



Flowy

Designing an assistive wearable technology for children with AD(H)D that increases attention in class

November 2018

Master Thesis
Strategic Product Design

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Designing an assistive wearable technology for children with AD(H)D that increases attention in class.

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Graduation project by:

Jesper Riche Voorendt
4154002

BSc. Technology, Policy and Management
MSc. Strategic Product Design

Supervised by:

Prof. ir. Jos Oberdorf | Chair
Industrial Design Engineering

PhD. ir. Jacky Bourgeois | Mentor
IDE - Internet of Things Section

Delft University of Technology

Harm Hogenbirk | Company mentor
Partner & CEO

Pilotfish Nederland BV

Executive summary

Attention Deficit (Hyperactivity) Disorder, AD(H)D is the most diagnosed disorder among children. Children with AD(H)D find it difficult to pay attention when needed, tolerate boring situations, reining impulses, transitioning from a fun activity and controlling their behavior. Their highly demanding behavior often leads to negative reactions, which damages the child's confidence and lead to more severe problems in later life. Good treatment during childhood can prevent the child from experiencing more severe issues in later life.

Medication treatment

Pharmaceutical treatment is the most common treatment for AD(H)D. Medication such as methylphenidate makes the child quieter, less hyperactive, and meet the constraints of our school systems. Although medications improve behavior on the short term, still a correlation with grade improvements has not been found. Additionally, more criticism has risen from researchers and therapists; medication come with many negative side effects such as insomnia, headaches and low appetite, and are ineffective for more than 20% of the users. In addition, researchers are concerned about the long-term effects of medications on the mental and physical development of children.

Since there is criticism on the high use of medications, popularity of alternative treatments has increased. For example, behavioral treatment comes without negative side effects, and has been proven to be effective on the long-term. A study shows that young scholars who have had behavioral treatment go through a more successful academic career, compared to students who have had medications.

Design challenge

However, behavioral treatment is often expensive and inaccessible; it requires expertise and effort from parents and the child. Therefore, there is a need for a more accessible and affordable ways to deal with AD(H)D, which is an opportunity for Pilotfish to contribute. Pilotfish has expertise in medical design and development of internet of thing (IoT), and shares the vision that wearable technologies could make treatment for AD(H)D more intelligent, accessible and affordable. Therefore, this project researches new technologies and market trends to come up with a proof of concept that supports children with AD(H)D.

Inattention is a core problem for children with AD(H)D, it leads to underachievement at school and much negative reinforcement, which damages the child's self-esteem. Finding a way to support a child to focus better early in childhood, can prevent a negative loop in the school career. Therefore, the design challenge is formulated as:

“How to design a wearable technology that increases the attention span of children with AD(H)D?”

Sub-questions

Looking into existing wearable technologies that increase attention, led to three products offering tactile stimulation in different ways. One uses vibrations as a reminder, another

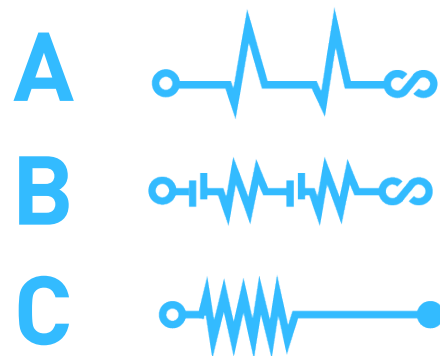


Figure 0.1 Different type of vibration patterns tested in prototyping

one gives rhythmic vibrations like a 'lub-dub' of a heartbeat to alter the brain's state, and another one gives vibrations for 30 seconds to relax when activated. All three claim to increase concentration, but do it differently. Using this technology for children raised two questions:

- **Which vibration pattern is most desirable among children with AD(H)D?**
- **How to use and increase the effect of vibrations on the attention span of children with AD(H)D?**

Method

These two questions have been answered through qualitative research. Prototyping has been used to gather user data, and to encourage discussions. Each pattern has been implemented in a prototype and tested among six children and six older participants with AD(H)D or strong symptoms of inattentiveness.

Among the group of older users, four experts have tested the prototypes. Interviews with prototypes resulted in theories about the mechanism behind the vibrations and how usage could be optimized.

Results

All users preferred either the heartbeat vibration or the reminding vibration while doing activities that required concentration. The heartbeat pattern was more calming, but also had a reminding functionality such as the slower vibration pattern. One of the older users described it as: "The vibrating wristband acted as a reminder to stay focused. The vibrations made me aware of when my mind started to wander off, therefore acting as a trigger to put my focus back where I wanted it". Children described the vibrations as: "It is nice because it is calming" or "It kept me aware of the work I had to do".

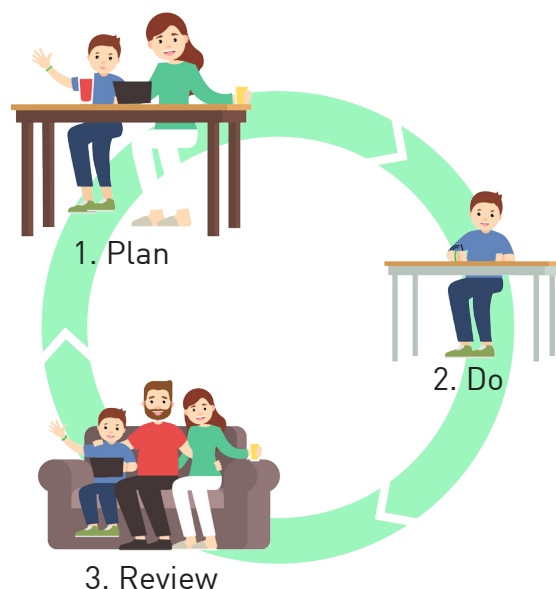


Figure 0.2 Plan - do - review cycle

Reactions of participants showed that both patterns types have a reminding effect, and users had strong personal preferences. Therefore, it is suggested to give users control on the speed of vibrations patterns, and as well intensity of each vibrations. In addition, some of the test users described the high probability that they would forget the device when going to school, so the band should be easy to wear and hard to forget.

Therapists suggested a plan – do – review cycle (figure 0.2) to enhance the learning effect. This can explain clearly what behavioral interventions could be supported by the vibrations and strengthen the learning effect.

Thinking of behavioral goal before using vibration can strengthen the effect, as well as reflecting on the session. For example, asking yourself, "how did it go?" increases the learning effects according to two psychologists in the interview.



Figure 0.3 Flowy wearable Lion

Concept

The findings from prototyping and interviews have been translated into a new product concept. In short, the new product concept is called Flowy and is assistive activity tracker for children with AD(H)D to study better, using silent tactile stimulations to alter the brain's state, which increases concentration and empowers behavioral training."

Flowy is unique because of two core elements. First, it is designed for children, like a buddy. Secondly, Flowy gives children ownership of self-regulation, because it let children create own vibration patterns for activities that require focus. This is realized by providing an app that brings the 'buddy' alive through animations, explains self-regulation techniques and involves parents to monitor the process to create a positive reinforcement within the family.

Concept details

The wristband is detachable which allows it to offer the band in multiple styles that are interesting for different age groups. Most of the styles are cartoons, to make the child bond with the wearable. The wristband is like a buddy for the child, because it reminds and motivates the child to adjust behavior during the day. The child can activate 'focus sessions', which vibrate in a specific pattern that reminds of planned intentions. Lastly, the design is robust and water resistant to survive all child's play.



Figure 0.4 Flowy wearable Lion on charger

Parents are updated about the progress of the child, to be able to reward to help the child after school. The band is an activity tracker that measures movement data, which can be used for activity/focus monitoring, sports and other research purposes in future.

Future work

The design and development of the concept requires further work and research. It needs expertise from psychologist to design a behavioral therapy program around the wearable and neurologist should look further into the effect of the rhythmic vibrations on the brain.

Future steps will be extending the use of collected data. For example, recognizing inattention from activity data. Newer versions could be equipped with other sensors such as a heartrate sensor or electro dermal activity.

Conclusion

In conclusion, Flowy is a comfortable tactile stimulation wearable that connects with the child, and can enhance behavioral training in daily life by giving the child ownership of behavioral regulation.

Further development needs expertise from multiple different areas, but Pilotfish can take a leading role in development of this product. In this way, Pilotfish can provide a better alternative to medications and learn children how to deal with their AD(H)D in a natural way.

Abbreviations

ADD	Attention Deficit Disorder
AD(H)D	Attention Deficit Hyperactivity Disorder
ASD	Autism Spectrum Disorder
CBT	Cognitive Behavioral Therapy
DSM	Diagnostic and Statistic manual
HR	Heart rate
ODD	Oppositional Defiant Disorder

Glossary

Cognitive behavioral therapy	A type of psychotherapy in which negative patterns of thought about the self and the world are challenged in order to alter unwanted behaviour patterns or treat mental disorders.
Etiology	The cause, set of causes, or manner of causation of a disease or condition.
Prevalence	The proportion of a particular population found to be affected by a medical condition.
Psycho-education	Providing people being treated for mental conditions with information about the causes, symptoms, prognosis, and treatments of their diagnosed condition.
Stimulant	A substance that raises levels of physiological or nervous activity in the body.
Tactile	Of or connected with the sense of touch.

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Introduction

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Context

AD(H)D

Attention Deficit Hyperactivity Disorder (AD(H)D) is the most diagnosed mental disorder of children (Rowland et al. 2002). AD(H)D is a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with daily functioning and development. For example, children with AD(H)D find it difficult to pay attention when needed, tolerate boring situations, reining impulses, transitioning from a fun activity and controlling their activity.

In the latest decades, the number of people diagnosed with AD(H)D has risen. On average over 11% of the children in the US are diagnosed with AD(H)D. In 2003 this was 7.8%, and increased by 43% in 8 years (CDC, 2018). Compared to other countries the prevalence in the US is very high, because according to a meta-analysis in 2014 (Polanczyk et al.) the prevalence of AD(H)D is around 5-8% worldwide.

The amount of diagnosis is culturally and geographically different. Evidently, there is already much variation between states in America. Figure 1.1 shows the amount

of people diagnosed in the US by each state, the wide variety indicates that AD(H)D can be over-diagnosed. A reason why this can happen is hard to define, but how we perceive the pain of AD(H)D has certainly effect (Luman, 2018), and makes it culture dependent.

Eventually, everyone has symptoms of AD(H)D more or less. Officially being diagnosed with AD(H)D, means that you have more than 6 out of 9 symptoms, for adults this is 5 out of 9. Everyone can experience symptoms of AD(H)D, only the most severe group is diagnosed with AD(H)D. This shows that a larger group deals with the difficulties of AD(H)D, such as missing focus, feeling restless or behaving too impulsive.

There are three main symptoms of AD(H)D; inattention, impulsivity and hyperactivity. All three symptoms can lead to problems in daily life, such as; unstable relationships, poor work or school performance and a low self-esteem.

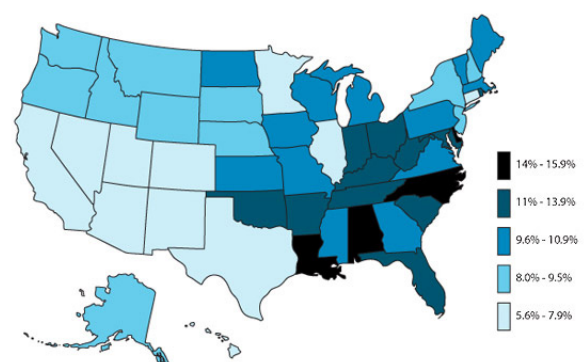


Figure 1.1 Percent of Youth 4-17 ever Diagnosed with AD(H)D by state: National Survey of Children's Health, 2007

ATTENTION!

According to a recent statistical research of Sokolova et al. (2016), inattentiveness is a core driver for the other hyperactivity and impulsivity. Additionally, the average attention span of people is getting less. Research shows, that in 2012 people spent time on one computer screen was one minute and 15 seconds on average. Two years later it was an average of 59.5 seconds (~BBC., 2015~). This indicates that people have less focus nowadays, and one of the suggested causes is media technology.

It is easy to spent all your time on your phone or tablet. Also, these technologies make it easy to start multi-tasking, which is negative for your focus. Another research (Mark et al. 2016) found that the average duration on one task is around 40 seconds. We are constantly disturbed by these technologies, and you need discipline to manage all these distractions.

Especially people with AD(H)D find it difficult to focus, and to control their impulses, such as checking their phone. They often do multiple things at the same time and rarely complete their tasks. The inability to focus

on one task can lead to negative attention, which damages the child's self-esteem. This is a negative feedback loop, which is hard to break.

In conclusion, attention is a limited resource, and we should try better to control it ourselves. The strength of attention span at a young age can predict academic performance. The attention span persistence of children at age 4 was an important predictor of later math and reading skills at age 21 and the change of completing college by age 25 (McClelland et al., 2013). Charles Dickens once said, "I never could have done what I have done without the habit to concentrate myself on one subject at a time".

"I never could have done what I have done without the habit to concentrate myself on one subject at a time"

- Charles Dickens

Products

Besides all the research on medications for AD(H)D, there is also much to read about alternatives that help people managing symptoms of AD(H)D. Two articles are selected to give a short summary of work in this field.

First, Sonne et al. (2015) did an explorative research to find possible solutions with real-time assistive technologies. They defined three core components, sense, recognize and assist. Also, intervention with smartphones could potentially assist a child with AD(H)D.

Second, Shih et al. (2014) show how activity trackers can be used to detect events when a child stand up in class, and remind to sit back again when it's not allowed.

Some technologies are available on the market that help people focus more. First, concentration music is a popular and widely available way of getting more focus at work and school.



Figure 1.2 Octopus Watch by Joy Familytech

But more technological advanced is the Octopus watch. This is an American startup [7], that creates smart watches that help kids to learn good habits and the concept of time. Parents can manage the schedule of the kids with an app. Another product, that use of neuroscience is Buzzies. Buzzies are non-invasive lifestyle wearables that use neuroscientific technology to relieve stress.

A product that is improving focus is Senseez (figure 1.3). Senseez offers vibrating pillows that to ease senses to concentrate better.

The number of researches on wearables that help cognitive thinking processes is increasing and multiple businesses developing new products for this people with AD(H)D. These trends point out a growing interested in using technology as a supportive tool for people with AD(H)D, and for people who want to improve their focus.

This projec continues into this direction, by creating a technology that helps kids to focus on what they do, that helps them to better understand how their attention span works.



Figure 1.3 A Senseez cushion

Assignment

Academic relevance

This research has academic relevance, because it builds further upon recommendations of multiple studies that tested assistive wearables for AD(H)D (Shih et al, 2014, Sonne et al, 2016,, Flobak et al, 2018) or non-invasive stimulations (Powel et al, 2017). These articles recommend continue developing wearable technologies for children with AD(H)D, because it gives promising results. Also, some design areas and challenges have been recommended (Sonne et al., 2015 & Benyakorn 2016), which are described in the 'literature review' section.

Based on the recommendations of the articles above, research findings and existing are reviewed through prototyping.

Pilotfish BV

Pilotfish is a design consultancy located in Amsterdam, Munich, Berlin and Taipei. Pilotfish is specialized in UX design for automotive and healthcare, and experiences in new product development projects.

Harm Hogenbirk, CEO and partner of Pilotfish has shown interest in exploring new product development opportunities for children with AD(H)D. Therefore, the goal of this project is to end with a new product or service value that meets the strengths and capacities of Pilotfish.

The final result of this project should be ready to build further upon. A specific target market and technology should be selected, including a vision that is future proof. The vision could be supported with an roadmap that gives an overview of trends, and next steps.

Approach

Project scope

This project consists of three phases. First, the research phase, this aims to map out the current situation of AD(H)D worldwide and products that are available or under development. At the end of the research phase, key findings are presented in the 'Synthesis', which leads to a design challenge and design goal for the rest of the project.

In phase two, 'build, test & learn, the goal is to gather information from user tests with prototypes. Multiple versions will be tested, each version will be improved by using findings from previous tests.

Phase three 'conceptualization', findings from prototyping and user interviews will be translated into one concept. The concept includes; a system design, implementation plan and a roadmap.

The total duration of the project is 24 weeks. This is longer than the standard period of 20 weeks, because I will work 8 hours a week on a part-time job at Pilotfish. Hence, each week has 34 hours scheduled on the graduation project.

Project goal

The goal of this project is to increase the attention span of children with AD(H)D, to make them perform better at school, which results into more self-confidence.

This will be pursued by exploring wearable technologies, because wearable technologies are increasingly being used for health purposes. For example, Fitbit and Apple have released multiple health features in their newest smartwatches, such as improved health and sleep tracking. Wearable devices can contain multiple sensors that are worn many hours each day, which generates a lot of useful data for health purposes.

The project goal is to deliver a proof of concept that can be used in the classroom, and is formulated as:

Develop a new wearable as a proof of concept that increases the attention span of children with AD(H)D.

Research

17	Literature review
24	Market research
29	User study

Literature review

About AD(H)D

Symptoms

Attention Deficit (Hyperactivity) Disorder, AD(H)D have been characterized by the same symptoms for decades. These symptoms are; hyperactivity, impulsivity and inattention, which have significantly impact on many aspects of behavior and performance, at school and at home (Faraone et al., 2003).

Hyperactivity means a person seems to move constantly, also in situations in which it is not appropriate. This may be less observable in adulthood, then it may be more like extreme inner restlessness or tiring others with constant activity.

Impulsivity means a person makes hasty actions without thinking first about the possible consequences. Impulsive people may be socially intrusive, interrupt others excessively, and make important decisions without considering the long-term consequences.

Inattention means a person wanders off task, has difficulty sustaining focus, and is disorganized; and these problems are not due to defiance or lack of motivation.

Type of disorder

In the latest decennia, AD(H)D is recognized as a brain disorder, before it was seen as a behavioral disorder. Neurologists have proven that certain areas in the AD(H)D brain are underdeveloped. These areas are responsible for executive functioning. However, the causes, mechanisms of the disorder and the nature of the atypical brain

development underlying, remains poorly understood (Konrad & Eickhoff, 2010).

Behavioral experiments confirm differences between normal developed children and children with AD(H)D. Research by Marco et al. (2009) suggests that AD(H)D children are unwilling to delay their need for gratification. When given a choice between a small immediate reward and a large delayed reward, AD(H)D children chose immediate reward but only when this led to shorter total task duration irrespective of the amount of reward available. When trial length was paced by the experimenter, AD(H)D children waited for the larger delayed reward.

Main challenges

As a behavioral disorder, the symptoms of AD(H)D lead to many challenges in daily life. A review article by Sonne et al. (2016) categorized these:

A. Social disability

e.g., poor peer and family relationships, poor social skills.

B. Academic and occupational failure

e.g., underachievement, special education needs.

C. Health problems and psychiatric comorbidities

e.g., disruptive behaviors, executive dysfunction, sleep disorders.

D. Psychological dysfunction:

e.g., Emotional dysregulation, lack of motivation.

E. Risky behaviors

e.g., accidents, injuries, and unplanned pregnancies.

Diagnosis

Culture differences

How we see and treat AD(H)D is culture dependent. Latest numbers show that 9-11% of children in the United States is diagnosed with AD(H)D (Froelich et al., 2007 & Danielson et al. 2018), which is high compared to France's prevalence of 3.5% (Lecendreux, 2011). Here are three explanations how this is possible. First, when France doctors see symptoms of AD(H)D, they initially consider it as a problem with the parents or teachers. Second, in France AD(H)D is treated by offering a child structure to increase security and feelings of acceptance. At last, and the most important reason according to Lecendreux (2015); is that AD(H)D is clinically invisible in France, "It's just not very well understood, nor is it very well-diagnosed, nor well-treated."

Though, the number of people with AD(H)D in the US is an exceptional high number compared to the worldwide prevalence average of around 5% (Polanczyk et al., 2014). Evidently, there is certainly some evidence that AD(H)D is over diagnosed in some parts of the United States (Elisson K., 2015). For example, a growth of 15% was detected in 2006 - 2008, with an additional 1.8 million US children with AD(H)D cases, which could lead to a portion of patients that are misdiagnosed as well as an imminent increase in diagnoses. (Pérez, 2012)

Rise of abuse medication

Next to the increase of prevalence of ADHD worldwide, abuse of AD(H)D medication is rising along with prescriptions (Setlik, 2009). Students and young professionals are increasingly misusing AD(H)D medication for better performance at work and study. A more demanding society could be one of the reasons for the increasing abuse of stimulants.

Diagnosis guidelines

Health care providers, such as child psychologist and psychiatrists can diagnose AD(H)D with the help of the standard DSM guidelines (American Psychiatric Association, 1994). A diagnosis involves collecting information from several sources, teachers, caregivers, and parents, to check if symptoms are present in multiple settings. In addition, symptoms of AD(H)D must be occurring on a regular basis for more than six months, and also must have been present during early childhood.

Diagnosis technologies

A research shows that movement data from activity trackers can be used for diagnosing AD(H)D among children. Kam et al. (2010) tested school children wearing a watch like sensor to diagnose AD(H)D, in parallel with professional practitioners diagnosing the children. Results showed that activity data from wearing smart watches for only several hours, could be used to screen patients on AD(H)D symptoms effectively.

Treatments

Seperation

Treatment of AD(H)D has two main components; behavioral and pharmaceutical treatments. Behavioral intervention examples are; psycho-education, cognitive behavioral therapy, neurofeedback and mindfulness. The goal of cognitive behavioral therapies is to change thinking patterns in order to change negative behavior.

Pharmaceutical treatment

Pharmaceutical treatment has proven effect on the core symptoms of AD(H)D (Jensen, 1999), but long-term effects are unknown (Langberg et al., 2012). Stimulants such as Ritalin and Adderall are the most common prescribed medications. Stimulants are affecting dopamine levels in the brain, while non-stimulants affect norepinephrine. Stimulants work for 70% - 80% percent of patients with ADHD (Childress, 2014). Non-stimulants are used much less, but considered when stimulants are not working correctly. In general, non-stimulants take longer to affect the body and stop gradually. Unlike stimulants, non-stimulants don't cause abrupt mood swings.

Behavioral treatment

Multiple studies have shown the positive effect of behavioral interventions. Behavioral interventions play an important role for long-term improvement of organizational skills and executive functioning. (Rajeh et al., 2017 & Parker et al., 2013). Self-management procedures were effective in enhancing classroom preparation behaviors (Gureasko-Moore et al., 2006 & Bambara, 1997). And adults with AD(H)D who didn't benefit from medication therapy, showed significant improvements from behavioral therapy (Sprich et al., 2016).

Combined treatment

Drug treatment for AD(H)D has been widely researched, but increasingly research shows that a combined treatment is most effective (Carlson et al, 1992 & Aghaee et al. 2017). The combination is successful, because medication appear to significantly reduce symptoms, and behavioral therapy appears to show positive long-term academic and social outcomes.

Changing perspectives

The view on medication treatment for ADHD is changing over time. For example, an empirical study compared people taking medication first and behavior therapy first. Beginning with behavioral treatment produced better outcomes overall than starting with treatment with medication (Pelham et al., 2016). Previously medication treatment was more often seen as the best treatment.

Technological innovations for AD(H)D

Design guidelines

In the search for technological innovation for AD(H)D, several guidelines are defined in previous studies. Sonne et al. (2015b) defined three core components of assistive technologies. Each component has been provided with design criteria relevant for designing real time assistive technologies for children with ADHD in school contexts.

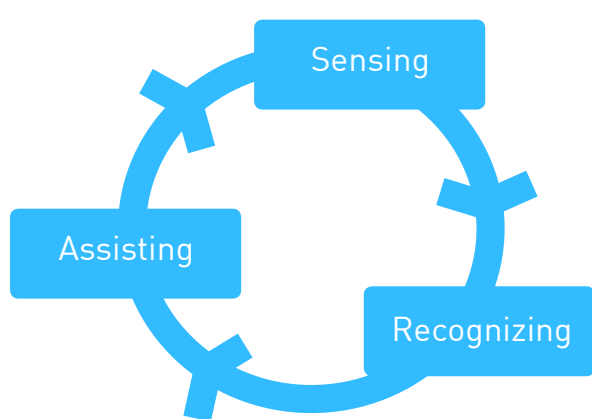


Figure 2.2 Core components of assistive technologies for mental health by Sonne et al. (2015)

Design criteria for technology that ‘senses’ movement activity or other physiological data should be; unobtrusive to wear, robust, avoid stigmatization, quick and easy to setup and real-time continuous sensing.

Once data is successfully collected, Sonne et al. (2015b) suggest three design criteria for ‘recognizing’. First, analyze seated conditions only, in that situation a high level of physical activity could indicate inattentiveness. Second, detect changes in physiological states: a quick change in physiological state could mark critical situations for the child, where assistance could be needed. Third, exclude off-seat activity with walk detection, walk detection can be used to temporarily disable focus mode for seated situations.

For assist, it is important to create something that is interesting and intuitive, in order to gain and sustain attention of the child. Including rewards can enhance the child’s interest in the system. Notifications should be effective and discrete, while not disturbing others nearby. The product should facilitate termination and provide guidance, because children with AD(H)D often have difficulty perceiving time and handling transitions between activities.

Next paragraphs outlines the most relevant studies in these areas. First, two studies are given that focus on sensing and recognizing inattention. Second, assistive technologies are given that don’t use any data from the users but manually interact. Third, studies are given about smart assistive technologies. Lastly, the high potential of non-invasive stimulations (vibrations) is discussed in ‘the power of vibrations’.

Using activity sensors

Three studies have explored the use of activity sensors for children with AD(H)D. One study used Wii controllers to make children aware of their activity in a classroom. When standing up from their chair, the Wii controller started to vibrate to remind the child of their active behaviour. Results showed that it significantly reduces the number children stood up during lessons, also a few weeks later without the Wii controller (Shih et al., 2014).



Figure 2.3 Setup Wii controller feedback test by Shih et al. (2014)

The last project increases the attention span of children by detecting inattention and alerting them about the event. The pen is used to follow reading behavior patterns, by pointing to what is being read. An accelerometer and a microcontroller measure movement patterns, when the pattern becomes inconsistent the user is notified. The results of this research show that it increases the attention span when people are alerted when they become inattentive (DePrenger et al., 2010).



Figure 2.4 Smartpen by Deprenger et al. (2010)

Simple assistive technologies

A technology that significantly increase attention span is whole body vibrations (WBV). Fuermaier et al. (2014) measured the effect of WBV on the attention span of people with and without AD(H)D. Both groups experienced an increase of attention span, although for people with AD(H)D this increase was largest. The positive effects are for young and old people.

During an interview with Fuermaier (2018) and a colleague of him, they said next step it to understand the mechanism behind the effect of WBV on attention, and find out what the long-term effect is. Also they shared information about some other projects by students who tested the WBV-effect on hands. This improved attention slightly.

A study by Azevedo et al. (2017) tested wristbands with heartbeat like vibration on a group of 50 persons. Participants had to do a public speech and all received a wearable. The group was divided in two, one half got inactive wristbands and others an active wristband. Participants with the active wristband displayed lower increases in skin conductance responses relative to baseline and reported lower anxiety levels compared to the control group.

Smart assistive technologies

At last, a recent paper that was published April 2018 by Flobak et al., describes the design process of TimeOut. TimeOut is a skill-building assistive technology to be used by adults with AD(H)D to improve self-regulatory abilities. The description of their design process points out that, participants with AD(H)D showed interest in being able to manage their focus better. "Of particular interest of this study was their reported need for stopping to focus their thoughts in various situations" (Flobak et al., 2018). User tests results show that much improvements are required in to prevent wrong prompting. In addition some of the users were most positive about the reminding effect; "I felt constantly reminded (by the visualization) to act constructively, and that was a very positive experience".



Figure 2.5 From top left to right: (a) Sensor wristband with TimeOut in the background; (b) main screen showing continuous visualization of EDA; (c) prompt for intervention; (d) one of five tasks in the behavioral intervention protocol (Flobak et al, 2018).

The power of vibrations

Most of the assistive technologies presented use vibrations to calm (Azevedo et al., 2017) or increase attention (Fuermaier et al., 2014). The exact mechanism behind these kind of tactile stimulations is unknown, but here is a theory of how tactile stimulation affect the brain.

Tactile stimulations, such as vibrations on the wrist directly affect the brain in the cerebellum area. This area receives information from the sensory systems and regulate motor movements, and may also be involved in some cognitive functions such as attention and language as well as in regulating fear and pleasure responses (Wolf, 2009).

The cerebellum is consistently active in cognitive tasks (Keren-Happuch, 2012 & Ivry, 1988), and may have a positive effect on the cognitive functioning. Latest research show that non-invasive stimulation of the cerebellum at a delta frequency normalizes brain activity in the frontal cortex of lab rats with schizophrenia-like thinking disorders (Parker, 2017). Frequencies of 1 – 4 Hz have been used in this research, which is same as 60 to 240 BPM.

More broadly, delta-range activity is found across diverse brain networks and appears to represent the need for cognitive control (Chen, Cavanagh, Laubach). Stimulating cerebellum projections in the thalamus might boost these cognitive control signals and counteract medial frontal cortex dysfunction induced by disrupting cortical dopamine signaling. Figure shows the proportions of neurons between the cerebellum and cerebral cortex. Parker (2017) concludes, that we have underestimated the effect and use of the cerebellum until now. The cerebellum is only 10% of brain volume but holds over 50% of the brain's total neurons.

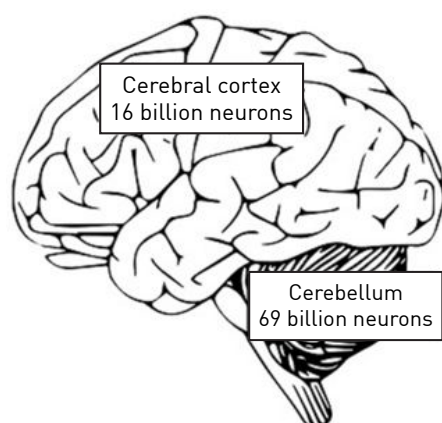


Figure 2.6 The brain: cerebellum & cerebral cortex

Conclusion

This literature review shows the growing amount of people diagnosed with AD(H)D and the increase of medication intake worldwide. Subsequently, criticism on medications arises and interest in alternative solutions grow. Multiple researchers have looked into the use of technologies to support alternative solution, and offer a starting point for this project.

Firstly, this project can build further upon the design criteria defined for each component of real-time assistive technologies by Sonne et al. (2015b).

Secondly, multiple studies have explored the development of assistive technologies for AD(H)D. Activity sensors have been used for diagnosing children with AD(H)D and recognizing inattentive behavior. Tactile stimulations such as vibrations are used to increase attention of users, which has been realized with Whole Body Vibrations. Also, vibrations on the wrist like a heartbeat have shown to increase calmness.

Lastly, the assistive technology project TimeOut (Flobak et al., 2018) shows that reminding users during activities can help them to act constructively.

KEY INSIGHTS

- › Vibrations can reduce stress and increase attention
- › Design guidelines for the components: sense, recognize & assist
- › Activity data can indicate inattentiveness
- › Reminders can invoke users to act constructively during activities

Market research

This market research analyzes products that either increase the attention span or improve productivity of people with AD(H)D.

Senseez

Senseez offers calming cushions for children with AD(H)D. The cushions help to relax, soothe and focus, by easing the senses through vibrations. The target users are children, although some parts of the website are focused on teenagers and adults.

Senseez provides information about the research behind their products; vibrations have a calming effect on the body, by stimulating nerves deep in the body. The vibration focus and concentration, and according to Senseez more than 70% of the users had an increase in attention span using the Senseez cushions.



Figure 2.7 Senseez cushion

\$ 39,-



Figure 2.8 Time timer products

Time Timer

Time Timer is a well-known brand. Products range from timers, watches, application and other accessories. Their target market is large, because it offers a simple tool for time management that can be used in classes, special care and many other purposes.

\$ 89,-

Epic Win

EpicWin is a to-do list app, but special for people with AD(H)D. EpicWin puts the adventure back into your life by integrating gamification in the to-do app. It has a role-playing spin, so rather than just ticking off your chores and reminders, completing tasks earns you XP to improve and develop your character in an ongoing quest to improve stats, gain riches, and level-up (iTunes store, 2018).



Figure 2.9 Epic Win app interface

\$ 3.49,-



Figure 2.10 Octopus Watch

Octopus.watch

“Teach your kid good habits and the concept of time” is the slogan of Octopus Watch. The watch helps parents to communicate tasks and schedules with their kids. The target users are children of 4 to 12 years old and parents. Parents provide daily tasks and activities via an app on their phone to the child’s watch. The product is only available in the US.

\$ 79,-

Touchpoints

The Touchpoints wristbands are designed by a neuroscientist. The devices are non-invasive and use BLAST technology to relieve stress in as few as 30 seconds.

Bi-lateral Alternating Stimulation tactile (BLAST) technology transfers alternating vibrations to alter the body's fight, flight or freeze response to stress and anxiety and to restore the homeostatic nervous system functioning, allowing you to think clearly (Touchpoints, 2016).

\$ 249,-



Figure 2.11 Touchpoints wristbands



Figure 2.12 Doppel wristbands

Doppel

A startup called Doppel, is bringing a new watch to the market that help users to stay alert of calm down, naturally, in real-time. The wristband works by creating silent vibrations on the inside of your wrist, which feels like the 'bump' a heartbeat.

\$ 179,-

Re-Vibe

Re-Vibe is a smartwatch designed by a psychologist to help children with attention deficits. The concept works like 'a tap on the shoulder' to continue working instead of getting distracted. The device has three different interval lengths between reminders; 1, 3 or 10 minutes.

\$ 99,-



Figure 2.13 Re-Vibe wristband by Fokuslabs

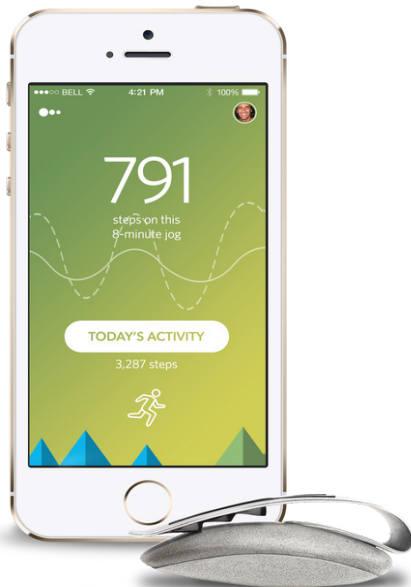


Figure 2.14 Spire breathing sensor

Spire Stone

The spire is new kind of wearable to monitor emotional well-being. The small device connected to teh inside of your belt, measures breathing patterns from body movements. This enables users to track stress from physiological data and to follow relaxation exercises.

\$ 129,-

Conclusion

There is a small number of technological products available that help people managing AD(H)D symptoms. A reason for this could be the difficulty of managing the symptoms, it requires expertise and experience.

Products have been categorized on the five categories of impairments of AD(H)D, and all products help people overcoming academic and occupational failure (appendix A.1). A reason for this is could be that school is a place where symptoms become highly visible, therefore parents are looking for products to overcome underachievement a school.

Most of the products' type of systems are 'manually interacting with information and services' (MIIS). This means that the product is directly controlled by the user and not using contextual data. The Spire is the only system with automatically executed services (AES) based on in-situ analysis of context information. This shows that MIIS systems have shown to have significant effect on AD(H)D symptoms, and AES system require further research, because it is for some reasons not yet as feasible as MIIS.

Lastly, the selected products have in common that they offer a single purpose product, it doesn't come with many different functionalities. For example, Senseez cushions provide an easy way to find relaxation and focus for doing homework, you just have to sit on it. Epic Win makes using to-do lists just a bit more fun, which already helps children a lot to become more productive. Octopus watch is a smartwatch, that is valuable for children and parents, by offering a way to simplify communication. A relieve for parents, because it is often hard to keep reminding their child. The simplicity of each product suggest that it is a key to success in this market.

KEY INSIGHTS

- > Most product focus on overcoming academic and occupational failure
- > Manual interaction is most used now, automatic interaction is near future
- > Simplicity wins, because most successful products are easy to use

User study

Interview experts

The goal of the expert interviews was to identify problem areas around AD(H)D. In total nine interviews have been conducted with researchers, psychologists and a entrepreneur. Most of them also had a strong relationship with AD(H)D in their private life, which led to interesting insights from personal and professional perspectives. For example, the founder of Superbrains has AD(H)D himself, and some of the psychologists were also parent of a child with AD(H)D.

Questions about the impairments of AD(H)D led to many detailed results. Especially psychologists and therapists were highlighting the pain of having AD(H)D. Either the challenges for the child or the parents. For example, many parents find it difficult to deal with the high amount of negative reinforcement they have to give to the child. Turning this into a positive balance, requires hard work to really change habits for long term effect. For the child it is difficult to deal with the continuous negative feedback, which lead to a low self-esteem.

Building friendships is another common problem for children with AD(H)D according to Luman (2018). They can find it difficult to get social cues, due to their inattentiveness or intrude others due to impulsive behavior. Often children with AD(H)D have a low self-esteem from a young age.

Also, a therapist A. Snoek described that she sees many children with AD(H)D suffer from anxiety. Therefore, therapy is very helpful to help children overcome their feelings. The interviewees were also asked about the current challenges for their treatments. In general, researchers were more supportive to drug treatment than therapists.

	Name	Type	Meeting
1	G. Chiazzese	Researcher	Call
2	M. Luman	Researcher	In person
3	K. de Loor	Psychologist	Call
4	R. den Hollander	Entrepreneur	In person
5	A. Fuermaier	Researcher	Call
6	D. Bijlenga	Researcher	In person
7	A. Snoek	Psychologist	In person
8	M. Wichers	Researcher	Call
9	B. den Blaauwen	Psychologist	In person

Figure 2.15 Interview participants list

However, therapists described how difficult it is to create good treatments for a child, because more people are involved than just a therapist. Success of a therapy is very dependent of parents and teachers as well to support a child continuously.

The disadvantages of medication treatments were also discussed. Long-term effects are still unknown (Bijlenga & Luman, 2018), and side-effects are for many children problematic (Luman, 2018). Also, many people with AD(H)D experience sleep problems, regardless using AD(H)D medication. Some researchers were most interested in improving sleep quality, and researching what the connection is between AD(H)D and insomnia.

All interviewees were asked about alternatives to drug treatment for AD(H)D, and the main challenges for their discipline in the coming years. Most suggested behavioral therapy as an alternative, like cognitive behavioral therapy and parental training. Some emphasized the success of combined therapy, because this has showed the best research results so far. The main challenge for psychology and mental health care was described as; using the data in the right way to help people, and conduct research less group based but more individually focused.

Observation children

The goal of class observation was to get an idea of the daily problems of children with AD(H)D in school.

Observation in two classes confirmed the difficult situations of children with AD(H)D. During the observation, children with AD(H)D showed clearly to be more inattentive and hyperactive. Compared to their peers, the children stood often up or moved actively while the teacher was giving instructions to the class.

Interview children

Interview sessions have been held in groups with most active children selected by the teacher. The goal of the interview was to get insight into the ability of children to reflect on their behavior.

Results showed that children of 9 and 10 years old couldn't easily reflect on their behavior on the hours before the interview. Older children of 11 and 12 were more able to describe moments of good focus, and what distracted them during lessons.

Conclusion

Expert interviews resulted in the following insights. First, most findings about AD(H)D are group based, so specific treatments and other solutions have very variable effects on each individual. Second, children with AD(H)D mostly suffer from a low self-esteem, because of academic underachievement and underdeveloped social skills. Adults with AD(H)D, mostly suffer from insomnia. Third, behavioral treatment is most effective when teachers and parents are involved.

Lastly, the class observation showed that hyperactivity was clearly visible. Interviewing children led to the insight that children of 9 and 10 years old were not able to reflect on their behavior. Older children of 11 - 12 showed a higher ability to discuss and reflect on own attentive behavior.

KEY INSIGHTS

- > Behavioral intervention is successful when users plan and reflecting on own behavior
- > People with AD(H)D often suffer from insomnia and a low self-esteem
- > Children of 10 years and older show to have reflective skills

Synthesis

33	Key insights
34	Vibration concepts
36	Design guidelines
37	Design challenge

Key insights

AD(H)D is anywhere

Results from a meta-analysis by (Polanczyk et al., 2014) show that the worldwide prevalence of AD(H)D is averagely 5% of the total population. However, the number of people getting diagnosed is increasing, according to research this is not because of people get more AD(H)D characteristics, but it gets more often recognized.

AD(H)D = low self-esteem

Children with AD(H)D experience many difficulties from their disorder. During childhood, they can find it difficult to make friends, because of their inattentive and impulsive behavior. Children with AD(H)D tend to play bossy, miss social cues, and often intrudes others. Also, it AD(H)D comes with many negative reactions from people around them, because they find it hard to follow instructions.

Inattention drives hyperactivity / impulsivity

A statistical research shows that inattention has significant influence on hyperactivity and impulsivity. Sokolova et al. (2016) found evidence for a causal relation between inattention and hyperactivity/impulsivity. When inattention get worse, people tend to behave more hyperactive and impulsive.

Reflective skills of children

The first interview session at an elementary school showed that children of 10 years old have knowledge of the concept attention and focus, but find it difficult to reflect on own attentive behavior. In a second interview at another school with children of 11 - 12 years old, showed a higher ability to reflect on their attention on previous tasks.

The future of assistive technologies

Several studies suggest the high potential of assistive technologies for people with AD(H)D. Some encourage to design for children, because it is technically feasible to measure attention from activity data. Also specific design criteria have been gives, to support future work that leads to a full functioning system.

Body vibrations applicability

In the department of clinical neuropsychology of Groningen university, research has also been focused on the applicability of body vibrations. In a master thesis, the use of vibrations on the hands has been tested. People who had vibrations on the hands showed slightly better results on the attention span test than the control group (call with Koerts, J., 2018).

Self-management for AD(H)D

Multiple researchers looked into the effect of self-planning and management techniques. Research in 2008 showed that calendars had positive effect on people with AD(H)D. Now these technologies are already widely adopted by the majority of people through the digitalization of the last decade.

Four types of vibrations

Most products found in the makret research use tactile stimulations to improve focus. Each uses vibrations in a slightly different way, and explains differently how it works. Next chapter outlines these three different kind of vibration patterns with one added from ideation.

Vibration concepts

Vibrations technologies can be used in different ways, and their effect is explained different. Here are all four concepts described, a more detailed overview is in Appendix X.



Heartbeat like vibration

This vibration pattern comes from the wristband of Doppel. This company has built the first heartbeat like vibrating watch, which should be worn inside the wrist. The frequency ranges from 30 - 220. Doppel target professional workers who want to reduce stress. How it works has been tested by Doppel; 50 users worn the wristband and showed less nervousness before a presentation than the control group (Doppel, 2018).



Relaxation vibrations

There are multiple products available that use this type of vibration. For example, Senseez cushions and the Touchpoint wristbands. These products offer no interval, but a continuous vibration calm the user or to improve focus.

It works by giving the body sensorial input, this keeps the brain busy, but keeps attention high...



Reminder vibrations

In daily life we are continuously reminded by vibrations when receiving messages and other notifications. However one company, funded by the US ministry of education, has developed a wristband that reminds scholars to not get distracted. It can vibrate each one, three or ten minutes. For each reminder the scholar has to ask him or herself, 'am I doing what I should be doing?'. It is like a tap on the shoulder to motivate kids to work more concentrated.



Breathing relaxations vibrations

This concept is an alternative to the relaxation vibrations, and has been ideated during the research phase. This vibration pattern offers guided breathing exercises. In most cases guides breathing exercises are visually or audibly, but using vibrations makes it more unobtrusive in any situation.

Design guidelines

Reducing the scope of this project is important for the feasibility and effectiveness of this project. Therefore, design guidelines are set based on findings in the research phase:

Intuitive to use

Based on the market research, the product should be intuitive to use. Products that are available worldwide, are simple to use and easy to understand. For example, the Octopus. Watch simplified the use of the watch, by giving control to the parents, having only one button and nice illustrations that are understandable for a child.

Unobtrusive

AD(H)D comes with many difficulties, and is not cool to have. Although many children with AD(H)D are gifted, the product shouldn't be visible and stigmatizing these children as 'different'. In addition, it should be useful in many daily activities, it should be light, easy to put on and off, silent and water resistant.

One size fits all

Most products in the market analysis are 'one size fits all' products. For example, the Razer Nabu X is easy to wear by children and adults. This is useful, because children of 10 to 14 years old grow rapidly.

Quick and easy setup

A morning routine with children with AD(H)D can be hard to manage, therefore the setup should be fluent.

Avoid stigmatisation

Children with AD(H)D often suffer from a low self-esteem, and wearing a band for their 'disorder' doesn't contribute to their self-esteem. Any kind of stigmatization should be avoided to ensure the child's well-being among peers.

Sense inattention from movements

Previous studies have tested activity sensors to measure inattentiveness and hyperactive behavior. Activity data can be used for detecting moments of inattention or indicating the level of hyperactive behavior throughout the day.

Robust

The band should be ready for most child's play. It needs to be robust and waterresistant, so the child can let it fall or take it into a swimming pool.

Design challenge

To continue this project some last selections have been made to formulate a design challenge.

First, inattention has been pointed out as the core driver of AD(H)D symptoms. Inattentiveness leads to more hyperactive and impulsive behavior according to Sokolova et al. (2016).

Second, most products use tactile stimulations to alter the brain's state or remind users about the behavior. Seemingly, tactile is the most appropriate and unobtrusive way to support people with AD(H)D in any situation. For example, children can unnoted use vibrations to help themselves doing math, instead of wearing big headphone or relocate to a silent workplace outside the classroom. This prevents the child from being stigmatized.

Lastly, vibrations are the most used technology for tactile stimulations.

Next steps of this project look into the desirability of vibration technology in wearable devices for children with AD(H)D. In this way, the design challenge is formulated as:

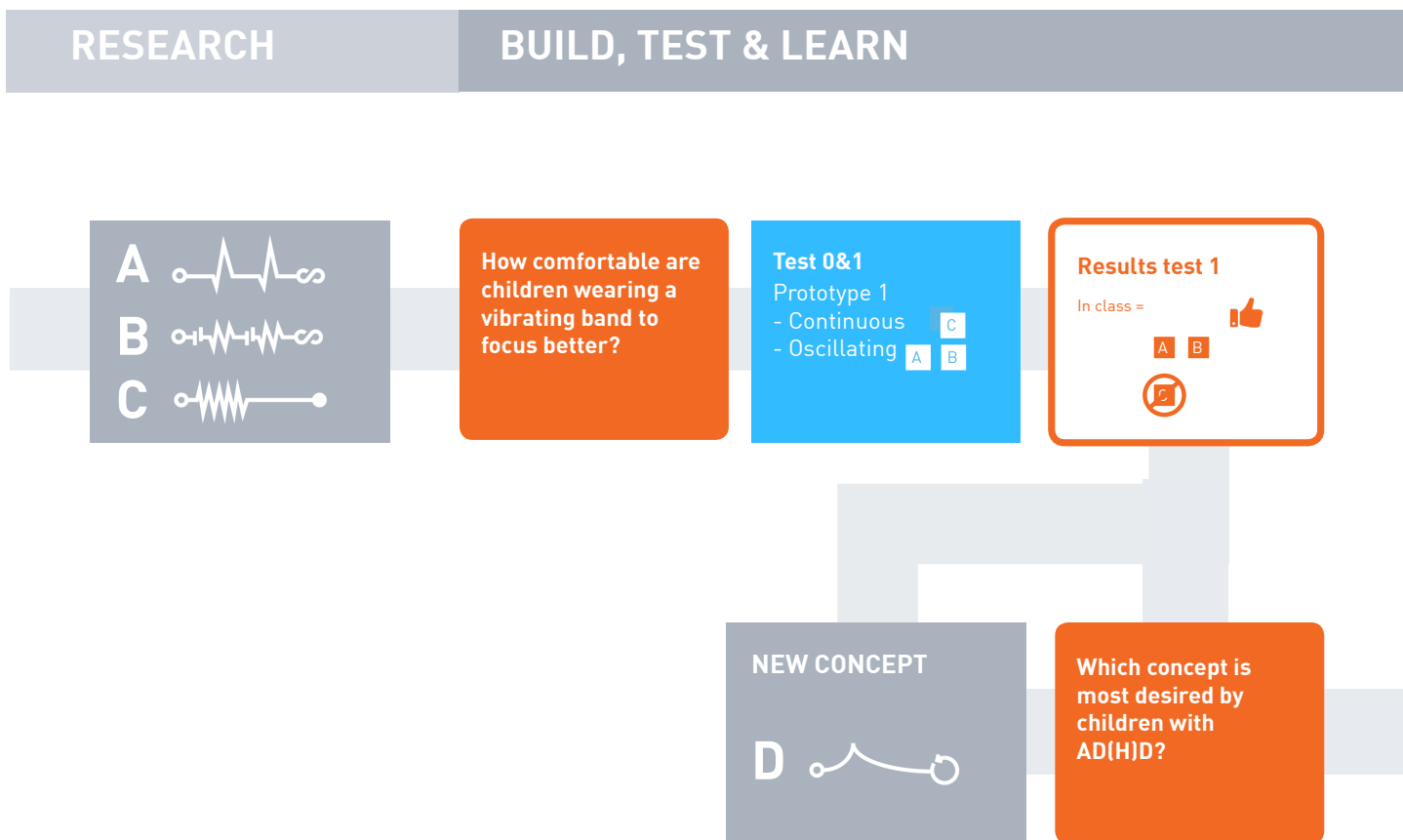
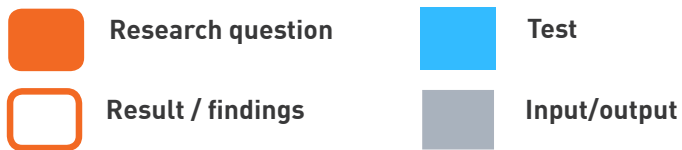
“How to design a wearable that assists scholars with AD(H)D by increasing their attention span on school tasks using vibration technologies?”

Build, test & learn

40	Process overview
42	Test 0 & 1
44	Test 2
47	Prototype V3
48	Design specifications
50	Use flow diagram

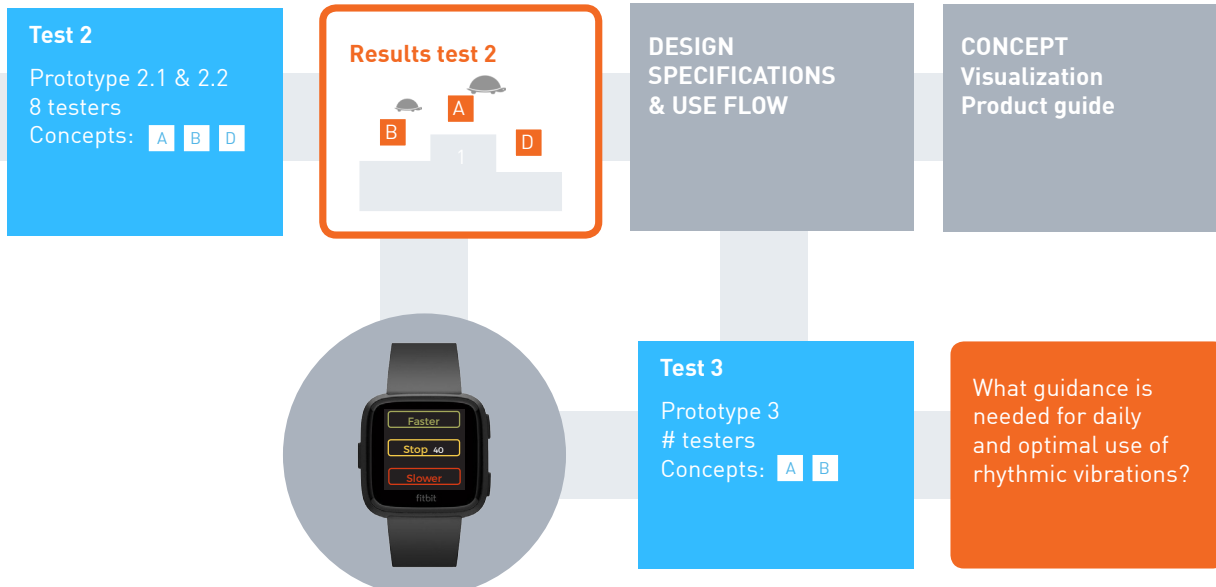


Process overview



- | | | | |
|----------|-------------------------------------|----------|---|
| A | A heartbeat like vibration | C | Continuous vibration |
| B | Reminder vibration Every 1/3/10 min | D | Breathing exercise guided with vibrations |

CONCEPTUALIZATION



Test 0 & 1

How comfortable are children wearing a vibrating band to focus better?

Description

Test zero and one are combined, because both explored the use of vibrating wristbands with children. Test zero used a Stroop test to measure attention. The quantitative data (Appendix A.2) of this test haven't been used, because of a too small sample size. However, this test gave insight in the attitude towards vibrating technologies to improve focus.

In test one, children with AD(H)D of 10 - 12 years old used the prototype in class for approximately two hours. Before they received instructions about the controls, and the differences of each mode. In class, children listened to instruction and did individual work. After the session, participants were asked to fill an evaluation form, and joined a short interview of 15 minutes.

Sample size

Test 0:
27 participants

Test 1:
4 children with AD(H)D

Prototype V1

2 functionalities 1 button
Mode 1: A & B combined
Mode 2: C

More info in appendix B.2

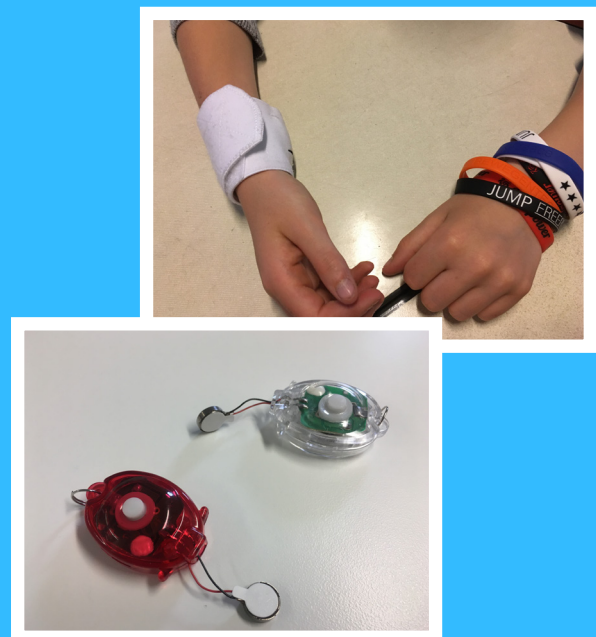


Figure 4.1 Prototype 1

Results test 1

1.1 No shame

All participants showed to be comfortable using the wristband in the classroom. Classmates were already aware of their conditions. This also suggest that it is quite common to use tools to improve concentration, for example some schools already offer some of the children headphones to concentrate better on individual work.

1.2 Oscillating wins of continuous

The oscillating vibration was most popular, because it was “strong and less annoying”. This means that the concept of ‘Touchpoints’, a continuous vibration to relax, is unfavored and therefore it wont be further researched in this project.

1.3 Wrist is the most preferred position

In the beginning of the test, children were asked to choose a position to wear the device. They tried on the ankle, upperarm and lowerarm. Three preferred to wear it as a wristband and one worn it on his upper arm. Arms were preferred, because it was ‘not weird’ and easy within reach of their other arm to control the device.

Next

Which concept is most desired by children with AD(H)D?

Test 2

Which vibration pattern of A, B and D is most desired among children with AD(H)D and why?

Description

Fourteen users tested a prototype with three concept functions; A, B and D. All users were instructed about the different functionalities and to plan some activities they could use the prototype for. These activities needed to be difficult to keep concentration at, such as reading, doing homework or cleaning. After testing, participants were asked to reflect on these activities.

Sample size

14 test users

For more information see Appendix C.

Prototype V2.1 & 2.2

Three functionalities 1 button

Mode 1: A - 50 vibrations/min

Mode 2: B - Every 3 min

Mode 3: D - Breathing exercise

More info in appendix B.2



Figure 4.2 Prototype 2.1 & 2.2

Results test 2

2.1 'I like it, because it is calming'

Most of the users described the experience of using the wearable as; 'nice, because it is calming' (Appendix C.2) or 'nice, because it helps me to remind of what I intended to do' (Appendix C.3). Nine out of the fourteen participants were open to use it for a longer period. Most of them asked it spontaneously, because they wanted to explore it more.

2.2 Filtering

Most of the users described a moment where they stopped noticing the vibration, approximately after 5 - 15 minutes. This effect is probably caused by the brain's filtering capacities. Once users by focused on the wristband again either by coincidence or on purpose, they would feel the vibration again. Also, three test users described the filtering of the vibration as an indicator for a focus flow, when they got out of the focus, they would know by feeling the vibration again. This effect and use of filtering needs further investigation.

2.3 Heartbeat (A) and the reminder (B) pattern

Patterns A and B were most preferred during the tests, Pattern D the breathing exercise was only chosen by one user. Among younger users pattern A the heartbeat like vibration was most popular. Older users preferred pattern B, as a supportive tool monitor and support their focus.

2.4 Personal preferences

User's opinions varied widely, some wanted a stronger vibration and others a softer vibration. For most of the testers was the HR mode (A) too fast with 55 times per minute and the 3min (B) pattern was too slow. This shows that users have strong personal preferences and like to be able to change it.

2.5 New controls and longer battery life

Most test users of prototype V2.2 were confirming that some controls are needed on the device instead of using a phone to control the modes. Besides, battery life was too short, it was only two hours.

2.6 Understandable

Pattern D, the guided breathing exercise was too complex for children of 10/ 11 years old. They were able to follow the breathing exercise together with their parents, but most importantly they are not able to know when to use it. Therefore, it should be easy to understand when a vibration pattern has to be started.

Next

How many modes are desired, and for what activity?

Next test (3)

What guidance is needed for daily and optimal use of rhythmic vibrations?

Description

The goal of this test is to evaluate the long term use of vibrations, and how use can be supported by providing information and exercises. The new prototype has been implemented in the Fitbit Versa and Ionic models, which provide many benefits compared to the previous prototypes. It offers a fully developed smartwatch, which users like to wear and comes with many other features and a long battery life. The popularity of Fitbit products help to get users wearing the devices all day. With only two clicks they can activate the Flowy app.

Prototype V3.0

App for Fitbit Versa or Ionic

Modes range from : 1/3 - 240 BPM

Prototype V3

Results of test 2 show that patten A the heartbeat like rhythm and B the 3 min reminders are most popular. Continous vibrations are not desired anymore, which allows ti to use an Fitbit for prytotyping. Initially the Fitbit device was not used because it can't give continuous vibrations. Prototype V3.0 is an app for the Fitbit Versa and Ionic smartwatches.

Vibration pattern:
From 1/3 - 400 bpm.

Good to wear

The Fitbit is a popular product that has been optimized for daily use.

Touch control

Using the touch interface users can easily select their preferred vibration.



Like any other apps

The prototype app is accessible in the app menu.

Better looks

The prototype looks like a real smartwatch, not a large and unhandy prototype.

Quick updates

The softwate is easily updatable via the Fitbit Studio.

Design specifications

Prototyping findings translated into product specifications

Personalizable

Easy to wear and not forget

Cool

Understandable

Reflective

Design specifications

Prototyping resulted in the following findings that will be added to the findings from the research.

Personalizable patterns

User tests showed that all participants had their own preferences for pattern speed and vibration strength. Personalizable patterns increase the comfortability of the watch.

Easy to wear and easy to not forget

Participants who used the prototype for multiple days described their difficulty of reminding themselves to start using it when needed. Therefore, this product should be easy to wear, perhaps like a normal smartwatch which users wear 24/7 to track activity. In this scenario, the wristband can send reminders to the users to use the band for work or study moments.

Cool to wear among peers

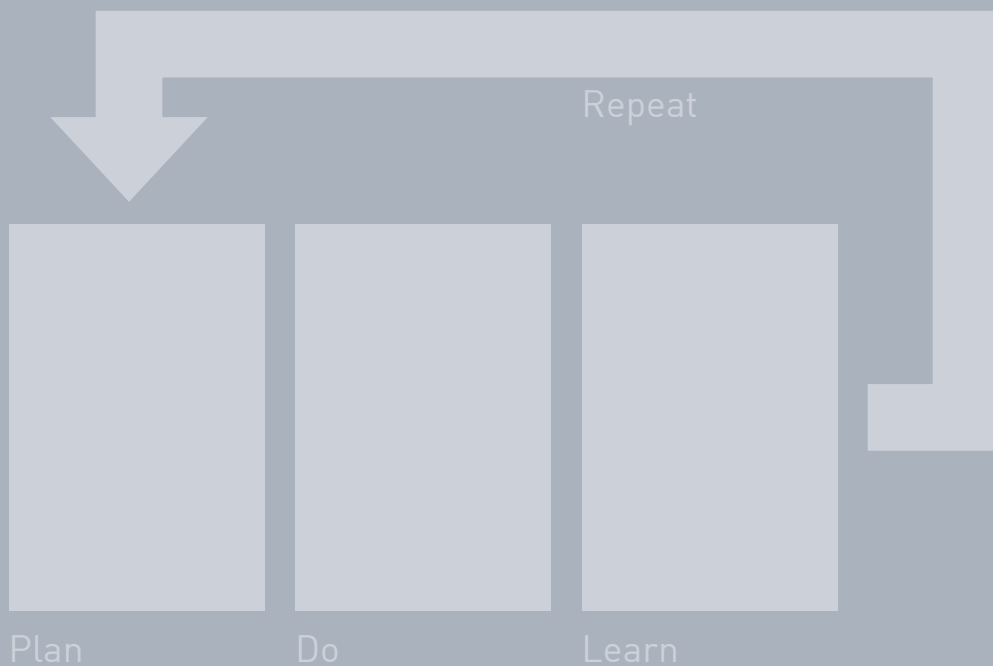
The target group of this project, children with AD(H)D of 10 - 14 years old are in a changing period of their life. Puberty is starting and social skills are strongly developing. Going to school with something that helps you concentrating can be uncool. Therefore, it should be no obligation to wear the wristband by making it look nicer, and as well less visible.

Reflective (plan, do, learn)

Interviews and user tests with therapists and psychologists led to a suggestion to implement a moment of reflection. Reflecting on a period of school work helps the users growing their cognitive abilities and as well adjusting the vibration pattern to the most effective settings.

Use flow diagram

The product's use systematically visualized.



Use flow diagram

This chapter illustrates the product system, which integrates a behavioral learning system to enhance the vibrating wearable device. A behavioral learning system has been suggested during expert interviews, to increase the effect of the wearable.

The use flow diagram provides a start and end point for each interaction with the product. The main actions are visualized in orange boxes, decisions in diamond boxes and around data connections and collections are illustrated.

The main value of the product system is the implementation of the 'plan, do and learn' phasing. This phasing activates the user to think about own behavior.

In the plan action, a user is informed about behavioral therapy and guide to planning behavioral goals. When using the wearable, they user will be reminded of specific 'planned' behavioral goals.

Once the user chooses to end the session, duration and activity data will be saved to the database. In parallel the user and the parent or caregiver will be notified about the session, and asked to review the day or session.

In the 'review' action, users reflect on their activity by answering questions like; "how did it go?", "what could be better next time?". This kind of questions activate the user's cognitive thinking processes, which strengthen development of self-managing behavior.

This use flow diagram illustrates how tactile stimulations can be used to enhance cognitive behavioral interventions, and what steps should be implemented in new concept designs.

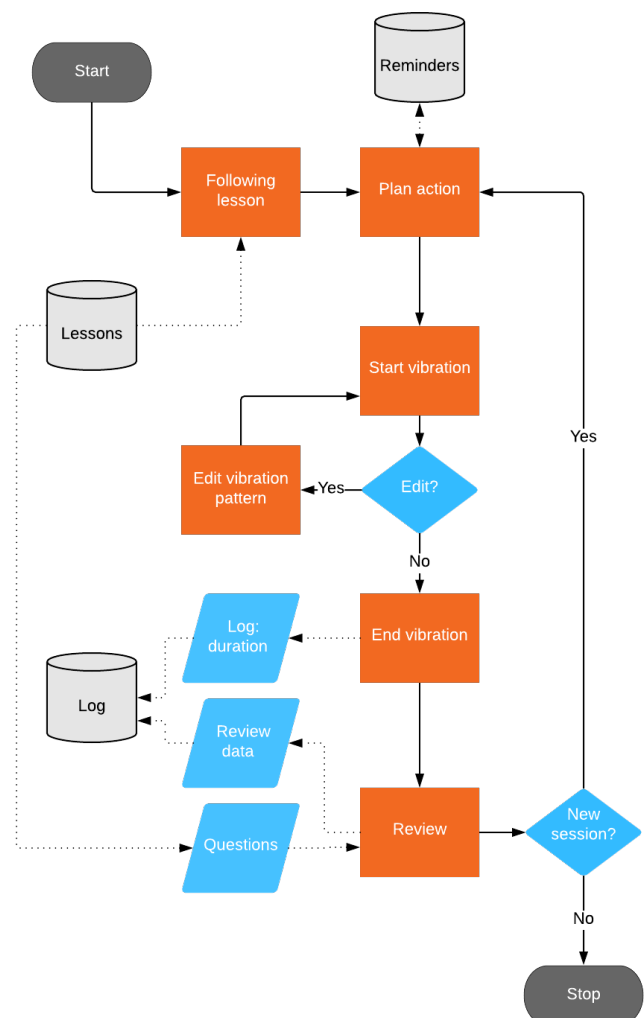


Figure 4.3 Flow chart app system with plan-do-learn phasing

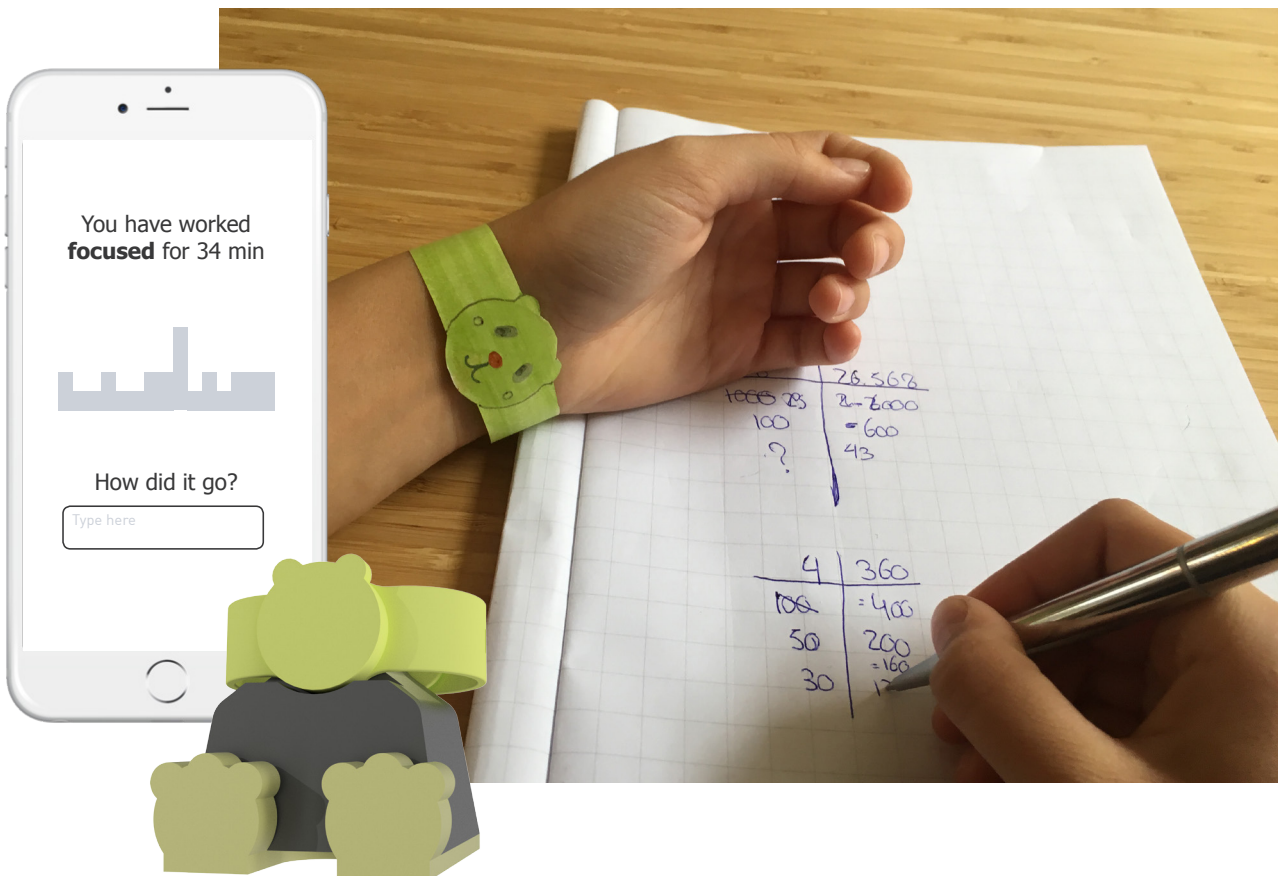
Conceptualization

54	Flowy
55	Product system
56	Product theory
57	Product components



Flowy

Flowy is an assistive activity tracker for children with AD(H)D, which helps them to focus longer at schoolwork in a natural way, by using silent vibrations that reminds for self-regulating behavior in a calming way.



"The vibrating wristband acted as a reminder to stay focused on the lecture. The vibrations made me aware of when my mind started to wander off, therefore acting as a trigger to put my focus back where I wanted it."

Product system

Use in practice

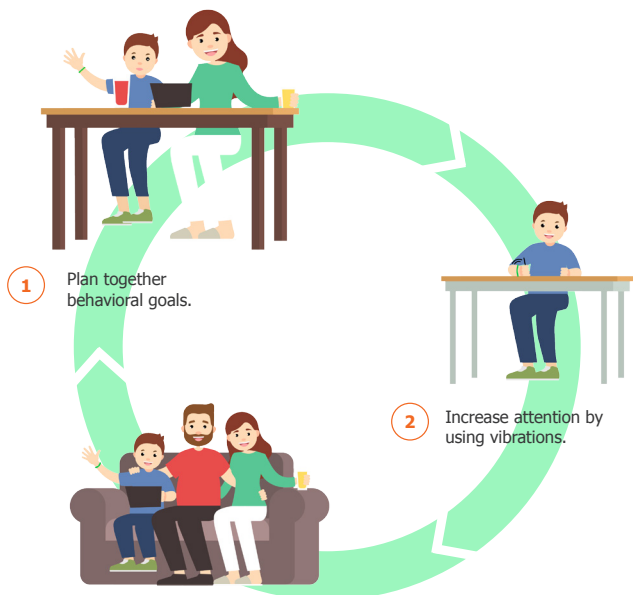


Figure 5.1 Flowy use steps overview

Step 1: The child follows interactive lessons on an app, where he/she learns about AD(H)D, and how to use Flowy. Parents can monitor the progress on their phone.

Step 2: In school, the child starts the wristband to help him/herself to increase focus. When working, it reminds to take a break and gives positive feedback on focus streaks.

Step 3: Parents receive updates about their child's study time and activity, to control the use of the band and reward the child.

The effect of the vibrating wristband is optimal when users are educated about cognitive behavioral therapy. This means that users understand wherefore they get reminders during a task. In other words, it is psychoeducation about behavioral management, that makes users understand why they get distracted, to accept it and how to deal with it more effectively.

This system integrates psycho-education with the Flowy wristband to optimally utilize vibrations. For example, when a user doesn't know what the vibration is for, the vibration can be experienced as irritating and ineffective, because thoughts are not steered into a specific direction. Additionally, this process is not being reviewed by the users, which is one of the core elements for mental development.

The process of psycho-education, also named behavioral training is designed to empower relationship between the child and parents. Exercises invite children and parents to interact. For example, sharing answers on questions about how they focus best to learn from each other. Also, parents can monitor the progress of their child. They are updated about course progress and can view daily focus and activity time. As a result, parents can ensure the wristband is used and reward their child for progress.

Product theory

Flowy gives tactile stimulations that affect the brain. Similar to music, vibrations can be relaxing, motivating, energizing, and remind you of specific thoughts. Flowy uses periodic vibrations as reminders for behavioral change, such as asking yourself: “Am I doing what I wanted to do?”. Additionally, it can give fast reminders which also have a calming effect. The combination of these patterns offers rhythmic vibrations that support behavioral change. This chapter gives a short description of the theories behind the two type of vibration patterns; slow and fast vibrations.

Slow vibrations as reminders (<10BPM)

Learning new behavior requires much effort and dedication for a long period. When trying to change, people often fall back in the old behavior. Periodic reminders can support this process, by giving gentle reminders for self-regulating behavior. For example, a child can be reminded to talk less in class or work longer on homework. The periodic reminders can occur in a range of every 5 minutes to 30 seconds, dependent on the needed intensity.

The power of fast vibrations (>10BPM)

Faster rhythms are also implemented because of the high popularity of faster rhythms of around 50BPM. Users experienced is as calming and had a similar reminding effect as ‘slow’ vibrations. In addition, two studies show the positive effect of faster vibrations on the brain.

The first study shows that heartbeat like vibrations have a calming effect Azevedo et al. (2017). The second study is more theoretically but indicates the high potential of vibrations on the functioning of the human brain. This shows that vibrations (60 to 240 BPM) can normalize schizophrenia-like thinking disorders among lab rats (Parker, 2017).

Components

Flowy is a product package that contains a wristband embodiment, a tracker device, charger and a phone app for Android and iOS.

Wristband embodiment

The wristband embodiment is made of silicone plastic, and covers the tracker device of flowy. Different looks are available to meet the wishes of different age groups and type of children. Three group types are used to target children from 6 to 18 years old.

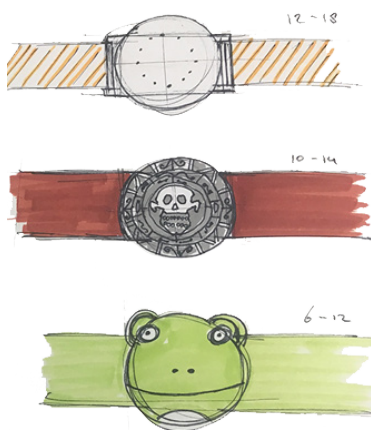


Figure 5.2 Embodiment styles for different ages

Tracker device

The tracker device contains the following sensors; 3-axis accelerometer and a 3-axis gyroscope. It comes with Bluetooth connectivity, 12 led light interface and a battery capacity of 4-7 days. The device is water-resistant and size approximately 30 x 8 mm.

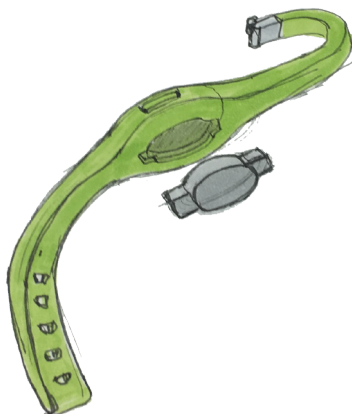


Figure 5.3 Wristband + tracker device

Charger

The charger is approx. 60x50x70mm and is extendible with a 'feet' plate, which come with the animal type wristbands. The charger can light up the wristband as a small bed light and alarm clock. The charger is designed to stand in the children's room, to make the animal become like a 'buddy'.

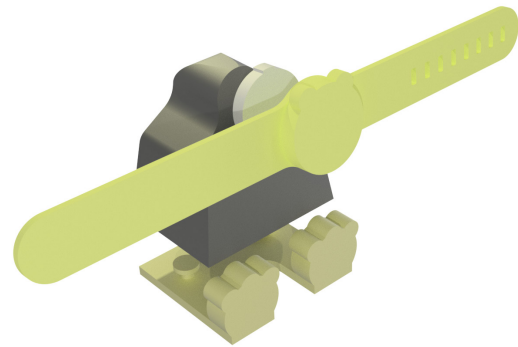


Figure 5.4 Exploded view charger + wristband

App

The app is a channel to communicate behavioral lessons to the child and parents. It offers a child and parent login. The child view offers a cartoon that explains about ADHD situations, and offers exercises using the wristband. The parents view offers monitoring and tips. The monitoring view offers insight in the child's behavior, such as activity rate, progress in the app course, focus time and relax time. It also offers behavioral training to the parents by suggesting to reward the child on specific behavior or progress with Flowy.

Conclusion & Recommendations

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60	Limitations
61	Recommendations

Conclusion

Vision and mission

Flowy is a new product concept including a vision that has been validated among experts and parents. The vision is to improve children's well-being by empowering daily behavioral interventions using wearable technologies, to provide a natural alternative to medications. Experts and parents confirmed the need for alternative ways to treat AD(H)D, due to the complications of medications. This resulted into the mission to support children managing the symptoms of AD(H)D in daily life using assistive wearable technologies. A technology has been selected which has been tested in multiple studies.

Scientific background

Flowy builds further upon research findings which show that the use of tactile stimulating technologies for AD(H)D is elevating. A research shows that heartbeat like vibrations can reduce stress prior a public speaking activity (Azevedo et al., 2017). Another research shows that non-invasive vibrations can increase pre-frontal cortex activity among lab-rats (Parker, 2017). The suggested vibrations speeds of these researches are implemented in Flowy.

The direct effect of vibrations on the wrist on the attention span of people with AD(H)D haven't yet been proved. However, hypothetically it could be similar to the effect of Whole Body Vibrations (WBV) that have shown to increase the attention span of people (Fuermaier et al, 2014). In this manner, more elaborate research is required to prove the direct effect of rhythmic vibrations on the wrist on the attentions span of people with AD(H)D.

Value proposition

The market of assistive technologies for AD(H)D is relatively new, because most products exists for less than three years. Compared to these existing products Flowy is unique because of two core characteristics. First, it is designed for children, like a buddy. Secondly, Flowy gives children ownership and understanding of self-regulation, because it let children create own vibration patterns for activities that require focus. This is realized by providing an app that brings the 'buddy' alive through animations, explains behavioral therapy, and involves parents to monitor the process to create positive reinforcement within the family.

Desirability of vibrations

Flowy prototypes have been tested among children with AD(H)D and reviewed with experts in psychology. Most test participants described the effect of the vibrations as positive. It helped to stay alert, by getting reminded about the work they intended to do. Outcomes of the user study suggest that tactile stimulation technology is desirable among children with AD(H)D. Additionally, users show to have personal preferences for the speed and intensity of vibrations. Providing controls to adjust the vibration speed and intensity may have a positive effect on the desirability. This led to a specific range of vibration patterns, it offers slow and fast vibrations.

Limitations

Small sample size

Regardless the total amount of participants of fourteen, is the sample size of the user test too small or the test users are too heterogeneous. The tests have been done in different locations, different age groups, and different stakeholders. Therefore, it is not viable to normalize the results.

Severity of AD(H)D symptoms is unknown

Most test users had AD(H)D officially diagnosed, but also some of the users said to have strong symptoms of AD(H)D. This group people never had participated in a diagnosis, but experienced symptoms of AD(H)D in the majority of their life.

AD(H)D + ADD

People with ADD and AD(H)D both suffer from inattentiveness, but there are many differences that haven't been considered in the research. The biggest difference is that they react differently on boring situations. AD(H)D start to do more, become hyperactive to create more arousal. ADD internalizes the stress and start thinking more to deal with the higher cortisol level (source), thinking (dissociating) to anticipate.

Medication intake

Some of the test users with AD(H)D had taken medication while using the wristband and others not. Unfortunately, the sample size is too small to detect differences between these user groups.

Expertise required

The prototype is giving the users a calming effect and works like a reminder to keep focusing on the work. This 'reminding mechanism' is related to cognitive behavioral theories, which requires psychological expertise to develop.

Not testing real products

The prototype was to simulate vibration patterns of existing products. One prototype with multiple vibrations has been built, to equally evaluate each vibration pattern. However, the real product experiences haven't been analyzed. These specific product experiences are not only different at vibration pattern, but also on looks, embodiment and how they communicate to users is different. This haven't been tested in user tests.

Friendliness bias

Test results could have been affected by the enthusiasm of participants. About a third of the user tests have been done at schools. These children showed much enthusiasm to participate, which could have affected the results, positive bias. The test had several advantages for the participants. By taking part in the test, children were free from the lesson, and seen as special, and could have led to an acquiescence bias, also known as friendliness bias (). In addition, children could also feel the need to show they really have AD(H)D, by confirming the wristband has effect on them.

Recommendations

Heartbeat vibrations

Vibrations with the speed of 30 - 50 times per minute were most popular in user tests, but also the slower rhythms of vibrations per every minute or three minutes. These results, suggest that users have personal preferences for similar situations, and having the ability to adjust the speed could makes the pattenrs more desirable.

Integrate CBT

The prototype has shown the be an unobtrusive reminder for different kind of activities. These kind of reminders can be used for behavioral intervention by the user itself. Therefore, it is most effective when users have knowledge of cognitive behavioral interventions. This means that users can reflect on their own thinking, and turn it into more actionable an positive self-talk. Based on recommendations of therapists and psychologist a plan, do an learn phase could be integrated to encourage this way of using reminders.

Implementation advices

Prototype V3 is developed in the Fitbit studio, and could be easily deployed to the Fitbit app store after being accepted as a publisher. Publishing the prototype into the Fitbit app store is an efficient way to gather new data. The Fitbit device is a fully devoped product, that is more attractive for users than the previous prototypes of this research. This helps to get users to test Flowy for a longer period and more situations. This can give insight in the real value of vibrations, because users can use it anytime. This test has been desribed in the chapter 'Build, test and learn'.

Integrate CBT

One of the main challenges is to implement behavioral training content, which requires psychological expertise. Therefore, it is suggested to cooperate with mental health care instances, such as PsyQ or AD(H)D Nederland.

Dedicated wristband

Once the content of the behavioral therapy has been created with experts. After testing with Fitbit devices, it is recommended to develop a dedicated wristband to meet the suggested design criteria for children, and it offers a optimization of vibration patterns, strenght and controls.

Funding

The Dutch government subsidizes multiple investment funds, these organizations looks for investments in medical startups. Hence, applying for national health funding programs such as 5square Tech Fund IV could be beneficial.

Pivot

Changing your market is easier than changing your product, therefore some pivots have been documented in appendix D. The first idea shows how the Flowy could be branded to increase interest of a specific target group, boys with AD(H)D. The second idea, suggest to target an adults with AD(H)D. It can offer similar vibrations and features as Flowy, and may as well guide mindfulness sessions using vibrationg wearables.

Reflection

63	Personal reflection
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65	Acknowledgement

Personal reflection

Before I started this graduation project, I did a three months long internship at Pilotfish. This was a great experience, where I already got to know the team. After this first internship I decided to do my graduation project at Pilotfish, because of the following reasons. First, I had a great time, in which I learnt much about design and prototyping. Second, I have a personal trait to continuously come up with new plans and be on the move, therefore I wanted to help myself by focusing longer on one direction. Lastly, Pilotfish offered a nice place, design expertise in IoT + medical care, and an opportunity to do some freelance work in parallel with my graduation project.

Once started, the freelance work went smoothly, because I already worked on that project before, and tasks were clearly defined. However, the graduation project had a slow start, I stumbled upon a very large area of information, and the project definition diverged quickly. The initial project goal was to design a product that helps making unconscious behavior conscious, to increase the life quality of children with AD(H)D. If I look back at this initial project goal, it was too undefined. I still cannot think of an example product that make unconscious behavior conscious, except cognitive behavioral therapies and analyzing video recordings of yourself. Hence, this could have been better defined, for example like; increase the effectiveness of cognitive behavioral treatments. Also, 'the quality of life' of children is broad. I had to spent much time on digging into the topic of AD(H)D, to define what exactly should be improved.

However, it was also good to have an undefined design challenge; it forced me into an explorative approach. I created an overview of most products and research projects on AD(H)D, and selected a direction that seems most promising and feasible for Pilotfish.

In the beginning of the research phase, I received feedback from Harm to change my interview style. I was searching too much confirmation, by asking suggestive questions like: "Do you think a wearable can help to focus?". During the explorative research, I trapped into a 'confirmation bias', because I was uncomfortable with not knowing where my project was going. Eventually, it disappointed me to hear some experts say, that I set myself in a very tough project, because AD(H)D is a heterogeneous disorder, which make it hard to design a solution for.

Progress meetings during the research phase were difficult, because I was not yet convinced about the direction of my project. Later this changed, and resulted in important personal learnings.

After the mid-term meeting, I started to feel more confident about my project. The reason was that I had to motivate myself to complete the executive summary to share it for feedback within Pilotfish. Putting this on paper made my story clear, and I regret I didn't do that earlier in the process. Although, I did document my work, but it should be more complete as soon as possible shared it with others.

Another turning point was based on the advice of my supervisory team: "start building and to get out of the building to test". This quickly led to new insights, that were useful and motivating for my direction. For example, it was a great to see people using my prototype live, and reviewing it positively.

In conclusion, I am happy about my project, because I have pushed myself through a difficult design phase. Now I am more confident about doing a solo design project, by means of knowing better to how keep on going when there is no clear direction.

Roadmap

The initial goal of this project was to find a new product or service concept for AD(H)D. This chapter describes trends that support the sustainability of Flowy.

Growing target group

The total amount of people diagnosed with AD(H)D is growing worldwide. One of the causes is that people are better informed about AD(H)D, and better recognizes the symptoms. The amount of people getting diagnosed a year is expected to grow from 2015 by 27% until 2040 (Volkgezondheid Toekomst Verkenning, 2018).

Mental health technologies

People are becoming more interested in products that improve mental health. Evidently, Fitbit and Apple have introduced many health features for their newest smartwatches. This could increase the social acceptance of wearing health wearables and using them for data collection.

Data collection

Research has pointed out the need for individual tracking of progress during treatments, because findings from group based research projects in the psychological area are often too general. Personal data collection can improve research and treatments. For example, at the University of Groningen a research project is using heartrate tracking devices to support recovery from depression (Hartogs et al., 2017).



Acknowledgement

This project couldn't have been a success without the help of some people. First of all, thanks to the team of Pilotfish to change the daily topic from 'cryptocurrencies' to 'AD(H)D'. The many talks and questions about my project have helped me a lot.

Thanks to Fabian for the help with prototyping, Frantz for the help with drawing and product design. Thanks Joke and Harm for giving me this unique opportunity to work on an entrepreneurial-like project within a company with so much expertise.

Jos and Jacky, thanks for your expertise and trust during the project. The multiple mid-term meetings really have helped.

I also want to thank my family, house mates and Jette to continually listen to my graduation stories. Especially thanks to Merijn, for helping to create a model for 3D printing and the nice renders.

Lastly, thanks to all the participants that took part in the research and the following schools; OBS de Zonnebloem, R.K. Basisschool Joannes and Nutsschool Zorgvliet.

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Appendix

A	Research
B	Prototyping
C	Test results
D	Pivot ideas
E	Concept

Appendix A.1

Product	Type	Type of system*	Target users	AD(H)D challenges	Component (Benyakorn)
Senseez	Cushion	MIIS	Children (Autism)	B, C	Assist
Epic Win	App	MIIS	Children (AD(H)D)	B, A, D	Assist
Octopus Watch	Smartwatch	MIIS	Children	B, C	Assist
Time timer	Watch/other	MIIS	Children + adults	B	Assist
Touchpoints	Wristband	MIIS	Children + adults	B, D, A	Assist
SmartPen	Pen/research	AES	Unknown	B	Recognize, assist
Re-Vibe	Wristband	MIIS	Children	B	Assist
Doppel	Wristband	MIIS	Adults	B, C, D	Assist
Spire	Wearable	AES	Adults	B, C	Sense, recognize, assist

Figure A.1 Overview of the selected products in market research

*MIIS: Manually interacting with information and services

*AES: Automatically executed services based on in-situ analysis of context information

A. Social disability

e.g., poor peer and family relationships, poor social skills.

B. Academic and occupational failure

e.g., underachievement, special education needs.

C. Health problems and psychiatric comorbidities

e.g., disruptive behaviors, executive dysfunction, sleep disorders.

D. Psychological dysfunction:

e.g., Emotional dysregulation, lack of motivation.

E. Risky behaviors

e.g., accidents, injuries, and unplanned pregnancies.

Sonne et al. (2016)

Appendix A.2

Test 0: the vibration effect

Setup

This first test has the goal to measure the effect of body vibrations on the attention span of people. The initial target group was children of 10 – 14 years old, of which at least half of them has AD(H)D. However, regard the goal of this research it important to gather a large sample size, therefore also people of older ages haven been asked to participate.

Method

In psychology, the Stroop effect is a demonstration of change in the reaction time during a task. The Stroop test is often being used to measure attentions span, it also has been used in the research of Chang et al (2012) and Fuermaier et al. (2014).

All participants were asked to say out loud to colors from left to right. First, the speed of reading colors was tested followed by a test to measure reading speed. Here are the font colors equal to the text. After this, the Stroop effect was added, words were interfering with the font color.

The Stroop effect step (figure A.2) was always first tested without any product, to calibrate the results of all participants. In the fourth step, one-third of the participants received a vibrating cushion, one-third a vibrating wristband and one-third none.



Figure A.2: Stroop test part 1/3



Figure A.3: Stroop test part 2/3

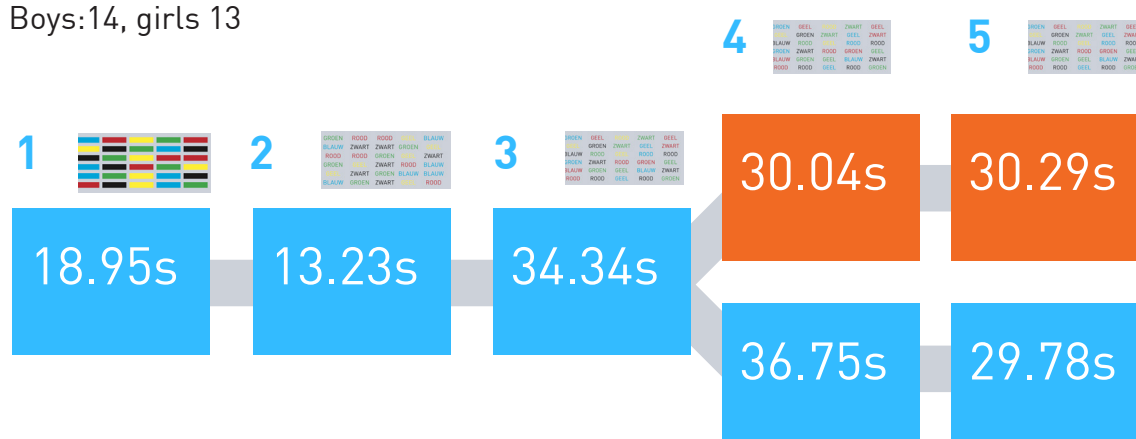


Figure A.4: Stroop test part 3/3

Results

27 testers

Boys:14, girls 13



Appendix A.3

Observation

The class observation is done in a class of children from 9 – 10 years old. In the back of the classroom notes were taken in combination with video recording. The video recording has been removed one day after the observation and names are fictitious to ensure anonymity.

Before the observation the teacher informed me about the two most active children in the class, Bas and Kees. During the observation, this was quickly confirmed because both were sitting often in different positions or standing up in class.

Bas was most active, by standing up several times which seemed to happen simultaneously. Once when a lesson started about reading, Bas was already reading while the teacher was talking and all the other kids were listening. Kees was paying attention to the teacher, but answering question loudly. Kees was compared to Bas less active. All kids were sometimes distracted, moving with their feet or playing with a gummy or something.

Overall, I think the class was an easy class, because of two reasons, the school is located in a highly educated area and the teacher has much experience. Peter, has 43 years' experience as a teacher, he showed to have control over class. The hyperactivity of specific children has been confirmed by Bas. His activity seemed to be very automatically, other children were moving less consistent.

Interview children

The first assignment was to draw themselves doing what they like to do the most. This was a starting point to talk about attention span. The children were familiar with the term 'aandacht' (attention span) and 'focus' (focus), but not familiar with the term 'flow'.

Also, they found it difficult to reflect on their attention during lessons, it was better possible to translate it to 'like' and 'dislike' of the lessons. This resulted in a lot of information and arguments why they liked or disliked some lessons.

In conclusion, the children of 9 to 10 years old seem to be too young for the concept of 'focus'. They find it hard to evaluate own attention of past activities. Also, a product that vibrates is very interesting for them, all were very enthusiastic about the idea of using it in the classroom, main reason was the 'relaxing' feeling.



Figure A.5 User study with children of 9 & 10 years old

Appendix A.4

Interview B. den Blaauwen

Bas is a therapist of AD(H)D centrum Nederland. This is a private institute that offers coaching for people with AD(H)D.

Bas explained the bucket model, a theory developed within the institute. This model is interesting, because it explains how AD(H)D behavior results in negative experiences and a negative loop.

The lowest layer represents the 'ADH' characteristics of a person. Often people with AD(H)D are very visual and kinesthetic. 'ADH' stands for Attention Deficit Disorder, this without the last D, because on itself it is not a disorder.

The second layer is 'HHH', and stands for 'Hoe Het Hoort' in Dutch. This means what the society or environment expects from you. People who grow up with 'ADH' characteristics learn to adjust behavior, because most of the ADHD symptoms do not fit with 'HHH'. For example, talking very loud, being hyperactive, or acting impulsive. This adjusted behavior eventually results in negative experiences, such as rejection. These negative experiences create 'damage', such as anxiety, feeling powerless, aggressions and other.

These stressful feelings affect the autonomous nervous system (ANS), which is shown in the fourth layer. When this ANS is continuously stressed it will increase the ADH behavior of layer. This becomes a negative loop.

In conclusion, this interview with Bas learned that distracting the brain is according to Bas a great way to reduce stress on the ANS. In therapy, clients learn to 'feel more and think less'. A wearable with sensorial input could support this process. Bas is open for testing the prototype himself and with some of his clients.

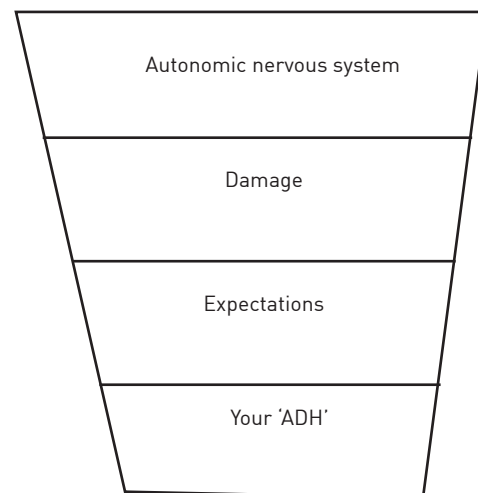


Figure A.6 The 'bucket model' by ADHD Nederland

Appendix A.5

Overview of the vibration patterns

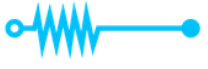
	A; 10 – 200 times /minute 	B: Every 1 or 3 min 	C: Relaxing 	D: Breathing exercise 
Main functionality	Calming, focusing	Self-management support	Calming, focusing	Calming
Helps you to	Feel less stressed, feel your body, be in the moment	Train positive self-talk	Feel less stressed, feel your body, be in the moment	To do breathing exercises
When to use	Individual work, in meetings, before sleep	During the day, in class listening to instructions, individual (school) work	Moments of stress, before sleep	Moments of stress
How it works	It distracts your brain by giving sensorial input	It continually reminds you of cognitive exercises	It distracts your brain by giving sensorial input	The vibration motor leads you through breathing exercises
For children because	It is simple to use and calming	It can support cognitive behavioral therapies	It makes them relax more	It learns them to control breathing to relax more
Optimal version	A small band with strong and soft vibrations that feel good, are silent and are easy to control	A smartwatch with a screen to give short messages, and measure activity and other physiological data	Whole body vibrations	With video and audio to guide through exercises
Weakness	Optimization of vibration motors and interaction. Clinical research.	Children require some CBT skills. Clinical research.	Difficult to know when to use	Difficult to know when to use
Strength	Simple, proven effects by study of Doppel.	Supports behavioral management	Neurological support	Breathing exercises are well known

Figure A.7 Vibrations matrix

Appendix B.1

Prototyping

Razer Nabu X

- \$20
- No interface
- 3 led lights
- Java and Objective-C only.
- Developer portal is closed and SDK repositories are deprecated



Fitbit Versa

- \$200
- Interface 300x300
- No led lights
- Web API + Device API



Fitbit Flex 2

- \$70
- No interface
- 5 led lights
- Web API – javascript
- Device API not available



Custom

- ~\$20 - \$1500
- No interface
- 100% customizable
- Custom development

Prototype	Price	Development	Testing	Risk
Razer Nabu X	€20	Professional	Cheap, small	High, no support and doc available, new code.
Fitbit Flex	€70	Regular	Limited vibration functionality	Medium, Limited vibration functions
Fitbit Versa	€200	Regular	With screen, expensive	Low, offers the required functionalities, but more.
Custom solution	€50	Veteran	Very customizable, but breakable	High, low experience in developing hardware

Appendix B.2

Prototyping

Prototype 1

The first prototype was 'quick and dirty'. Led bike lights were used as the controller for the vibration motor. The led light was simply replaced with a vibration motor, and the prototype was working with two modes. A Nike soccer band was used as embodiment.

Prototype 2

The next prototypes contained a microcontroller with Bluetooth, pulse with modulation (pwm) and Arduino. Picture X shows the circuit diagram, which illustrates the wiring between the other parts; 150mA battery, vibration motor and a transistor.

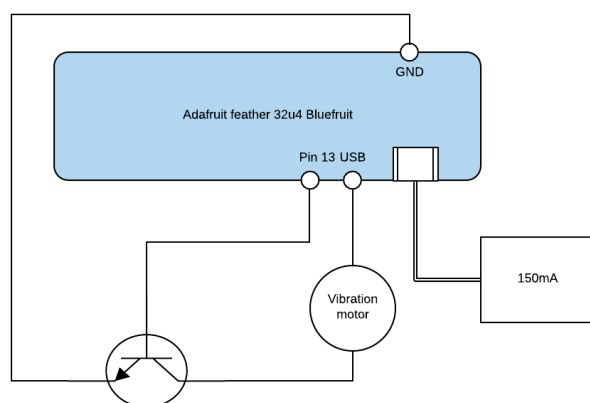


Figure A.8 Hardware diagram prototype 2.1 & 2.2

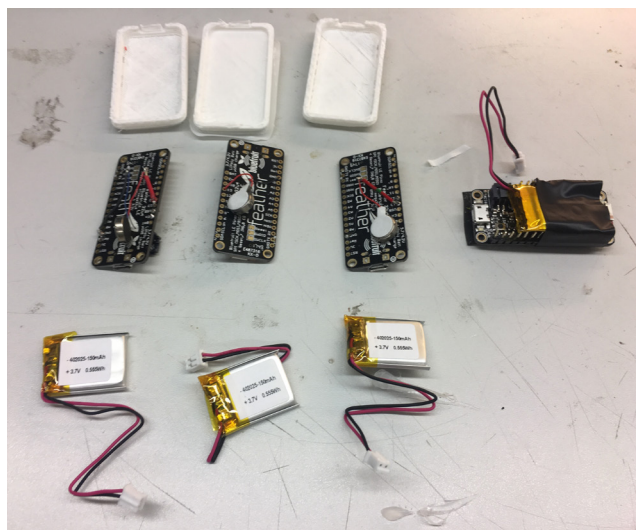


Figure A.9 Hardware components prototype 2.1

Prototype 2.1 & 2.2

After prototype 2, the embodiment and software have been improved. The embodiment of prototype 2.1 was large and fragile, because it had to be developed quickly. Speed was important, because schools were almost closing for summer holidays. Figure X shows the embodiment of prototype 2.1 and the improvements to prototype 2.2. The new embodiment was smaller, stronger and was combines with nicely looking elastic bands.

The software of version 2.1 had bluetooth comands and three modes (A, B and C). Bluetooth commands were used, because the prototype did not have a button yet. Prototype 2.2 offered an easier interaction by pressing the button, and cam with three modes. Mode C was changes to the breathing exercise, regard the unpopularity of C in previous tests.

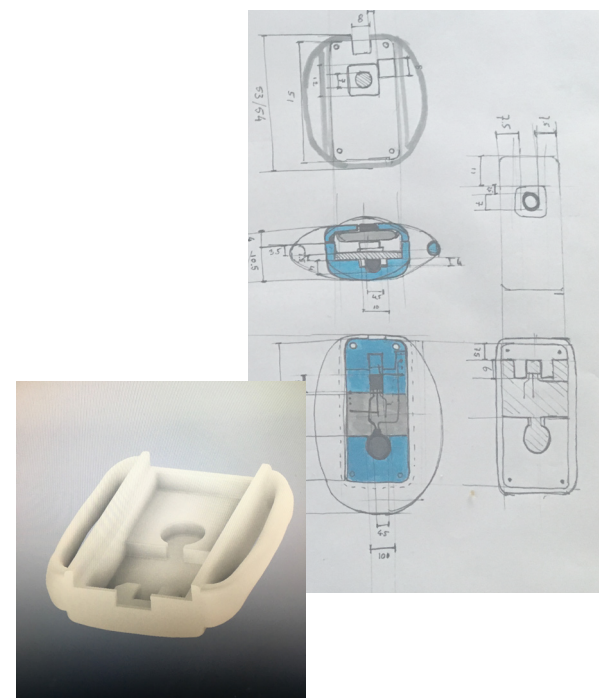


Figure A.10 Render and technical drawing prototype 2.2

Appendix C.1

All user test results

	Age	Gender	Preference	Activity	AD(H)D	Use length (h)	Version
1	12	M	A	School instructions	ADHD	2	2.1
2	11	M	A	School instructions	ADHD	2	2.1
3	11	F	A	School instructions	ADD	2	2.1
4	9	F	-	Playing	No, symptoms	4	2.1
5	14	M	A	Reading, cleaning room	No, symptoms	3	2.2
6	40+	F	B (3min)	Reading	No	3	2.2
7	35+	F	B (3min)	Car driving, reading	No	2	2.2
8	10	M	B	Reading	ADHD	2	2.2
9	30	M	A (50)	Administrative work	ADHD	2	2.2
10	29	F	A	Talking	ADHD	1	2.2
11	24	M	A (30-40)	Listening to instructions	ADD	3	2.3
12	24	F	A (80-100)	Writing report	No	1	2.3
13	23	F	A	Reading	ADD	2	2.2
14	24	M	B (3min)	Writing	No	1	2.3

Figure A.11 Test users table

Appendix C.2

Results test prototype 2.1 (1)

Wat denk je van de trilling?

Trilling 1: constant

Onprettig	☐	☐	☒	☐	Prettig
Onhandig	☐	☐	☐	☒	Handig
Rustgevend	☒	☐	☐	☐	Afleidend
Motiverend	☒	☐	☐	☐	Demotiverend
Saaï	☐	☐	☐	☒	Leuk

Opmerking over trilling 1:

die constant trilde

Trilling 2: afwisselend

Onprettig	☐	☐	☐	☒	Prettig
Onhandig	☐	☐	☐	☒	Handig
Rustgevend	☒	☐	☐	☐	Afleidend
Motiverend	☒	☐	☐	☐	Demotiverend
Saaï	☐	☐	☐	☒	Leuk

Opmerking over trilling 2:

De kracht is wat sterker endat is

Hoe vaak ongeveer heb je de band gebruikt?

0 / 1 - 5 / 6 - 10 / 10+

fijn

Op welke momenten?

zijn half
leser helpmaal

Hielp het? Zo ja, voor wat? Zo niet, waarom niet?

het hielp om het rustgevend was endat heb ik
echt nodig

Wat vind je van het gebruiken van trillingen in de les?

fijn

Op welke momenten zou je willen dat het bandje trilt of een ander signaal doorgeeft?

tijdens een les

Heb je nog overige opmerkingen?

nee, niet echt. (mou
name

Appendix C.3

Results test prototype 2.1 (2)

Wat denk je van de trilling?

Trilling 1: constant

Onprettig	☐	☐	☒	☐	Prettig
Onhandig	☐	☐	☐	☒	Handig
Rustgevend	☐	☐	☒	☐	Afleidend
Motiverend	☐	☒	☐	☐	Demotiverend
Saai	☐	☐	☐	☒	Leuk

Opmerking over trilling 1:

werkt goed en is fijn

Trilling 2: afwisselend

Onprettig	☐	☐	☒	☐	Prettig
Onhandig	☐	☐	☒	☐	Handig
Rustgevend	☒	☐	☐	☐	Afleidend
Motiverend	☒	☐	☐	☐	Demotiverend
Saai	☐	☐	☐	☒	Leuk

Opmerking over trilling 2:

is heel fijn omdat je goed merkt wanneer je moet werken

Hoe vaak ongeveer heb je de band gebruikt?

0 / 1 - 5 / 6 - 10 / 10+

Op welke momenten?

lezen/taal

Hielp het? Zo ja, voor wat? Zo niet, waarom niet?

ja, lezen, taal

Wat vind je van het gebruiken van trillingen in de les?

goed bedenken het werkt

Op welke momenten zou je willen dat het bandje trilt of een ander signaal doorgeeft?

als ik niet zit optelertien (gebeurt best vaak)

Heb je nog overige opmerkingen?

nee

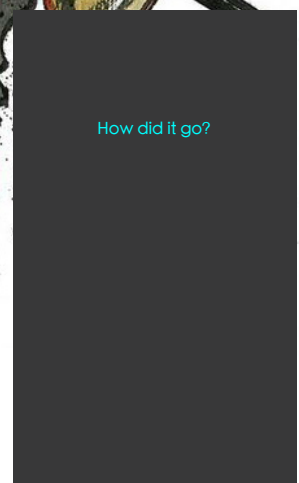
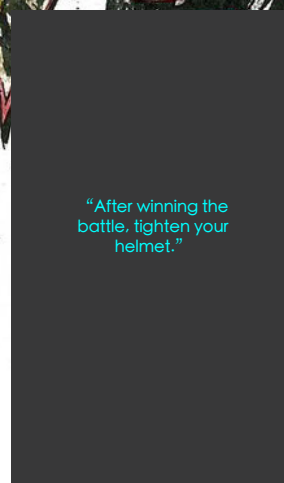
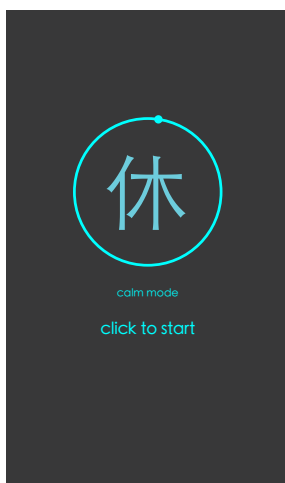
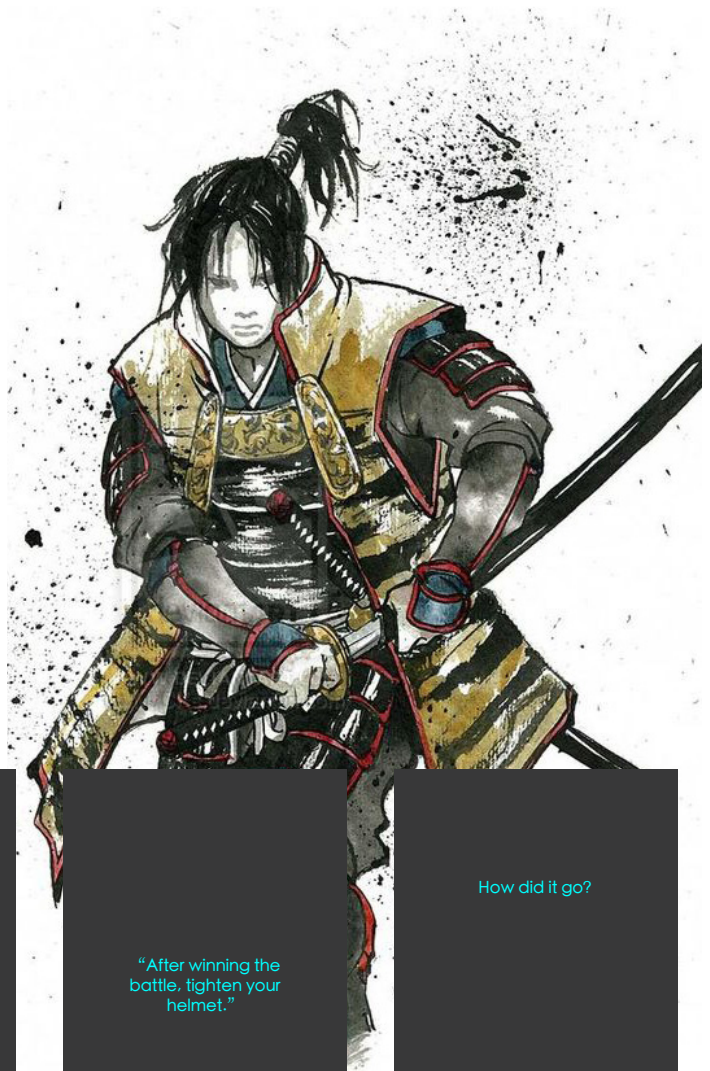
Appendix D.1

Pivot idea 1

Zanshin

Zanshin, is state of awareness, relaxed alertness, in Japanese martial arts. This comes with an ancient way of learning how to focus, and is implemented in an app and a wearable (Fitbit).

Children can learn about the story of Eugen Herrigel and start their own training by setting goals and creating vibration patterns that helps them to focus on the body during homework or other boring tasks.



Appendix D.2

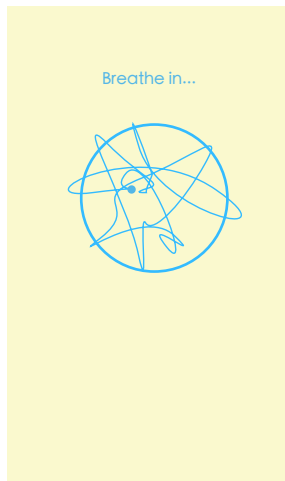
Pivot Idea 2

Medibrate

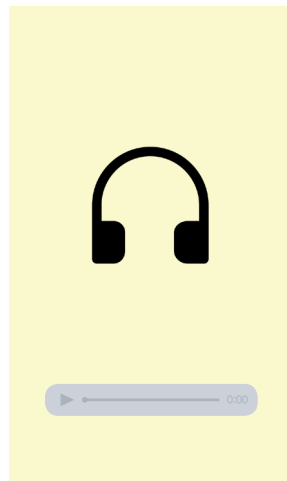
Tactile stimulations are integrated in a mindfulness app, such as Headspace and Calm. The tactile stimulations in a smartwatch enhance the mindfulness experience, by sending unobtrusive reminder to feel more and think less.

The app contains multiple lessons in which the users learn about mindfulness and dealing with distractions when studying or working.

Each guided meditation uses vibrations to keep the user alert, and to make the user follow exercises without audio. After each exercise, reflective questions make the user reflect on own behavior, thoughts and feelings.



Visual of pattern

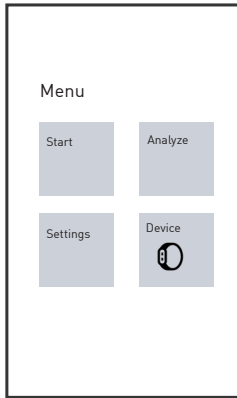


Podcast interface

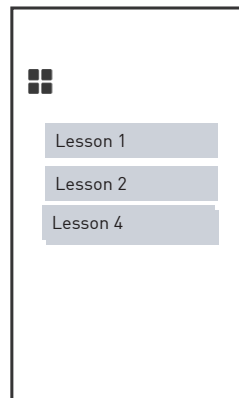


Appendix E.1

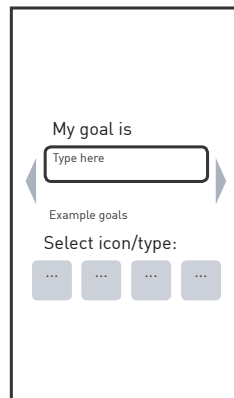
Companion app wireframes



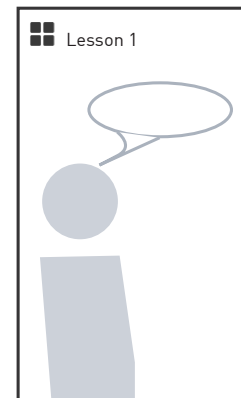
Home screen



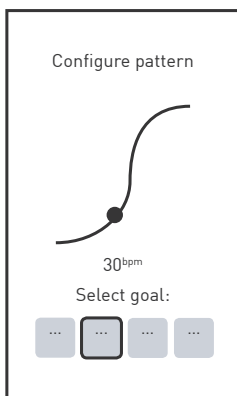
Overview lessons



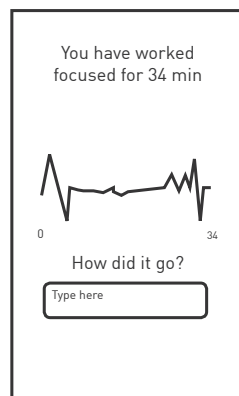
Set goal



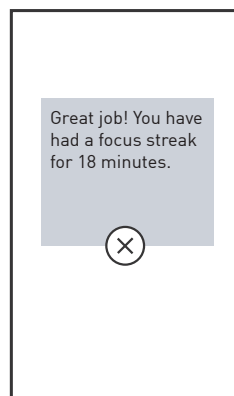
Lesson 1
introduction avatar



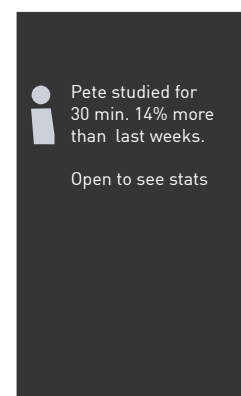
Add pattern to
goal



Analyze
session



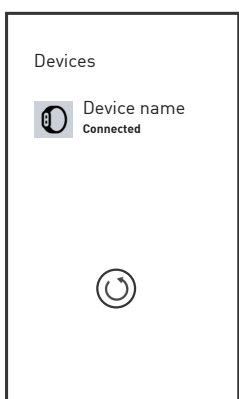
get notification
about succes



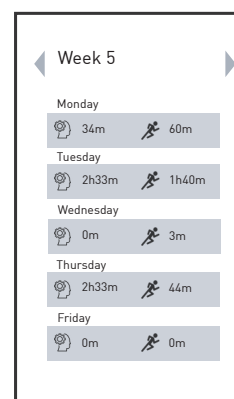
Notification to
parent



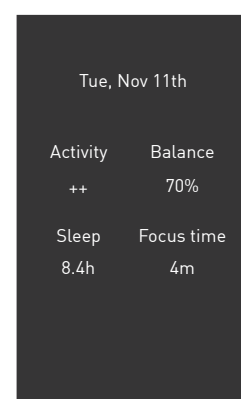
get notification
about fail



Devices



Analyze week



Monitor view
parent



“I never could have done what I have done without the habit to concentrate myself on one subject at a time”

- Charles Dickens