A little less stress...

Designing a stress monitor for employees with autism

Graduation thesis by Joost van Hoevelaak

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Preface

This report presents my graduation project for the master Integrated Product Design at Delft University of Technology. The graduation project consists of a design assignment carried out at an external company, supervised by a chair and mentor of Delft University of Technology.

This project was executed at Waag Society, a foundation developing creative technologies for social innovation. Bas van Abel, creative director at Waag Society, was company mentor for this project. The Dr. Leo Kannerhuis, a centre for autism, was not only the client of this project, but also collaborated in the process. This allowed for frequent contact with the target users.

From Delft University of Technology Dr. Henri Christiaans from the department of Applied Ergonomics & Design was the chair of the supervisory team. Ir. Helma van Rijn, PhD student at ID-Studiolab, was mentor during this project.

The report covers the project up to the presentation of a design proposal. The overall project is not finished yet: Waag Society will build prototypes based on the design proposal, to perform a pilot study. Based on this pilot more definite statements can be made regarding the effectiveness of a product like this.

Reading guide

The content of this report is presented in an order close to the chronology of the process. It starts with an introduction to the project in part 1, followed by the explorative study in part 2. Part 3 covers the synthesis where ideas are generated and elaborated into concept models. The evaluation of these concepts with user and experts is described in part 4. Part 5 presents the design proposal, and is followed by the discussion of both results and process in part 6.

Throughout the report different textboxes can be found besides the regular text. The boxes with a grey border contain extra information on a subject mentioned in the text. The blue-bordered speech balloons contain quotes from session participants representing the target users. Finally, the solid blue boxes present brief conclusions on preceding text.

The numbers between square brackets, [0], refer to the literature used in writing the preceding text. The literature list can be found at the end of this report.

Furthermore, the text addresses appendices for further information. These appendices are numbered in roman numerals and can be found on the CD-ROM enclosed with this report.

Abstract

For people with Autism Spectrum Disorder (ASD) it is usually hard to find a job and stay employed: only few of them have a paid job. Often a person with ASD is capable of performing professional activities, but encounters problems with the social context of a job environment. People with autism have impairments in socialization, communication and imagination. These lead to problems with social interaction, misunderstandings and reduced empathy. In a professional context this might cause tension between employees with autism and their coworkers. Furthermore, these problems lead to a lot of tension in the person with autism himself. This tension decreases the level of functioning and reinforces the impairments. When tension builds up people with autism might respond in an undesired way, which eventually might lead to them getting fired.

To stimulate job participation of this group, the Leo Kannerhuis started a number of projects. This graduation project, executed at Waag Society in Amsterdam, covers the design of a stress monitor for employees with autism. The stress monitor should raise awareness on the stress the user experiences during a day at work and it should help the user to deal with this stress.

This project explored the technical possibilities to measure stress as well as the user's context in order to develop an appropriate design proposal. Experts were involved in the fields of autism, stress, physiology and sensor technology. Furthermore, clients of the Leo Kannerhuis were involved as representatives for the target group. In multiple sessions their context and wishes were explored and finally the concept models were evaluated. The involvement of all these people was very valuable in this process and helped to develop a design proposal.

Heart Rhythm Variability (HRV) turned out to be the most reliable indicator of stress. From user studies it became clear that it is important to the target users that the solution is not stigmatizing. Some employees with autism do not even want their coworkers to know that they have an ASD. Integrating an electret microphone in a wrist watch is proposed as a solution to measure HRV in a non-stigmatizing way. From HRV the user's level of stress is deduced and the user is informed on high levels of stress using the 'pebble'.

The pebble is a stone-shaped object that attracts the user's attention by means of a vibration signal and informs the user on the stress measured by means of colored lights. Furthermore, it provides the user with a breathing pattern in order to relax in times of stress. The user is also provided with the possibility to respond to the measured stress level by adjusting the stress color according to his feelings. On the long term, this self-reflection might even help the user to identify indicators of stress himself.

The design of the pebble allows the user to choose the preferred way of using it. The pebble can be put in the user's pocket to avoid a stigmatizing effect, or it can be placed on one's desk to involve coworkers in dealing with stress.

All stress data is recorded and can be accessed via a personal reflection website. Most people with autism have a job coach that visits them at work regularly. The visualization of stress data can be used in these meetings to identify problems and reflect on them. In the long term it might even help to try and avoid stressful situations.

An appropriate job increases self-esteem and contributes to the perceived quality of life. This report presents a design proposal as a direction for further development. Hopefully the continuation of this project will help people with an ASD in their daily work.

Table of contents

1 INTRODUCTION

This first part of the report introduces the graduation project, involved parties and the design problem. It also covers a brief description of the process.

1.1 Project

For people with Autism Spectrum Disorder (ASD) it is usually hard to find a job and stay employed: only few of them have a paid job. Many of them end up in the 'Wajong' arrangement, which is a social security income for people with a disability since youth.

A person with ASD is often capable of performing his professional activities, but encounters problems with the social context of a job environment. People with autism have impairments in socialization, communication and imagination. These impairments lead to problems with social interaction, misunderstandings and reduced empathy. In a professional context this might cause tension between employees with autism and their coworkers. Furthermore, these problems lead to a lot of tension in the person with autism himself. This tension decreases the level of functioning and reinforces the impairments. When tension builds up people with autism might respond in an undesired way, which eventually might lead to them getting fired.

Currently people with autism are supported by a personal job coach. Apart from help with finding a job, these coaches also support their clients and their coworkers in the work situation itself. Coworkers and managers are informed beforehand and problems are discussed from time to time.

Job coaches try to prepare their client for the job as good as possible, however often problems occur. Since job coaches are not on site most of the time, they have to help their clients by discussing and reflecting on problems afterwards.

1.1.2 Background

The Dr. Leo Kannerhuis (LKH) initiated a Wajong project to contribute to the job participation of people with autism. Michel Vervaet works at the R&D department of the LKH and is project manager. The project is financed with government funding and consists of four subprojects as shown in figure 1.

The Dr. Leo Kannerhuis is a center for autism, with the mission to develop and provide optimal and specialist treatment for people with an Autistic Spectrum Disorder. The goal is to support independency of the clients and the development of communicative and social skills.

Digital CV:	a way for job applicants to present themselves and their strengths online
Digital job coach:	a troubleshooting iPhone application to help with practical advice
Bio-guide:	a product to raise awareness on the occurrence of stress
Video coaching:	video-chat connection between a client and his job coach.

Figure 1: Overview of the sub-projects within the Wajong project.

The Leo Kannerhuis hired Waag Society for the development of the bio-guide. This graduation project was conducted as an internship at Waag Society specifically on this assignment. Therefore this report deals only with the bio-guide subproject.

Waag Society is an organization with the objective to develop creative technologies around cultural and social issues. A lot of their projects are focused on special target groups like elderly or children in hospitals.

To deal with the problem of the personal job coach not being available all the time, a digital coach for use when travelling with public transportation was developed in an earlier project. A small pilot showed that the users were travelling more and were more at ease when using the digital coach. The digital job coach will be a new module for this existing digital coach system.

Noticing problems in an early stage is the key to success of such a system, but people with autism often have difficulties with identifying problematic situations. Therefore the LKH wants to enhance the system with a product to signal problems in an early stage. For the development of this product they hired Waag Society.

The assignment is to design a bio-guide, which is defined as a product that monitors the stress level of the user and gives the user feedback about it. In this project one or more prototypes will be developed in order to test the concept.

1.1.2 Problem definition

Employees with autism experience a lot of stress in their working environment, due to their sensitivity for stimuli and difficulties in socializing and communication. The stress reduces their functioning, thereby causing problems for example in social contact with colleagues, reduced productivity or even aggression.

Often the person might not notice that he or she is experiencing stress and is not able to cope with it because of that. The device to be developed in this project should deal with the awareness of (causes of) stress and the possibilities to reduce stress. The device should not be stigmatizing and should fit the target group in their needs and wishes. Since the device is part of an integral approach of the problem it should fit within this system in an effective way.

1.1.3 Assignment

Design a product that monitors stress for employees with autism. The product should raise awareness on the stress encountered during a day at work and it should help the user to deal with it. The product might also link to the digital job coach when stress levels are too high.

1.2 Process

This chapter broadly describes the process followed in this project. It focuses mainly on aspects that distinguishes this process form others. Specific methods and techniques that were used are described throughout this report and its appendices.

Experimental project

The design problem had an experimental character, as it is not sure how such a product would be received by the target users. The ultimate goal at this stage was to study what the product could do for the users. Because of this experimental character, the approach was a combination between designing and researching. Multiple directions have been explored and subsequently evaluated in order to come up with a good solution for the design problem.

Involvement of users and experts

This experimental approach has been enabled by collaboration with both target users and expert like job coaches. Their involvement was especially necessary because of the specific target group. Throughout the different phases in the process sessions and consultations were planned with different people. Especially in the exploration phase a lot of experts were consulted on topics like autism, physiology and stress. Figure 2 shows a chronological overview of the collaboration with users and experts during the project. Tables 1-4 explain the sessions and interviews in terms of topics, goals methods.

Design through modeling

One other aspect that distinguishes this process from many others is the use of modeling throughout most of the project. The Fablab facility made this very accessible by providing tools for rapid prototyping. Early in the process experiments were conducted with different sensors. Later on the focus was on the user interaction and physical appearance.

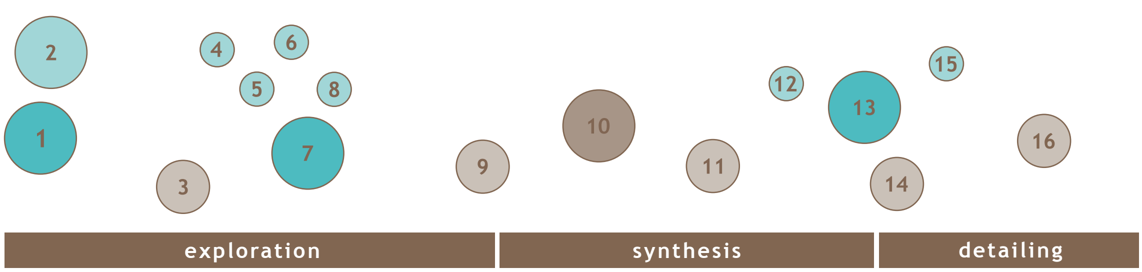


Figure 2: Chronological overview of the design process.

User sessions

	Name	Goal	Method	Appendix
1	Intiation	Introduce project Getting acquainted	Focus group Storyboarding	I
7	Contextmapping	Gain empathy for target users	Sensitizing booklets Generative session with collage making, group discussions and dream product mockups.	VI
13	User evaluation	Evaluation of concepts	Individual interviews using concept models.	X

Expert interviews

	Experts	Topic	Appendix
2	Alida Stukker, community worker, LKH Marianne Veltman, community worker, LKH Dianne Nijenhuis, coordinator pathcoaches Annebeth Leijzer, behavior scientist, LKH Rick Teunissen, job coach, Jobstap Lent Pennie Lincewicz, job coach, Jobstap Arnhem	Verifying the interest of professionals in the project, defining the (design) problem.	II
4	Dr. Lisette Verhoeven, Department Research & Development, LKH	Evoking and measuring stress, the stress reaction of people with autism	III
5	Prof. dr. ir. H.Hermens, Professor, University of Twente	Myofeedback, the potential of measuring muscle activity	IV
6	Lilian Janssen, MSc Psychology and MSc Education and Child Studies	Autism, characteristics of people with autism and way to deal with these.	V
8	Dr. J.M. Karemaker, Integrative Physiology, AMC Amsterdam	Physiological reactions to stress and how to measure them.	VII
12	Mariëlle Post, job coach, Werkpad Amsterdam	Evaluation of concepts, using concept models	IX
15	Peter Vos, job coach, Jobstap Den Haag	Evaluation of concepts, using concept models	XI

Mentor meetings

	Meeting	Topic
3	Kickoff	Getting acquainted, discussing the assignment and approach of exploration
9	Exploration	Discussion of exploration report, approach synthesis
11	Synthesis	Discussion of ideas and concept direction
14	Green light	Discussion of concept evaluation and planning of report and presentation
16	Draft report	Discussion of draft version of the final report

Brainstorm

	Session	Goal	Method	Appendix
10	Tinkering session	Generating ideas, informing project team	Brief presentations, quick brainstorms (HKJ's), tinkering concept creation.	VIII

Tables 1-4: Different topics, goals and methods for the sessions and interviews.

2 EXPLORATION

This part of the report covers the explorative study at the beginning of the project. This study focused on the target users and their context, theories on autism and stress and also on technological possibilities and existing products. It is concluded with a design framework as a guide for the rest of the project.

2.1 Users

The involvement of user has been an important factor in this project. In order to design a product that fits the future users' preferences, these users and their context were defined and explored. In collaboration with the Leo Kannerhuis a target group was defined and subsequently seven clients were asked as representatives for this group. In this explorative phase two sessions were organized to explore the users' context and preferences, resulting in five persona posters.

2.1.1 Target group

Due to the experimental character of this project it is not yet clear to what extent the product to be designed could be applied. Therefore it was decided in consensus with the Leo Kannerhuis to define a target group for a pilot study only. After successful testing on this group it could be considered to extend the group for further testing.

Characteristics of the target group:

- 20 – 35 years old
- Average IQ
- Familiar with technology and new media
- Paid job
- Working at office or workspace (not at home)
- Diagnosed with ASD
- No co-morbid disorders
- Aware of his/her situation
- Accepting support/help from professionals and a product

2.1.2 Representatives

To represent the target group seven clients of the Leo Kannerhuis were asked to participate in user sessions. The names of the participants are fictive due to privacy reasons. The pictures and quotes however are real and for use within this project only. Most participants have a job, either voluntary or paid. Two of them are currently looking for a job. Below, they are introduced briefly.

Mathieu works in an activity center for people with disabilities four days a week. He is modeling head in clay and taking pictures of others' work. One day a week he works for the Leo Kannerhuis as well.

Rienk works as assistant accountant, 28 hours a week. This is a perfect balance between work and leisure for him. He works in a room with one co-worker and likes to listen to the radio during his job.

Jaap has got a new job during this project. He is working 4 days a week as programmer, but hopes to start working 5 days a week soon. He likes the 'puzzling' side of programming, except when there is too much work to do.

Henk is working for the Leo Kannerhuis as system administrator 5 half days a week and this is enough for him. He needs his free time, for himself and for his family. After work he is usually tired, especially on Wednesdays when he works a little longer.

Jeroen works in a supermarket. He likes best to work behind the cash register, but finds this also most difficult.

Ben has worked on the market some time ago. Right now he is looking for a new job. He did not join the contextmapping session, because he overslept.

Rick is currently looking for a job. Like Ben, he missed the context mapping session because he overslept.

The group of participants, representing the target group, is very diverse in both capabilities and preferences. A design should fit with those different needs and wishes, either by providing basic functionality for all or by customization.

2.1.3 Orientation session

Two sessions with target users were organized: first an orientation session, next a contextmapping session. The orientation session was meant to get to know each other and to discuss some early questions that came in mind after the briefing. Furthermore, scenarios were developed during this session, to give an impression of daily life of an employee with autism. More about this session can be found in appendix I.

In order to create storyboards quickly, some illustrations were made beforehand of people in different postures and in different settings. The users could use these illustrations to tell their story by pasting them together and add quotes or explanation.

2.1.4 Contextmapping session

The contextmapping session was planned at the end of the exploration phase. Contextmapping helps designers gain empathy for the user [1]. Generative techniques were used to elicit contextual information. The goal of this session was to gain insight in the target group's working experiences and stress related problems.

The contextmapping session was preceded by sending out sensitizing booklets to the participants. These booklets contained some general assignments about daily work. In the workshop the topic was more focused on stress. In small steps the participants worked from making a collage on experiences at work towards the last exercise, where they had to make a mockup of their dream product for stress relief. They were also asked to explain what they had created, because these stories usually contain rich information for the design process [2].

The contextmapping session was set up using literature on this topic [1, 2], but nuances were made to adapt the techniques to the target group. First of all, the assignments were formulated explicitely. Normally the facilitators leave the participants quite free, to express their feelings and stories, however this might not work with people with autism. Not knowing exactly what to do might lead to uncertainty and thus stress.

Furthermore, between the generative techniques of making a collage and creating a dream product, group discussions were planned. Since the implicit ways of expressing oneself might not work as good with people with autism as normally, this explicit discussion offers the possibility to explain things in a direct, explicit way. The detailed setup of the session can be found in appendix VI.

It turned out that the sensitizing booklets were not appreciated by some participants, because they felt it was not serious enough. In the session however, all participants collaborated enthusiastically. The collage and mockup assignments were completed in very short time: the participants followed the instructions and finished their creations as quick as possible. The attitude of 'done is done' could be linked to the impairment in imagination of people with autism, or could just be their functional approach. Nonetheless, the results were suitable for presentation and in-depth discussion. Appendix VI presents the insights gained in this session.

2.1.5 Personas

The information gathered in the contextmapping was used to create five persona posters. In this case the personas represent the participants of the sessions one on one, only under different names. The posters could be used to inform and inspire the other team members who were not present at the session, or possibly also participants of a brainstorm.

The posters, displayed in figure 3 to 7, contain excerpts from the transcripts of the sessions. The personas are personally introduced on the top of the posters. The collage they made in the second session on their daily experience at work and the dream product made at the end of the session are presented, together with the explanation of the participants. Furthermore some interesting bits from the sensitizing booklets were added to complete the picture.

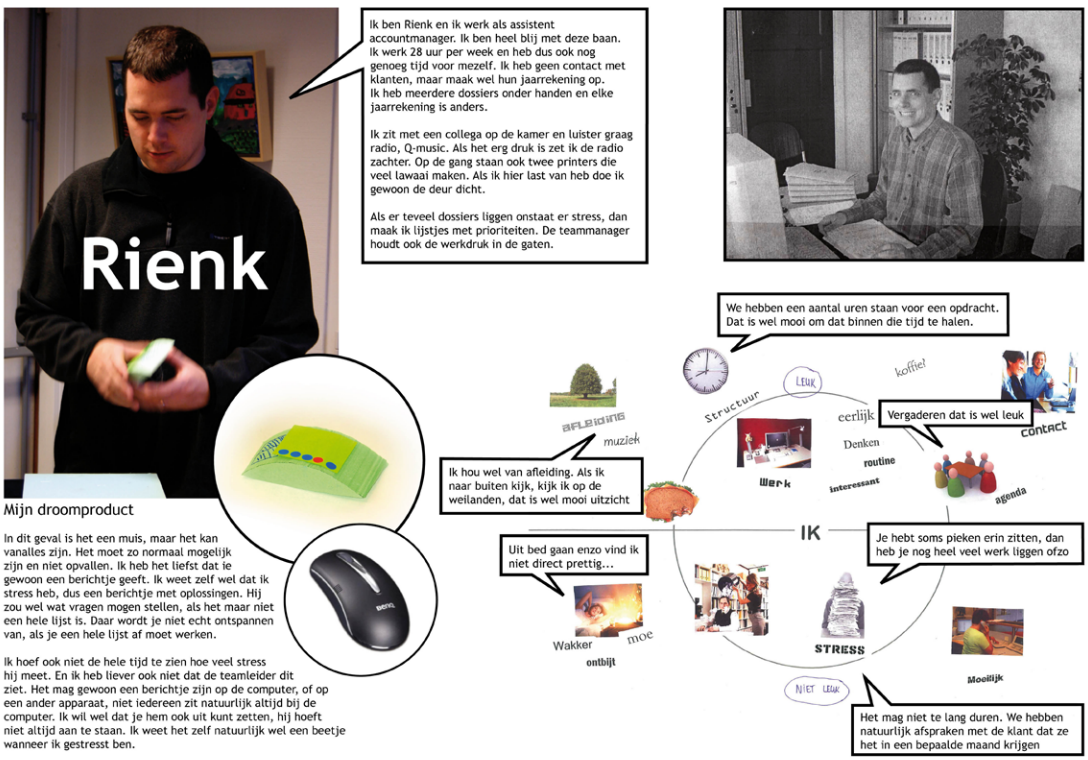
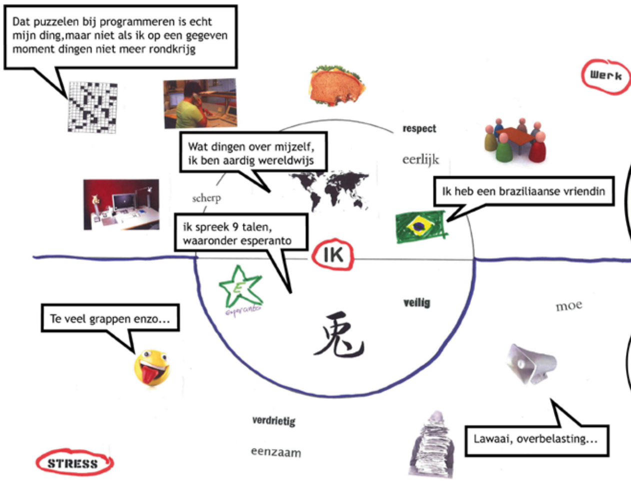


Figure 3-7: Persona posters based on the session participants. (Figure 4-7 on next pages)

Ik ben Jaap, ik heb net een nieuwe baan als programmeur. Ik hoefde niet te solliciteren, want ik had genoeg ervaring in het maken van websites. Ik werk nu 32 uur per week, deels thuis, maar ik wil toe naar gewoon 40 uur per week werken. Deze baan is ideaal, omdat iedereen net zo functioneert als ik. We hebben dezelfde werkwijze dus communiceren is makkelijk.

In mijn vorige baan had ik soms moeilijkheden. Het ging ook niet goed met mijn begeleiding, dat was niet iemand die mij goed begreep. Toen ik uiteindelijk vroeg om andere begeleiding ging dat al beter.



Mijn droomproduct

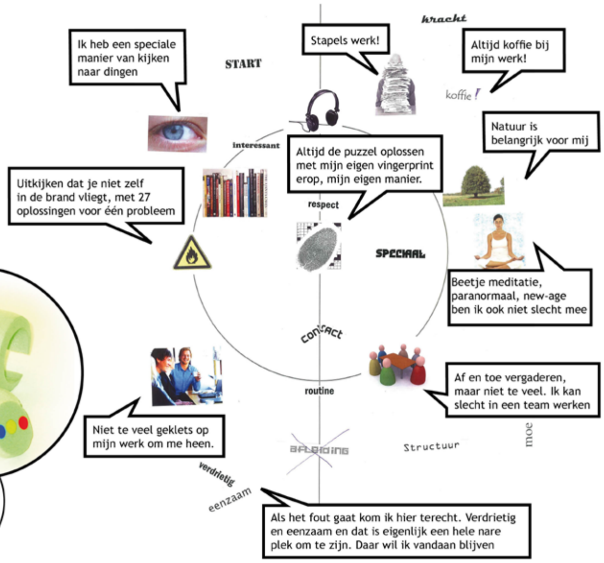
De basis is gewoon een mobieltje, waarin je dingen kan bijhouden. Hij kan je helpen met stresszaken ofzo, je kan vanalles bedenken, eventueel ook met externe apparatuur. Een externe sensor zou je met bluetooth eraan kunnen koppelen, dat ie dingen doorgeeft naar je mobiel en eventueel naar een online database.

Dan zou bijvoorbeeld je begeleider een mailtje kunnen krijgen, een waarschuwing dat ie in moet springen. Of juist naar je eigen kant; dat je mobiel reageert met rustgevende muziek, je playlist aanpast. Allemaal afhankelijk van hoe je dat hebt ingesteld. Het belangrijkste idee ervan is dat je die om je te helpen met stress op heel veel manieren kan aankoppelen.

Ik ben henk. Ik ben pas op mijn 47ste de diagnose Asperger gehad. Ik werk nu 5 dagdelen per week als systeembeheerder bij het Leo Kannerhuis. Balans tussen prive tijd en werk is voor mij belangrijk. Anders gaat het mis. Dan kom ik niet aan mijn gezin toe. Woensdag is een lange dag, 's avonds ben ik dan afgebrand.

Stress op het werk iets van mij willen, dat ik dat dan moet 'leveren'. Nieuwe taken zijn leuk, maar als mijn huidige werk blijft liggen levert dat spanning op. Ik zoek wel nieuwe uitdagingen, ondanks de stress die dat oplevert. Ik wil bijvoorbeeld op de motor naar Santiago.

Als ik stress voel aankomen dan pak ik mijn oorlellen. De mensen in mijn omgegeven weten dan dat ik even aandacht nodig heb. Ik heb een externe prikkel nodig om de spanning te doorbreken. Op die momenten kan ik alleen maar naar binnen denken, een prikkel dwingt mij dan om weer naar buiten te denken. Ik heb er heel, heel veel voor over om van die stress af te komen. Het maakt me niet uit uit het chemisch, technisch of mechanisch is. Als het maar werkt!

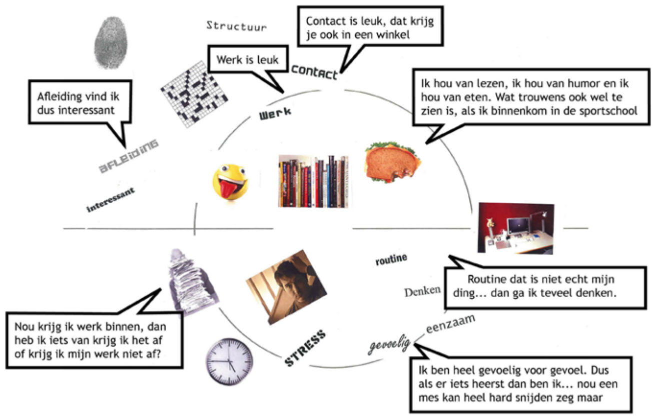


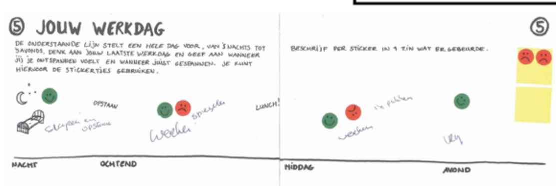
Mijn droomproduct

Heel simpel: een horlogeachtig apparaat d at alles meet, in geval van nood een injectie geeft, of anders een piepsignaaltje voor een pil, wat dan ook. Maar in ieder geval zodat ik mijn werk af kan maken, dat ik kan afmaken waar ik mee bezig ben. Displaytje erbij. Als je dan toch mijn pols gaat meten, laat het dan zien. Als je temperatuur gaat meten, laat het me zien. Een stress-niveau indicator erin. En doe er dan ook een klok in, want dan ben ik van mijn horloge af. Het maakt me eigenlijk helemaal niet uit hoe het eruit ziet. Ik moet van die spanning af.Dat is waar het bij mij om draait: het moet werken.

Ik ben Jeroen en ik werk in de buurtsuper. Achter de kassa vind ik het leukst, maar ook het moeilijkst. Vakken vullen en spiegelen vind ik minder leuk. Contact met de klanten vind ik leuk, anders moet je ook niet in een winkel gaan werken. Het liefst zou ik in een speelgoedwinkel werken. Ik hou veel van playmobiel en robots.

Als ik alleen ben, ga ik teveel denken, aan dingen die niet handig zijn. Ik maak scenarios en bedenk alle mogelijke problemen. Ik ga ook voor anderen denken. En als ik dan zoveel denk, gaat er een deurtje open waar stress achter zit. Als dat eruit komt, dan is het te laat...





Droomproduct

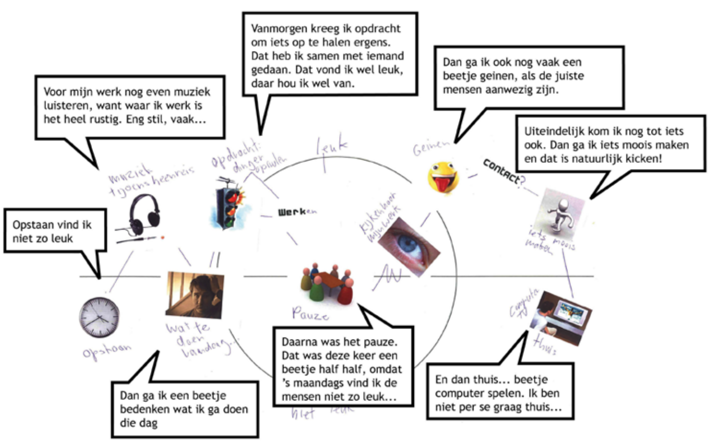
Dit is de robot.
Een soort van huishoudrobot die 101 verschillende situaties uit zijn hoofd kent. Hij meet via een systeem of armband of iets modieus hoe jij je voelt en kan dat dan verwoorden. Of situaties zo veranderen dat het wat minder gespannen is. Misschien kan ie ook nog wel de mensen om je heen ook nog wel wat beter kan beoordelen dan jij zelf. Dat je niet zelf dat hoeft te doen, laten we maar zeggen.

Het zou ook bijvoorbeeld als een soort horloge kunnen, met een soort holo-apparaatje erin. Dat je ineens zo'n ding voor je neus ziet zo: "May the force be with you" of dat soort dingen.

Ik ben Mathieu, ik werk op atelier. Hier boetsier ik hoofden. Ik fotografeer ook het werk van anderen, dat is fijn voor de afwisseling. Ik kan niet de hele dag creatief zijn. Ook werk ik een dagdeel voor het Leo Kannerhuis, dan help ik het Hoofdkwartier opbouwen enzo. Ik probeer de hele week te vullen, want ik ben niet zo graag thuis. Thuis blijf ik maar achter de computer zitten, dingen opzoeken over films of muziek, terwijl je dat in een uurtje eigenlijk wel gezien hebt.

Mijn droombaan is erg afwisselend en creatief, maar ik moet er dan ook geld voor krijgen. Dat is nu niet zo. Ook wil ik graag samenwerken met de juiste mensen. En een beetje geinen!

Stress begint vaak met een kleine irritatie, dat ik klungelig doe bijvoorbeeld. Dan krijg ik het idee dat de hele dag mislukt en is mijn zelfvertrouwen weg. Dan stapelen de dingen zich op. Ik word boos op mezelf, maar anderen denken dat ik boos ben op hun.



Mijn droomproduct

Ik vind het belangrijk dat het er normaal uitziet, als een iPhone of GSM, dat het vooral niet apart is. Hij zal dan aan moeten geven wanneer hij stress meet, meet een ringtone ofzo. Het misschien ook gesproken tekst kunnen zijn. Ik vind dat een mens mij altijd nog beter kan troosten, of op mijn gemak stellen. Beter dan een apparaat. Het moet wel verdomd goed zijn, wil een apparaat dat kunnen...

2.2 Autism

Autism is a brain development disorder characterized by a triad of impairments: problems in socialization, communication and imagination [3]. This chapter briefly describes the characteristics of autism and the implications for this project.

2.2.1 Diagnosis

Autism is diagnosed on behavioral symptoms, not on cause or mechanism. The symptoms start before the age of three, but might not be diagnosed until later age. From the standardized criteria at least six items should be met: at least two items of impaired social interaction and one of both impaired communication and repetitive/restricted behavior [4].

Autism is nowadays seen as a spectrum disorder, categorized under the Pervasive Developmental Disorders (PDD). From the five PDD's, three are called Autism Spectrum Disorders (ASD): classical autism, Asperger syndrome and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS). Rett syndrome and Childhood Disintegrative Disorder (CCD) share some symptoms with ASD, but have different causes. The Broader Autism Phenotype (BAP) also describes people who only have some autistic-like traits [5]. Figure 8 shows the classification of autism.

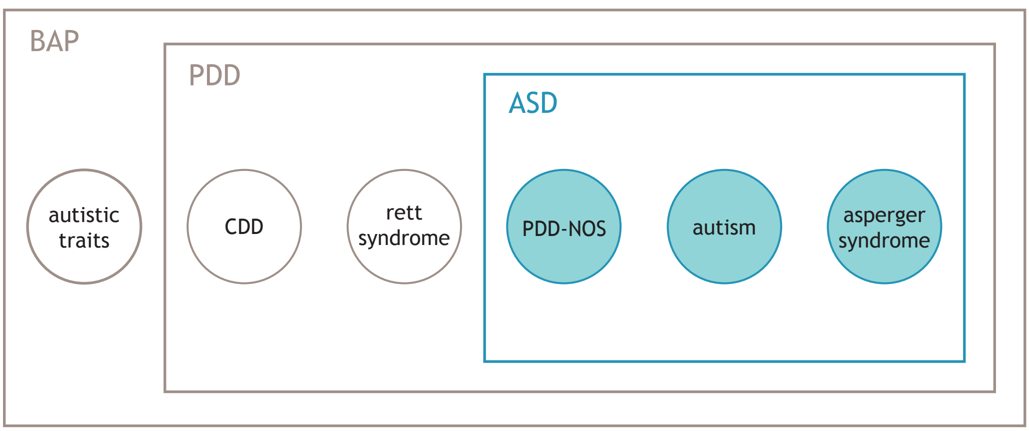


Figure 8: Classification of autism.

In addition to the different diagnoses described above, ASD can also be categorized according to IQ or the extent to which an individual can function independently: low-, medium- and high-functioning autism (LFA, MFA and HFA) [5]. This project is focused on people with an ASD that are functioning on a quite high level, capable of fulfilling a job position.

2.2.2 Evolvement

Symptoms might ease with age, but continue through adulthood. Often adults with a subtle form of ASD have gathered skills and knowledge on normative behavior and might give the impression that they have insight in their inner, emotional life or even in other people's emotions and intentions. However, this so-called insight is mainly based on reason instead of the ability to think about others thoughts [6]. It is a way to deal with everyday situations, but because it is based on knowledge and patterns, it is not flexible.

2.2.3 Theories of impairment

There are three main theories explaining the impairments of people with ASD: Theory of Mind, Central Coherence Theory and Executive Functions Theory.

Theory of Mind

People with an ASD have a severe impairment of the Theory of Mind (ToM). ToM is the ability to attribute independent mental states to oneself and others [3]. This insight is important to be able to explain behavior. It means that one has the ability to understand that others might have other feelings or believes than oneself. This ability is often tested with False believe tests, for example the Sally-Ann task. Only 20% of autistic children understand Sally's false belief of the marble still being in the basket.

In the Sally-Ann task, the participant is shown two dolls, Sally and Ann. Sally then places a marble in a basket and leaves the room. While she is out, Ann moves the marble from the basket to a box and leaves. When Sally returns, the participant is asked where Sally will look for the marble.

The ToM describes the decreased ability to understand one's feelings. It also means that people with autism have difficulties identifying stress. Objective measurement of stress might help them, when applied appropriately.

Central coherence theory

The central coherence theory is about perception. People with a weak central coherence are not able to see 'the big picture'. Sensory information is perceived in a fragmented way. Usually humans combine sensory information before assigning a meaning to it. People with ASD assign meaning to every fragment itself. This results in a view where the perception is very detailed, without an overview of the context. This sensory stimulation can be very disturbing, especially in busy environments.

The fragmented perception of people with autism asks for a product with clear and unambiguous communication and interaction.

Executive functions theory

The executive functions are controlling many of the brain's processes, like planning, initiation and inhibition of action, abstract thinking and selecting relevant information. People with ASD often have difficulties with these functions. For example with inhibition of actions: they tend to behave in a restricted way and once an action is initiated it cannot easily be stopped.

2.2.4 Adaptive skills

People with an ASD usually have restricted adaptive skills. One needs these skills to perform daily activities. The adaptive skills influence, more than cognitive skills, to what extend a person can function independently in society [7]. In table 5 the categorization of adaptive skills is shown and the restricted categories are marked.

Communication	Daily skills	Socialisation	Motor skills
Expressive	Practical (self-care)	Play & Leisure	Gross
Receptive	Domestic	**Interaction with others**	Fine
	Society	**Social skills**	

Table 5: Categorization of adaptive skills.

The restricted skills in communication often lead to misunderstanding. In practice, a person with autism might become very uncertain or even stressed because of the problems he has in either expressing himself or understanding others.

The socialization skills lead to the same problems described above. The interaction between an employee with autism and his coworkers might be uncomfortable, again causing uncertainty and stress.

The social interaction and communication in a working environment uses a lot of energy of employees with autism and might lead to uncertainty or even stress.

2.2.5 Behavior problems

Problematic behavior is described as behavior that is a problem to a person himself or to his environment, respectively called internalizing and externalizing. Internalizing problems might include problems with sleeping, eating or depressions. Physical and verbal aggression, lying and cheating are examples of externalizing behavior problems.

Most of these problems are related to, but not specific for ASD. They originate with a lack of understanding of a situation or communication or lack of behavior alternatives caused by the triad of impairments [7] described above. Behavior problems are the most important factors influencing integration and education participation [8].

Problematic behavior can be divided into three categories:
- Specific and associated problems, directly caused by the triad of impairments.
- Related problems, that have to do with ASD, but are not directly caused by it.
- Comorbid problems, other impairments that autism often comes together with.

Examples of these problems can be found in table 6.

Specific problems	Related problems	Comorbid problems
Resistance to change	Aggression	Mentally impaired
Restricted interests	Destructive bevavior	Neurological problems
Repetitive actions	Automutilation	
Stereotypical behavior	Sleeping problems	
Compulsive behavior	Extreme withdrawal	
	Screaming	

Table 6: Categorized examples of problematic behavior

Under pressure or in unexpected situations a person with an ASD might make a threatening impression, lose control and behave desperate or even aggressive [6].

I was swearing because I was angry at myself. Others thought I was angry at them and were offended.

Mathieu

2.2.7 Employment

Only 27% of people with an ASD have a paid job, according to research in 2008 [9]. According to the KIRA project there are some factors that can have a positive influence in finding and keeping a job. First of all one's age when diagnosed with ASD; the younger a person is, the easier one finds a suitable job. Also the acceptance of the ASD raises the chances of finding a job. Finally, not so surprising, the level of education is also important to find a job [10].

Research shows that working has a positive effect on the appreciation of quality of life [11]. It contributes to increased self-esteem and daily structure. The desired type of work is useful, paid, close to home and with flexible working hours [9]. The participants of the user sessions confirm this. Their job is important to them and within their job it is important to be taken seriously.

Having a job and being able to perform well in this job is good for the self-esteem of people with autism. When they feel incapable of a task this leads to uncertainty or even stress.

2.3 Stress

Stress is the biological condition that occurs when one fails to respond appropriately to a physical or emotional threat [12]. The perception of a threat, whether real or imaginary, becomes a stressor: a stimulus triggering a bodily reaction. The changes in these bodily functions are called defense physiology. Physiological changes that might occur in case of stress include an increased heart rate, decreased skin electrical resistance (due to transpiration) and lower skin temperature.

2.3.1 Stress response

Figure 9 visualizes the stress response. The three systems that are involved in the physiological reaction to stress are the nervous system, endocrine system and immune system [13].

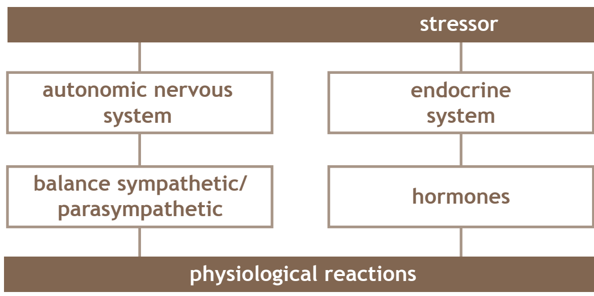


Figure 9: A visualization of the bodily response to stressors.

The autonomic nervous system initiates the immediate reaction to a stressor. It controls the sympathetic and parasympathetic nervous systems. These systems regulate many of the physiological functions. They work simultaneously, but the ratio of their influences changes over time. This balance is controlled by the autonomic nervous system. The sympathetic system is responsible for the ‘fight or flight’ reaction, a rapid change in metabolism to create energy for movement. It causes an increase in heart rate, heart muscle force, respiration and blood flow to working muscles, while digestion is decreased. The parasympathetic system on the other hand controls the anabolic functioning: energy conservation, relaxation and regeneration of the body.

The endocrine system regulates metabolic functions that require more endurance: the intermediate reaction to a stressor. It controls the secretion of adrenaline from the adrenal medulla.

The prolonged effects are caused by the neuroendocrine pathways: series of physiological events that take place during an even longer period of time. These reactions are described on different axes, indicating secretion of different hormones. The reaction on the hyphothalmic-pituitary-adrenal axis results in the release of cortisol from the adrenal cortex. Cortisol is a stress hormone that helps the body in the 'fight or flight' state by releasing glucose and lipids to provide energy. The vasopressin axis regulates fluid loss by reabsorption and decreased perspiration. Finally the reactions on the thyroxine axis increase metabolism, but since the production of thyroxine takes several days, the effect might take ten days to manifest.

The immune system is suppressed in a reaction to stress. On short term cortisol metabolizes white blood cells in order to provide energy for the 'fight or flight' reaction. On a longer term the reactions are more complicated and not fully understood, but over-activity of both the nervous and endocrine system is believed to affect the immune system in a negative way [14].

2.3.2 Physiological reactions

As described above, the systems involved in the stress response initiate many physiological reactions. In table 7 on the next page, an overview is shown of physiological parameters that can be used as indicators for stress and the reaction to stress they display.

Later in this report the possible sensors to measure these functions are discussed, together with their practical advantages and disadvantages.

Hormones	A lot of the physiological reactions are initiated through hormones like adrenaline and cortisol. The secretion of these hormones is a good indicator for stress, but can only be measured from bodily fluids.
Heart rate	The sympathetic nervous system causes the heart rate to increase, when one experiences stress. The heart rate also increases with physical activity and positive arousal. It is therefore difficult to use as an indicator of stress.
Heart rhythm variability	Fluctuation in beat-to-beat frequency of the heart, gives an indication of the activity of the sympathetic and parasympathetic systems. The general response to a stressor is an increase in Low Frequency HRV and a decrease in High Frequency HRV. This response has been perceived in acute laboratory stressors, acute real-life stressors as well as chronic perceived stress [15].
Respiration	When experiencing stress one's breathing changes as well. Usually respiration becomes more frequent and more superficial.
Blood pressure	The state of defense physiology and the corresponding heart activity causes the blood pressure to rise. However, changes in blood pressure can also be caused by movement, for example changes in posture.
Perspiration	Perspiration, or transpiration, is a mechanism to help the skin to cool down when one's body temperature is too high. One other situation that stimulates the sweat glands is emotional stress.
Body/skin temperature	Defense physiology redirects resources to vital organs and muscles. Skin temperature at the limps decreases, while the core temperature of the torso increases.
Muscle tension	Tension in certain specific muscles can also be an indicator for stress. However, physical activity can hinder the significance severely.
Brain activity	Some parts of the brain are especially active when one is experiencing stress. In order to use this as an indicator for stress, the different areas in the brain should be monitored very accurate.

Table 7: Overview of physiological functions and their reaction to stress.

The increase in sympathetic activity or decrease in parasympathetic activity is commonly seen as a good indicator for stress [15]. HRV can be used to monitor this balance. Figure 10 shows the difference in HRV during stress and appreciation. A steady sine wave indicates relaxation and regular breathing.

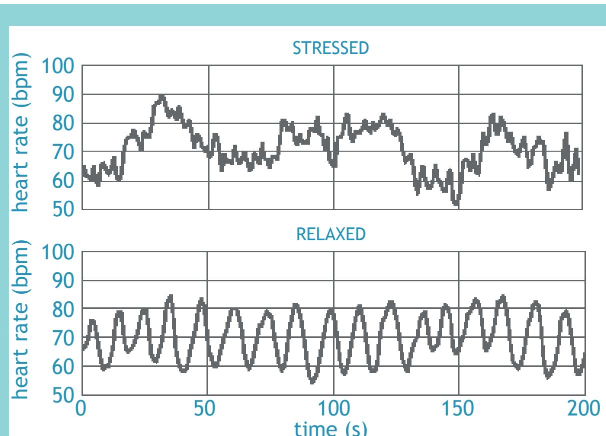


Figure 10: Heart Rhythm Variability graphs during stress and relaxation.

2.3.3 Chronic stress

The response to stress could be broken into three chronological stages. This is called the General Adaptation Syndrome model, shown in figure 11 [16]. First, in the alarm stage, the body realizes the threat or stressor and produces adrenaline and cortisol for the defense physiology. When the stressor persists, the body tries to adapt itself to deal with the stress; this is called the resistance stage. Finally, in the exhaustion stage, the body is getting tired and cannot keep up the high state of resistance.

Figure 11: Diagram General Adaptation Syndrome.

The stressors causing this response can be divided into acute and chronic stressors, the first cause short term stress, whereas the latter continue for a longer time. When a stressor continues for a longer time, the parasympathetic system cannot return the body to homeostasis, resulting in exhaustion of the body.

When experiencing chronic stress the excessive production of adrenaline after time results in a deficiency of this hormone. This might lead to fatigue, dizziness, low blood sugar and depression [17].

Both the mental and physical reaction to stress can become very unhealthy when lasting over a longer period of time: it affects the immune systems and can cause anxiety and depression.
Now that many people are under pressure and experiencing stress, a stress monitoring device might be of use also for a broader public than only employees with autism.

2.3.4 Autism and Stress

Little is known about reactions to stressors by people with autism. Verhoeven recommended one research focused in this area (Jansen et al, Autonomic and Neuroendocrine Responses to a Psychosocial Stressor in Adults with Autistic Spectrum Disorder)[18]. The question is whether the reaction of people with autism is the same as others', because much is known about reactions to stress in general. However, it could also help to look for stress reactions of people with fear and panic disorders. For this group experimentation with biofeedback on the autonomic nervous system led to positive results according to Verhoeven. In appendix III the interview with Verhoeven can be found.

Research shows that children with autism respond in a peculiar way to novel and threatening events, resulting in an exaggerated cortisol production [19]. Other research shows that patients with autism have a significantly lower serum level of cortisol than a control group: Curin et al. suggest that the lower level of cortisol might be chronic stress, which could lead to adaptive mechanisms of regulation with long-term low levels of cortisol [20].

The only article that could be found on the autonomic response to stress of adults with ASD is from Jansen et al. 2006 [18] and shows dissociation between heart rate and cortisol response. Adults with ASD seem to have a decreased heart rate response to stress, but there is a response. Heart rate increases, but less than in the control group. The cortisol response does not differ significantly from the controls, according to this research.

In user sessions the causes and effects of problems at work were discussed. While the professions, diagnoses and problems differ from person to person, the participants share the notion that little irritations add up to bigger problems because of the stress they experience. In figure 12 the progression of stress over time is visualized according to the descriptions of the participants of the user sessions. On the right side a visualization is shown of the desired situation: the stressors are the same, but every time the person relaxes after a stressor. This way one is more capable of dealing with future stressors.

> One doesn't notice the stress, or suppresses it.
>
> **Ben**

> I would do almost anything to get rid of this stress.
>
> **Henk**

Little stressors pile up to a high level of stress. When stressed one is less capable of responding to new stressors, which might lead to an escalation.

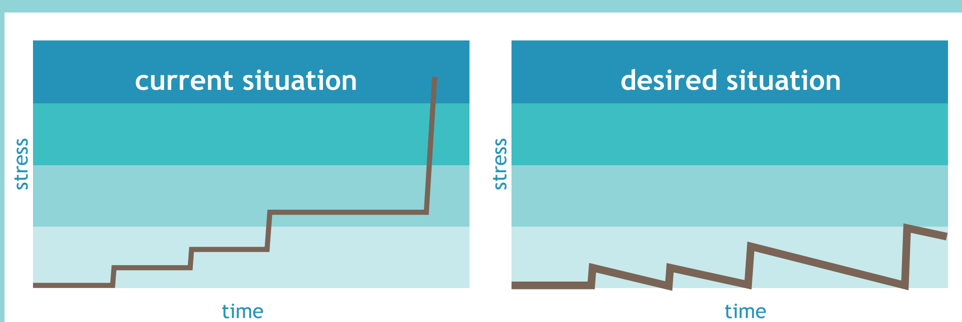


Figure 12: Addition of little stressors leads to escalation.

2.3.5 Stress management

There are many different ways of dealing with stress [21]. Some are practical like time management and setting limits, others are chemical like Valerian and Ginseng. Below, some physical and psychological relaxation techniques will be discussed, because they might be interesting to the design problem at hand. Most relaxation techniques are focused on balancing the sympathetic and parasympathetic parts of the autonomic nervous system as described before in the section on stress response.

> When I am stressed I like to act like I conduct an orchestra when listening to music like 'the final countdown'.
>
> **Henk**

Relaxation techniques

Table 8 presents a brief overview of some relaxation techniques and exercises that might be suitable for use in this project as a way of counteracting stress.

Biofeedback	The use of biofeedback was already suggested in the briefing from the Leo Kannerhuis. It is a technique to make autonomic bodily functions perceptible to one's senses in order to gain some element of mental control [22]. Many different functions can be measured and also the form of feedback can range widely.
Myofeedback	Myofeedback is a form of biofeedback where feedback is provided on the activity of one or more muscles.
Meditation	A very old discipline and part of many different religions. Many different forms of meditation exist since long, nowadays also many non-religious techniques are available to choose from [23].
Natural Stress Relieve	A form of meditation using a silent mantra [24]. Research shows an effect of NSR on skin electric resistance. It is claimed to reduce anxiety and perspiration, thereby raising the skin resistance.
Fractional relaxation	A technique to reach deeper relaxation by releasing muscular tension in one small part of the body at a time: step by step [25].
Progressive muscle relaxation	Alternately tensing and relaxing muscles in parts of the body in order to reach a deeper relaxation [26].
Autogenic training	A technique executed in sessions of 15 minutes. In a relaxed posture a person has to visualize a series of situations like "my arms and legs are heavy and warm" [27].
Diaphragmatic breathing	This breathing technique, sometimes called deep breathing, uses the diaphragm below the ribcage, thus using the stomach instead of the chest to expand the lungs [28]. It is considered a healthier way to ingest oxygen and a way to relax.

Table 8: Some physical and psychological relaxation techniques

Diaphragmatic breathing seems a promising simple technique to counteract the physiological reactions to stress. It is easy to learn, easy to remember and does not require a specific session time. Furthermore it is down-to-earth, which might be appreciated by people with autism.

2.4 Vision & criteria

Based on the previous research into the user's context, autism and stress a vision was formulated to direct the further process. This vision is furthermore translated into criteria for later evaluation.

2.4.1 Vision

The product should be a tower of strength for autistic employees: it should give them the strength to face their problems and increase their autonomy, especially at work.

By measuring stress the product should raise awareness on occurrence of stress, support stress relieve and thereby help avoid escalation. The feedback provided by the product should make the user aware of the stress he is experiencing, without disturbing him. To fit the specific needs of autistic users the feedback should be subtle and gentle, but also clear and consistent. The user should decide if and how he wants to share the feedback with his coworkers. The product should help the user in dealing with the stress, first of all by distracting the user from the situation causing stress, furthermore by supporting relaxation after a stressor.

The interaction should be intuitive and simple to allow the user to reply even when stress decreases their functioning: according to his mood, the user can interact with the object in different ways. By repetition and conditioning the interaction with the product should easily become a routine in their everyday life. To make the usage attractive, the autistic user should feel in control of the product and should be rewarded for using it.

The product should also record measurement data. Together with a job coach the user could reflect on the stress experienced, identify problems and discuss them. This way job coaching with insight in stress occurrence at work should encourage the user to reflect on daily activities and his behavior, which might even lead to an overall stress reduction. Recording the data might prove to be useful for future development of the product, providing insight in the occurrence of stress and the usage of a stress relieve tool.

2.4.2 Criteria

Next, the vision and findings are translated into criteria. These criteria should be met in order for the design to be functional and appropriate. The criteria are listed per product aspect:

General

- The product should be considered supportive
- The wearable should be comfortable to wear all day, every day
- The product should have an intuitive interaction
- The product should support relaxation
- The product should allow for repetitive behavior, routine
- The product should reward user for using it

Input

- The product should monitor stress
- The product should contain sensors to measure physiological functions
- The product should interpret sensor data to stress score
- The product's thresholds should be adjustable

Output

- The product should inform the user about his stress
- The product's feedback should be subtle and gentle
- The product's feedback should be clear and consistent
- The product's feedback should be adjustable
- The product should allow both private and public use

Reflection

- The product should provide access to stress history
- The product should allow for personal goals and checking
- The gathered information should support job coaching

2.5 Technology

Now that a vision is formulated regarding the product to be developed the technical possibilities are explored regarding input, output and processing of the product to be designed. First off, existing products and concepts are analyzed, then sensor technology is researched and tried out in some experiments.

2.5.1 Existing products & concepts

Existing products and concepts with a relation to physiology or emotion are analyzed and categorized as shown in figure 13. This is not a complete or objective overview; it is just an impression of the current consumer applications of physiology and an inspiration for this design project. The categories are arbitrary but create some kind of order in this broad analysis. Below, they are described briefly. All products shown are individually discussed in Appendix XII.

Figure 13: Categorization of existing products and concepts

Sport & Exercise

The products in this category all contain a pace sensor to measure strides. Some more advanced systems can be enhanced with more sensors like heart rate and GPS. This way users can keep track of their training, or just day-to-day movement. Most systems offer the option to upload data to a website to visualize the information. Figure 14 shows an example by Nike.

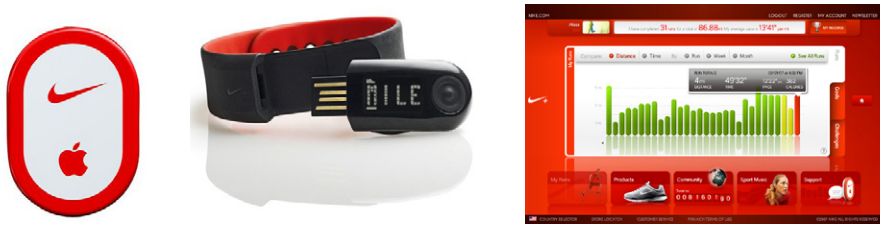


Figure 14: Nike+ system.

Games & Gadgets

The use of physiological sensors is increasing rapidly in this segment. Some early concepts are presented to use heart rate or brain activity in a game environment, respectively by Nintendo Wii and NeuroSky.

Furthermore mood-sensing gadgets are developed, measuring GSR or heart rate. These are defined as gadgets here since the output is ambiguous; it is unclear what to do with the information presented. An example is this computer mouse measuring heart rate, shown in figure 15.

Figure 15: Asus Vito mouse

Health & Wellbeing

Quite some different products are placed in this category, but they share the goal of improving one's quality of life. In the fields of sleep, food, breathing, pain relief and general care physiological sensors and/or actuators are used to achieve this goal. The sleep coach shown in figure 16 measures brain activity and deduces sleep patterns. Data is uploaded to an alarm clock to give the user insight in sleep patterns.

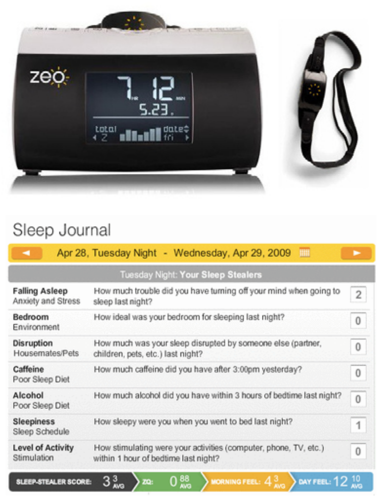


Figure 16: Zeo Personal Sleep Coach.

Stress & Relaxation

This category seems the core application of physiological sensors on the consumer market. Many products provide the user with some kind of biofeedback in order to relieve stress. On the input side GSR and pulse oximeters are used most often, the output ranges from simple audio or LED feedback to computer interfaces with training software. The StressEraser shown in figure 17 works with a pulse oximeter to provide the user with a breathing exercise.

Figure 17: StressEraser breathing pattern.

Emotion & Expression

This category contains the more artistic products and projects. Most of them are experiments on the field of expressing one's emotion or state of mind in wearables like clothes or accessories or on a geographical scale. Different sensors are used to measure the wearers' emotions, like the 'Bubelle' dress by Philips, shown in figure 18. Some others can simply be set explicitly by the user.

Figure 18: Philips' Bubelle dress displaying emotions.

Safety & Security

These products fulfill functions for safety or security, like detecting lies or suspect behavior. Extra functionality like infrared temperature measurement is added to video surveillance in order to automate the process of monitoring spaces, like in the Febril Screening System and head count shown in figure 19 and 20 . Both are using infrared light to measure temperature and detect human silhouettes.

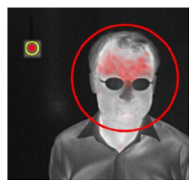


Figure 19: Infrared Febril Screening System.

Figure 20: Infrared head count

This analysis shows a variety of products dealing with stress. There seems to be great interest in stress relief. Most products are, unlike this project, meant for use in sessions or exercises, not for long-term monitoring. As mentioned before, a broader introduction of such a product might be interesting, considering the omnipresence of stress.

2.5.2 Sensors

As mentioned above, it is envisioned that the product will monitor the user's stress. In order to monitor stress, sensors will be used to measure physiological functions. Different types of sensors are reviewed, as well as the possibilities for locating and applying these sensors.

Types of sensors

As described before, stress causes a lot of bodily reactions to take place. These reactions can be measured using different sensors. Table 9, on the next page, summarizes the sensors and their advantages and disadvantages.

Location of sensors

As mentioned before, the different sensors need different placement on the human body to measure physiological functions. The placement of sensors is of influence on both the accuracy and the design: when designing a wearable to measure stress this should be taken into consideration. Therefore the possible locations of measurement are mapped in figure 21.

Considering applicability, comfort and non-invasiveness many of the sensors are not suitable for use in this project. GSR, ECG, respiration band, thermometer, accelerometer and microphone are the options left. Since Hearth Rhythm Variability was chosen as primary parameter, an ECG or microphone will be used as a main sensor

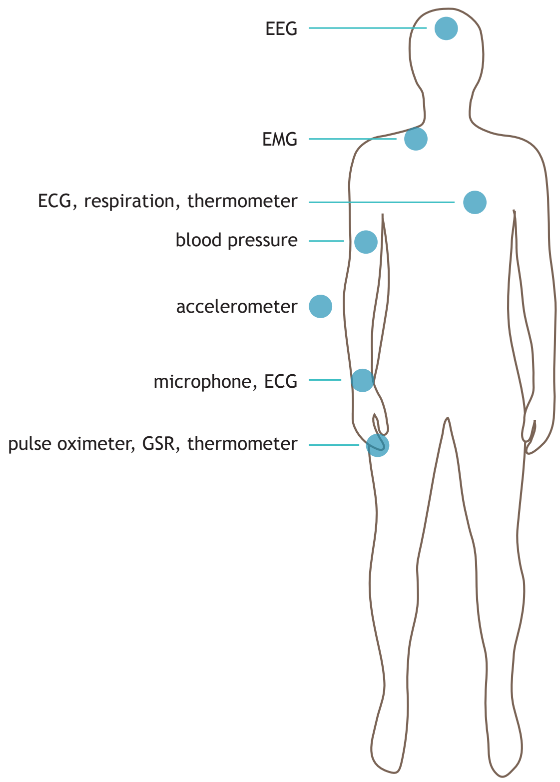


Figure 21: Placement of sensors on human body.

Sensor	Parameter	Description
Pulse oximeter	Blood saturation Heart rate HRV	This sensor measures oxygen saturation of the blood and pulse can be deduced from this data. The sensor is commonly placed in a clip that has to be attached to ones finger or earlobe, which makes it difficult to hide.
GSR	Skin electric resistance	A convenient technique: two electrodes are placed directly on the skin and a small current is sent through the body. This way changes in electrical resistance of the skin can be determined.
ECG	Heart rate HRV	This is a very accurate technique, measuring electrical activity of the heart muscles [29]. The electrodes should be placed on the chest and can be used invisible under clothing. It might however be an inconvenience to wear it on the chest.
EMG	Muscle activity	Similar to ECG, but where ECG is used to monitor activity of the heart muscles, EMG is used for all kind of muscles. There are two kinds of electrodes, either attached on the skin or inserted in the muscle as a needle. The first is painless, whereas the other is more accurate.
EEG	Brain activity	Electrical activity of the brain is measured with EEG. According to which parts of the brain are active it is possible to say something about ones state of mind. It requires a lot of electrodes on one's head and very specialistic interpretation.
Blood pressure band	Blood pressure Heart rate	The band on the upper arm needs to be inflated to measure blood pressure and can therefore not be used to monitor continuously, only on time intervals. The inflation can be heard and seen and is therefore not subtle.
Blood pressure finger sensor	Blood pressure Heart rate	This finger sensor can be used to monitor blood pressure continuously, but is very sensitive and expensive equipment.
Respiration band	Respiration rate	This band measures expansion of the chest and/or stomach in order to monitor respiration rate, but tidal volume cannot be deduced accurately. The band contains stretch sensors and can be used invisible under clothing.
Respiration mask	Respiration rate and volume	A mask can be used to monitor tidal volume of respiration by measuring gas volume flow in and out of the body. However, a mask is far too obtrusive to be considered in this project.
Thermometer	Temperature skin/body	A thermometer can be placed on many different places, but most interesting is the balance of temperature of the torso and limps. Therefore two thermometers should be placed on one's body, for example on the chest and the wrist.
Accelerometer	Movement (acceleration)	Measuring movement and vibration [30], it does not give an indication of stress, but it could be used for interpreting the other data. Physiological functions like heart rate will also increase due to physical activity. Accelerometers could be considered to counteract this effect.
Microphone	Heart rate HRV	Multiple iPhone applications are available that monitor heart rate using a microphone. The built-in microphone or the headset should me pressed on the wrist, neck or chest to get a signal [31]. Accuracy is doubtable, but furthermore it is an elegant option.

Table 9: Overview of different sensors and their advantages and disadvantages.

Application of sensors

Most of the sensors mentioned above make use of one or more electrodes. These electrodes are placed directly on the skin to make good (electrical) contact. The usual electrodes for ECG and EMG are filled with Ag-AgCl conductive gel, which improves the galvanic contact between the electrodes and the skin. With long-term monitoring it might cause discomfort due to constant skin contact.

At Yonsei University in Korea an ECG system was developed using dry electrodes made of conductive fabric. Because of the high impedance between the electrode and skin, the system had to adapted.The result of this experimental ECG design is quite good. Although the baseline is drifting more than with the usual ECG system, the output was useable [32].

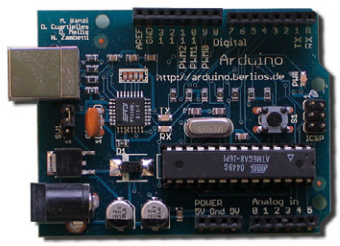
Innovation in electrode techniques make these products more and more comfortable in long-term use.

2.5.3 Experimentation

To explore the possibilities of different sensors, some products were purchased and examined. Furthermore some experiments were conducted with these products and other sensors by attaching them to a computer.

Arduino and Processing

Some of the products and sensors were connected to establish understanding of the sensor data. This connection was made using an Arduino board and Processing software to visualize and process measurement data on a computer. Arduino is an open-source electronics prototyping platform, shown in figure 22: an input/output board that can be connected to the computer via USB and that can be programmed for interaction. In Processing one can read and write the ports of the Arduino and process data on the computer as shown in Figure 23.



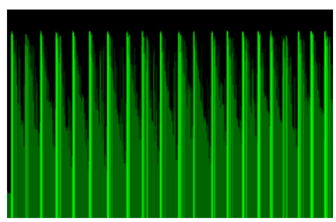


Figure 22: Arduino electronic prototyping board.

Figure 23: Processing window with readout from the Arduino.

Galvanic Skin Response

First some experiments with GSR were done, using two electrodes and a simple amplifying circuit, connected to the Arduino. This setup is shown in figure 24. The output of these measurements was very unstable and presumably more dependent on the impedance between electrodes and skin than on the electric resistance of the skin itself. A redesign of attaching the electrodes to the skin helped a little, but remains unstable. Professional applications of GSR measurements make use of straps around separate fingers and a conductive solution between the electrodes and the skin. Another disadvantage of GSR is that beside averaging values, no corrections can be applied to the data and no control is available to validate data.

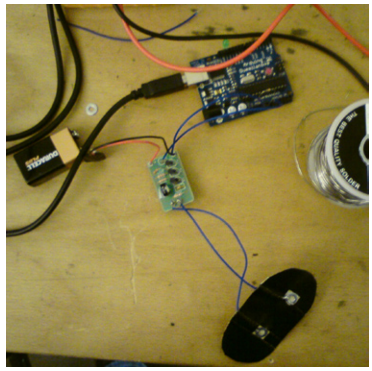


Figure 24: Setup to measure GSR.

The GSR data obtained seems too unstable to be a reliable indicator of stress.

Cresta watch + heart rate chest band

This sport watch works with an external chest band to measure heart rate, see figure 25. The chest band contains two flexible electrodes, the most basic form of a passive ECG. This data is transferred wireless to the wrist watch, using radio frequency signal. ECG is a very reliable way of measuring heart rate, but the user comfort of wearing a chest band for a longer period of time is questionable. Therefore this commercially available band was tested. The electrodes are smoothly integrated in the rest of the band and therefore not irritating. The manual suggests moisturizing the electrodes with some water, but even without this, the pulse is measured correctly in this test.

Figure 25: Watch and chest band.

The comfort was tested in two sessions of four hours continuously, including a jogging session. The band was actually quite comfortable, even after hours of usage and did not slide down even when running. It is, however, quite noticeable in wearing, thus creating consciousness on the monitoring.

From experimentation with a commercially available chest band it is concluded that though it is comfortable to wear, it is not ideal due to the consciousness on measurement when wearing a chest belt.

Emwave biofeedback stress reliever

The Emwave, shown in figure 26, works quite similar to the StressEraser discussed above. By means of an infrared sensor the Emwave measures blood saturation in finger tissue or earlobe. From this data it deduces pulse and HRV. The regularity of HRV is displayed using a red, blue and green LED. These LED's can be seen in Figure 27. It also shows a breathing pattern to regulate the HRV, using a LED bar.

Figure 26: Emwave.

Since HRV is mentioned often as the best or even only way to measure stress, it was interesting to analyze a product using this parameter. The product was tested in different settings, explicit as well as implicit. Figure 28 shows the Emwave in a test session during a game. At first impression the color coded stress level seemed very unstable, but when breathing relaxed and purposeful the light turns steady green. With little disturbance the light changes rapidly to blue or even red and back, which might be experienced as disturbing itself.

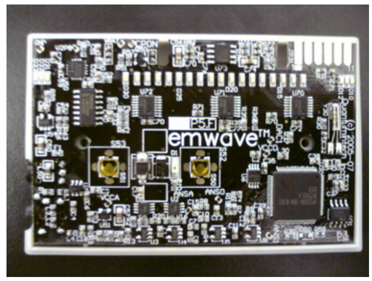


Figure 27: Emwave electronics.

According to the manual, the red light stands for "low to normal coherence", so no difference can be observed between stress and a regular state of mind. This product is clearly meant to be used in relaxation exercises, not to measure stress. A different scale would be needed to use HRV in the current project, focused on the difference between stress and normal to relaxed condition.


Figure 28: Emwave during a game.

HRV experiment

In this setup, the Emwave Stress Reliever was used to measure pulse. The LED that indicates every beat is read out by a light sensor and sent to the Arduino, as shown in figure 29. This data was first visualized in Processing. In order to deduce HRV, the pulses had to be detected and timed. Figure 30 shows a plot where every pulse is marked with its time since the last peak in milliseconds. From this time the beat-to-beat frequency is calculated and also averaged over two pulses. The beat-to-beat frequency is the heart rate, based on the time between only two peaks. Therefore this frequency varies severely.

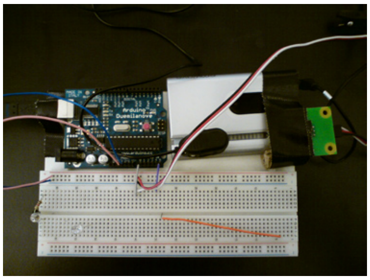


Figure 29: Emave attached to Arduino

Then these two frequencies are plotted over a longer period of time. The two graphs in figure 31 show about 4 minutes of HRV. A clear distinction can be made between the first and second half of the graph. The first half is just a regular measurement, the second half is while breathing deep and slowly. It shows a quite regular sine wave in the second half, just like literature stated. A question that remains for the time being is how this graph will look when the subject is experiencing stress and whether this is distinguishable from the 'normal' state.

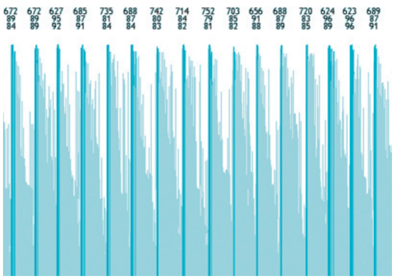


Figure 30: Heart rate in processing

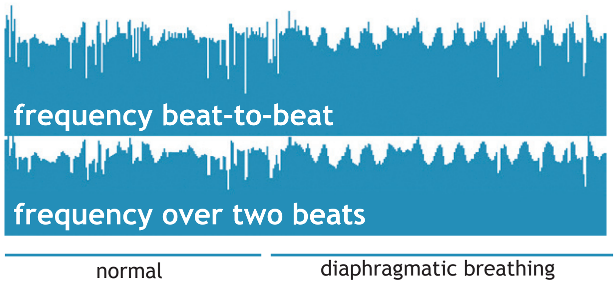


Figure 31: HRV graphs in processing

Reading the graphs

The two graphs at the top of figure 31 show a clear difference between the first and second half, but there is more to see. Both show some strange white lines throughout the graph, in the top one they are a little bigger. These lines are caused by 'missing' pulses, partly due to the Emwave and its sensor, partly due to the processing code. However, in a spectrum analysis these errors would not be significant: they are of such a high frequency which is not of any interest in this analysis.

When plotting these graphs real-time, it becomes clear that the heart rate rises slightly when breathing in, and decreases when breathing out, with a very short delay. When breathing fast and superficial the heart rate does not follow respiration that much.

In order to assess this data in more depth, a frequency spectrum should be calculated. This can be done using a Fourier Transformation. According to Tom Demeyer, head of technology at Waag Society, a simple Discrete Fourier Transformation (DFT) should work in real time in this case. There is so little data that optimization is not needed. However, further analysis is not conducted yet. Based on design decisions the data analysis will focus on the chosen sensors and their data. For this moment an insight in the possibilities is gained through experimentation.

iPhone Heartbeat Monitor

As described before, multiple iPhone applications use a microphone to measure heartbeat. Since these are the only products found that utilize this technology this was explored in practice to test the principle.
Heartbeat Monitor 1.0 by iTourSoftware was downloaded and tested on an iPhone. This application should work with the internal microphone of the iPhone, as well as with a headset microphone, on either the wrist, chest or neck. All these situations were tested at two persons to get an idea of the accuracy of such a device. Since the application does not only display a heart rate value, but also plots the input, one can see how well the microphone picks up the pulses. It turns out that the application is working best when using the external microphone and placing this on the wrist or neck, close to a vain. Figure 32 and 33 show the Iphone screen, with a neat graph of pulses measured on the wrist.

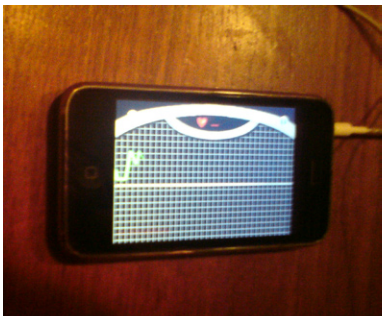


Figure 32: Heartbeat Monitor on iPhone.

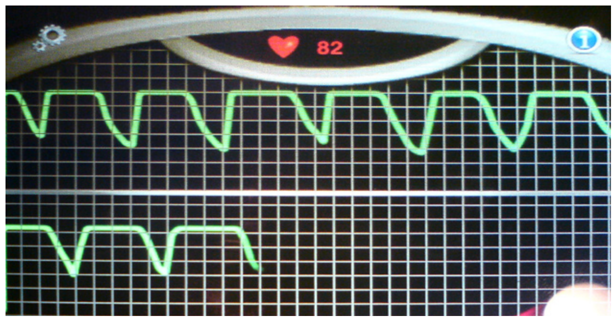


Figure 33: Heartrate visualization.

3 SYNTHESIS

In this phase ideas are generated and elaborated into concept models. The first chapter describes the ideation, where a lot of different ideas took shape. The ideation is concluded with a scenario and a framework, describing the product system. Then the ideas are developed to concepts in different directions. The final chapter of this part describes the process and results of modeling these concepts.

3.1 Ideation

Actual ideation started as soon as the design brief was read, but really took off after the completion of the explorative study. Besides the individual sketching and regular discussions with different people, a brainstorm session was organized to 'think outside of the box'. Finally a scenario was made to give an impression of user-product interaction and furthermore different parts of the system are identified.

3.1.1 Sketchbook

Ideas were noted from the beginning of the project: some as sketches, others in diagrams or words. Some are about interaction, others concern physical design. Figure 34 shows an impression of the images created in this process. Some of the most interesting ideas are briefly discussed below.

Figure 34: Sketchbook.

Wearable

A wearable will be necessary to measure stress, but the kind of wearable is open for ideation. Different options are considered and sketched as can be seen in figure 35, but with the criteria regarding comfort and non-stigmatizing in mind, many of these seem to be unsuitable. The two most promising possibilities are either integration in a wrist watch or a comfortable, invisible band underneath one's clothes.

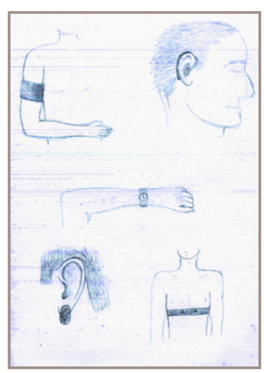


Figure 35: Sketches of different wearable.

Desktop objects

In order to give the user other feedback than only through the wearable the possibilities of an external object are explored. Integration in the user's environment could be reached by combining it with an everyday object like a lamp or photo frame. This way one can also avoid a stigmatizing effect of a recognizable self-help object. Some of the ideas are shown in figure 36.

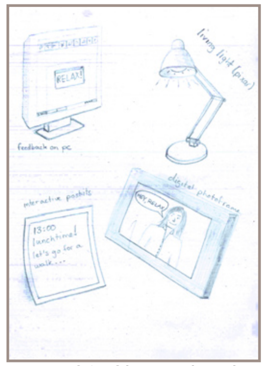


Figure 36: Object sketches.

Levels of interaction

The interaction between user and product can differ with the level of stress measured. The more stressed the user gets, the more the product asks for attention. An escalation of stress could for example make the product warn one's job coach, when measuring a slight tension it only distracts the user for a second or two.

3.1.2 Brainstorm session

On January 8th a brainstorm session was organized to generate new idea directions as input for this project. These directions could be used in combination with the ideas that were developed already. The secondary goal of the session was to inform and involve the new project team members within Waag Society.

A mixture of people both known and unknown to the project is perfect to form a group that is open-minded as well as realistic. Nine participants were present: three designers within the project, three designers at Waag Society and three fellow design students.

Figure 37: Brainstorm session at Fablab Amsterdam.

Method

The session consisted of two parts. In the first part information from the explorative study was presented to the participants alternated with quick brainstorms on some key aspects of the design problem.

The second part was a tinkering session where the participants were asked to create a product model in groups of three persons. Tinkering is an experimental process of thinking and creating physical objects synchronously [33]. Therefore the session was held at the Fablab, at Pakhuis de Zwijger in Amsterdam, where machines and materials for prototyping are available.

Each group consisted of one member of the project team, a Waag designer and a student. They were asked to explain their concept during lunch. The concepts were discussed briefly and after lunch they were elaborated further and presentation models were fabricated.

Results

Below the results of the session are discussed briefly, first the outcomes of the quick brainstorm, then the concepts created by the three teams. An elaborate version can be found in appendix VIII.

Figure 38: Flipover with sticky notes.

Brainstorms

The brainstorms in the first part of the session were meant as a brain exercise as well as to make the participants think about some key aspects of the design problem. The results of these brainstorms are presented below in figure 38. No conclusions are drawn of this part; it is merely a warming up for the latter part.

Modular system

This concept is a modular system of sensors, wireless connected to an iPhone. According to user preferences and habits a combination of sensors is chosen to measure stress. Figure 39 shows a sensor watch and a shoe inlay, figure 40 shows the iPhone. Sensors in the user's shoe could measure nervous tremors as an indication for stress. The iPhone shows a possibility to ask the user to reflect on the measurement to calibrate the system. The output is not yet defined, but could be in the form of an iPhone application.

Figure 39: Models different sensors.

Figure 40: Model iPhone feedback.

Bead-your-stress

This bracelet makes you count to ten. Figure 41 and 42 show the model, which exists of two loops of beads: one loop is fixed and measures stress, while the beads on the other can be moved around. When the bracelet detects stress in the wearer, one side of the second loop is detached. Now the wearer can play around with the beads to calm down. This action is inspired by the Greek men that play with their 'komboloi', a string of beads.

Figure 41: Model bead-your-stress.

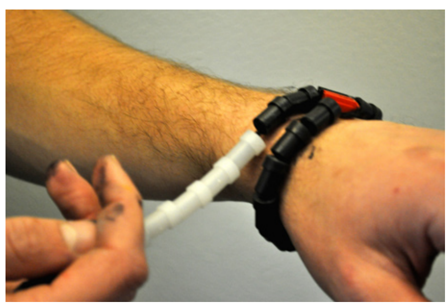


Figure 42: Playing with the beads.

Wobble

The idea consists of a wristband and a physical object. The sensors are integrated in a simple, neutral wristband (like the “live strong” etc. wristbands). This wristband contains an actuator as well, probably a vibration or contraction, providing a subtle signal to the wearer. The wobble object is for example standing on the user’s desk. It starts wobbling when the user gets tensed. The more stress the user experiences, the more it moves. This calm movement will invite the user to pick it up and hold it for a moment. It will look like the wobble is restless and needs attention, instead of the user. This way the user is distracted from his work or situation and focuses on the object.

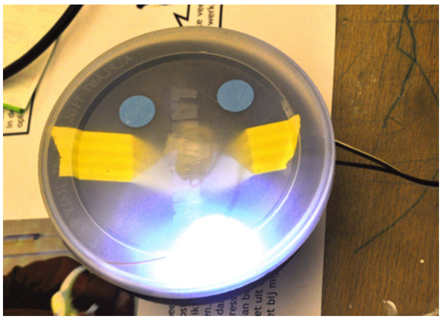


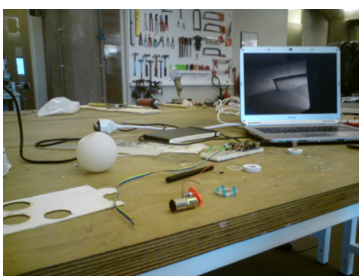
Figure 43: Model wobble.

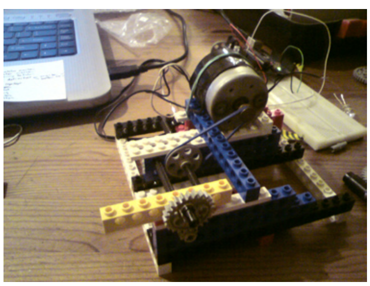
Figure 43: Model sensors wristband.

The results of the brainstorm show very different directions to solve the design problem. These directions have to be explored deeper in conceptualization.

3.1.3 Tinkering

Not only at the brainstorm session was the Fablab used for tinkering: also later on quick mock ups were made to try out ideas. Figures 44-46 show some of the objects fabricated in this process.





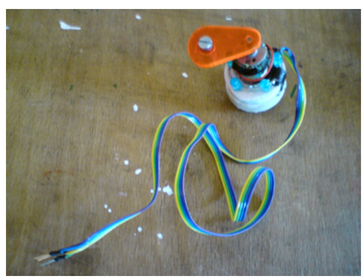


Figure 44: Tinkering a second version of the wobble.

Figure 45: Using LEGO for a quick mockup.

Figure 46: Wobbling mechanism with LED’s.

3.1.4 Scenario

A scenario was developed to define and visualize possible interactions between user and product. The interaction was divided into three stages of using the product:

- **Wear & use:**
  Integration in daily life, also before and after usage at work
- **Tension & stress:**
  Different interactions when slight tension is measured, or severe stress
- **Reflect & adjust**:
  Hindsight reflection on stress data and personalization of the product

Figure 47, on the next page, shows the interaction scenario for the three stages.

3.1.5 Framework

In the scenario it becomes clear that the design solution can be seen as a system instead of a single product. The three interaction stages are translated into three system parts. This distinction allows for separate development of the different parts, breaking down the design problem into smaller sub-problems.

Figure 48 visualizes the idea cloud and the convergence into 3 system parts. These parts are briefly discussed after the scenario.

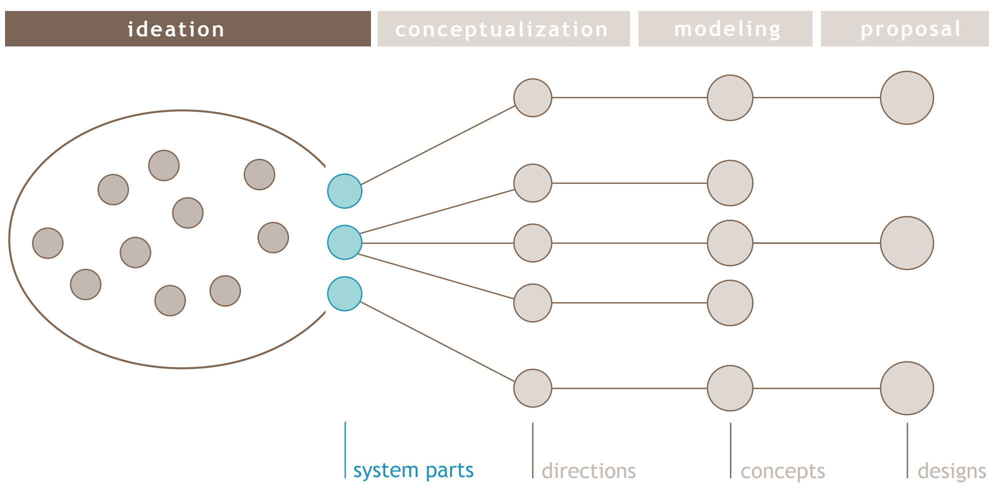


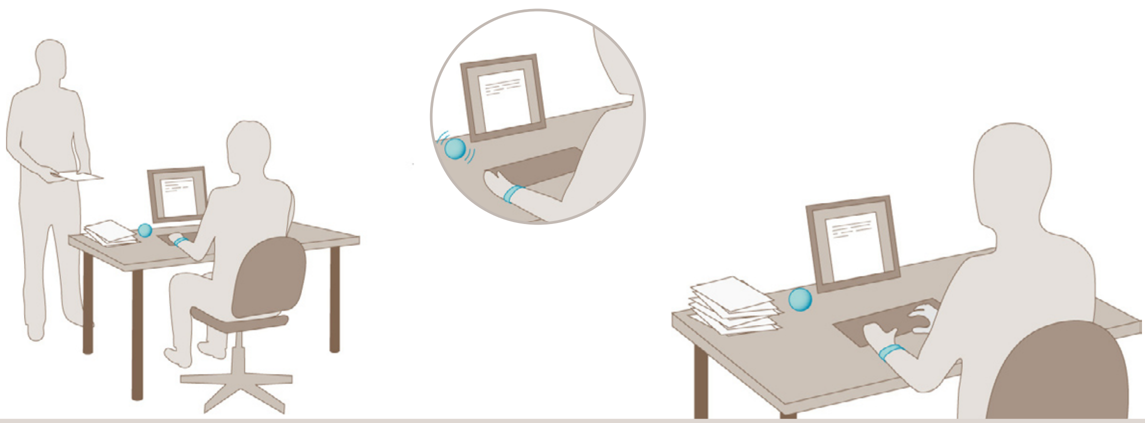
Figure 48: Visualization of the convergence into three system parts.

Henk is 34 years old and diagnosed with Asperger. For the last year he has been working at a company, mostly performing administrative tasks. We are following Henk during a normal day at work to see how he uses his bioguide to deal with tension and stressful situations, and how he consults his job coach to optimalize the use of the guide.

wear & use

Half past seven his alarm clock rings for another day of work. He takes a shower, eats his breakfast and puts on his bioguide before leaving the house. Just like every day, he is in good time to catch the bus. When he arrives at work, he positions the bioguide on his desk next to the monitor to remind him to stay relaxed. He starts working on his daily tasks: checking and completing employment files for a big consultancy firm.

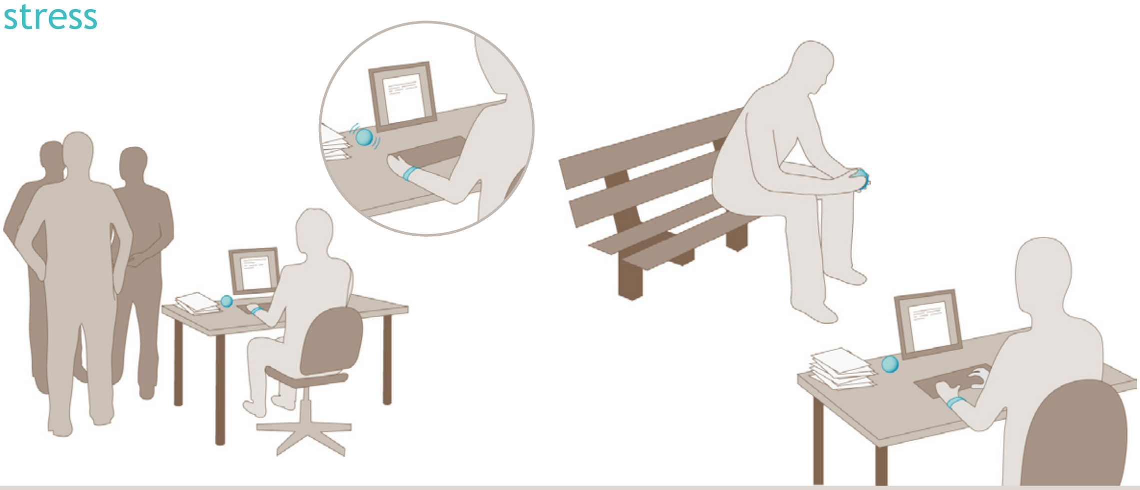
tension



The pile of files keeps growing as his boss repetedly drops files on his desk! Henk notices his bioguide on the desk, which indicates that he is getting more tensed under these circumstances. Luckily, he is feeling good today! He is aware of his limits and therefore decides to work on in an ordinary pace ignoring the growing pile.

Figure 47: Scenario of preliminary interaction.

stress



After lunch, some colleagues start a loud conversation right next to Henk’s desk. He gets really irritated as the conversation goes on and on. He doesn’t want to join, but can’t continue his work either. Not only is his bioguide restless, his wearable also signals him that he is getting too stressed. He should do something about it! He takes his bioguide outside and uses it to relax. When feeling calm again after some minutes of relaxing, he goes back to work.

reflect & adjust

Once a month Henk meets with a job coach to discuss his progress at work. When they plug the bioguide into the computer, they can review his recent stress experiences. On the computer they can view daily, weekly or overall statistics. They identify and discuss problems, so Henk can try to avoid them in the future. To make the bioguide fit his personal needs, they can also adjust preferences and settings like sensitivity and output levels.

Wearable

This part is where the stress measurement takes place, therefore it should be a wearable. Ideally this part should be invisible to coworkers or unrecognizable as a device for people with autism. A wearable under the user's clothing would be one option, integration into a regular product another.

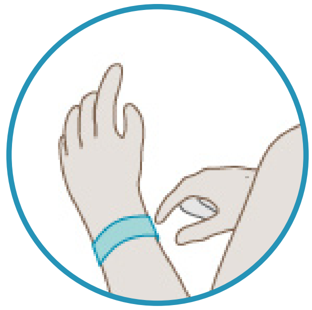


Figure 49: Wearable system part.

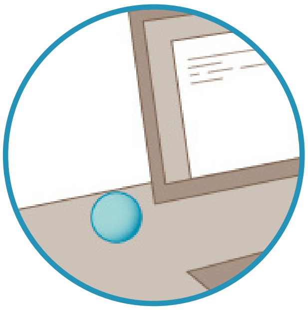


Figure 50: Object system part.

Object

This is the part that informs the user on his stress level. It should be able to differentiate between slight tension and severe stress. It should both attract the user's attention and communicate the level of stress. It should also help the user deal with the stress. This can be done in many different ways, as already discussed in the exploration phase.

Interface

The collected stress data should be accessible via an interface. It could be a computer program, a secured website or a mobile application. The user could review the data at home, or in the regular meetings with his job coach. The interface should furthermore allow the user to change product settings.

Figure 51: Interface system part.

3.2 Conceptualization

In this chapter the development of the ideas described above into concepts is presented. The starting point consists of the system parts and scenario as defined in ideation. For the system parts design directions and subsequently concepts are developed.

The wearable and interface are both depending on the technology to be developed later on in this project, so for now the object part is the most interesting to look at. Therefore it is decided to develop multiple concepts for the object and only one concept for the other parts.

Figure 52 visualizes the concept directions formulated for the different system parts. In every direction a concept is developed. Below, these concept directions and the corresponding concepts are described briefly.

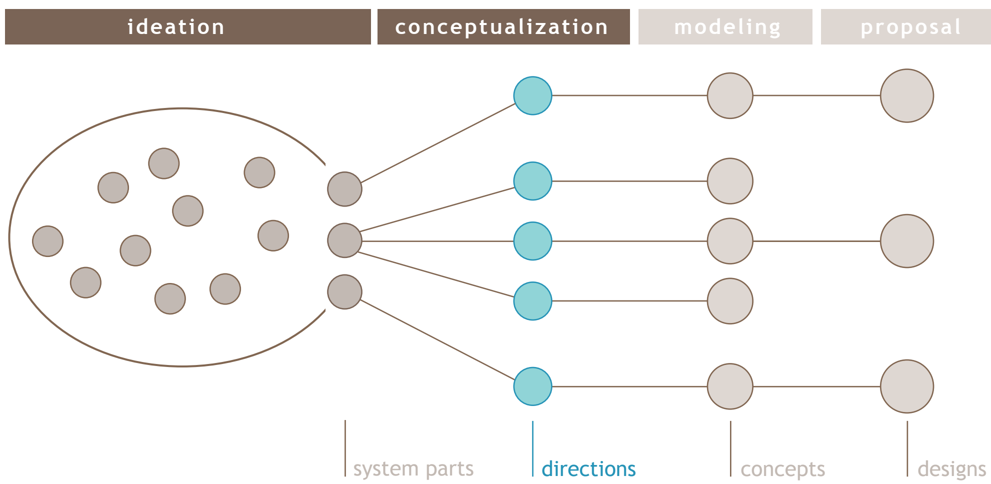


Figure 52: Design directions for the different system parts.

3.2.1 Wearable

This is the system part where the sensor technology should be attached to the user's body. A direction is formulated to do so and a concept is developed. These are described below.

Wrist watch

This direction is the integration of both measurement and feedback in a wrist watch. Tactile, visual or audio signals could attract the user's attention and a display could be used to present the user with feedback on the stress.

This wearable represents an integrated concept, where measurement and feedback are positioned in one device. In the form of a wristwatch, this concepts measure stress using heart rate readings on the wrist. The feedback is presented to the user using vibration signals. Stress levels can be read out by the user on the display on demand. In normal modus the watch will only display time and date, not giving away anything of the nature of the product to unknowing witnesses.

Figure 53: Wrist watch concept.

3.2.2 Object

For this system part three different directions were formulated and three corresponding concepts were developed. An overview of the directions can be found in figure 53. The directions have different approaches to solve the user's problem. The first direction is the most functional approach: the problem causing stress has to be solved. The second direction focuses on the physical effects of stress and tries to calm the user down before dealing with his problems. The third direction is more indirect: the relaxation is realized by distracting the user from the situation. Below, the directions and corresponding concepts are presented briefly.

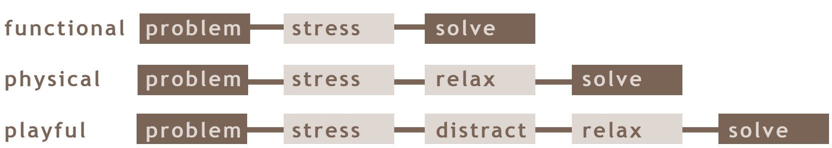


Figure 53: Overview of the three design direction for an object.

Functional object: Planning application

The idea of this direction is dealing with stress by dealing with the cause. Helping the user to organize his work and keep a good overview might reduce stress. When stress still occurs, the user is asked to reflect on the cause and work it out.

This phone application helps users organize tasks and workload. As a preparation on a day the user enters his tasks in this application. In consensus with a supervisor tasks are defined and prioritized.

When stress is measured, the user is informed by the phone giving a vibration or sound signal, just like a text message. The user is asked to reflect on his stress and the relation to his workload. Tasks can be reorganized, postponed to another day, or sent to others in order to create peace of mind for the user.

Figure 54: Planning application.

Physical object: breathing pebble

This direction supports relaxation through influencing one’s physiological functions. Mainly breathing exercises are said to be an easy way of influencing one’s bodily functions and thus one’s state of mind. By first getting rid of the stress, the user can deal with his problems afterwards in a more concrete way.

This concept serves as a breathing coach to calm down the user when he is stressed for what reason whatsoever. When stress is measured the pebble gives a vibration signal and lights up in a color as an indication of the stress level. The user is asked to reflect on his feeling and if necessary adjust the color. Subsequently the stone will start glowing in a relaxing breathing pattern of nine cycles per minute. The color will slowly fade to green during the breathing exercise. If the user does still not feel relaxed when the pebble arrives at green, he can adjust the color again However, hopefully he is relaxed and ready to face his job again.

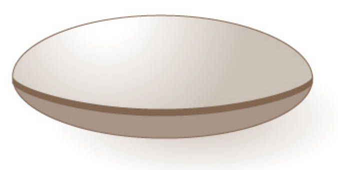


Figure 55: Breathing pebble concept.

Playful object: pellet game

In this direction the feedback is not asking the user to deal with stress in a direct way; it is distracting the user from the situation or problem causing stress through playing or fiddling with the object. The idea behind it is that a short distraction could calm the user down so that he can deal with the problem afterward in a sensible way.

The objective of this concept is to distract the user from the situation or problem causing the stress. Once stress is measured, the game will ask for attention by a vibration signal, inviting the user to play. It is a simple game that can be played actively as well as thoughtlessly: there are three balls that have to go in the three holes. For every ball that does, a light will lid, when all three balls are in place a vibration signal will indicate victory. This reward is thought to stimulate positive emotions, to counteract the stress.

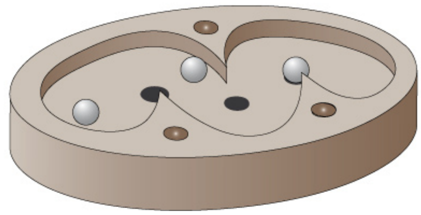


Figure 56: Pellet game concept.

3.2.3 Interface

All measurement data will be logged and an interface should be created to access and visualize this data. The question remains whether this data will be used only for improving stress algorithms, for job coach consultations or by the user himself as a reflection tool.

Reflection website

In this interface concept the collected stress data is visualized in graphs and can be viewed per day, week, month or year. The measured data can be viewed synchronously with averaged values of the same time span. The data of specific days or weeks could be used to reflect on experiences, while averaged data can give insight in the underlying patterns and might be used to avoid stress on the long run.

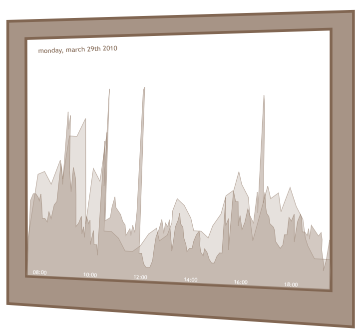


Figure 57: Reflection website concept.

Furthermore the interface allows the user to personalize different settings. The sensitivity can be set in multiple ways and feedback signals on both wearable and object can be adjusted to one's preferences.

3.3 Modeling

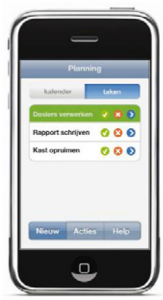
The concepts described above are materialized into models at the Fablab prototyping facility and two digital representations were made on the computer. The models described below are not functioning prototypes, but merely mockups meant to facilitate evaluation by both target user and experts.

3.3.1 Wrist watch

The key aspect of this model would be the vibration signal applied to one's wrist. Therefore a simple mockup of a watch was built using the laser cutter. Figure 58 shows the model. Underneath the display a pager motor is included to generate a vibration signal. The watch is connected to a computer by means of an Arduino electronics prototyping board. This way the signal can be programmed in different patterns and controlled remotely.

Figure 58: Wrist watch model.

3.3.2 Planning application



This concept was translated into a computer mockup resembling an iPhone application with limited functionality. Figure 59 shows a screenshot of the mockup. One can navigate through the calendar and tasks and check tasks as finished.

Figure 59: Planning application mockup.

3.3 .3 Breathing pebble

The model of this concept was most complex, since the purpose of the model was not only to show a breathing pattern, but also generate a vibration signal and allow user input. These functions had to be integrated into a reasonable small object. The result is shown in figure 60.

Figure 60: Breathing pebble model.

The two halves can be turned with respect to each other. They are connected by a potentiometer that measures the position, in order to allow the user to change the color. The two halves of the shell are casted in PU. Variations in hardness were made to find a good compromise between the protection of electronics and a soft tactility.

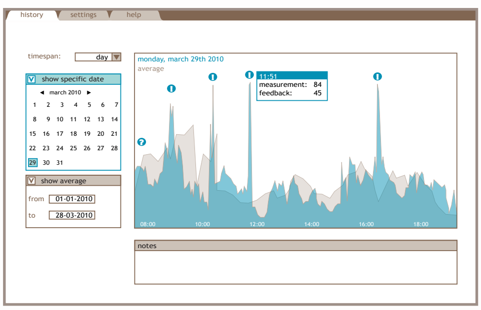
The software for this model runs on an Arduino again, therefore the stone needs a wire at this stage. The potentiometer is read out by the Arduino and the LED’s and pager motor are controlled by the software.

3.3.4 Pellet game

This model was build up out of different layers of Perspex. The laser cutter was used to cut all the different layers. The top half was for the game itself, the bottom half contained batteries and electrical connections. Copper foil was stuck on the playground around the holes to create an electrical circuit. Steel balls from ball bearings were used to play the game and complete the circuit. The electrical resistance of this connection turned out to be so high that the LED’s only lid every now and then. Luckily the game could also be played without the feedback from the lights.

Figure 61: Pellet game model.

3.3.5 Reflection website



Like the phone application, this is just a mockup with limited functionality. The screens show the controls to visualize data and control settings. The mockup allows for navigation between screens, which gives an impression of a functioning program.

Figure 62: Reflection website mockup.

4 EVALUATION

After finishing the concept models, these were used to evaluate the concepts. Both target users and experts were interviewed in order to make a good decision between the different concepts. The set-up and results of these sessions are presented in this part, followed by the conclusion drawn from them in the form of decisions and considerations for the rest of this project.

4.1 User interviews

The Leo Kannerhuis organized a user session with five of their clients. Henk, Mathieu, Jeroen, Ben and Rick were introduced in chapter 2.1. These participants were present in the two previous sessions, only Ben and Rick were absent at the second session. The familiarity with the project allowed for detailed, in-depth interviews.

4.1.1 Method

The interviews were conducted individually, except for Ben and Rick who were interviewed together. Two interviewers were present, Dick van Dijk from Waag Society and myself. The questions were postulated alternated and informally. Both interviewers took notes of the interviews, both concluding answers and quotes were noted. The two interviewers allowed for one accurate notation while the other could continue the interview.

The sessions were structured like a hypothetical scenario. After a short introduction the users were asked to think of a daily work and particularly a situation that could cause them to feel stressed. They were asked to put on the wrist watch and imagine it would measure stress. Then they were presented with a vibration signal through this watch, followed by the question what they would think of such a signal in their daily work. Figure 63 shows a picture of a participant wearing the watch and trying the breathing stone.

Figure 63: Participant with models

Next the possibility of a signal on a mobile phone and an attached planning application were discussed using the mockup on a computer. Subsequently the model of the breathing stone is introduced as a way to relax by means of a breathing exercise, before solving the problem causing stress. Then the game model is handed to the participants and it is discussed whether this distraction could help them relax. In the previous session the possibility to access the data was discussed, therefore it was only discussed briefly in this session.

Finally the session was concluded by summarizing one's opinion. A preferred concept was selected and possible changes or additions were inquired. The preferences were linked to the 'dream product' created in the preceding generative session in the case of the participants that were present at that time.

Appendix X presents an elaborate description of the setup for this user interviews.

4.1.2 Results

The results of these sessions are the opinions of the five participants. These are merged and summarized briefly below per concept. An extensive description of the results can be found in appendix X. A lot of general remarks from the participants are accounted for in the considerations further on in this report.

Wrist watch

The idea of integrating measurements into a wrist watch is received positively, though only one participant was wearing a watch. However, the appearance of the watch is an issue for some. Another way of measuring physiological functions could be acceptable as well for most participants, some want it to be invisible or unrecognizable, others just want it to work.

> In early stages of stress, there is still a way out.
>
> **Henk**

The vibration signal on the wrist does not seem to bother them. Most indicate that they would sense it even in a working situation, but that it is not too disturbing. While some participants know what to do when they get such a signal, to others it is not enough on itself.

> When you choose for such a product, you will get used to the signals.
>
> **Ben**

> When you get such a signal, the question is: what to do?
>
> **Jeroen**

Planning application

An application to organize and plan tasks seems interesting to some participants. They like the idea of organizing work in such a way that they only work at one task at a time. Forwarding or postponing tasks is interesting, but should come with feedback from supervision. However, the general remark is that it is not suitable for use when one is experiencing stress. This means there is no added value perceived in connecting such an application to a stress monitor.

> Even when I know what to do next, I stay stressed...
>
> **Ben**

Pebble

While none of the participants has experience with breathing exercises to relax and some raise questions on the discipline needed to do so, all are open to try it out. Even though it does not directly help with solving the problem causing stress, the participants accept the exercise to help them deal with the situation.

Reflection on stress levels seems possible according to most participants: when the question is asked they can think about their state of mind, although they might not notice stress naturally.

The physical object itself is met by mixed opinions: some like the object, to show others when they are stressed, while other participants would like a more discrete solution better. Most inidicate they would isolate themselves to make use of such a product.

> It has to look like something normal.
>
> **Mathieu**

> Physical disabilities are visible to others, not my mental (in)capacities. I would like to show this to others: for me it is a good thing to put the solution outside of myself.

Pellet game

Only one of the participants likes this concept, the others have various reasons why this would not work for them. It is not perceived as a constructive way to deal with stress. Most participants indicate that they do not want to play a game when they are stressed. They want to solve the problem causing stress, or reduce the stress itself: avoiding is not appreciated.

> I don't want to avoid the problem, I want to solve it.
>
> **Ben**

> When I am stressed, I cannot concentrate on a game, not even Tetris.
>
> **Mathieu**

Reflection website

Some participants indicated that they would like to have access to the recorded data. Two participants doubt whether the data can be used to avoid stress, they think it is more about how to deal with it. However, the big question is what this data will look like.

4.2 Expert interviews

Besides target user, also experts were asked for their opinion on the concepts. Two job coaches from different companies were interviewed to evaluate the concepts. Mariëlle Post works at Werkpad in Amsterdam, Peter Vos is jobcoach at Jobstap in Den Haag.

4.2.1 Method

The job coaches were interviewed individually at their work. Since both job coaches are new to the project, the interviews started with a short introduction to the project. A slideshow on a laptop and some presentation material was used to explain the problem definition, assignment and process so far. The introduction was done informally, so that questions and remarks could be made directly.

After the introduction, the concepts were discussed one by one, in the same order as with the target users: wearable, planning application, breathing stone, game and finally the computer interface. The job coaches were asked about probable reactions of their clients, possible problems and also the role of a job coach in the usage of such a system.

The setup of these interviews and the questions prepared beforehand can be found in appendix IX.

4.2.2 Results

The abstracts from both interviews can be found in appendices IX and XI. In this section the results will be summarized per concept, preceded by the general feedback on the project.

General feedback

The job coaches, who were not involved in the project up to now, were very enthusiastic about the idea of the project. The possibility to give the user a timely warning, to avoid escalation of stress, seems an interesting way to help them. However, both job coaches point at the pitfall that the measurement itself could become a fixation.

Wrist watch

The idea of integrating the measurements in a wrist watch is received positively. The job coaches confirm the problems that people with an ASD often have with stigmatizing situations. However, Vos states that he would even suggest a more stigmatizing product to his clients as long as it works. He thinks it is just a matter of time until everybody gets used to it: then the stigmatizing effect is vanished.

Planning application

An application to organize tasks seems an interesting idea to both job coaches, because uncertainty is a serious cause of stress for people with an ASD. Post explains how her clients use time management methods to organize work, but also foresees trouble when an application would ask too much from the user when he is stressed. Since one's functioning decreases with stress, it might not be the right time to reorganize tasks or review the planning.

Breathing pebble

Both job coaches are familiar with breathing exercises as a way to relax, but none of their clients uses this method as far as they know. Since guided breathing is a very simple and quick activity they think it might work well. Vos thinks it might work with lower functioning, or even intellectually disabled as well. Post states that it can work only if it becomes a well known habit after time, because that is what people with an ASD fall back to when they experience stress.

Pellet game

While Post doubts whether this concept could work, Vos is quite sure that it will not work the way that it is meant. He thinks this distraction will not be appreciated by the users. He thinks it might be an end-of-the-road solution to distract someone that is close to escalation, by forcing him to play a game.

Reflection website

Vos is most interested in the idea of having insight in the recorded stress data, but both coaches indicate that it will depend mostly on the form of this data. Since it is still not known what the graphs will look like it is hard to say whether the data is easily interpret by job coaches. The settings seem very clear to both. There is a strong need for personalization, since the people with an ASD differ so much in the intensity of their disorder as well as personal acceptance. Vos proposes an option to adjust the settings separately for different parts of the day; for example different sensitivity for job and leisure situations, or even during lunch.

4.3 Conclusions

After evaluating with both user and expert , conclusions were drawn on the suitability of the concepts. Below, the conclusions are formulated briefly as a generalization of the evaluations above and own insights.

Wrist watch

Integrating the sensors to measure stress in a wrist watch is a good solution. Making the product unrecognizable will help more people with autism to accept it as a part of their life. The question that remains is how the watch will look like. Therefore a small addition to a regular watch might be even more appreciated.

Planning application

While both target users and job coaches showed interest in this concept it is not suitable to use to deal with stress. It might help people with autism to avoid stress, but even then only in certain situations. There are many situations that cause stress that have nothing to do with a planning and can therefore not be solved by this application.

Breathing pebble

The concept of breathing exercises to relax is not unknown to the target users and job coaches, but still it is not used as such. This concept might introduce a simple breathing exercise to these user to help them deal with stress. The participants indicate that they would give it a try and also job coaches are curious.

Pellet game

This concept seems not appropriate to reduce stress. Most respondents are clear that distraction is not a desired approach in stressful situations. It requires the user to switch from the situation to something completely different and then back. Since people with autism have problems with switching between tasks this is not suitable.

Reflection website

The main conclusion on the reflection website is that it will only be useful if the data displays explicit peaks. The visualization itself is considered appropriate and the possibility to change setting is received with agreement.

4.4 Concept choice

After evaluating the concepts decisions were made concerning the further project. A direction had to be chosen out of the different concepts for the object. Furthermore some considerations were formulated based on the evaluation of the concepts.

4.4.1 Direction

Based on the evaluation described above, the choice is made to continue the development of the object in the direction of the breathing pebble concept. The feedback on the concepts confirmed the assumption that an object supporting relaxed breathing might be an interesting direction for this project.

The fact that this is a very basic way of dealing with stress makes it applicable to a lot of different situations. It is not trying to solve the problems causing stress, which is a very difficult thing to do for so many different situations and individuals. Instead it tries to calm down the user so he can deal with the problems himself.

The multiple ways of using the pebble support a broad target group with diverse demands. It can be used as publicly or privately as one wishes by wearing and using it in different places.

This concept direction will be developed into more detail with the feedback of the user session in mind, especially the different ways of desired usage indicated by different participants. The product should allow for these different demands as good as possible.

4.4.2 Considerations

Some of the feedback from the users can be used to improve the different parts of the product. These aspects are discussed below, to keep in mind while defining the design.

Virtual version

Some participants indicated a desire for integration of the pebble concept into a phone application. This would avoid the necessity of an extra object and decrease the stigmatizing effect that some assign to a dedicated object.

On the other hand, the psychological effect of a physical object should be considered as well. As stated in the vision, it should feel as a tower of strength to the user. A cell phone already has a lot of associations from other usage: calls, text messages, maybe a calendar, internet or even as an alarm clock. This reduces the strength of a new association. The pebble with its limited functionality is dedicated to information and relaxation at times of stress. If the product works well for the user, a bond should originate that reinforces the effect. The user should feel more relaxed knowing that he has a way to deal with stress.

Observation during the interviews showed that most participants fiddle around with something a big part of the time. The pebble seemed very suitable for this, maybe the tactility can be improved to make it even more fitting.

Due to the psychological and tactile advantages it is decided to develop the physical pebble, instead of making a virtual version.

Continuous stress level

It was not yet defined whether the pebble shows one's stress level all the time, at demand, or only when stress is measured. A possibility for the user to check his stress level manually is considered valuable by some users. This way one can for example take the stress level into account when making a planning for the rest of the day.

The job coaches talk about the downside of this option: it might become a fixation to the user, to check his stress level all the time or even test the product. This might also be the case when the pebble shows the user's stress level continuously. The lights and colors could distract the user from his work, even when he is not experiencing stress.

The possibility to show the stress level continuously or on demand should be available by activating these options in the settings. It will differ from person to person whether these options are valuable and not distracting.

Stress notes

Furthermore, some participants suggested implementing a way to enter information about the situation or problem causing stress. These notes should not be entered at the specific times of stress, but preferably shortly afterwards, when the user is more capable of reflecting on the situation. Later on this information can be analyzed, for example with a job coach.

The option to add notes will be included in the reflection software, not in the pebble. The interaction at times of stress should be kept as simple as possible and therefore the functionality of the pebble is kept restricted on purpose.

Random check-ups

In order to calibrate, the product should ask for feedback on the measured stress level. A participant suggests that the product could also ask for input at random moments, to improve the calibration. This might also help for the users to become acquainted and comfortable with the signal. When the signal only comes with high stress levels, it might become associated with negative feelings and increase stress by itself.

The effect of asking user feedback at random moments should be studied more to evaluate the effect. Therefore the option to do so should be built in and tested in the pilot study after this graduation project.

External messages

Some participants indicate a desire to let others know how they feel, not only the people around them, but possibly family or job coaches as well. The possibility of sending text messages to these relatives is discussed and turns out to be a controversial subject. Some like the idea, but others are very strong against it.

The idea of the product is to warn the user early in the process of building up stress. At this moment the target user, defined as high-functioning, is considered capable of making a decision to call or text someone himself. Ideally the user should be able to help himself, with help of the product, without depending on others. Furthermore it is questionable to what extend family or job coaches are able to respond to such messages. A lack of (timely) response to the message might even make things worse: when the user expects a reaction that does not come, he might feel uncertain, leading to more stress.

The product is meant as a ‘tower of strength’ for the user, a self-help tool. Sending messages to others would be a different approach to the problem and is therefore not integrated in this project.

5 PROPOSAL

In this part of the report the design proposal is formulated, following the conclusions from the evaluation of the concept. First, the system is described, followed by the design proposals for each of its parts. A scenario is used to explain the product's interaction in usage.

5.1 System

As described earlier the product to be designed is a system consisting of three parts: a wearable, an object and an interface. Figure 64 shows the process of synthesis where concept directions and models were created for all system parts. For every part a direction was chosen and elaborated into a design proposal. In the next chapters the design proposals for the different system parts are described respectively.

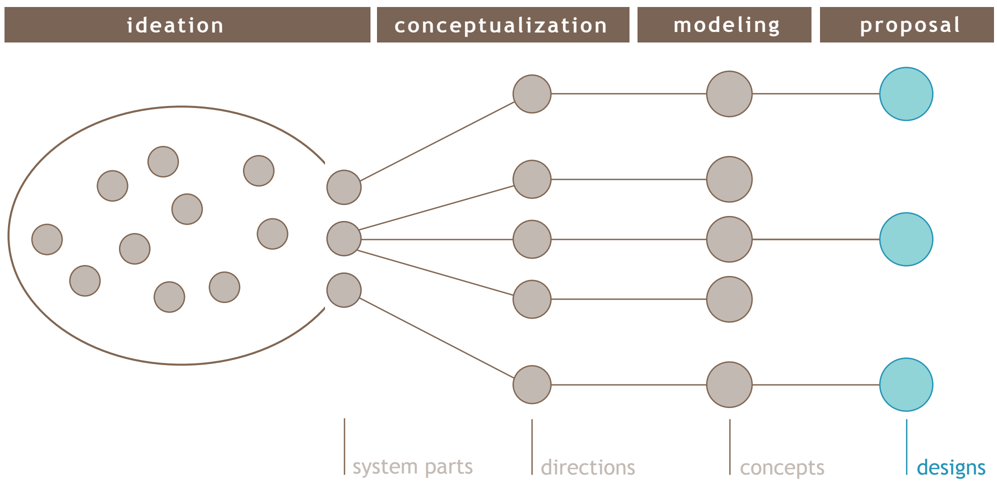


Figure 64: Overview of the process, leading to design proposals.

5.1.1 Communication

The different parts of the system communicate with each other in different ways. Figure 65 shows the communication schematically. The pebble and wrist watch are the parts that are used on daily basis. They communicate wireless using Bluetooth: the stress data measured by the watch is sent to the pebble and the user's feedback is returned.

The communication between the pebble and the reflection website is by means of an USB cable. The pebble does not only send the recorded stress data to the interface, it is also used as a way of identifying the user. This way the confidential information is kept private.

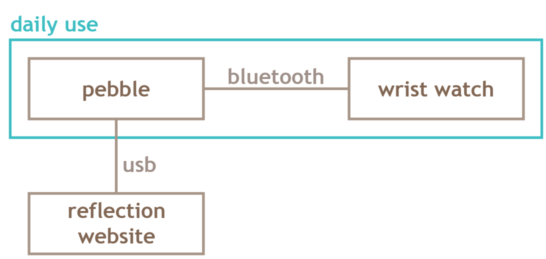


Figure 65: Communication within the system.

5.2 Wrist watch

The wrist watch is the wearable measuring stress. It needs to pick up the pulse of the user on his wrist. From this data the Heart Rhythm Variability is calculated and interpreted into a stress value. When this stress value exceeds a set value the pebble is triggered to attract the user's attention and help him relax.

The watch is also capable of giving a vibration signal to the user. This signal will act according to the preferences set by the user. It is meant as an extra stimulus for the user, for example when the pebble is left at home or ignored.

The measurements are all saved in a data log with a time stamp. These data will later be used to reflect and possibly adjust the product. This is described in chapter 5.4.

The sensor watch should be designed to resemble a normal watch in its appearance. Most of the extra hardware can be built in in the clock: some extra electronics, a Bluetooth radio and a pager motor. However, the sensor itself has to be placed on the other side of the wrist. This is explained in the next paragraph. It means that the band of the wrist watch will be a little thicker than normal, especially on the location of this microphone sensor. Luckily this type of microphones is very small: a few millimeters in all dimensions.

5.2.1 Pulse detection

In order to detect pulse the watch contains an electret microphone. This microphone needs to be placed on a vein in the wrist to monitor pulse. The pressure changes in the radial artery are picked up, filtered and analyzed to determine heartbeat. To create a better signal a chamber around the electret microphone causes acoustic amplification. The position of the microphone and the suggested chamber are shown in figure 66.

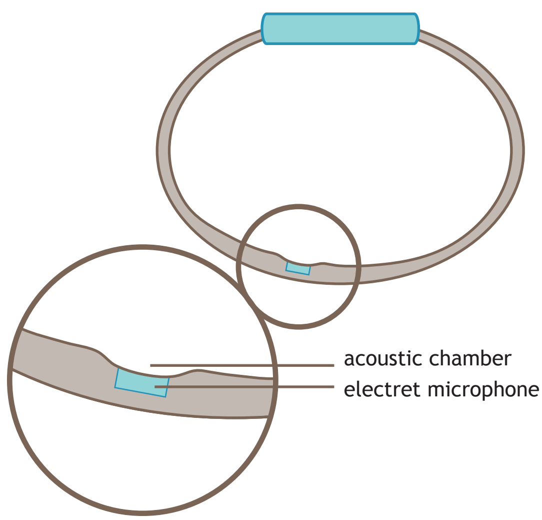


Figure 66: Cut section of the wrist watch.

5.2.2 Data interpretation

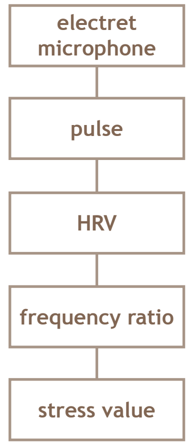


Figure 67: Steps in data interpretation.

With the pulse monitored by the electret microphone, a stress level has to be calculated. Figure 67 shows the steps in data interpretation from the microphone to a resulting score. As described in chapter 2.5 the frequencies present in the Heart Rhythm Variability are used as indicator for stress. First the pulses will have to be translated into frequencies, by measuring the beat-to-beat time. This will show the periodic changes in heart rate.

On this signal a Fourier Transform has to be calculated to see the presence of different frequencies. According to research [34, 35] the ratio between Low Frequency (LF: 0.04 – 0.15 Hz) and High Frequency (HF: 0.15 - 0.4 Hz) is the best determent of stress. Figure 68 shows two graphs: the top one shows the heart rate, the bottom graph shows the LF/HF ratio. It is clearly visible that a rise in heart rate does not lead to a higher LF/HF ratio. However, the highest peak nearly reaches 5, while research reaches scores up to 13 [34]. The algorithm will have the be tested in stressful situations to see whether it shows such high and clear peaks.

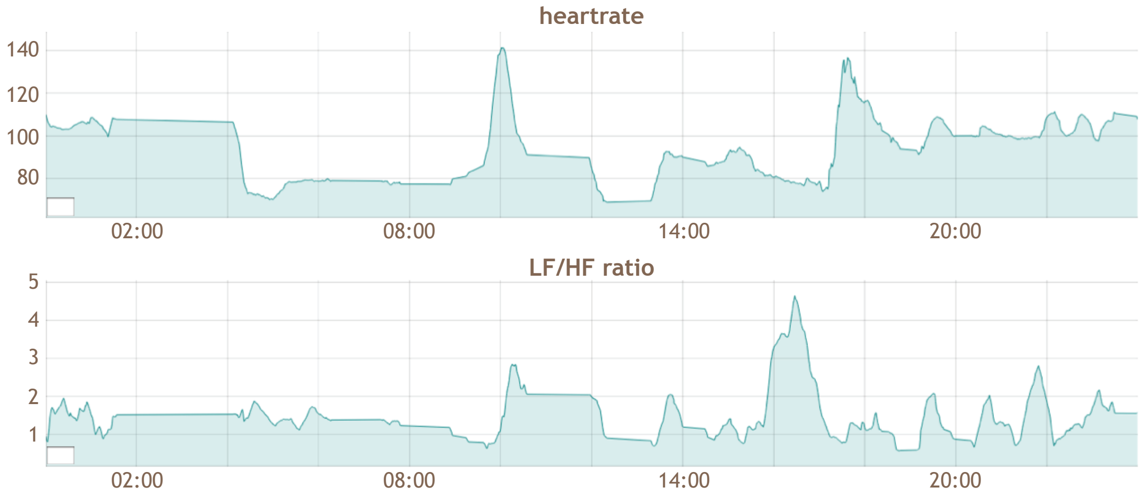


Figure 68: Graphs of heart rate and LF/HF of Heart Rhythm Variation.

Finally this stress value will have to be integrated over time, in order to monitor the stress building up. This last integration is however a step that should be studied deeper and it should probably be customizable per person.

5.3 Pebble

The pebble is the chosen concept direction for the main object in the system. The design proposal described below is based on the concept model. The appearance is maintained, the pebble is shown in figure 69, but some improvements are made in interaction and technique. The possibility for the user to check his current stress level is added, as well as the option to start a breathing exercise at any time. Some different electronical components realize a better translation from these ideas into a product.

Figure 69: The pebble.

5.3.1 Interaction

The pebble facilitates the user-product interaction at times of stress and therefore this interaction should be as simple as possible. Figure 70 shows the state transition diagram of the pebble. Below, the interaction with the user is described for the different states. Chapter 5.5 presents a scenario where the interaction is explained visually.

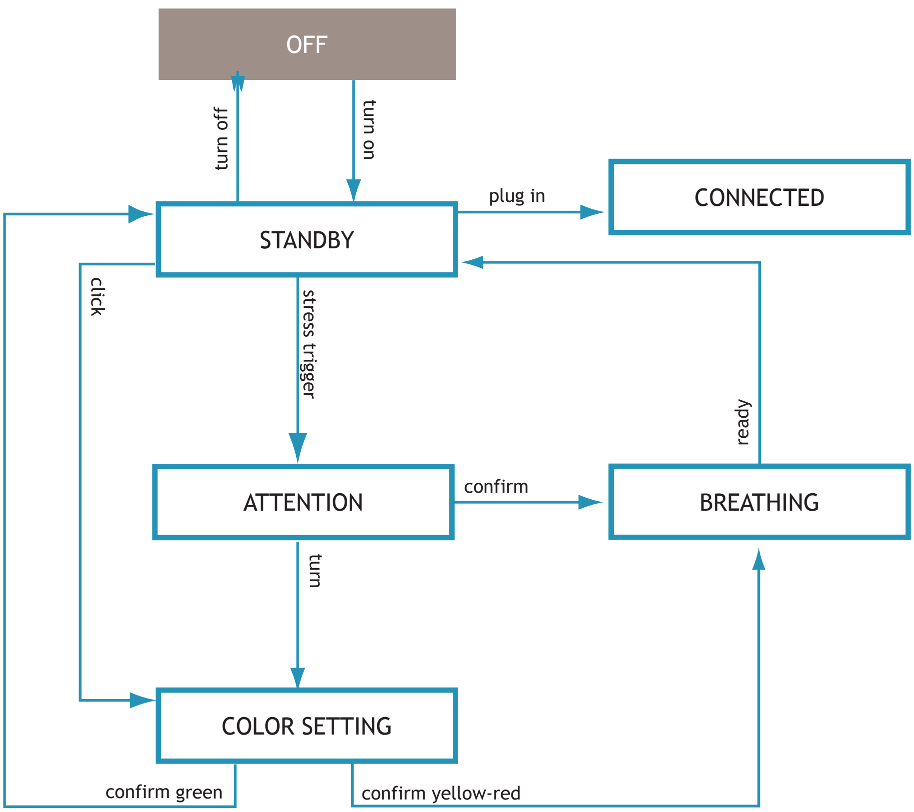


Figure 70: State transition diagram of the pebble.

When the user takes the pebble with him to work and turns it on, the pebble will stay in **standby** mode until it is triggered. In standby mode, the pebble will either display the user's stress level or remain dark, according to the user's preferences. When using in public to inform coworkers, one will turn this option on. If not, one will turn it off, to use it only in times of stress.

To get out of the standby mode, it can be triggered by the user pressing it to see his stress level, or by a signal from the wrist watch when stress is perceived.

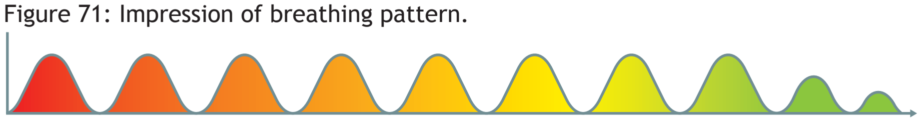
In times of stress, the first function of the pebble is to attract the user's **attention**. This will be done with a vibration signal. The pebble will give a short signal and communicate the measured stress level on the color scale. If ignored it will give another signal after some time and will continue to do so.

To communicate the stress level a scale from green to orange is used to communicate tension in an unambiguous way. The measures stress level is translated into a color on this scale. Red is not used, not even for severe stress, since this might cause unwanted negative feelings.

Then there is the possibility of **color mixing** for the user, to adjust the suggested color according to his own interpretation of his state of mind. The pebble states a color (between green and orange) as a suggestion and the user replies by either confirming or adjusting. Now the user can either turn towards green, or red. As mentioned above, the color red will not be used by the pebble itself, only the user can set this color. The user's input is saved together with the measured stress values for later reflection.

When the user confirms the stress by choosing a color other than green, the pebble will start showing a **breathing** pattern by fading the lights in and out. The pattern will start with the color set by the user and will slowly slide to green. Figure 71 shows an impression of this breathing pattern with intensity and color changing over time. The speed of this transition is dependent on the stress level measured: when the user calms down quickly, the color will slide to green quite fast; when the user stays stressed longer this will take more time. Even when the user stays stressed, the color will turn green eventually. If the color would remain red it might cause even more stress for the user, knowing that he is not able to calm himself down.

Figure 71: Impression of breathing pattern.



When the pebble is **connected** to a computer via an USB cable, the user can access his reflection website. The pebble will send the recorded data to the database and will recharge its battery.

5.3.2 Electronics

The pebble is able to display colors on the scale from green to red by means of RG-LED's (RGB-LED's without blue). The LED's used in the concept model turned out to be too weak for use in broad daylight. These 0.5 Watt LED's have a luminous intensity of 32mcd for both green and red. The four LED's used in the model spread the light neatly over the complete surface of the pebble. Therefore it is proposed to use brighter LED's: four 1 Watt LED's will probably deliver enough light. The LED's are controlled simultaneously by a microcontroller. This microcontroller creates the smooth fading in the breathing pattern.

The pebble consists of two parts that can be rotated with respect to each other. In the concept a potentiometer was used to connect the parts and measure the position of the rotation. This component implies that the position is measured absolute: when the pebble suggests a color and the user starts turning, the color changes abruptly. When a rotary encoder is used the parts can be turned indefinitely with respect to each other: the position is not measured, but rotation itself. When the pebble suggests a color, the user can adjust this by turning either left or right, to a more red or green color.

The use of a rotary encoder comes with the advantage that these often have a built in push button. This button will be used to let the user confirm his feedback. In the concept model a color is confirmed by letting it stay on the same color for 3 seconds.

An indication of the layout of the required circuit board is shown in figure 72.

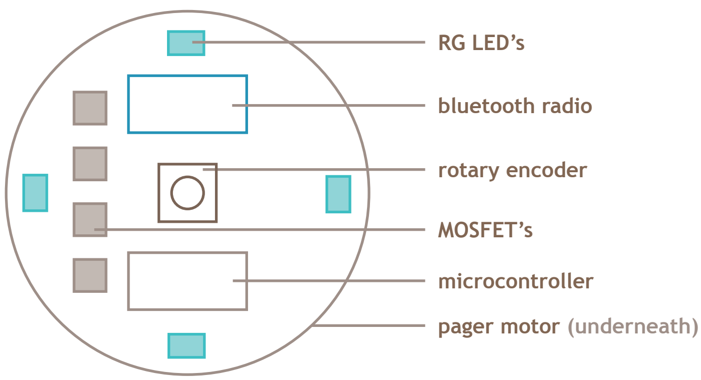


Figure 72: Circuit board with components.

5.3.3 Tactility

When making the concept model tactility was already taken into account. The choice for urethane liquid rubber was made to create a smooth but gentle surface. The hardness could be varied: a low hardness allows for fiddling and shaping the pebble, however a hardness below 90 Shore D allowed for too much flexibility. The electronics inside require a solid casing. Therefore in the model a harder shell was used for the bottom part containing the electronics and a softer shell for the top. This solution worked quite well, except that the difference between top and bottom should not be too big. Therefore it is proposed to create the shells out of two layers:: an inner layer to maintain shape and protect the electronics, the outer layer soft and slightly textured. This way the pebble will invite the user to fiddle with it even more.

5.4 Reflection website

The data from stress measurement is logged continuously. Insight in this data will stimulate the user, with help of his job coach, to reflect on these stressful situations and possibly adjust the settings to his personal preferences. An interface will display the data graphically and provide the options to adjust the product.

5.4.1 Stress data

The data collected by logging stress measurements can be visualized in different ways: the time span can be set to a day, a week or a month; specific data can be compared to averages; user feedback can be viewed. Figure 73 shows a screenshot of the data visualization.

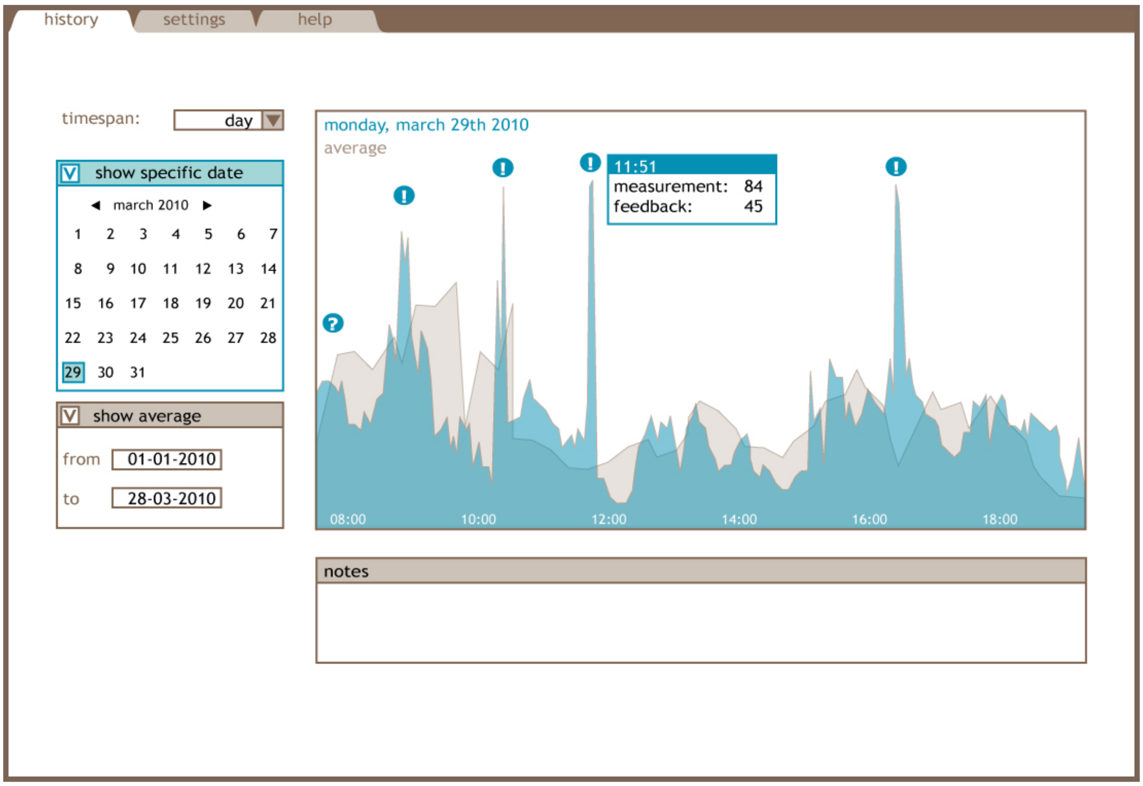


Figure 73: Visualization of stress data.

On the left side, the data to be shown can be specified. First a time span of a day, a week or a month can be chosen. Subsequently a specific date (or week/month) can be selected and/or the average value for this time span. In figure 73 both specific data and the average data are shown, in different colors, for the time span of a day. This way the user can compare this day to an average day, probably with the help of his job coach.

In the graph, on the right side of figure 73, the data is visualized and also the user feedback is visible. Every time the pebble is activated, either by an elevated stress level or the user himself, the stress level and the user's feedback are stated. The icons represent these moments: when clicked upon, a popup box shows the values.

5.4.2 Settings

Figure 74 shows a screenshot of the page where the settings for the complete system can be adjusted. First of all, the sensitivity can be set by using a slider. The response time can also be adjusted. This is the time it takes for an elevated stress level to trigger a signal. Some users might want a fast response to avoid escalation of stress; others might get annoyed by inappropriate signals at times of short arousal.

Furthermore, the settings for the pebble can be adjusted. The user can choose to use the vibration signal, the light signal or both. The vibration signal can also be adjusted to personal preferences. Finally, the options for the wearable can be set. The vibration signal can be adjusted just like that of the pebble and the response time of the wrist watch signal can be given. The user can choose to let the watch give a warning immediately (by setting a delay of 0 seconds), or only after ignoring the pebble for a number of seconds.

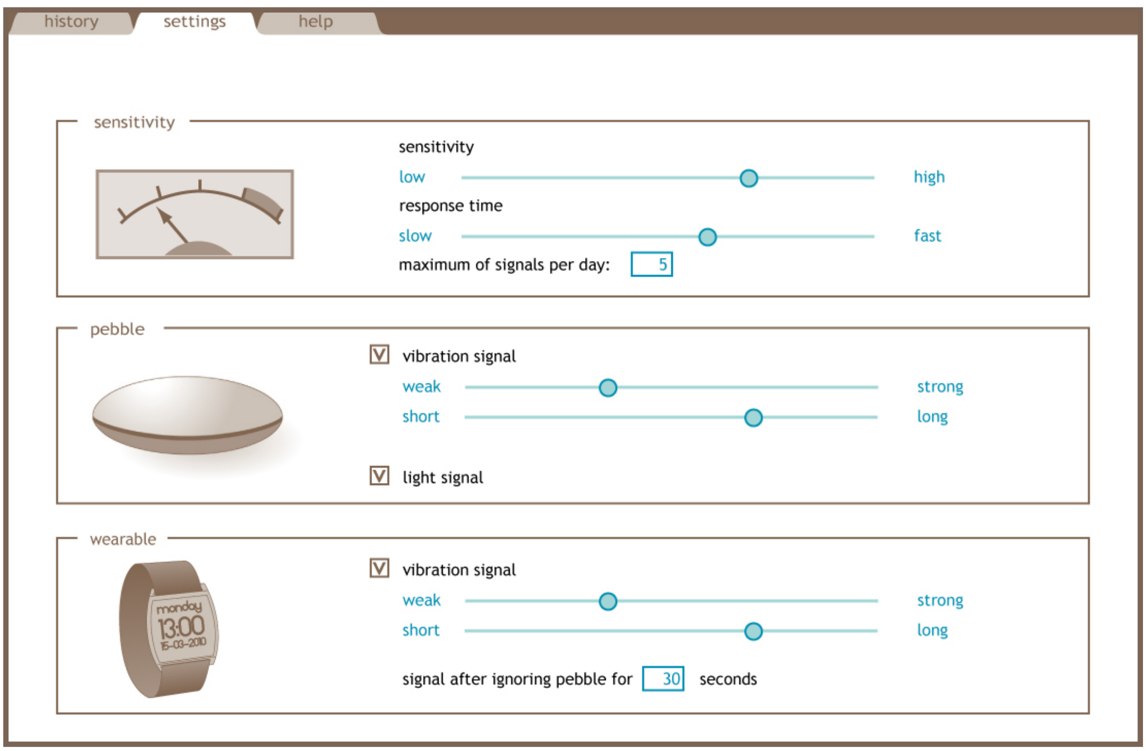


Figure 74: Interface for settings.

5.5 Scenario

A preliminary scenario was presented before, in the synthesis phase. Now that the interaction is refined and alternative behavior is accounted for, a definite scenario is presented. In figure 75, on the next pages, the interaction scenario is shown. Below, the different phases interaction phases are described in addition.

5.5.1 Wear & use

This phase covers the embedding of the product in the user's daily routines. The user will have to put on the watch every day. He will also have to take the pebble along to his work. Furthermore he needs to decide whether he will use the product publicly or privately. These options are explained below.

When he wakes up in the morning...

...he puts on his wrist watch with integrated sensor.

He puts his pebble in his pocket and leaves for work.

At his work, he starts his day by checking his e-mail and planning his tasks.

5.5.2 Tension & Stress I

This phase describes the interaction at the times when the user becomes slightly tensed or severely stressed. In the scenario two situations are shown to explain the difference between these states. In both cases the user gets a signal from the pebble. In the first case the user thinks this reminder is enough: he can work on, but keeps in mind that he should take it easy.

During the day the pile of files keeps on growing, he can't keep up!

His pebble gives a vibration signal. He takes a look and notices it is orange.

He feels he is quite okay and turns the pebble back to green.

He works along, but he is reminded to keep his head cool and just do what he can do.

Figure 75: Usage scenario presenting the user-product interaction.

Tension & Stress II

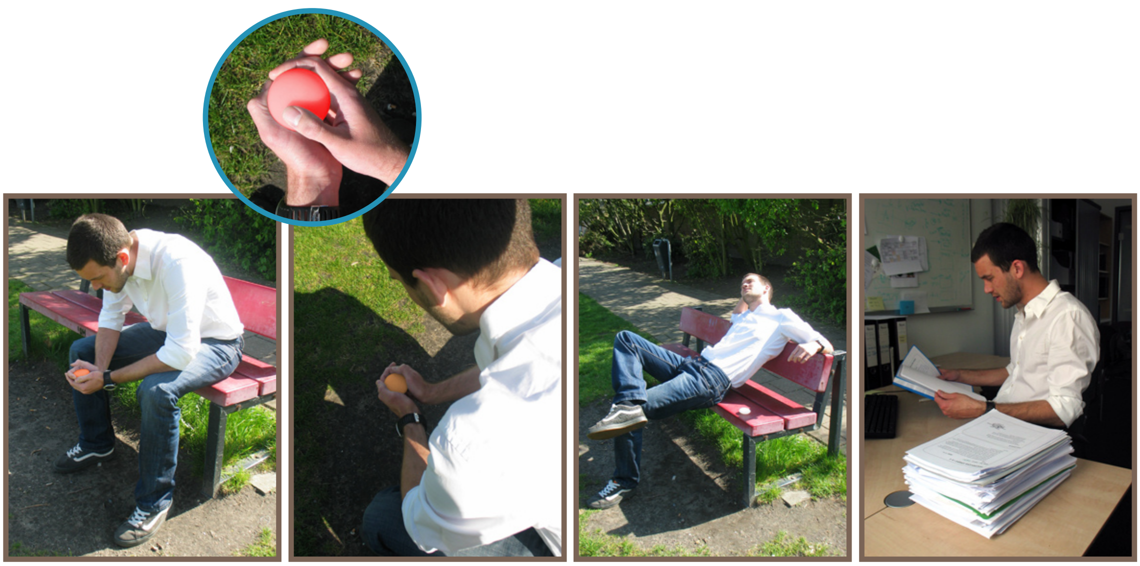
In the second case the user realizes that the stress is really disturbing him and therefore decides to do something about it. He goes outside for a moment, to do a breathing exercise with the pebble. Alternative behavior options for this phase are described under "Communicate stress level" and "Display stress level", below as well as at the end of the scenario.

Later that day one of his coworkers appears with an extra task he didn't take into account.

How to finish all this work, when he is already behind on schedule?

He decides to take a moment for himself and leaves the office.

This time the pebble gives him an deep orange color.



In the park he takes out his pebble. He is feeling stressed and turns it to red.

The pebble start glowing slowly. He follows the pattern with his respiration.

Slowly the pebble returns to green and yes: he is feeling relaxed again.

He goes back to work and makes the best of it!

5.5.3 Reflect & Adjust

The usage of the reflection website is described in this part of the scenario. The job coach visits his client at his work and together they discuss problems and progress. The recorded stress data can be used to identify specific problems and trends. Furthermore, the job coach can help his clients in adjusting the settings.

Every week his job coach visits him at work.
He plugs in the pebble.

He logs in to his personal reflection website.

Together they look at his stress levels during the week, compare with his averages and every now and then they adjust a setting to calibrate the pebble.

5.5.4 Communicate stress level

This alternative scenario part shows how the user could use the product to communicate his stress level to coworkers. Sometimes people with autism have difficulties speaking when they are severly stressed. Showing the red pebble could be a visualization of the stress one experiences. Coworkers could be involved in dealing with this stress by making agreements on how they should react.

One day when the pile of work is really disturbing him.

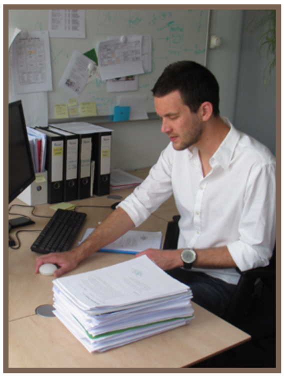
His pebble is clear: red.
He is feeling stressed.

When his coworker comes in, he shows the pebble. Due to the stress, he is not able to speak, but the coworkers knows what this means and calms him down.

Figure 75 (continued): Usage scenario presenting the user-product interaction.

5.5.5 Display stress level

This alternative is the most public way of using the pebble: the user puts it on his desk to display his stress level to everyone around him. This way his coworkers can consider his stress level when they approach him with new tasks or another request. This might be considered stigmatizing by most target users, but for others it is a good option to involve the people around them.



At work he puts his pebble on his desk to show others his state of mind.

When his coworker comes in with an extra task, the coworker notices the pebble is orange. Clearly this is not the time to introduce extra work!

He decides to leave and find someone else to do it.

6 DISCUSSION

In this part the project is evaluated and discussed. First the design proposal will be discussed, then the further development of this proposal. Finally the process within this project is discussed on personal basis.

6.1 Design proposal

In this chapter the design proposal will be discussed and assessed. Besides personal reflection, also a discussion session was held to assess the design. The overall opinion on the proposed design is positive. It is believed that it can help employees with autism in their daily work, but this should be researched before a statement on this matter can be definite. A strong point of the concept is that it is designed to function on two levels: in real-time and for hindsight reflection. In a study it will have to be explored which of these levels works best.

Expectations

Michel Vervaet indicates that the direction chosen for the design proposal is different from the idea that he, and the Leo Kannerhuis, had for the product to be designed. They had a more functional approach to the product, an approach of signaling stress and linking to the troubleshooting digital job coach.

In this report it is proposed to put an extra step in between: helping the user to relax, before attempting to solve the problem causing stress. This includes the physical method of the breathing exercise. It approaches the problem on a more abstract level, not looking at the cause, but at the physiological result. Since this choice is justified in the process, by both target users and experts, it is accepted as a good direction, despite the different expectations of the Leo Kannerhuis.

The function of the pebble is twofold: to draw attention to the stress one experiences and to comfort the user. Only the first one was explicitly asked for by the Dr. Leo Kannerhuis in the briefing, but an integral approach seemed more suitable during the project.

Pebble

The proposal of the pebble as an external object dedicated to stress awareness and reduction is still received with mixed opinions. Some think the idea of taking along the pebble when going to work might give the user a more relaxed feeling already. Others are afraid that the users might forget it at home or even lose it.

As an external object, independent from the digital job coach, the pebble might also be suitable for other target groups. Maybe people with fear or panic-disorders, or maybe even for people that just want to reduce their stress.

Fixation

There is a risk that the measurement itself could become a fixation for some users. Job coaches pointed out this possibility and Raoul Wissink from Waag Society confirms that the measurements seem like an addiction, when wearing a sensor. The possibility of getting insight in what your body is doing at any time leads to curiosity. This curiosity is probably a natural thing and not a problem at first, but when this becomes a long term problem for the user, the option to see one's mood at any time should be reconsidered.

Breathing

The effect of the breathing exercise on the stress level of the user and his functioning will have to be studied. The participants of the evaluation session indicated that they have no experience with such exercises, but are willing to give it a try.

A little tweak might be to make the speed of the breathing pattern adjustable. Now the speed is based on a consensus on optimal diaphragmatic breathing. For a beginner it might however be too difficult to start off with this breathing pattern, especially when he is stressed.

Self reflection

The possibility to change the pebble's color, the stress level displayed, will have to prove itself in further research. Although most participating target users and job coaches think it is reasonable to ask one to indicate his stress level, some doubt the appropriateness. It might however be a simple way to stimulate the user to reflect on his own feelings.

Intuitive interaction

The interaction between the user and the pebble is kept very simple on purpose: a user with stress acts on intuition and basic behavior patterns. Still there might be an option to reduce the subsequent steps in the interaction. The design as proposed requires the user to confirm a stress level, before it continues with a breathing pattern. It could be considered to make this reflection a more 'voluntary' action. This would mean that the pebble should display a breathing pattern right away, based on the calculated stress level. The user would have the option to adjust the stress level during this breathing pattern, but only if he wants to.

Stress algorithms

One thing still left to define is how the user's feedback is to be processed in the calculation of the stress level. Not only the real-time stress measurements and a time factor should influence this level, but also previous user feedback.
When the product suggests that the user is stress and the user denies this by turning it back to green, the stress level should be composed from both objective measurements and subjective user input.

Furthermore, the user input can be used to improve the algorithms that calculate the stress level. This could be done in two ways: real-time personally or afterwards in general. The first way would require some artificial intelligence in the algorithms. They would have to adapt the way of calculating the stress level in such a way that it fits better with the user's self-reflection. The other option is to log all data (anonymously) and rewrite the algorithm for a product update.

6.2 Development

The end of this graduation project is not the end of the project itself. Waag Society will continue by building a functioning prototype to test in a pilot experiment. Based on the results of this pilot it could be decided to develop a product for serial production. Below some aspects of this further development are discussed and some suggestions are formulated.

Chest band

Instead of integrating a sensor in a wrist watch, Waag Society will work with an open source chest band, shown in figure 76. This band transmits heartbeat data wireless via Bluetooth. The choice for this chest belt is made out of practical reasons: it is commercially available, affordable and does not require technical development on the sensor side of the product. Since the prototyping and the following pilot study are meant to test the hypothesis that such a product can help employees with autism, it would be excessive to develop dedicated, complex hardware at this stage.

Figure 76: Zephyr HxM chest band.

Eventually in a future redesign of the product it might be possible to use a wrist watch with sensor. Probably an open source product like the Zephyr chest band will become available. As long as Bluetooth is the standard for wireless communication it will not be a problem to implement different or multiple sensors in the system.

Pebble

Waag Society will build a functional prototype of the proposed design for the pebble. Some considerations might change details in the design, but the pebble is accepted as a good solution to the design problem.

It is not yet decided whether the pebble prototypes for the pilot study will be wireless. Development of a wireless pebble would take more time, due to the extra electronics that would have to be fitted into the small pebble, especially the battery. The question to be asked is about the benefits: will a wire between the pebble and a controller unit influence the pilot study in such a way that the results are not reliable?

Virtual pebble

The pilot study with the functioning prototypes will have to prove the effectiveness of the product. In order to increase the relevance of the results, the study will be set up with two versions of the pebble: the physical one, described in this report and a virtual one. This one was considered in this project as well, but it was regarded as less appropriate. For a research setup however, it is very interesting to see how the two versions differ from each other.

The virtual pebble is a translation of the chosen concept into a phone application, in order to satisfy the target users that might find the physical object stigmatizing. Below, some aspects of a virtual pebble are discussed.

Stress level

Just like the physical pebble, the virtual version will suggest a color as an indication of the stress level and ask the user to confirm or adjust this. A possible way to ask the user for feedback on the measured stress level is shown in figure 77. The user can slide the ring over the screen to select a color and tap to confirm.

Figure 77: Determination of color as indication for the stress level.

Breathing exercise

The main part of this application remains the guiding of relaxed breathing. The same principle is used as in the physical pebble, but the phone screen offers more options in visualizing. The pattern of breathing in and out is guided by a circle growing and shrinking, as shown in figure 78. This is a metaphor for lungs expanding and contracting and thereby probably easy to follow.

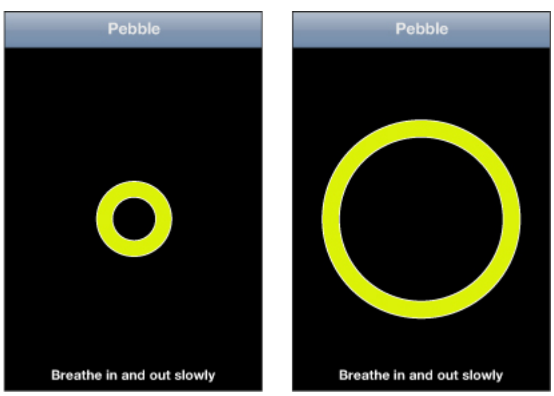


Figure 78: Visualization of relaxed breathing, the circle grows and shrinks rhythmically.

Reflection website

A database will have to be built to store the measurement and feedback data. The data from the pilot study sessions will have to be analyzed to look for possible improvements of the algorithm. Furthermore, an interface will have to be developed to make this data accessible and visual in a clear way.

This data will have to be discussed with the pilot study participants in order to identify possible differences between measurements and the user's experience. It will also be interesting to discuss the data with job coaches. They might have suggestions on how to improve accessibility or visualization of the data in order to make it more useful for their coaching sessions.

6.3 Process

This chapter contains a personal reflection and discussion on the process of this graduation project.

Initiation

As a graduation intern I was welcomed enthusiastically in the project team. The start of the graduation project was at the very beginning of the project for Waag Society as well, which meant I had the possibility to be present in the initiation sessions with the briefing, where expectations were discussed. This was a very valuable and inspiring starting point for the project.

Exploration

After the start of the project I was free to start exploring the subject in a way that I found appropriate. Clients of the Leo Kannerhuis and experts in various fields were involved which made it very interesting. I learned a lot speaking with so many different people. Applying context mapping techniques was new to me, but with the help of Helma and some extra lectures I think this went really well. After the exploration the boundaries for the product to be designed were quite clear.

Synthesis

The synthesis started slowly with sketching product ideas and possible interaction scenarios. The boundary conditions described earlier made it hard to come up with suitable ideas. Therefore the brainstorm session was really valuable, delivering 'out-of-the-box' ideas to solve the design problem. Another issue found in this phase was the complexity of designing a system instead of a single product. The decision to focus on one of the system parts made it easier to develop a strong concept.

At this stage it also became clear that the project would be delayed due to contractual negotiations. The project team at Waag Society would not develop a prototype in the scope of my graduation project. Therefore it was decided to make an experiential model instead. This felt like a pity at first, but the modeling turned out to be very interesting nonetheless.

Evaluation

The evaluation of the concepts with target users and experts was valuable, but it was regrettable that it could not be done with a functioning prototype. The models were discussed with both target users and experts, but there was no link to stress measurements. The evaluation was only meant to differentiate between different concept directions. Therefore the question still remained whether such a product could be effective.

Detailing

The detailing phase was most chaotic. The goal was to propose a design for the system parts, but not to build any models or prototypes. Therefore it sometimes felt more like formulating recommendations for further development. I hope however that the design proposal presents a clear description of what this product should be like. I think the scenario might be an informative and inspiring summary.

Finally

I would like to say that it has been a very interesting project to me. I enjoyed and learned a lot from working with a lot of different people. It has been challenging, mainly because it is by far the biggest individual project I have worked on. However, with the help and support from all this people I think it came to a good end.

Looking back, I think the process was suitable for the project. However, with the decision to focus on informing the user and helping him relax, the research into the physiology of stress and the technical possibilities for sensors was a bit too extensive. The time put into this research could have been more useful spent on usage aspects.

References

[1] Sleeswijk Visser et al., Contextmapping; Experiences from Practice. CoDesign Vol. 1, No. 2, June 2005.

[2] Stappers, P.J. and Sanders, E.B.N., Generative tools for context mapping: tuning the tools. Design and Emotion: The Experience of Everyday Things. 2003, Taylor and Francis, London

[3] Happé, Autism; an introduction to psychological theory. Harvard University Press 1994

[4] American Psychiatric Association. (2000). Pervasive developmental disorders. In Diagnostic and statistical manual of mental disorders (Fourth edition-text revision (DSM-IV-TR). Washington, DC: American Psychiatric Association, 69-70.

[5] Wikipedia, Autism. http://en.wikipedia.org/w/index.php?title=Autism&oldid=315370240 22/09/2009

[6] Edrisi & Eurelings-Bontekoe, Begaafd doch beperkt. Wetenschappelijk Tijdschrift Autisme. 8e jaargangnummer 2, augustus 2009

[7] Jansen, Autisme, Competentiebeleving en Probleemgedrag. Graduation paper, University of Leiden Augustus 2008.

[8] Dijkxhoorn, Onbegrepen: Gedragsproblemen bij mensen met autism. From: Autisme in orthopedagogisch perspectief 2007.

[9] Pruim, Autisme arbeid en kwaliteit van leven. Graduation paper, University of Leiden October 2008.

[10] KIRA(2005) Arbeidstoeleiding voor mensen met autisme. Uitgave Equal project KIRA.

[11] [Schalock, Bonham & Marchand. Consumer based quality of life assessment: a path model of perceived satisfaction. Evaluation and Program Planning, 2002.

[12] Seyle, The Stress of Life. New York: McGraw-Hill, 1956.

[13] Wikipedia, Stress. http://en.wikipedia.org/wiki/Stress_(biology)

[14] Seaward, Managing Stress: Principles and Strategies for Health and Well-Being (fifth edition). Jones and Bartlett, 2006 Ch. 2: Physiology of Stress

[15] Berntson & Cacioppo. Heart Rate Variability: Stress and Psychiatric Conditions. Dynamic Electrocardiography, chapter 7. Blackwell Publishing, 2004

[16] David G. Myers, Diagram of General Adaptation System, Exploring Psychology 7th ed. (Worth) page 398.

[17] Seaward, Managing Stress: Principles and Strategies for Health and Well-Being (fifth edition). Jones and Bartlett, 2006 Ch. 2: Physiology of Stress.

[18] Jansen, Gispen-de Wied, Wiegant, Westenberg, Lahuis & van Engeland. Autonomic and Neuroendocrine Responses to a Psychosocial Stressor in Adults with Autistic Spectrum Disorder. Journal of Autism and Developmental

Disorders, Volume 36, Number 7, October 2006.

[19] Corbett, Mendoza, Abdullah, Wegelin, Levine, Cortisol circadian rhythms and response to stress in children with autism. Psychoneuroendocrinology, Volume 31, Issue 1, January 2006, Pages 59-68

[20] Curin, Terzic, Petkovic, Zekan, Marinovic Terzic, Marasovic Susnjara: Lower Cortisol and Higher ACTH Levels in Individuals with Autism. Journal of Autism and Developmental Disorders, Vol. 33, No. 4, August 2003

[21] Wikipedia, Stress management. http://en.wikipedia.org/wiki/Stress_management

[22] Merriam-Webster's Medical Dictionary. biofeedback. (n.d.). 29/09/09 Dictionary.com http://dictionary.reference.com/browse/biofeedback

[23] Wikipedia, Meditation. http://en.wikipedia.org/wiki/Meditation

[24] ElettroEncefaloGrafia, Natural Stress Relieve http://www.eeg.it/eeg/anxiety-nsr.php

[25] Wikipedia, Fractional relaxation. http://en.wikipedia.org/wiki/Fractional_relaxation

[26] Wikipedia, Progressive relaxation. http://en.wikipedia.org/wiki/Progressive_relaxation

[27] Wikipedia, Autogenic training. http://en.wikipedia.org/wiki/Autogenic_training

[28] Wikipedia, Deep breathing. http://en.wikipedia.org/wiki/Deep_breathing

[29] Wikipedia, Electrocardiography. http://en.wikipedia.org/wiki/Electrocardiography

[30] Dimensionengineering, accelerometers. http://www.dimensionengineering.com/accelerometers.htm

[31] IPhonestalk, hear monitor. www.iphonestalk.com/images/heartmonitor1.jpg

[32] Lee, Jung, Lee, Jeong, Cho, Yoo. Wearable ECG Monitoring System Using Conductive fabric and Active Electrodes. Proceedings of the 13th International Conference on Human-Computer Interaction. Part III: Ubiquitous and Intelligent Interaction, 2009.

[33] Gever Tulley, http://www.ted.com/talks/lang/eng/gever_tulley_s_tinkering_school_in_action.html, 2009

[34] Pagani M, Mazzuero G, Ferrari A, Liberati D, Cerutti S, Vaitl D, Tavazzi L, Malliani A. Sympathovagal interaction during mental stress. A study using spectral analysis of heart rate variability in healthy control subjects and patients with a prior myocardial infarction. Istituto Richerche Cardiovascular, CNR, Milan, Italy. Circulation. 1991

[35] George B. Moody, Frequency Domain Measures:The Fourier Transform, the Lomb Periodogram, and Other Methods MIT 2006 – Boston.

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These appendices can be found on the CD-rom enclosed with this report, or via: www.joostvanhoevelaak.nl/graduation