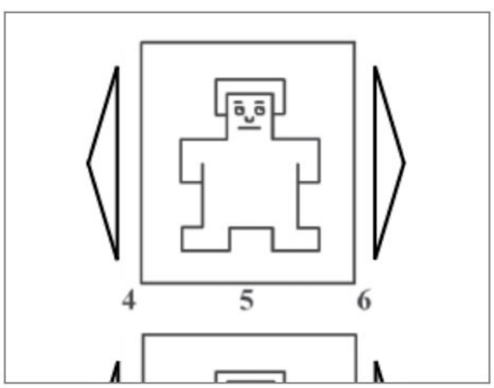
☐ 6-wheel smiley representation



☐ Valance and arousal sliders

☐ Other:

7. **What sampling techniques would you prefer to use to self-map your emotion/mood?** *
Check all that apply.



☐ Self-assessment manikin (SAM)

14. **What sampling technique would fit best on what sampling location?**

Mark only one oval per row.

	on chest with magnets (above shirt)	on chest (under shirt)	Wristband	Key hanger	Smartwatch app	Smartphone app
Self-assessment manikin (SAM)	⬭	⬭	⬭	⬭	⬭	⬭
8-wheel representation	⬭	⬭	⬭	⬭	⬭	⬭
6-wheel smiley representation	⬭	⬭	⬭	⬭	⬭	⬭
Valance and arousal sliders	⬭	⬭	⬭	⬭	⬭	⬭

15. **Explain the above given answer**

____

____

____

____

____

E2. Script usability test

Script Usability test

1. Introduction to what we do

We are designing a system that can detect mood. It consists of a combination of biosensors, mood feedback and machine learning. To determine what the best way would be to obtain mood feedback we ask for your participation in this usability test.

2. Play video

3. Order showing sampling techniques

1. SAM
2. Valence and arousal sliders
3. 6 slice representation -> say: possible to select multiple options
4. 8 slice representation -> say: possible to select multiple options

High valence: an event is positive.
Low valence: an adverse event.
High arousal: one is in a state of alertness.
Low arousal: means the opposite.

4. Fill in first part of questionnaire

Be around but not too present!

5. Order showing locations

First place all the locations on the test subject/participant

Order:

1. On Escalade -> normally under shirt, but easier for now
2. Wristband
3. Smartwatch
4. Key hanger

6. Fill in first part of questionnaire

Be around but not too present!

E3. Form for extra feedback

Form Extra feedback # respondent:

Sampling techniques; SAM

Valence and arousal sliders

6 slice representation

8 slice representation

Emotion	I	II	III
Joy			
Trust			
Fear			

Surprise			
Sadness			
Disgust			
Anger			
Anticipation			

Sampling locations; On Escalade

Wristband

Smartwatch

Key hanger

Other

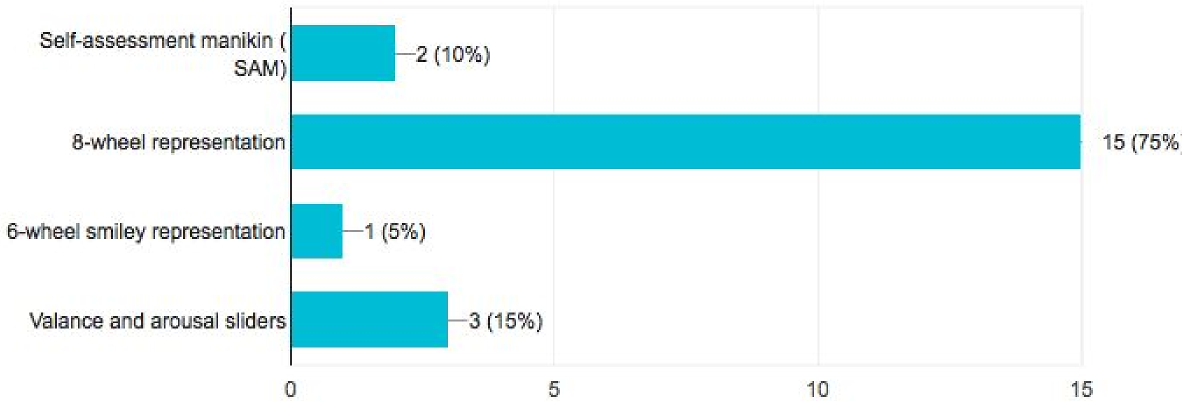
Additional notes

E4. Questionnaire responses

Sampling techniques

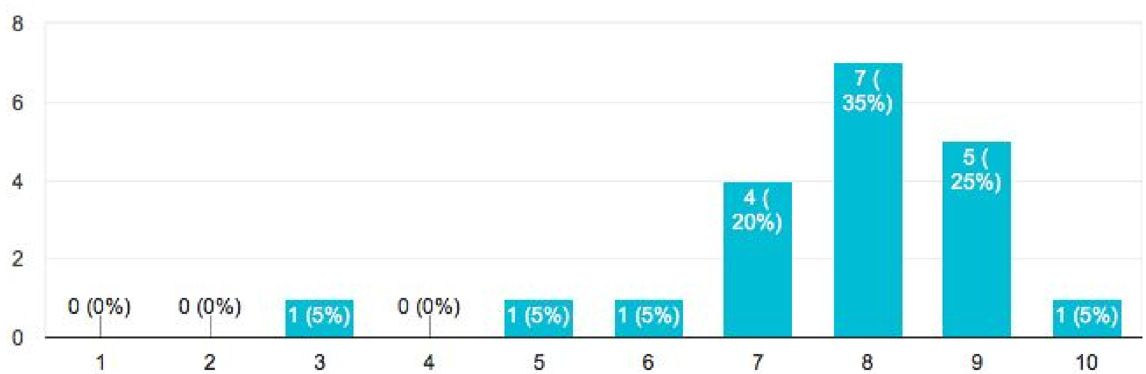
What self-sampling technique is most accurate to the moods you experience?

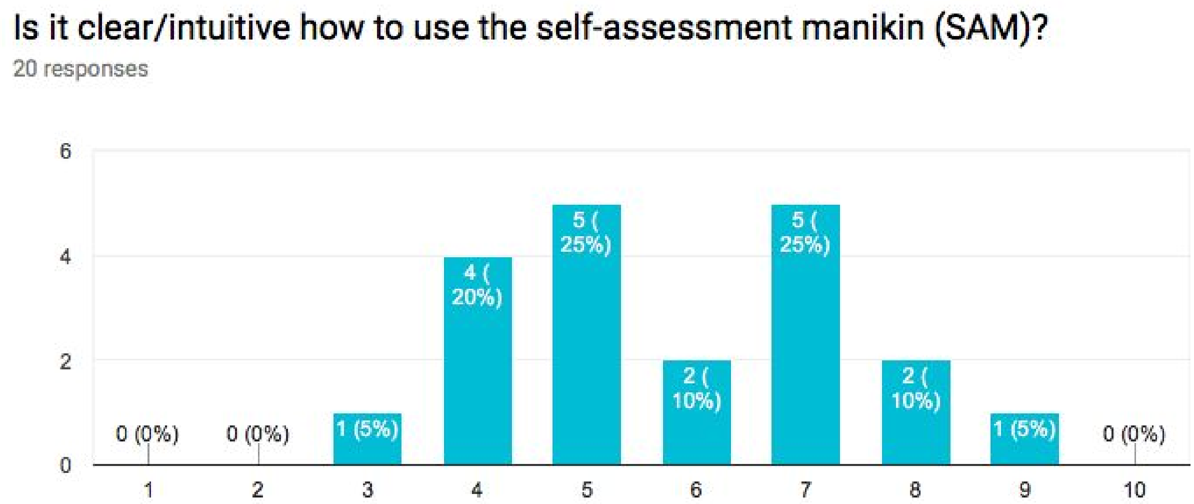
20 responses

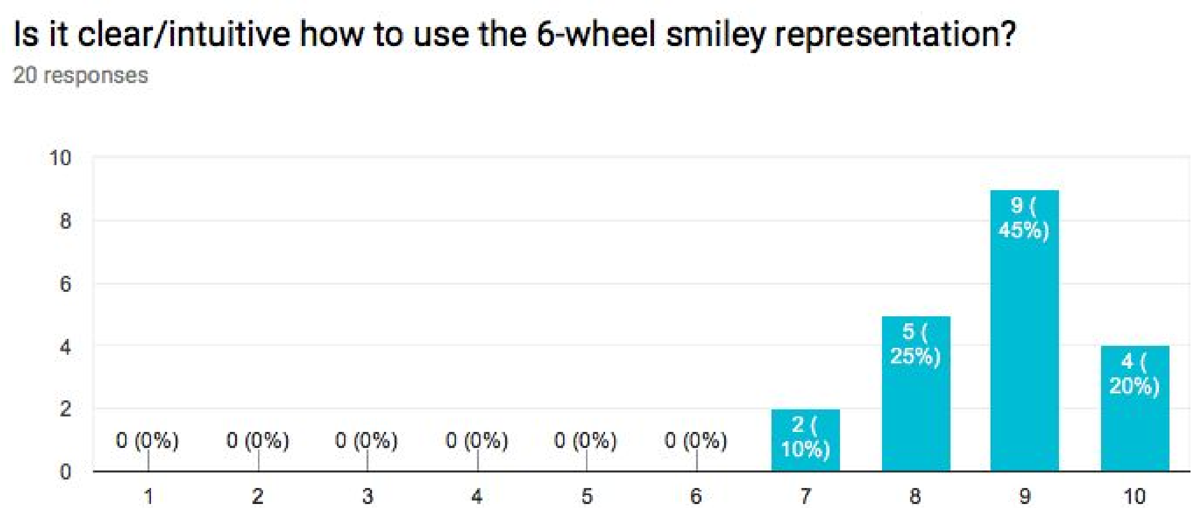


Is it clear/intuitive how to use the 8-wheel representation?

20 responses

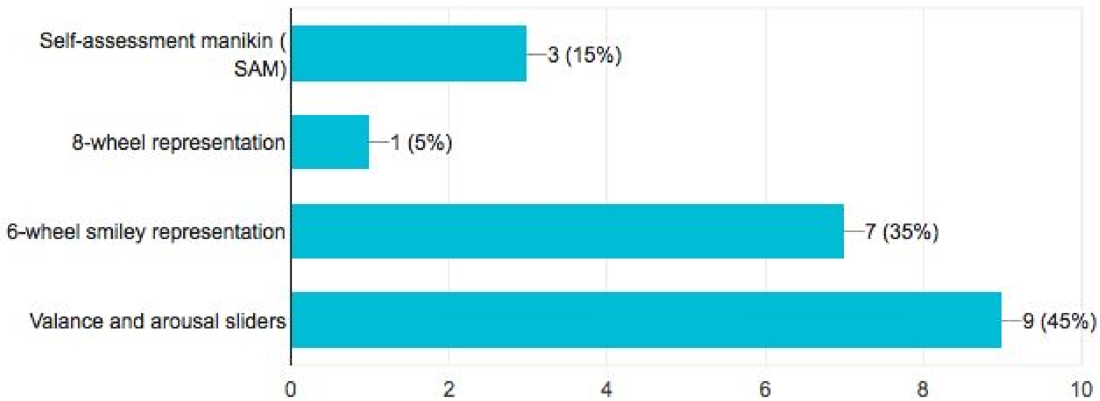



Is it clear/intuitive how to use the self-assessment manikin (SAM)?
20 responses
6
4
2
0
0 (0%)
0 (0%)
1 (5%)
4 (20%)
5 (25%)
2 (10%)
5 (25%)
2 (10%)
1 (5%)
0 (0%)
1
2
3
4
5
6
7
8
9
10


Is it clear/intuitive how to use the 6-wheel smiley representation?
20 responses
10
8
6
4
2
0
0 (0%)
0 (0%)
0 (0%)
0 (0%)
0 (0%)
0 (0%)
2 (10%)
5 (25%)
9 (45%)
4 (20%)
1
2
3
4
5
6
7
8
9
10

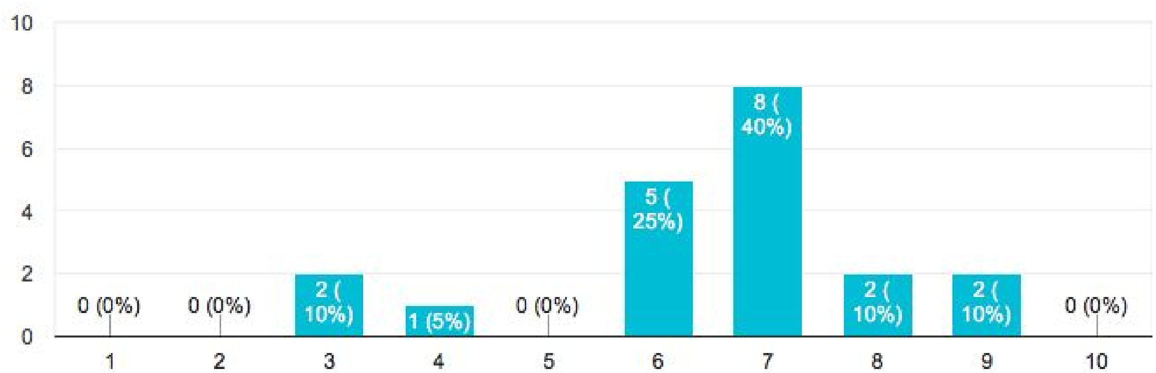
What sampling technique is fastest according to you?

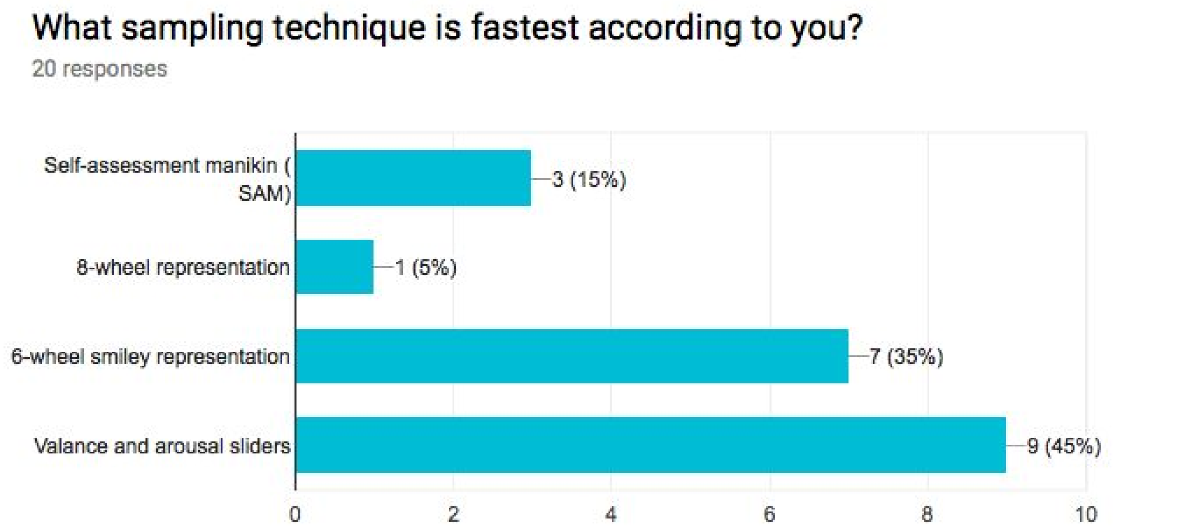
20 responses

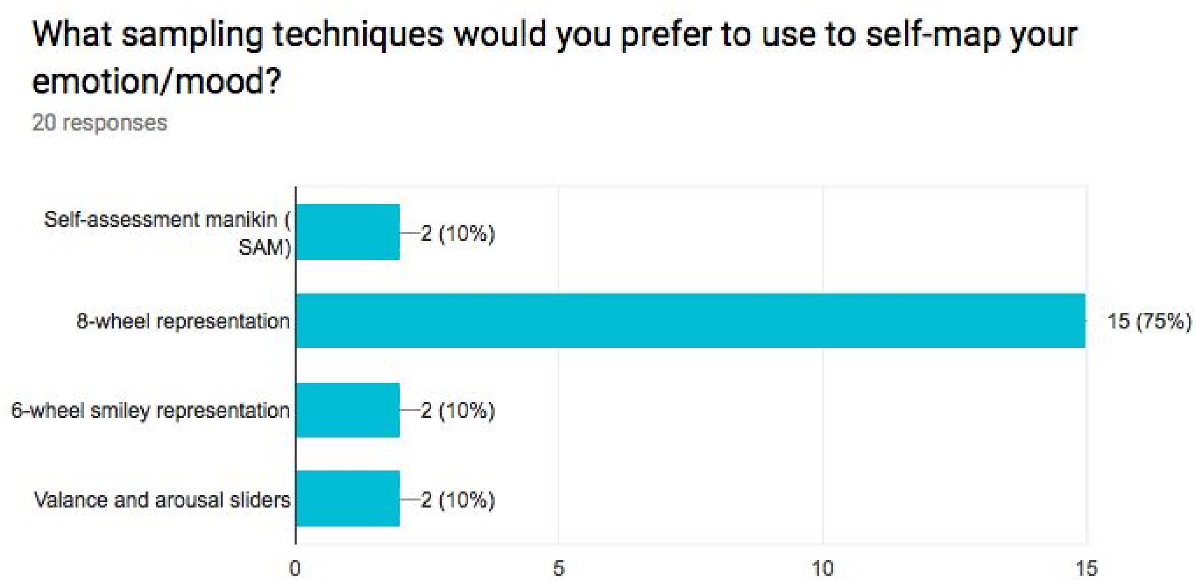


Is it clear/intuitive how to use the valance and arousal sliders?

20 responses



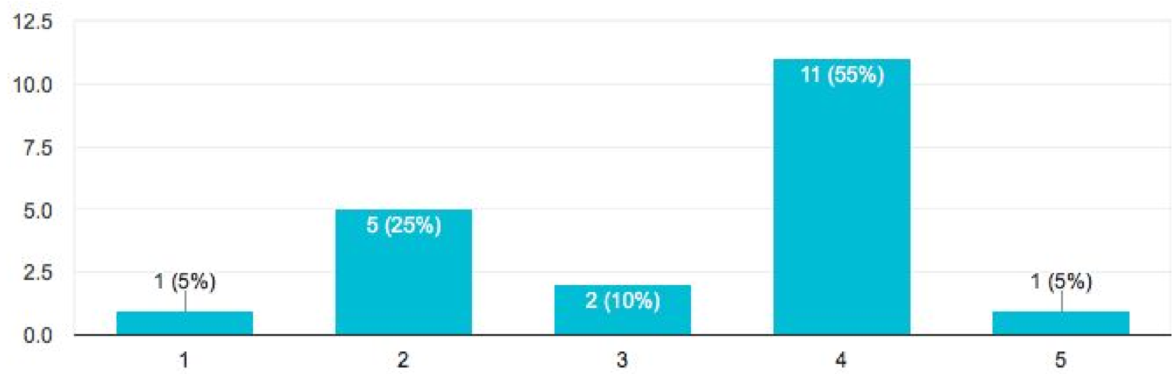




Sampling locations

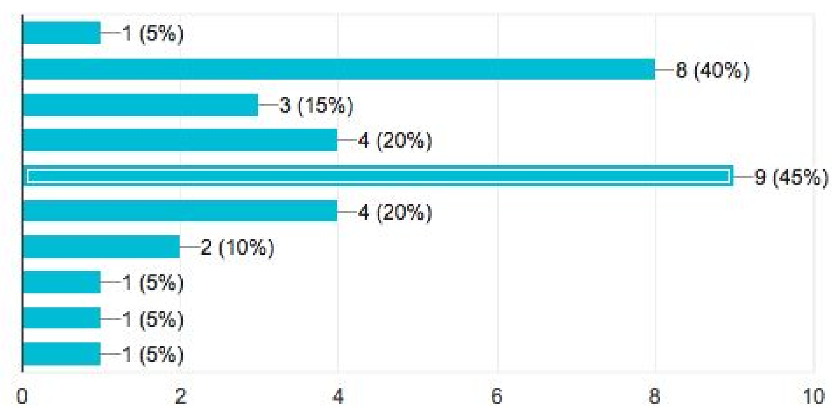
Do you want privacy when using a mood tracking system?

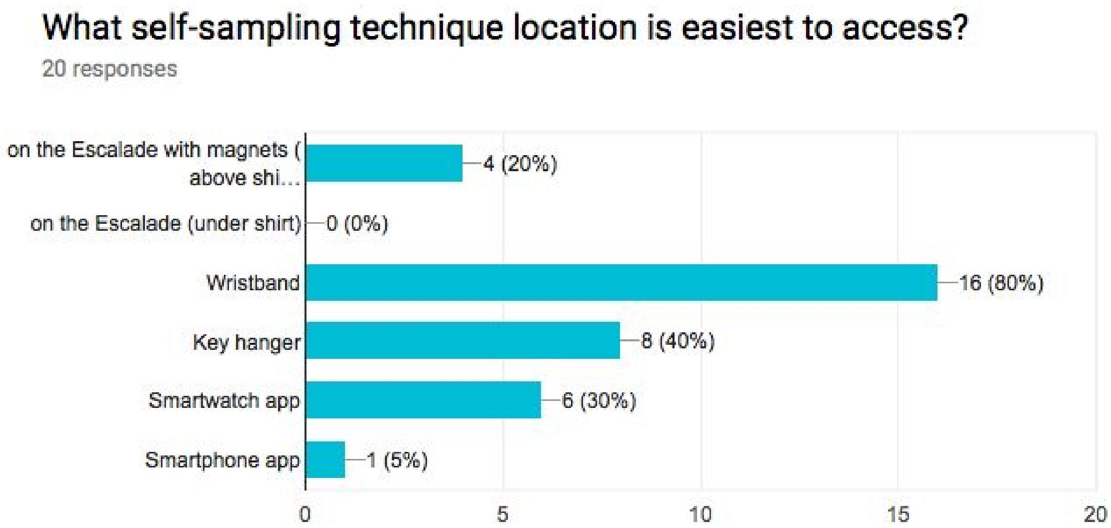
20 responses

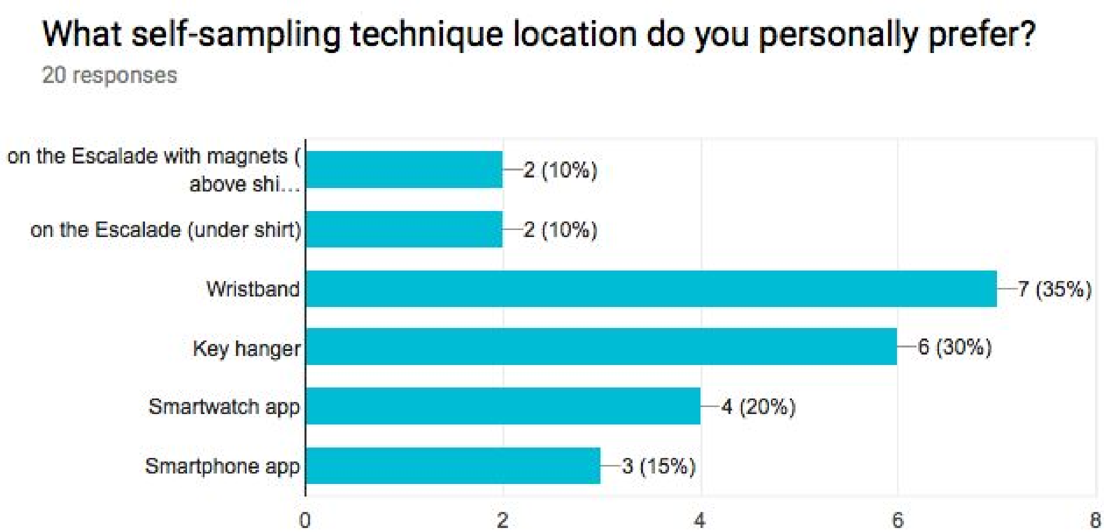


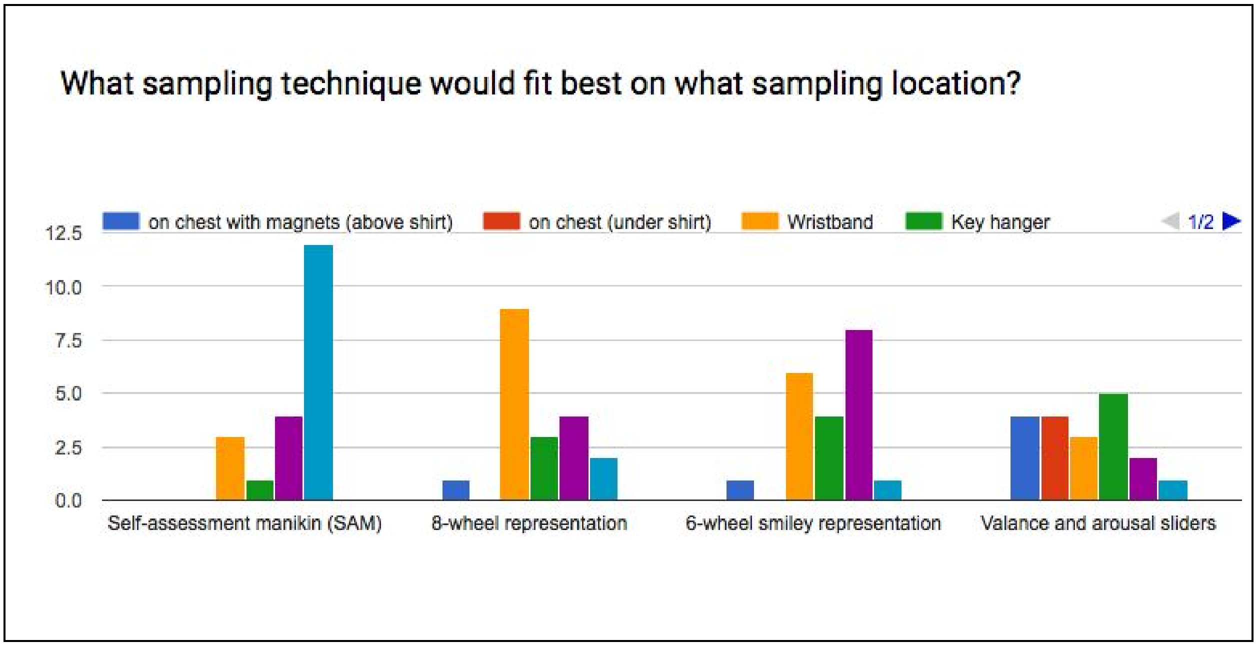
What self-sampling technique location is most discreet according to you?

20 responses




What self-sampling technique location is easiest to access?
20 responses
on the Escalade with magnets (above shi...
on the Escalade (under shirt)
Wristband
Key hanger
Smartwatch app
Smartphone app
4 (20%)
0 (0%)
16 (80%)
8 (40%)
6 (30%)
1 (5%)
0
5
10
15
20


What self-sampling technique location do you personally prefer?
20 responses
on the Escalade with magnets (above shi...
on the Escalade (under shirt)
Wristband
Key hanger
Smartwatch app
Smartphone app
2 (10%)
2 (10%)
7 (35%)
6 (30%)
4 (20%)
3 (15%)
0
2
4
6
8

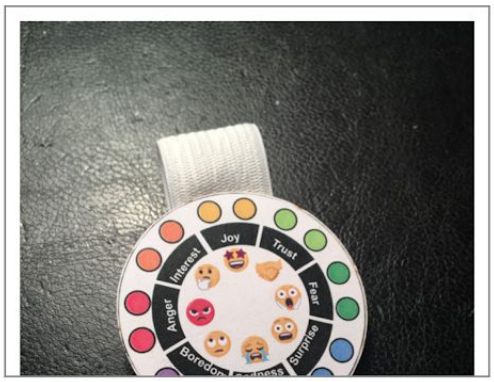


F. Second usability test

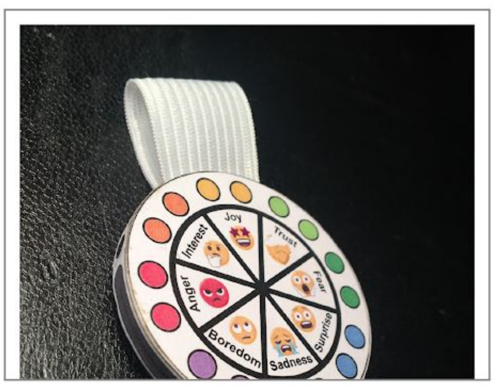
F.1 Questionnaire

3. **What interface do you prefer?**
Mark only one oval.

◯ Button interface



◯ Capacitive sensing interface



◯ Slider interface

4. **Explain the above given answer**

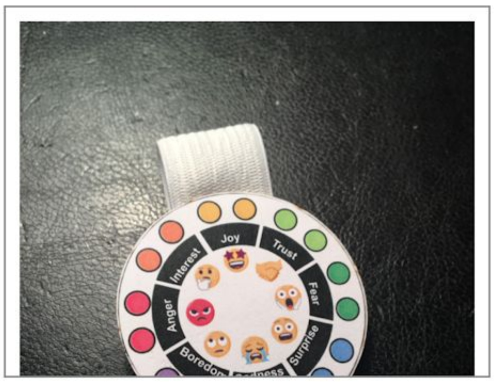
____

Mood representation

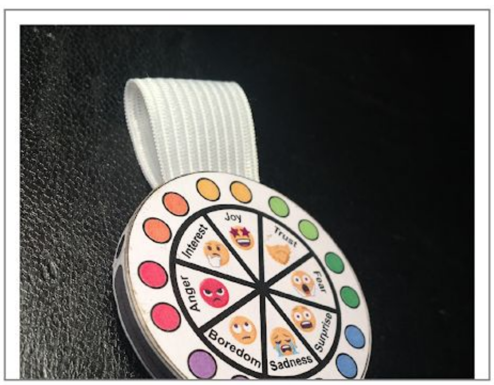
How the mood will be represented by the device; by only color or a combination of color and smileys.

3. **What interface do you prefer?**
Mark only one oval.

◯ Button interface



◯ Capacitive sensing interface



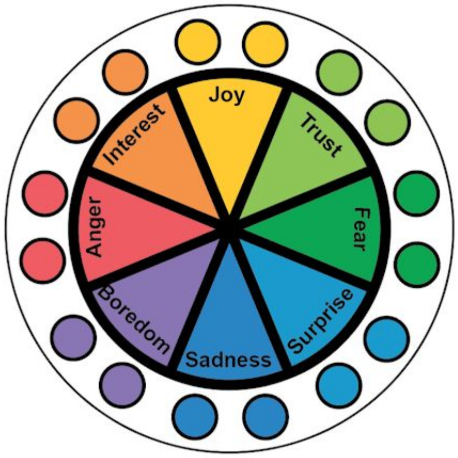
◯ Slider interface

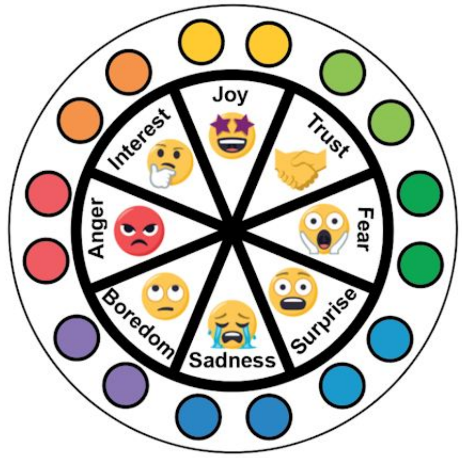
4. **Explain the above given answer**

Mood representation

How the mood will be represented by the device; by only color or a combination of color and smileys.

5. **What representation do you prefer?**





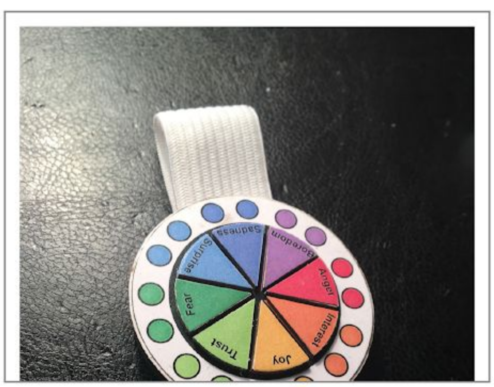
Mark only one oval.

- [ ] Plain representation (left)
- [ ] Emoji representation (right)

6. **Why do you prefer the above selected representation?**

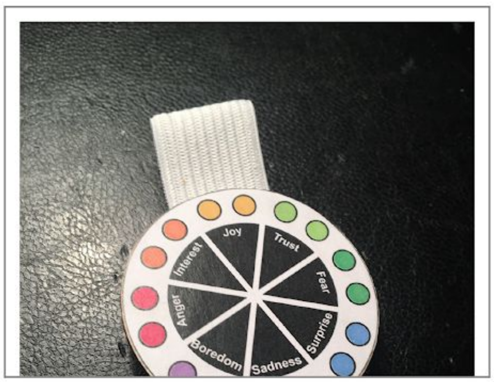
Personal preference

7. **What user self reported emotion feedback device do you personally prefer?**
Mark only one oval.

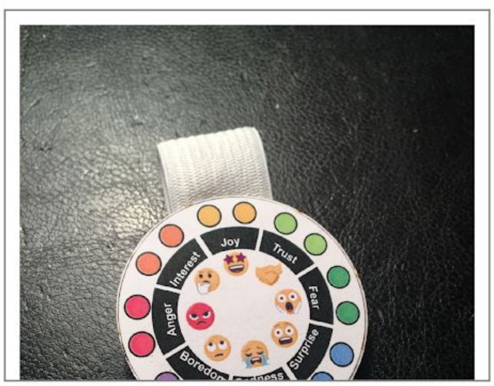


- [ ] BUTTONS with colours

BUTTONS with emoji's



CAPACITIVE SENSING black



CAPASITIVE SENSING with emoji's

SLIDER with colours

SLIDER emoji's

Other:

8. **Explain the above given answer**

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F.2 Script usability test

Script Usability test

1. Introduction to what we do

Let the participant read the first page, give them additional feedback when questions are asked.

2. Interface options

Tell the participant there are three interface options: one with buttons, capacitive sensing and with a slider system. The first video shows the interface for buttons and capacitive sensing.

3. Let the participat watch the video (interface buttons/capacitive sensing) and answer the first part of the questionnaire.

4. Let the participant watch the video for the slider interface and show the paper models with all 3 options. Let the participants wear them and explain additionally to the video's what they do.

Order of showing paper prototypes:

- buttons
- Capacitive sensing
- slider

5. Place on the one arm of the participant a smiley representation interface and on the other arm a representation with only colours. And let him fill in the questionnaire.

6. Show the participant all options on the table and let him fill in the last part of the questionnaire.

F.3 Questionnaire response

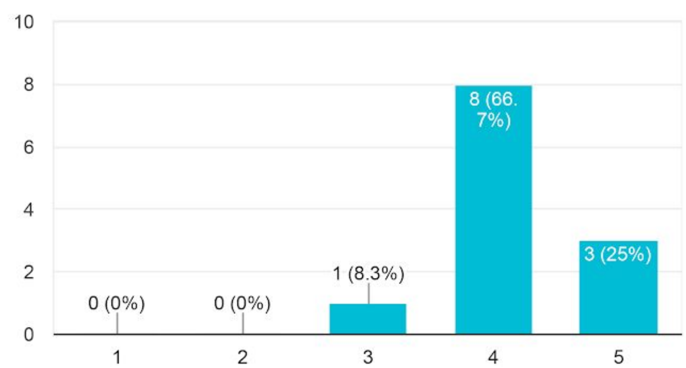
Self Reported emotion feedback interface

12 responses

Interfaces

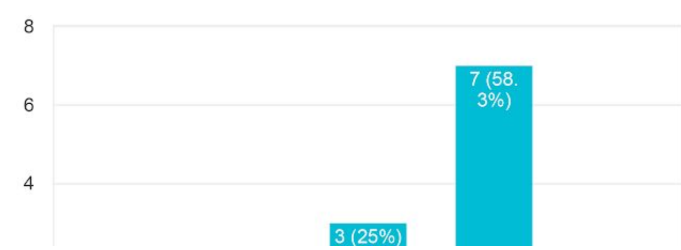
Does the combination of sound and light grab your attention?

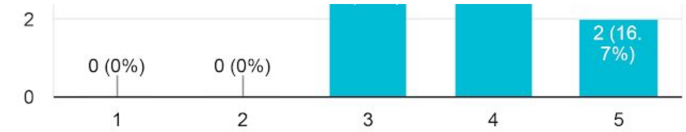
12 responses



Is the intensity of light able to show you your selected mood level as feedback?

12 responses

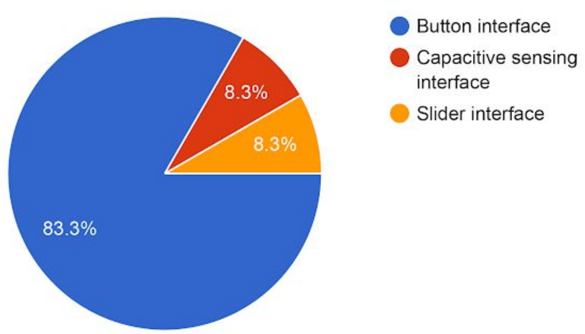




Capacitive sensing

What interface do you prefer?

12 responses



Explain the above given answer

7 responses

Buttons give you the feel you touched it because of the resistance, capacitive sensing doesn't and the slider is more time intesive.

quick and intuitive, the slider takes too much time!

better response since a button gives click feedback

buttons are too old school

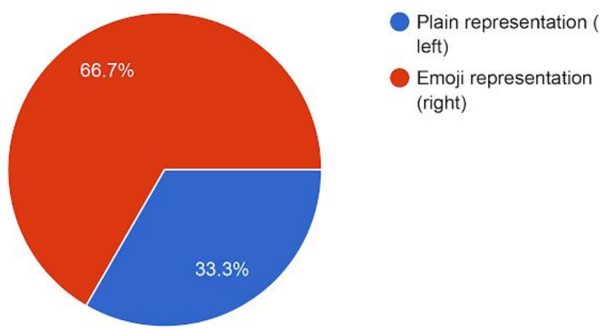
buttons are underrated but work fine you feel what you do, direct feedback from button, capacitive sensing might not always work pressing multiple times is reflecting intensity of a mood

Better overview

Mood representation

What representation do you prefer?

12 responses



Why do you prefer the above selected representation?

9 responses

plain representation more peaceful and visual pleasing

Because emoji's representing the moods are a cute addition.

cute and fun

Catches attention more

It seems more serious

It gives me a clearer picture of the meanings and I would make a correct choice earlier

For long term, for short term the smiley representation would be beter since it illustrates better.

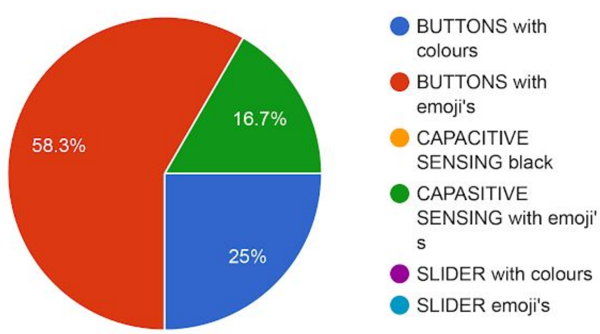
Illustrating the desired mood, but a bit messy. Maybe you can change the buttons over time. good when the emoji's represent the emotions better.

illustrate moods nicely, might be childish for some users

Personal preference

What user self reported emotion feedback device do you personally prefer?

12 responses



Explain the above given answer

8 responses

Because it is the combination of emoji and buttons, my favourable options.

When I make a choice here, I immediately see how I should feel, because of this I know what I choose instead of a text

happy and cute

happy and cute

combi of the things I preferred before

I can better identify with colours

The most elegant solution, and I prefer buttons over capacitive as it gives a more firm feedback.

but over time I would like to change to buttons with colours because it is more plain

because prettiest

G. Emoji emotion questionnaire

G.1 Questionnaire

Emoji emotion representations

Nowadays Emoji's are everywhere in our daily life. But everyone has different meanings for these emoji's. This short questionnaire (10 questions) is focussing on linking certain emotions to their smiley representations. In case the question doesn't match your preferred emoji; you can use the smiley matrix below to fill your preference at the bottom black option in each question. Advised is to do the questionnaire on a device with a big screen.

Smiley Matrix with numbers 1 to 136

1. **1/10 According to you; which of the following options represents JOY most accurate?**

Check all that apply.

- [ ] Option 1
- [ ] Option 2
- [ ] Option 3
- [ ] Option 4
- [ ] Option 5
- [ ] Option 6
- [ ] Option 7
- [ ] Option 8
- [ ] Option 9
- [ ] Option 10
- [ ] Option 11
- [ ] Option 12
- [ ] Option 13
- [ ] Option 21
- [ ] Option 22
- [ ] Option 23
- [ ] Option 24
- [ ] Option 25
- [ ] Option 30
- [ ] Other: ____________________

2. **2/10 According to you; which of the following options represents FEAR most accurate?**

Mark only one oval.

- ⬭ Option 39
- ⬭ Option 40
- ⬭ Option 41
- ⬭ Option 42
- ⬭ Option 51
- ⬭ Option 52
- ⬭ Option 67
- ⬭ Option 68
- ⬭ Option 69
- ⬭ Option 70
- ⬭ Option 71
- ⬭ Option 37
- ⬭ Option 38
- ⬭ Other: ________________

3. **3/10 According to you; which of the following options represents SURPRISE most accurate?**

Mark only one oval.

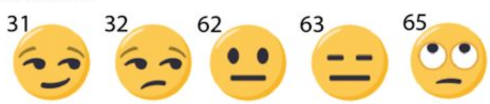
- ⬭ Option 67
- ⬭ Option 68
- ⬭ Option 69
- ⬭ Option 70
- ⬭ Option 71
- ⬭ Other: ________________

4. **4/10 According to you; which of the following options represents SADNESS most accurate?**

Mark only one oval.

- ◯ Option 32
- ◯ Option 33
- ◯ Option 34
- ◯ Option 35
- ◯ Option 36
- ◯ Option 37
- ◯ Option 38
- ◯ Option 39
- ◯ Option 40
- ◯ Option 41
- ◯ Option 42
- ◯ Option 43
- ◯ Option 44
- ◯ Other: ______________________

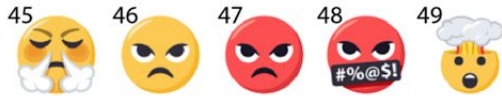
5. **5/10 According to you; which of the following options represents BOREDOM most accurate?**



Mark only one oval.

- ◯ Option 31
- ◯ Option 32
- ◯ Option 62
- ◯ Option 63
- ◯ Option 65
- ◯ Other: ______________________

6. **6/10 According to you; which of the following options represents ANGER most accurate?**



Mark only one oval.

- ◯ Option 45
- ◯ Option 46
- ◯ Option 47
- ◯ Option 48
- ◯ Option 49
- ◯ Other: ____________________

7. **7/10 According to you; on a scale from 1 to 5, how much does this smiley represent TRUST?**

Mark only one oval.

	1	2	3	4	5	
not at all	◯	◯	◯	◯	◯	fully represents TRUST

8. **8/10 According to you; what other smiley could represent TRUST? (fill in the number)**

____

9. **9/10 According to you; on a scale from 1 to 5, how much does this smiley represent INTEREST?**

Mark only one oval.

	1	2	3	4	5	
not at all	⬭	⬭	⬭	⬭	⬭	fully represents INTEREST

10. **10/10 According to you; what other smiley could represent INTEREST? (fill in the number)**

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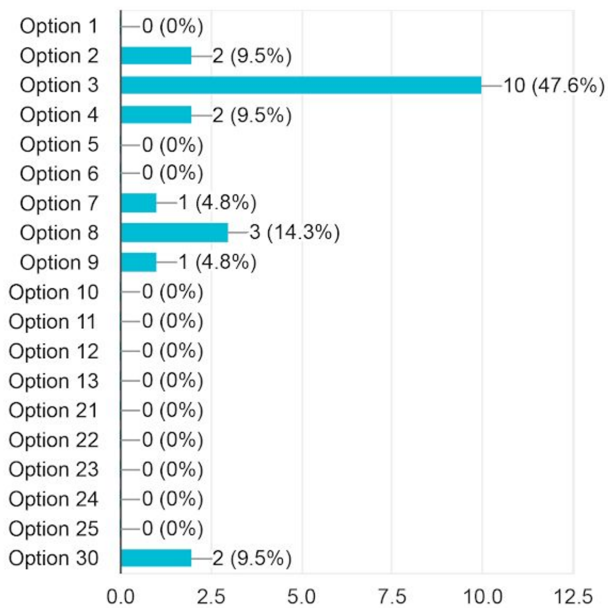
G.2 Results

Emoji emotion representations

21 responses

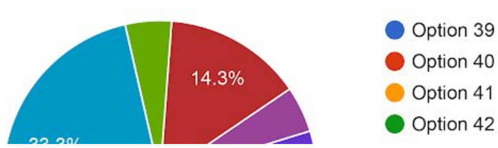
1/10 According to you; which of the following options represents JOY most accurate?

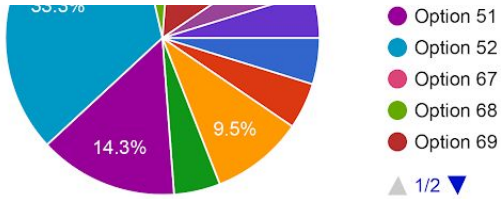
21 responses



2/10 According to you; which of the following options represents FEAR most accurate?

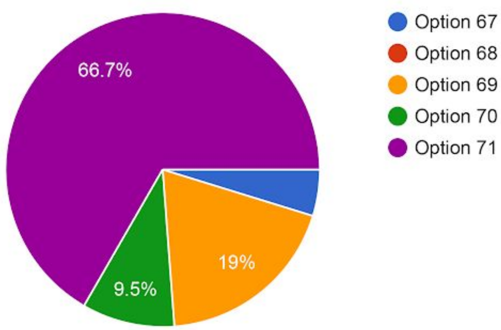
21 responses





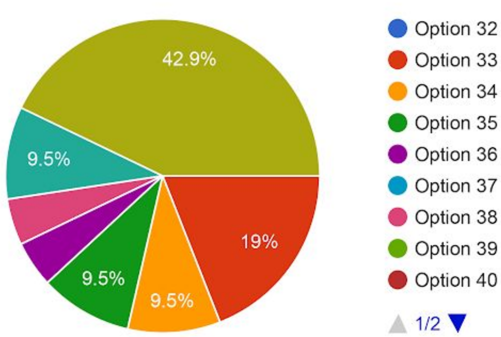
3/10 According to you; which of the following options represents SURPRISE most accurate?

21 responses



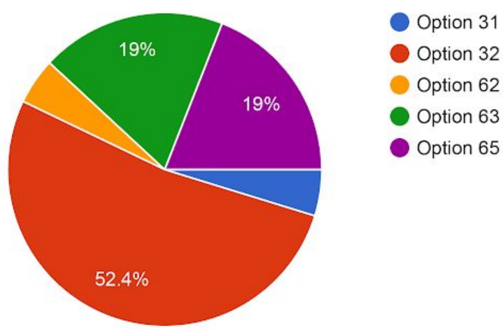
4/10 According to you; which of the following options represents SADNESS most accurate?

21 responses



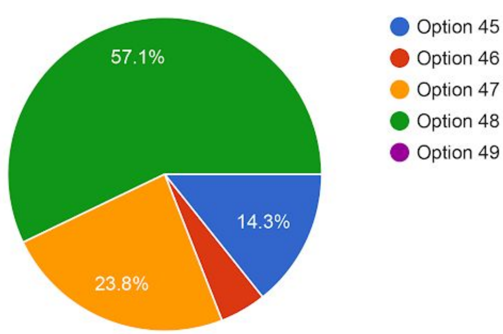
5/10 According to you; which of the following options represents BOREDOM most accurate?

21 responses



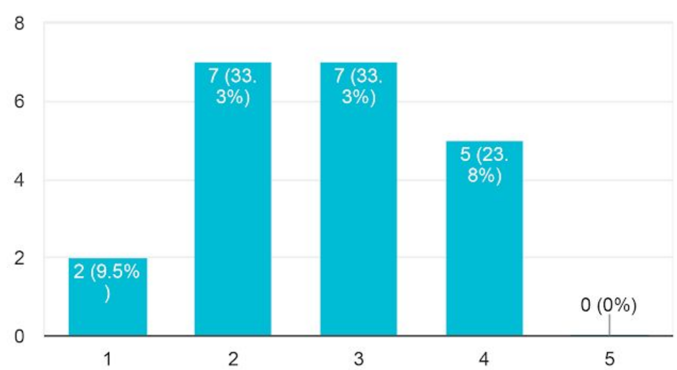
6/10 According to you; which of the following options represents ANGER most accurate?

21 responses



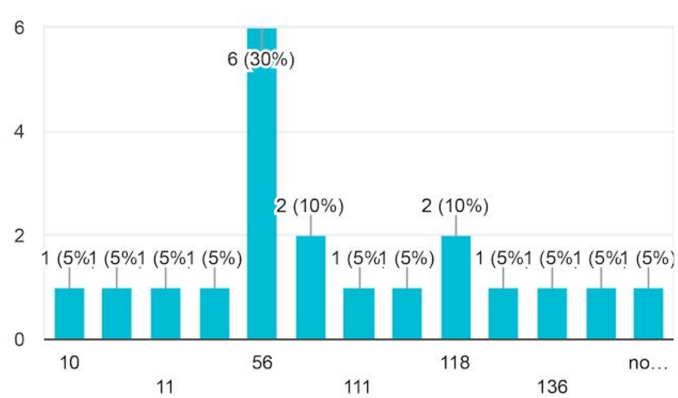
7/10 According to you; on a scale from 1 to 5, how much does this smiley represent TRUST?

21 responses



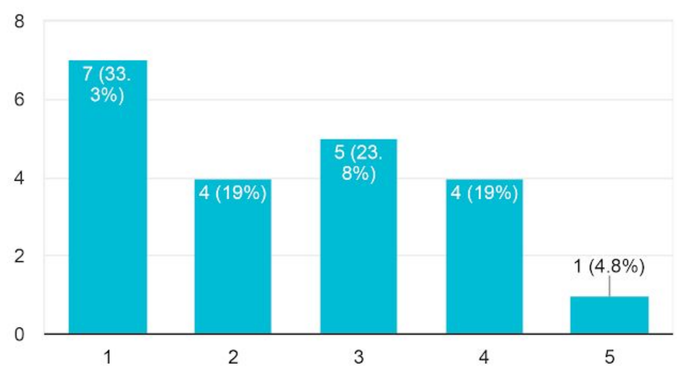
8/10 According to you; what other smiley could represent TRUST? (fill in the number)

20 responses



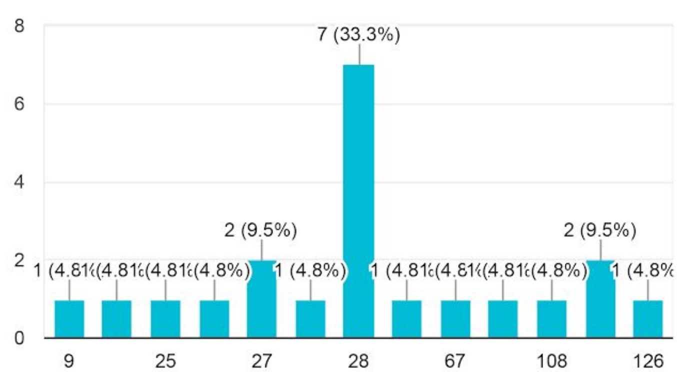
9/10 According to you; on a scale from 1 to 5, how much does this smiley represent INTEREST?

21 responses



10/10 According to you; what other smiley could represent INTEREST? (fill in the number)

21 responses



H. Prototype

H.1 Software Wristband

```
#include <Adafruit_NeoPixel.h>
#define LEDPIN 19
#define BUZZPIN 6
#define BUZZFREQ 440 // buzz frequency
#define TIMEMIN 900 // minimum delay time per measurement (s) (=15min)
#define TIMEMAX 1200 // maximum delay time per measurement (s) (=20min)
#define STARTUPLOOPS 2 //amount of 20 second startup loops per measurement

Adafruit_NeoPixel strip = Adafruit_NeoPixel(16, LEDPIN, NEO_GRB + NEO_KHZ800);
const int LEDoptions = 8; //Number of options to choose from
const int emotionColor[LEDoptions][3] = {{60,85,0}, {85,43,10}, {80,0,0}, {43,5,85}, {0,0,80}, {10,30,85}, {0,85,0}, {10,85,10}};
//Array of colors per emotion
const String emotionIndex[LEDoptions] = {"joy","interest","anger","boredom","sadness","surprise","fear", "trust"};

const int buttonList[9] { // digital pin numbers of buttons
  15,
  5,
  2,
  3,
  4,
  10,
  11,
  9,
  8
};

int buttonStates[9] = { // track button position
  1,
  1,
  1,
  1,
  1,
  1,
  1,
  1
};

int LEDlist[LEDoptions] = { // List of miltipliers per LED to save levels
  0,
  0,
  0,
  0,
  0,
  0,
  0,
  0
};


int readButtons(){ // function returns number for pressed button if any, otherwise -1
  for(int i=0; i<9; i++){
    int prevState = buttonStates[i];
    buttonStates[i] = digitalRead(buttonList[i]);
    if(buttonStates[i] == 0 && prevState == 1){
      return(i);
    }
  }
```

```
  return(-1);
}


void setLEDS(int lednum){ // function sets color of 2 pixels
    strip.setPixelColor(lednum*2, LEDlist[lednum]*emotionColor[lednum][0], LEDlist[lednum]*emotionColor[lednum][1],
LEDlist[lednum]*emotionColor[lednum][2]); // Set colors of LEDs multiplied by level
    strip.setPixelColor(lednum*2+1, LEDlist[lednum]*emotionColor[lednum][0], LEDlist[lednum]*emotionColor[lednum][1],
LEDlist[lednum]*emotionColor[lednum][2]);
    strip.show(); // Display pixel changes
    return;
}


void startInput(){ // start input and detecting buttons


  int lednum = -1; // currently no button pressed
  int p = 0; // keep track of LED index
  unsigned long startTime = millis(); // time of start for buzz timing
  int beepCount = 0; // index of buzzes
  int toneOn = 0; // tone is not on initially
  int startUpLoop = 1; // startup loop counter is 1
  while(lednum < 0){ // startup animation
    if((millis() - startTime > 200) && ((beepCount < 5) || toneOn)){ // if 200 ms have passed and (less than 5 beeps have occured or
the tone is playing)
      if(toneOn){ // if tone is on, turn it off, and vice versa
        noTone(BUZZPIN);
        toneOn = 0;
      } else {
        tone(BUZZPIN, BUZZFREQ);
        toneOn = 1;
        beepCount += 1; // increment amount of beeps played
      }
    }
    p %= 16; // when the 16th LED is reached, go back to 0 (mod 16)
    lednum = readButtons(); // check for pressed button
    strip.setPixelColor(p, 3*emotionColor[p/2][0], 3*emotionColor[p/2][1], 3*emotionColor[p/2][2]); // set new pixel values
    strip.show();
    delay(100);
    strip.setPixelColor(p, 0,0,0);
    p++;

    if(millis()-startTime > 20000){ // if more than 20 seconds have passed
        if(startUpLoop >= STARTUPLOOPS){ // if the amount of startup loops reaches maximum, end function
          strip.show();
          return;
        }
      startTime = millis(); // else set starttime to current time, and wait another 20s
      beepCount = 0; // reset initial buzzer variables
      toneOn = 0;
      startUpLoop++; // increment startup loop count
    }

  }

  for(int i = 0; i<LEDoptions; i++){ // clear LEDs
    strip.setPixelColor(i*2,0, 0, 0);
    strip.setPixelColor(i*2+1,0, 0, 0);
  }

  strip.show();


  while(lednum != 8){ // while end button is not pressed read buttons
```

```
    noTone(BUZZPIN);
    if((lednum>=0) && (LEDlist[lednum] < 3)){ // Check for correct integer given, and level below 3
      LEDlist[lednum] += 1; // Increase level/multiplier
      setLEDS(lednum);
      delay(100); // Delay after every press, can be longer/shorter
    } else if(LEDlist[lednum] == 3){
      LEDlist[lednum] = 0;
      setLEDS(lednum);
    }
    lednum = readButtons();
  }

  for(int i = 0; i<LEDoptions; i++){ // after end button is pressed, write to SD, clear leds and levels
    Serial1.print(emotionIndex[i]);
    Serial1.print(": ");
    Serial1.print(LEDlist[i]);
    Serial1.print(",\t");
    strip.setPixelColor(i*2,0, 0, 0);
    strip.setPixelColor(i*2+1,0, 0, 0);
    LEDlist[i] = 0;
  }
  Serial1.print('\n');
  strip.show();
  return;
}


void setup() {
  Serial1.begin(38400);
  strip.begin();
  strip.show(); // Clear strip LEDS
  for(int i = 0; i<9; i++){ // set all buttons to input pullup
    pinMode(buttonList[i], INPUT_PULLUP) ;
  }
}


void loop() {

  int delayTime = random(TIMEMIN, TIMEMAX); // delay between 100 and 200 seconds
  delay(delayTime*1000);
  startInput();

}
```

H.2 Updated software Escalade

```
#include "buffer.h"
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_ADXL345_U.h>
#include <Adafruit_HMC5883_U.h>

#include "I2Cdev.h"
#include "ITG3200.h"

Adafruit_ADXL345_Unified accel = Adafruit_ADXL345_Unified(12345);
Adafruit_HMC5883_Unified mag = Adafruit_HMC5883_Unified(54321);
ITG3200 gyro;

#define channelAm 12
Buffer sensorBuffers[channelAm];
String sensorNames[channelAm] = {"ECG", "GSR", "RES", "ACX", "ACY", "ACZ", "GYX", "GYY", "GYZ", "MGX", "MGY", "MGZ"};
```

```
IntervalTimer ecgTimer;
IntervalTimer accelTimer;
IntervalTimer gsrTimer;
IntervalTimer respTimer;

boolean bufferError = false;

int sendSensor = -1;

const byte SD_SW_Pin = 2;

int currFileNr = 0;

void saveAll(boolean save) {
  for (int i = 0; i < channelAm; i++) {
    sensorBuffers[i].setWriteSD(save);
  }
}

void lockAllBuffers() {
  for (int i = 0; i < channelAm; i++) {
    sensorBuffers[i].lockCurrentBuffer();
  }
}

void resetAllCounters() {
  for (int i = 0; i < channelAm; i++) {
    sensorBuffers[i].resetCounter();
  }
}

void setup() {
  saveAll(false);
  pinMode(SD_SW_Pin, INPUT_PULLUP);
  Serial1.begin(38400);
  initSensors();
  stopRec();
  ecgTimer.begin(ecgISR, 2000);
  accelTimer.begin(accelISR, 4000);
  gsrTimer.begin(gsrISR, 100000);
  respTimer.begin(respISR, 10000);
}

void initSensors() {
  if (!accel.begin())  {
    serialPrintln("Ooops, no ADXL345 detected ... Check your wiring!");
    while (1);
  }
  accel.setRange(ADXL345_RANGE_16_G);

  if (!mag.begin())  {
    serialPrintln("Ooops, no HMC5883 detected ... Check your wiring!");
    while (1);
  }

  Wire.begin();
  gyro.initialize();
  serialPrintln(gyro.testConnection() ? "ITG3200 connection successful" : "ITG3200 connection failed");
}

void loop() {
  checkSerial();
  checkSD();
  if (bufferError) {
```

```
    serialPrintln("Buffer error!");
    bufferError = false;
  }
  checkBuffers();
}

void checkBuffers() {
  size_t bytesAvailable;
  for (int i = 0; i < channelAm; i++) {

    bytesAvailable = sensorBuffers[i].bytesAvailable();
    if (bytesAvailable != 0) {
      if ( sensorBuffers[i].getWriteSD() ) writeToSD(sensorBuffers[i].getSendBuffer(), bytesAvailable, String(currFileNr) + "/" +
sensorNames[i] + ".TXT"); // String(currFileNr) +
      if (sendSensor == i ) serialSendData(sensorBuffers[i].getSendBuffer(), bytesAvailable);
      sensorBuffers[i].unlockSendBuffer();
    }
  }
}

#define NUM_RES_SAMPLES 100
int16_t gx, gy, gz;

volatile int16_t ecgRead;
void ecgISR() {
  //  ecgRead = analogRead(0);
  ecgRead = analogRead(0);
  bufferError = bufferError || !sensorBuffers[0].writeInt(ecgRead);
}

volatile int16_t gsrRead;
void gsrISR() {
  gsrRead = analogRead(1);
  bufferError = bufferError || !sensorBuffers[1].writeInt(gsrRead);
}

volatile int16_t respRead;
void respISR() {
  uint8_t i;
  float average = 0;
  for (i = 0; i < NUM_RES_SAMPLES; i++) {
    average += analogRead(2);
  }
  average /= NUM_RES_SAMPLES;
  respRead = average;
  bufferError = bufferError || !sensorBuffers[2].writeInt(respRead);
}

volatile int16_t valRead;
void accelISR() {
  sensors_event_t event;
  accel.getEvent(&event);
  valRead = event.acceleration.x * 100;
  bufferError = bufferError || !sensorBuffers[3].writeInt(valRead);
  valRead = event.acceleration.y * 100;
  bufferError = bufferError || !sensorBuffers[4].writeInt(valRead);
  valRead = event.acceleration.z * 100;
  bufferError = bufferError || !sensorBuffers[5].writeInt(valRead);

  gyro.getRotation(&gx, &gy, &gz);
  bufferError = bufferError || !sensorBuffers[6].writeInt(gx);
  bufferError = bufferError || !sensorBuffers[7].writeInt(gy);
  bufferError = bufferError || !sensorBuffers[8].writeInt(gz);

  mag.getEvent(&event);
```

```
  valRead = event.magnetic.x*100;
  bufferError = bufferError || !sensorBuffers[9].writeInt(valRead);
  valRead = event.magnetic.y*100;
  bufferError = bufferError || !sensorBuffers[10].writeInt(valRead);
  valRead = event.magnetic.z*100;
  bufferError = bufferError || !sensorBuffers[11].writeInt(valRead);
}

#define CPU_RESTART_ADDR (uint32_t *)0xE000ED0C
#define CPU_RESTART_VAL 0x5FA0004
#define CPU_RESTART (*CPU_RESTART_ADDR = CPU_RESTART_VAL);

#include <SPI.h>
#include <SD.h>


File file;

boolean SDinited = false;


void checkSD() {
  if (digitalRead(SD_SW_Pin)) {
    if (SDinited) {
      SDinited = false;  // no SD card inserted
      serialPrintln("SD card removed");
    }
  } else {
    if (!SDinited) initSD();
  }
}

void initSD() {
  if (!SD.begin(10)) {
    serialPrintln("Initialization failed!");
    serialPrintln("RESTART IN 2 SEC.");
    delay(2000);
    CPU_RESTART
    SDinited = false;
    return;
  }
  SDinited = true;
  serialPrintln("SD card inited");
  currFileNr = getBiggestDirNr();
  serialPrintln("last folder: " + String(currFileNr));
}

void writeToSD(const uint8_t *buf, size_t s, String _filename) {
  if (!SDinited) return;

  char filename[_filename.length() + 1];
  _filename.toCharArray(filename, sizeof(filename));
  //  serialPrint("Opening " + _filename + "...");
  file = SD.open(filename, FILE_WRITE);
  if (file) {
    //    serialPrint(" Writing...");
    file.write(buf, s);
    file.close();
    //    serialPrintln(" Closed");
  } else {
    // if the file didn't open, print an error:
    serialPrintln(" error opening");
  }
}
```

```
boolean saveTimeStamp(String stamp, String _filename) {
  if (!SDinited) return false;

  char filename[_filename.length() + 1];
  _filename.toCharArray(filename, sizeof(filename));
  file = SD.open(filename, FILE_WRITE);
  if (file) {
    file.print(stamp);
    for (int i = 0; i < channelAm; i++) {
      file.print('\t');
      file.print(sensorBuffers[i].getCounter());
    }
    file.println();
    file.close();
  } else {
    serialPrintln(" error opening");
    return false;
  }
  return true;
}

boolean saveStringToSD(String stamp, String _filename) {
  if (!SDinited) return false;

  char filename[_filename.length() + 1];
  _filename.toCharArray(filename, sizeof(filename));
  file = SD.open(filename, FILE_WRITE);
  if (file) {
    file.print(stamp);
    file.println();
    file.close();
  } else {
    serialPrintln(" error opening");
    return false;
  }
  return true;
}

void makeDir(String _filename) {
  if (!SDinited) return;

  char filename[_filename.length() + 1];
  _filename.toCharArray(filename, sizeof(filename));
  if (SD.mkdir(filename)) {
    serialPrintln("Created new dir: " +  String(filename));
  } else {
    serialPrintln("Failed creating new dir " +  String(filename));
  }
}

int getBiggestDirNr() {
  File dir = SD.open("/");
  int maxNr = 0;
  serialPrint("Root scan: ");
  while (true) {
    File entry =  dir.openNextFile();
    if (! entry) {
      break;
    }
    serialPrint(entry.name());
    serialPrint(", ");
    if (!entry.isDirectory()) {
      continue;
    }
    String entryName = String(entry.name());
```

```
    if ( entryName.charAt(0) < 48 || entryName.charAt(0) > 57) {
      continue;
    }
    int dirNr = entryName.toInt();
    if (dirNr > maxNr) maxNr = dirNr;
  }
  serialPrintln("");
  return maxNr;
}


#include "Arduino.h"
#include "buffer.h"


boolean Buffer::write(uint8_t data) {
  lastWrite = millis();
  if (lockedBuffer[currentBufferId] != 0) {
    return false; // if the current buffer has yet to be sent wait for it to be unlocked, (0 means unlocked)
  }
  byteBuffer[currentBufferId][bufferSlotId] = data;
  bufferSlotId++;
  if (bufferSlotId == BUFFER_SIZE) { // start filling the next buffer
    lockCurrentBuffer();
  }
  return true;
}

boolean Buffer::write(String data) {
  for (unsigned int i = 0; i < data.length(); i++) {
    if (!write(data.charAt(i))) return false;
  }
  if (!write(';')) return false;
  return true;
}

boolean Buffer::writeInt(int16_t data) {
  if (!write(highByte(data))) return false;
  if (!write(lowByte(data))) return false;
  if(writeSD) intCounter++;
  return true;
}

unsigned long Buffer::getCounter() {
  return intCounter;
}

void Buffer::resetCounter() {
  intCounter = 0;
}

void Buffer::lockCurrentBuffer() {
  if (bufferSlotId != 0) {
    lockedBuffer[currentBufferId] = bufferSlotId;
    bufferSlotId = 0;
    currentBufferId++;
    if (currentBufferId == BUFFER_AM) { // start filling the first buffer again;
      currentBufferId = 0;
    }
    writeSDBuffer[currentBufferId] = writeSD;
  }
}


size_t Buffer::bytesAvailable() {
```

```
  noInterrupts();
  if (millis() > lastWrite + 1000) {
    lockCurrentBuffer();
  }
  interrupts();
  return lockedBuffer[nextSendBuffer];
}

boolean Buffer::getWriteSD() {
  return writeSDBuffer[nextSendBuffer];
}

void Buffer::setWriteSD(boolean _writeSD) {
  writeSD = _writeSD;
}

uint8_t* Buffer::getSendBuffer() {
  return (uint8_t *)byteBuffer[nextSendBuffer];
}

void Buffer::unlockSendBuffer() {
  lockedBuffer[nextSendBuffer] = 0;
  nextSendBuffer++;
  if (nextSendBuffer == BUFFER_AM) {
    nextSendBuffer = 0;
  }
}

#ifndef Buffer_h
#define Buffer_h

#include "Arduino.h"

static const size_t BUFFER_AM = 4;
static const size_t BUFFER_SIZE = 1000;


class Buffer{
  public:
    Buffer(){};
    boolean write(uint8_t);
    boolean write(String);
    boolean writeInt(int16_t);
    size_t bytesAvailable();
    uint8_t* getSendBuffer();
    void unlockSendBuffer();
    void lockCurrentBuffer();
    boolean getWriteSD();
    void setWriteSD(boolean _writeSD);
    unsigned long getCounter();
    void resetCounter();


  private:
    volatile uint8_t byteBuffer[BUFFER_AM][BUFFER_SIZE];
    volatile size_t lockedBuffer[BUFFER_AM];  // keep track of which buffers are locked and what part of the buffer is locked
    volatile size_t writeSDBuffer[BUFFER_AM];

    volatile size_t bufferSlotId = 0;
    volatile size_t currentBufferId = 0;
    size_t nextSendBuffer = 0;

    unsigned long lastWrite = 0;
    boolean writeSD = false;
    unsigned long intCounter = 0;
```

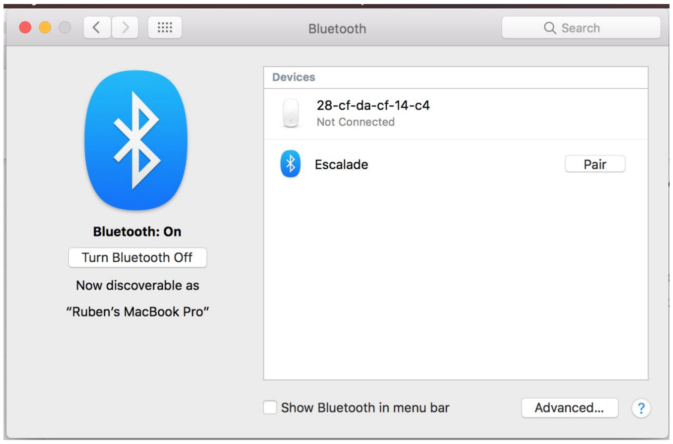
```
};


#endif

String serialBuffer = "";
String serialBuffer3 = "";


void checkSerial() {
  while (Serial1.available()) {
    char inChar = (char)Serial1.read();

    if ( inChar == '\n' || inChar == '\r' ) {
      parseSerialString();
      serialBuffer = "";
    } else {
      serialBuffer += inChar;
    }


  }
}

void checkSerial3() {  // Check for incoming serial data at serial port 3
  while (Serial3.available()) {
    char inChar = (char)Serial3.read();

    if ( inChar == '\n' || inChar == '\r' ) { // carriage return or newline will terminate the string
      saveString(); // save the string as a file
      serialBuffer3 = ""; // reset the string
    } else {
      serialBuffer3 += inChar;
    }


  }
}

void parseSerialString() {
  char startChar = serialBuffer.charAt(0);

  if (serialBuffer.length() > 1) {
    if (startChar == ':') {
      serialPrintln("write timestamp: " + serialBuffer.substring(1));
      if (!saveTimeStamp(serialBuffer.substring(1), String(currFileNr) + "/" + "TAG.TXT")) {
        serialPrintln("error writing tags");
      }
    } else if (startChar == ';') {
      sendSensor = serialBuffer.substring(1).toInt()-1;
      if (sendSensor == -1) {
        serialPrintln("Disable streaming");
      } else {
        serialPrintln("Switch to " + sensorNames[sendSensor]);
      }
    } else if (startChar == '/') {
      char inChar = serialBuffer.charAt(1);
      switch (inChar) {
        default:
          break;
        case 'a':
          startRec(serialBuffer.substring(2));
          break;
        case 'z':
          stopRec();
```

```
        break;
      case 'q':
        lockAndSend();
        break;
    }
  }

 }

}


void serialPrint(String m) {
 Serial1.print(m);
}

void serialPrintln(String m) {
 Serial1.println(m);
}

void serialSendData(const uint8_t *buf, size_t s) {
 Serial1.print("raw:");
 Serial1.print(s);
 Serial1.print(':');
 Serial1.write(buf, s);
 Serial1.println();
}

void lockAndSend() {
 sensorBuffers[sendSensor].lockCurrentBuffer();
 checkBuffers();
}

void startRec(String expID) {
 lockAllBuffers();
 checkBuffers();

 resetAllCounters();
 currFileNr++;
 serialPrintln("mkdir " + String(currFileNr));
 makeDir("/" + String(currFileNr));

 saveStringToSD(String(millis(), DEC),String(currFileNr) + "/" + "time.TXT"); // save time (since boot)

 saveAll(true);

 saveTimeStamp(expID,String(currFileNr) + "/" + "ID.TXT");
 serialPrintln("Start measuring");
}

void saveString() {

 Serial3.println("Saving emotion levels");
 currFileNr++;
 Serial3.println("mkdir " + String(currFileNr));
 makeDir("/" + String(currFileNr));  // make a new directory
 saveStringToSD(serialBuffer3,String(currFileNr) + "/" + "emotions.TXT"); // save string
 saveStringToSD(String(millis(), DEC),String(currFileNr) + "/" + "time.TXT"); // save time (since boot) of saving

}


void stopRec() {
 saveAll(false);
 lockAllBuffers();
```

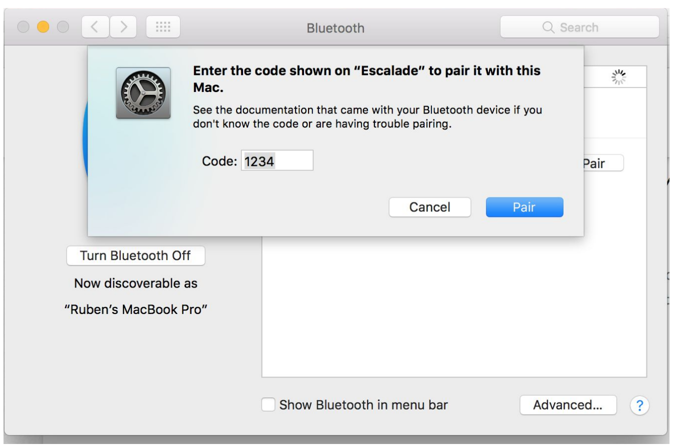
```
  serialPrintln("Stop measuring");
}
```

H.3 Bluetooth protocol

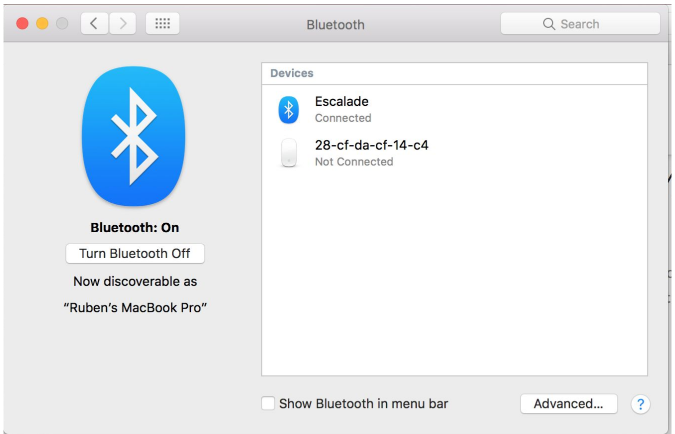
Step 1: Turn on the escalade and open Bluetooth settings in the System Preferences menu. In the list of devices the Escalade should be visible.



Step 2: Click on the Escalade and fill in the code: 1234 to pair the Escalade to your Mac.



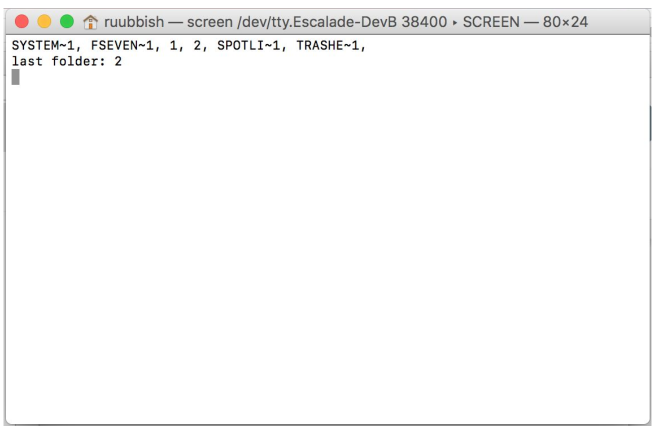
Step 3: press pair and the Escalade will be connected indicated by the device list as seen in the screenshot below.



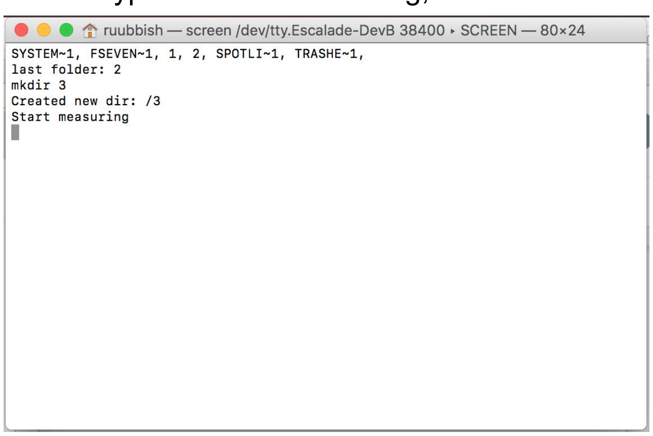
Step 4: Open Terminal application and type: ls /dev/tty.*

Step 5: type 'screen' + the Escalades vales from the list and end with 38400 (the baud rate)
In the case of the Example it will be: screen /dev/tty.Escalade-DevB 38400

Step 6: you now enter the serial communication screen as seen in the screenshot below:

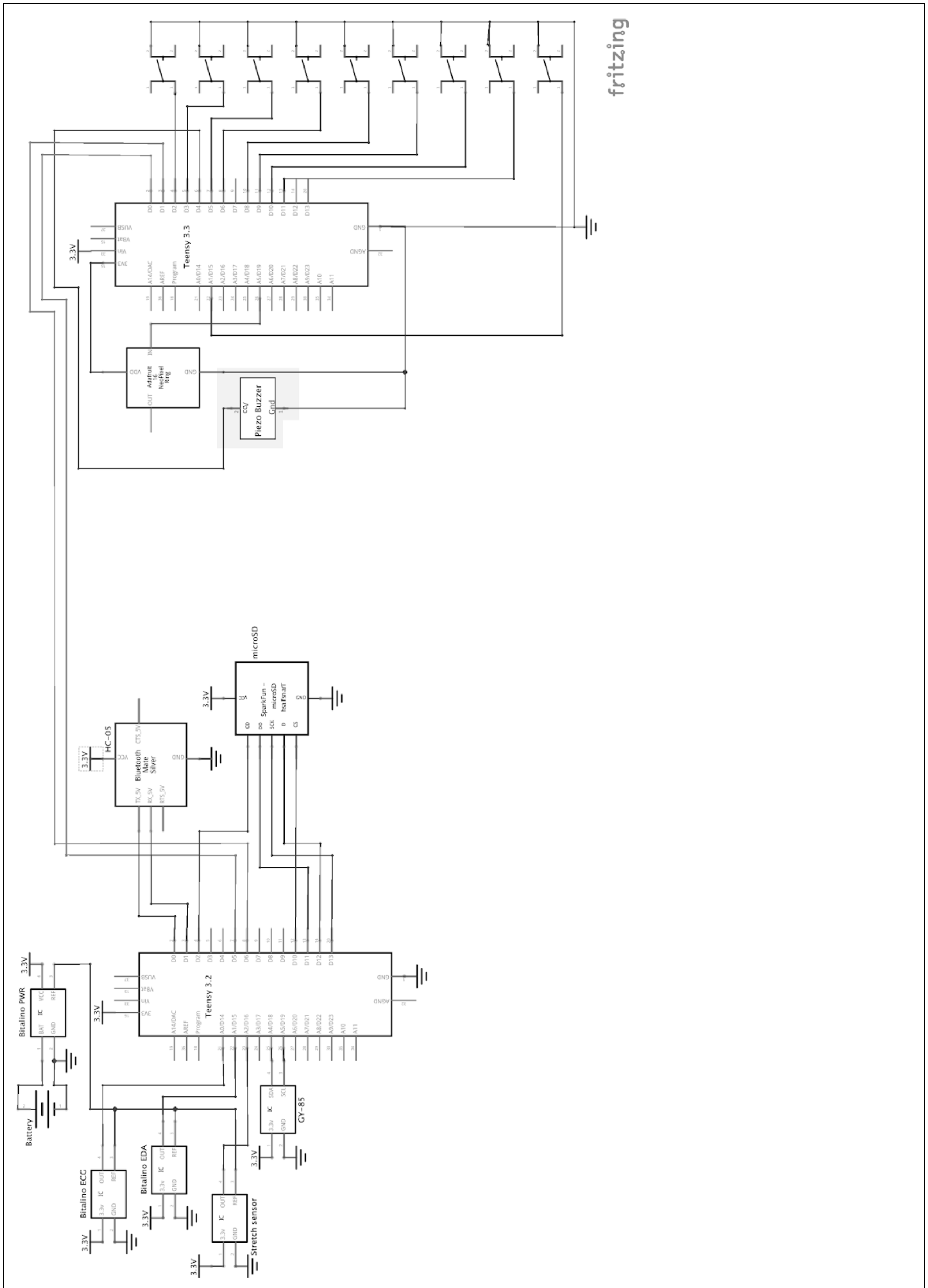


- Type /a to start recording, as seen in the screenshot below:



- Type /z to stop recording

H.4 Prototype circuit



fritzing
Teensy 3.3
3.3V
Adafruit 16 NeoPixel Ring
Piezo Buzzer
microSD
SparkFun - microSD
HC-05
Bluetooth Mate Silver
Teensy 3.2
Bitalino PWR
Battery
Bitalino ECG
Bitalino EDA
Stretch sensor
GY-85

I. User test

I.1 Script

Script User test

1. Introduction to what we do

> We are designing a system that can detect mood. It consists of a combination of biosensors, mood feedback and machine learning. To determine what the best way would be to obtain mood feedback we ask for your participation in this usability test.

2. Play video “Interview Kristin Neidlinger”

3. Show the device, explain how it works.

> The escalade will be placed on your chest to measure your physiological data.
> The wristband device will be placed on your left wrist.
>
> There are 8 emotions, represented by color and emojis. You can select multiple emotions and for each emotion the level of intensity.
>
> Give mood feedback when the system asks you to do so.
>
> Answer additional questions by the user.

4. Ask the participant to fill in the consent form. (Appendix I.2)

4. Place the prototype on the participant.

5. Participant will be asked to use the device for a minimum time of 3 hours.

6. After 3 or more hours a semi-structured interview takes place. Questions/subjects as in Appendix I.3 will be addressed.

I.2 Consent form user test

Consent form for participating in user test

This form is about your participation in a user test for the development of a mood recognition system. The user test is carried out by R.Brouwer, student Creative Technology, at the EEMCS faculty of the University of Twente.

- your participation in this project is voluntary and unpaid

- you have the right to decline answer any question, to stop the user test or to withdraw your participation at any time, without consequences

- Physiological sensor data in combination with your mood feedback is generated. This data is saved without your personal information to determine if the system works and will be deleted afterwards. The interview recording will be used to transcript only and will be deleted afterwards.

- your anonymity in this project will be protected. The subsequent use of recordings and data will be done using Universities policies protecting anonymity of individuals and institutions

- questions about the research and the process can be addressed to:
R.Brouwer, r.c.brouwer@student.utwente.nl

- queries, complaints or comments about the research can be addressed to the project supervisor:
dr. ir. E.Dertien, e.dertien@utwente.nl

- you have read and understand the explanation provided

The participant	The researcher
Name: …………………………	Name: …………………………
Date: …………………………	Date: …………………………
Signature: …………………………	Signature: …………………………

I.3 Interview user test questions

Interview user test questions (subjects to address)

1. What is your age and level of education?

2. Do you know what the quantified self movement is?

3. Do you think personal data logging is useful to gain self knowledge about your emotions and body?

4.1 Was it clear how to use the mood feedback device?

4.2 Are the moods on the device representative of your felt emotions?

4.3 Did the colours represent the moods according to you?

4.4 If there was an option to fill in a neutral mood state, would you use that one out of laziness?

5.1 Was it clear when to give mood feedback?

5.2 Would people in other age categories or capabilities understand how to use the mood feedback device?

6.1 Did you think more about your emotions using the mood recognition system?

6.2 Would this add on to self-awareness regarding moods?

7.1 Is it discreet using a mood recognition system?

7.2 Did the combination of sound and light grab your attention?

7.3 Did the combination of sound and light to grab your attention annoy you or others around you?

7.4 Did the annoyance of others regarding u using the device make u willing to give feedback?

---

8. Is the mood feedback device wearable and easy accessible?

---

8. What did you think of the frequency you are asked for mood feedback?

8.1 What would be the ideal sample rate according to you?

---

9. Would you be willing to wear such device in daily life in order to improve treatments regarding mental or physical health?

I.4 Interviews

Interview participant #1

Brouwer: Allereerst bedankt voor het meedoen aan de user test.

Participant: Geen probleem!

Brouwer: Mag ik vragen om je leeftijd en opleidingsniveau?

Participant: Ik ben 22 jaar en momenteel bezig met mijn bachelor.

Brouwer: Wat vond je ervan?

Participant: Aan het begin moest ik een beetje wennen want ik voelde mij benauwd met het prototype om mijn borst. Maar ik kon mij goed vinden in elke emotie, ik had niet het gevoel dat ik er een miste. Het werkte allemaal goed, het was ook niet storend om in te vullen. De invultijd is ook kort. Ik had er geen last van om feedback te geven tijdens het werken.

Brouwer: Dat klinkt goed. Als het systeem je vroeg om feedback te geven, was dat dan storend? Afleidend?

Participant: Nee. Maar stel ik zou in een vergadering zitten, dan kan ik mij voorstellen dat

dat wel vervelend is. Zonder het piepen had ik niet gemerkt dat ik feedback moest geven.

Brouwer: Je bedoelt dat als er alleen een licht signaal zou zijn dat dat niet voldoende is?

Participant: Het piepen maakt voor mij duidelijk dat ik moet invullen. Mensen in mijn omgeving merkte het licht juist op.

Brouwer: Als het systeem om jouw feedback vraagt, en mensen in je omgeving zien dat, voel je dan druk om hem snel in te vullen? Omdat zij dan geen last hebben van het signaal?

Participant: Ze hebben er geen last van, maar ze waren wel erg nieuwsgierig.

Brouwer: Omdat die mensen zo nieuwsgierig zijn, was het dan wel mogelijk om het discreet te gebruiken? Het zou zo kunnen zijn dat jij het vervelend vind, om wat voor reden dan ook, dat anderen kunnen zien dat je zo'n device gebruikt.

Participant: Ow zo, nou ik had wel een paar keer dat ik boredom in zou vullen, terwijl de rest van mijn projectgroep juist druk aan het werk is. Sociaal gezien zou ik dan interest, joy en surprise moeten invullen.
Ik had het gevoel dat er meer negatieve emoties te selecteren waren.

Brouwer: Het device is zo opgesteld dat twee uiterste emoties aan elkaars weerzijden staan. Zo zijn joy en sadness tegen tegenover gesteld.

Participant: Misschien was ik vandaag dan in een meer negatieve bui dan normaal.

Brouwer: Dat zou heel goed kunnen. Heb je ook het idee dat je, door het invullen van je device, meer stil staat bij je eigen emoties?

Participant: Ja tuurlijk! Soms moest ik meer nadenken over hoe ik mij precies voelde, ook qua intensiteit. Dat vond ik lastig, ik was bezig met iets wat mij interesseerde, maar ben ik nou een beetje of heel erg geïnteresseerd? Daar moest ik extra over nadenken, daardoor kon het invullen ook langer duren. Er waren ook momenten dat ik al wist hoe ik mij voelde en ik het zo kon invullen.

Brouwer: Zou je, als je dit device niet zou dragen, ook stil staan bij je gevoelde emoties?

Participant: Nee.

Brouwer: Zou het bij kunnen dragen aan self-awareness, aangezien dit device jou er, meer of minder, toe dwingt om daarbij stil te staan?

Participant: Ik dacht wel, toen ik boredom level 3 had ingevuld, dat ik andere mensen moest zoeken om te helpen met dat onderdeel van het project.

Brouwer: Dus omdat je stil stond bij je eigen emoties heb je andere keuzes gemaakt omtrent je gevoelde emotie?

Participant: Ja eigenlijk wel. Later merkte ik ook op dat ik surprise wilde invullen. Dat wel verassend was omdat ik dat onderdeel binnen het project eerst erg saai vond. Dat was verassend. Zonder dit device had ik die keuze niet gemaakt.

Brouwer: Zou je de hele dag met dit device kunnen lopen? Bijvoorbeeld als je bij een psycholoog of andere health provider therapie krijgt, die jou vraagt om dit device te dragen jouw therapie te optimaliseren of verbeteren?

Participant: Als je ervan bewust bent dat je mentaal of fysiek niet goed met je gaat, heb je veel motivatie om zo'n device te gebruiken. Voor normale alledaagse gebruikers ligt dat toch anders.

Zelf sta ik er toch wel wat nuchter in, ik denk eigenlijk niet na over mijn emoties. Zonder dat er aan mij word gevraagd om iets in te vullen zou ik er eigenlijk niet aan denken.

Brouwer: Dat is erg begrijpelijk. Gelukkig geeft hij het al aan. Hoe hij het aangeeft is dus duidelijk?

Participant: Ik vind het goed en subtiel. Het piepje is goed. Het draaien van de LED's is ook goed. Die trekken je aandacht om iets in te vullen.

Brouwer: Het piepje geeft je aan dat je iets moet doen en de LED's herinneren je dan wat je moet doen.

Participant: Ja, maar het piepje hoorde ik soms niet.

Brouwer: Zou het goed zijn om het volume te verhogen?

Participant: Dan ik zou ik waarschijnlijk schikken. Ik vond het eigenlijk prima zo.

Brouwer: Voor jou was het goed in te vullen toch? Denk je dat dat voor andere mensen van andere opleiding niveaus en leeftijden dat ook zo is?

Participant: Ja! Je moet alleen wel aangeven dat je meerdere opties kunt aangeven. Ik vond zelf dat aangeven wel lastig. Omdat ik niet zo extreem denk in wat ik voel. Als van in dat ik extreem verveeld ben. Dat geeft denk ik ook aan wie ik ben.

Brouwer: Dat doet het zeker. Stel er was een optie geweest om een neutrale mood in te vullen, zou je dat dan vaak geselecteerd hebben?

Participant: Ja dat denk ik wel.

Brouwer: Is het goed dat dat er niet op zit?

Participant: Ja, want je word gedwongen om te kiezen wat het dichts bij jouw gevoel ligt.

Brouwer: Als in dat het je indirect pusht om meer na te denken over hoe je je voelt?

Participant: Ja. Maar als er een neutrale knop was dan had ik die wel een aantal keer ingevuld. Dan was ik ook makkelijker voor die optie gegaan.

Brouwer: Misschien ook uit luiheid?

Participant: Ja dat kan zeker wel. Ondanks dat ik niet super veel moeite hoefde te doen om in te vullen hoe ik mij voelde.

Brouwer: Hoe lang deed je daar gemiddeld over ongeveer?

Participant: Ik denk een minuut.

Brouwer: Dat is best prima toch.

Participant: Ja. Maar ik had niet het gevoel dat ik nou heel vaak blij was. Als iemand mij dat vraagt zou ik dat wel zeggen. Nu ik het voor mijzelf invul toch minder snel.

Brouwer: Dus je hebt het nu voor jezelf ingevuld? Omdat je eerder zei dat je je schuldig voelde tegenover de andere mensen in je project om bored in te vullen.

Participant: Nee wel echt voor mezelf. Als ik bored wilde invullen zorgde ik ervoor dat de anderen dat niet konden zien, ik drukte het niet expres over om anderen dat konden

Zien. Als andere mensen het kunnen zien had ik het anders ingevuld, om anders

over te komen. Ik vind bijvoorbeeld sadness erg zwaar.

Brouwer: Je kunt ook een beetje sadness voelen toch?

Participant: Geïrriteerd is één keer drukken op anger?

Brouwer: Ja.

Participant: Ik zou eigenlijk nooit anger invullen, maar als er stond irritated dan zou ik dat eerder aanklikken.

Brouwer: Als je heel erg geïrriteerd bent dan ben je niet boos toch?

Participant: Daarom staat er dus anger.

Brouwer: Irritated is een zwakke verzie van anger.

Participant: Ik zou dan toch kiezen voor lichte gevoelens, aangezien dit eind definities zijn. Die zijn wel moeilijker om te plaatsen.

Brouwer: Se emoties in het model zijn de basic emotions, de volgorde voor anger is dus: annoyance, anger, rage.

Participant: Logisch. Ik kies dus wel heel vaak surprise, interest, joy of boredom omdat ik

andere andere vier: anger sadness, fear en trust erg extreem vind. Ik snap die intensiteit wel, maar ik vind die worden te zwaar.

Brouwer: Dus wat je eigenlijk zegt is dat als je de weak emotion als optie neerzet, het voor jou duidelijker is om die vaker te selecteren om een basic of intens

emotion te
selecteren dan wanneer de basic emotion als optie staat aangegeven?

Participant: Ja misschien wel. Ik zou eerder drie keer geïrriteerd invullen als ik kwaad ben dan kwaad invullen als ik geïrriteerd ben.

Brouwer: Dat is heel goed opgemerkt. Zo heb ik er nog niet naar gekeken.
Hoe vaak hij naar feedback vraagt, is dat goed volgens jou?

Participant: Drie keer in het uur is naar mijn mening goed.

Brouwer: Quantified self movement, ben je daar bekend mee?

Participant: Nee.

Brouwer: Het houd in dat je data over jezelf genereerd, fysiologische data, wat je gegeten hebt, hoeveel je slaapt, etc. En dan kun je daar zelf conclusies uit trekken.
Dat is nu upcomming met allerlei fitness trackers en apps die dingen voor je bijhouden. Mijn hartslag is bijvoorbeeld hoog de laatste tijd, vervolgens bezoek je een dokter. Je bent misselijk dus misschien was het avondeten van gisteren niet goed meer. Dat idee.

Participant: Dat valt niet onder hypochondrie?

Brouwer: Nee, het is meer een soort lifestyle.

Participant: Oke.

Brouwer: Zou jij die data willen genereren met dit device? Denk je dat dat zin heeft, omdat je nu een device gaat gebruiken die je gemoedstoestand en je fysiologische signalen registreert in combinatie.

Participant: Dat zou ik preventief nooit gebruiken, alleen als er iets mis is. Je zou ook alleen een Nike Fuel band kopen om af te vallen. Want dan ben of voel je je al dik.
Ik voel mij nu emotioneel stabiel dus om dat bij te houden lijkt mij op dit moment zinloos. Als ik mentaal niet in orde zou zijn is dat natuurlijk anders.

Brouwer: Dat is zeer begrijpelijk. Ik heb alle onderwerpen aangekaart die besproken moesten worden. Zijn er nog dingen die jij kwijt wil omtrent het prototype?

Participant: Als mensen het echt bij willen houden, moet daar wel een reden achter zitten. Verder was alles duidelijk en wel goed, de kleuren representeren de moods ook. Daar had ik toevallig laatst les over en het was leuk om dat terug te zien.

Interview #2

Brouwer: Allereerst bedankt voor het meedoen aan de user test. Wat is je leeftijd en opleidingsniveau?

Participant: Geen probleem, ik ben 20 jaar en doe een MBO opleiding.

Brouwer: Weet jij toevallig wat de quantified self movement inhoud?

Participant: Nee.

Brouwer: Het houd in dat je data over jezelf genereert, fysiologische data, wat je gegeten hebt, hoeveel je slaapt, etc. En dan kun je daar zelf conclusies uit trekken. Dat is nu upcoming met allerlei fitness trackers en apps die dingen voor je bijhouden. Mijn hartslag is bijvoorbeeld hoog de laatste tijd, vervolgens bezoek je een dokter. Je bent misselijk dus misschien was het avondeten van gisteren niet goed meer. Dat idee.

Participant: Oke.

Brouwer: Zou je dan eventueel dit device gebruiken om zulke metingen te verrichten?

Participant: Ik denk als je zulke dingen wilt gaan bijhouden dat daar eerder een medische reden achter zit. Dus dan wel.

Brouwer: Zonder die medische reden zou je dat niet doen?

Participant: Nee. Al die dingen die je zei meet ik nu ook al niet, dus mijn emotie zou ik eigenlijk ook niet vrijwillig meten.

Brouwer: Begrijpelijk. Was het duidelijk hoe je je mood moest invullen?

Participant: Alleen het bevestigingsknopje snapte ik zonder uitleg niet, de rest wees zichzelf.

Brouwer: Na de uitleg was dat wel duidelijk?

Participant: Ja dan wel.

Brouwer: De emoties die aangegeven worden, zijn die representatief aan de emoties die je zelf voelt?

Participant: Niet helemaal, ik ben bijvoorbeeld niet vaak boos, dus ik zou eerder geïrriteerd invullen.

Brouwer: Waren de emoties misschien te intens, te heftig?

Participant: Ja.

Brouwer: Als er bijvoorbeeld geïrriteerd staat, in plaats van boos, zou je dan drie keer geïrriteerd invullen om boosheid aan te geven? Aangezien een beetje boos nu gelijk staat aan geïrriteerd.

Participant: Nee, boos is naar mijn mening een hele andere emotie dan irritatie.

Brouwer: Vond je dan ook dat de andere emoties te intens waren? Verdrietig bijvoorbeeld.

Participant: Verdrietig vond ik wel oké eigenlijk. Want depressief zou wel weer te intens zijn.

Brouwer: Representeerde de kleuren de moods volgens jou? En waarom dan?

Participant: Ja. Het deed mij denken aan die Disney film Inside Out, de personages die emoties representeren in die film hebben dezelfde kleuren.

Brouwer: Heel gaaf! Dat is dan gebaseerd op hetzelfde. Als er een neutrale mood was geweest, had je die dan regelmatig gebruikt?

Participant: Denk het wel, zelf heb ik geen sterke gevoelens, vooral neutraal met een combi van een andere emotie.

Brouwer: Omdat deze er niet bij zat, werd je daardoor geforceerd om wel te kiezen?

Participant: Zeker. Ik wist soms ook niet precies wat ik moest gaan invullen en werd daardoor getriggerd om over mijn gevoel na te denken.

Brouwer: Stond je dan ook meer stil bij wat je voelde?

Participant: Ja dat zeker.

Brouwer: Is dat positief?

Participant: Misschien wel, maar als je bijvoorbeeld verdrietig bent dan wil je daar misschien niet over nadenken. Dat versterkt het gevoel meer. Maar als je blij bent en daar bij stilstaat kan dat hierdoor ook weer versterkt worden.

Brouwer: Gaaf. Heb je andere keuzes gemaakt in wat je deed omdat je stilstond bij je emoties. Bijvoorbeeld als je je verveelde en dit ook invult, je daarna je bezigheid aanpast naar iets wat je meer intereseert?

Participant: Ja, als dat niet door verplichtingen belemmert wordt zou ik dat wel doen.

Brouwer: Was het voor omstanders onopvallend dat je met het device rondliep?

Participant: De elektronica op de band was erg groot en duidelijk zichtbaar onder mijn kleding. Bij een vrouw zou dat minder opvallend zijn door de boezem, aangezien ik die niet heb was het duidelijk zichtbaar.

Brouwer: Begrijpelijk. Dus als hij platter zou zijn zou dit al verholpen kunnen worden?

Participant: Groter qua oppervlakte maar wel platter zou al enorm helpen.
Het polsbandje mag ook kleiner.

Brouwer: Is de combinatie van licht en geluid duidelijk genoeg voor jou als signaal dat je je current mood moet invullen?

Participant: Ja, dat was duidelijk. Omdat hij om je pols zit is het knipperen een goede toevoeging om je aandacht te trekken.

Brouwer: Hebben omstanders ook opgemerkt dat het device je om feedback vroeg.

Participant: Voor zover ik weet niet.

Brouwer: Maar stel dat dat wel zo zou zijn, zou je dan sociale druk voelen om feedback te geven aangezien omstanders hinder ondervinden door het device?

Participant: Misschien, in een sociaal gesprek met iemand dan zou je hem snel invullen om daarna weer verder te kunnen met het gesprek. Dus het zou wel kunnen?

Brouwer: Toen je hem invlude, hoe lang deed je daarover?

Participant: Ongeveer een halve minuut, tot een minuut. Het apparaat gaf ook druk om in te vullen door het knipperen het geluid.

Brouwer: Voor jou was het duidelijk hoe je hem moest invullen, denk je dat mensen van andere leeftijden en opleidingsniveaus het wel zouden begrijpen?

Participant: Met de uitleg erbij kan iedereen dit begrijpen. Kinderen in ieder geval, want die zijn veel beter met elektronica.

Brouwer: En ouderen?
Participant: Als je de levels goed uitlegt dan moet dat goedkomen.

Brouwer: Wat vond je van de hoeveelheid dat er om feedback wordt gevraagd?

Participant: Wel oke, maar ligt er ook aan wat je aan het doen bent. Op een normale dag zou dit goed zijn. Op andere dagen zou het vaker of minder vaak kunnen.

Brouwer: Zou je dit device in het dagelijks leven dragen?

Participant: Zonder medische reden zou ik dit device denk ik niet dragen. Maar op verzoek van een dokter of in verband met een therapie zou ik het wel doen..

Brouwer: Bedankt voor je tijd. Volgens mij heb ik nu alles.

I.5 Mood feedback

Mood feedback data participant #1

Timestamp	Emotion feedback
960811	joy: 0, interest: 3, anger: 1, boredom: 0, sadness: 0, surprise: 0, fear: 0, trust: 0,
4431103	joy: 0, interest: 1, anger: 0, boredom: 0, sadness: 0, surprise: 0, fear: 1, trust: 0,
5399311	joy: 0, interest: 2, anger: 0, boredom: 0, sadness: 0, surprise: 0, fear: 0, trust: 0,
7420731	joy: 0, interest: 1, anger: 0, boredom: 0, sadness: 0, surprise: 0, fear: 0, trust: 0,
8384931	joy: 0, interest: 0, anger: 1, boredom: 0, sadness: 1, surprise: 0, fear: 0, trust: 0,
12591211	joy: 0, interest: 0, anger: 0, boredom: 0, sadness: 1, surprise: 1, fear: 0, trust: 0,
13523283	joy: 1, interest: 1, anger: 0, boredom: 0, sadness: 0, surprise: 0, fear: 0, trust: 0,

Mood feedback data participant #2

Timestamp	Emotion feedback
961891	joy: 1, interest: 1, anger: 0, boredom: 0, sadness: 0, surprise: 1, fear: 0, trust: 0,
4632203	joy: 0, interest: 0, anger: 0, boredom: 2, sadness: 0, surprise: 0, fear: 0, trust: 0,
5698412	joy: 0, interest: 0, anger: 0, boredom: 1, sadness: 0, surprise: 0, fear: 0, trust: 0,
7020431	joy: 1, interest: 0, anger: 0, boredom: 0, sadness: 0, surprise: 0, fear: 0, trust: 0,
8274522	joy: 2, interest: 2, anger: 0, boredom: 0, sadness: 0, surprise: 0, fear: 0, trust: 0,
12691333	joy: 2, interest: 1, anger: 0, boredom: 1, sadness: 0, surprise: 0, fear: 0,

	trust: 0,
12543292	joy: 1, interest: 0, anger: 0, boredom: 2, sadness: 0, surprise: 0, fear: 0, trust: 0,

J. Used Methods and Techniques

J.1 Brainstorm

The brainstorm for new ideas will be conducted with two techniques, mind-mapping and free-form brainstorming with Kristin Neidlinger (Mind Tool Content Team, 2018). For both techniques four rules are taken into account. First, criticism is ruled out during the brainstorms. Secondly, unconventional ideas are embraced, since often the final idea is based upon an unconventional idea. Thirdly, quantity is wanted, quality will be the focus in later design stages. The more ideas generated, the greater the chance a successful solution will be found. And lastly, combinations of and improvement on ideas are wanted. (Hender et al., 2001)

J.1.1 Mind mapping

Mind mapping will be done individually within this thesis. A mind map starts by writing and encircling the main concept in the middle of a sheet of paper. From this concept various branches are drawn describing components of the concept. These components can again be split in branches of various subcomponents. This process goes until no new branches can be conducted.

J.1.2 Free-form brainstorming

Free-form brainstorming is done in collaboration with Neidlinger. The assignment, mood sensing in general is stated and new ideas are suggested. Idea's and branches are written down on a whiteboard to give some sort of structure. The benefit of this type of brainstorming is that this is easy to set up and can be done relatively quickly.

J.2 Expert meeting

During the expert meeting an expert that will continue with the project after this thesis will be asked for additional feedback. The expert, in this case Truong, gives an advisable project direction to be able to integrate AI into the project. The expert, in this case Truong, gives an advisable project direction to be able to integrate AI into the project. Troung is closely related to the project since she might implement machine learning in a later stage of the project. This meeting will be in some form of interview. An interviewer is a method for gathering qualitative data. An interview consists of two people, an interviewer and an interviewee. An interviewer, is the person asking the questions. The interviewee, who is the person answering the questions and providing information to the interviewer. The interview is performed unstructured, which is more or less equivalent to a guided everyday conversation. (Crabtree et al., 1999)

J.3 Usability testing using paper prototypes

Usability testing is a technique used to evaluate a product ideas by testing it on users. This way direct feedback from the users to the designers is made possible. For this thesis hallway usability test are used in both the ideation and the specification phase. Hallway usability is an technique in which you grab the next person that passes by in the hallway and make them to try to use the designed product. It doesn't have to be the actual end-users of the product (Rangarajan, 2017). During the usability tests using paper prototypes are used to illustrate different idea implementations to the user (Mifsud, 2012). The user can, with a combination of open and closed questions, give feedback on different design iterations.

J.4 Description of product

The iPACT and FICS are closely related. The iPACT describes the product from a user-perspective focusing on intended usage and feel of the system, whereas the FICS describes how the system works and what happens with the input provided by the user.

J.4.1 iPACT

iPACT is used to gain insight into who will use the product and their interaction with the system. The iPACT analysis described, in relation to the product or system, the following:

- **Intention**: aims to describe the goal of the product.
- **People**: describes who will use the product, which is conducted in the form of a persona.
- **Activities**: descriptions of situations in which the product will be used.
- **Context**: describes the environments in which the product will be used.
- **Technology**: describes the essential technologies used by the product. This analysis can be used to create a scenario in which the product will be used. The scenario will be in the form of a story, showing the interaction with the system.

(Larburu et al., 2013)

J.4.2 FICS

FICS is a way to describe the system from a system perspective. FICS describes:

- **Functions and events**: describes what the system does and how it reacts to certain events.

- **Interaction and usability issues**: describes how the user is intended to use the system.
- **Content and structure**: is the backbone of the system,this is how the data is stored and how to access it.
- **Style and aesthetics**: describe the look and feel of the system.

(Larburu et al., 2013)

J.5 Requirement analysis

An requirement analysis is a structured method describing what a system encloses and how the system is supposed to work (Ross & Schoman, 1977). The requirements will be categorised by making use of the MoSCoW method.
The MoSCoW method is used to represent four different priorities of the product:

- **Must have**: must have requirements are requirements which must be in the product to not fail the project.
- **Should have**: are requirements that would be nice to have.
- **Could have**: are equivalent to should have requirements, however these are less important.
- **Won't have**: describes requirements which will not be implemented in the product. Some of these requirements could be implemented later on.

(Hatton, 2007)

J.6 Functional system architecture

The goal of the system architecture is to show in a technical view how the system works. The system architecture shows various components and how these are connected to one another. The architecture of the system of this final application idea will be described in three levels. The first level describes the inputs and outputs of the prototype in general. The second level describes different functionalities of the system portrayed using blocks in a diagram. In which each block represents a different functionality of the system. Between these different blocks, the transfer of data will be illustrated. The third level will describe the decomposition of each of the functionalities described in the second level. In other words, the sub-functionalities of the system are described. The functional system architecture will form the base for the realization phase. (Luckham et al., 1995)

J.7 Persuasive technology techniques

As described in the state of the art, NUDGES includes: incentives, understanding mappings, defaults, give feedback, expect error and structure complex choices. The Fogg Behaviour Model (FBM), as seen in Figure 12, includes three factors. According to Fogg (2009) these three factors are: motivation, ability and triggers. The assets of the FBM model include a sufficient motivation, the ability to perform the behaviour and be triggered to do such behaviour. These assets should occur at the same time otherwise the person that should perform the desired behaviour will not succeed doing this. Three types of triggers exist according to BJ Fogg in 2009: signals, spark and facilitators. Thus, since incentive of the NUDGES model is in close relation to motivation in the FBM model, both describe ways of adapting persuasive technology into a design are overlapping.

J.8 Evaluation

In this graduation project two types of evaluations are performed. The first being functional testing, which is used to test whether the application is actually working and second the user evaluation which tests what the users think of the application and to test whether the requirements are met.

J.8.1 Functional testing
Functional testing will be conducted by the designer to check if various features of the product work as intended, to do so the designer checks if the product meets all of the “must have” requirements. It is preferred that the prototype also meets some of the “should have” and “could have” requirements. If the prototype meets enough requirements, the user test can be conducted. The goal of these tests is to determine if the tested feature works and if not what causes the error. These errors could be fixed later, if desired.

J.8.2 User evaluation
The final iteration created in this thesis project will be evaluated by a user evaluations. It is important to first determine the purpose of the test. This purpose will be to see whether the set requirements are met and accepted by the users as well as seeing what still can be improved. The user will wear the device for a few hours. The interaction between the first iteration of the user and the prototype is evaluated. At the end of the trail a user is interviewed in order to determine the positive and negative aspects of the prototype. An interviewer is a method for gathering qualitative data. An interview consists of two people, an interviewer and an interviewee. An interviewer, is the person asking the questions. The interviewee, who is the person answering the questions and providing information to the interviewer. The interview is performed semi-unstructured, to make sure all preferred MoSCoW requirements are met (Crabtree et al., 1999). In addition it would be interesting to ask if the user would want to actually wear such device for the the predefined reason.

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