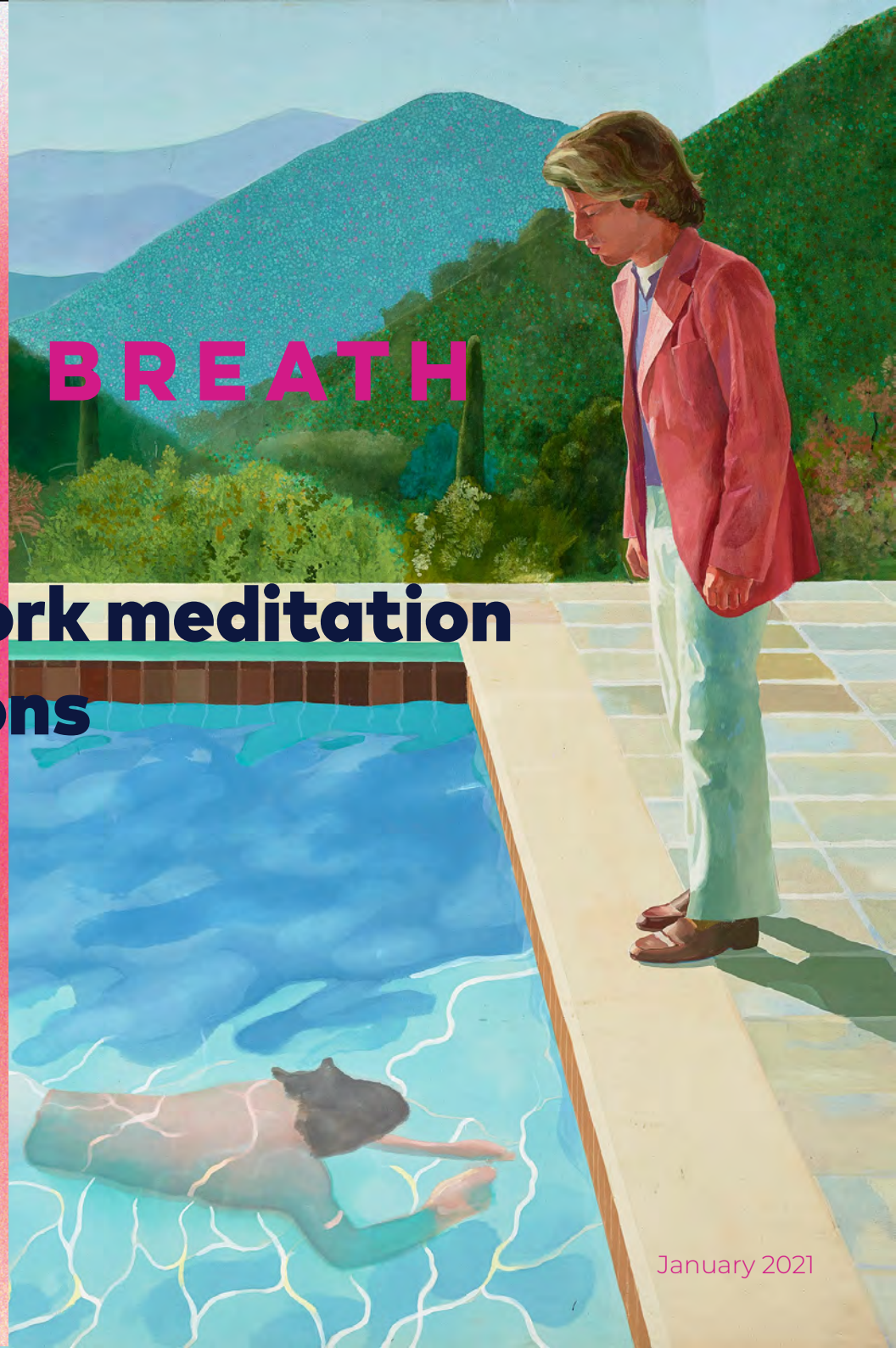
THE MARKET OF BREATH

A design strategy to productize breathwork meditation through tactile vibrations



Graduation Project
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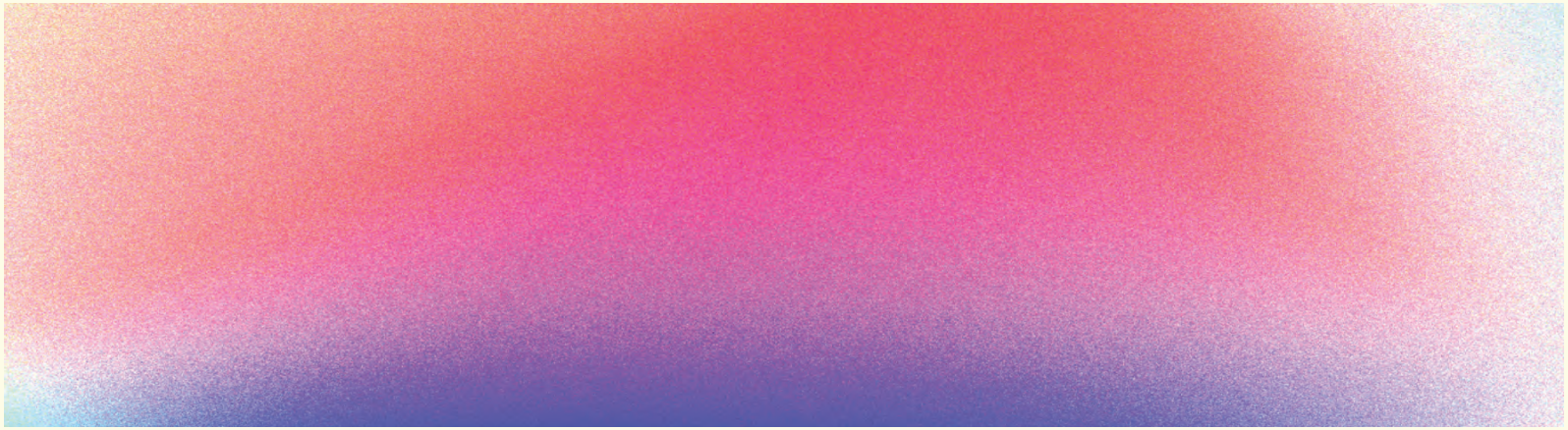

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Vibe Research Labs.

Investigating the human experience of vibrations
— and how they might be harnessed for good.

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"Glattes Eis.
Ein paradeis für den,
der gut zu tanzen weiß."

- Nietzsche



Gratitude

Like some of your first steps on the ice during early winter. Finishing this Master thesis for me means I will step away from solid shores and stand my ground within the design industry.

As every project I have undertaken, the result is always an amalgamation of exchanges with people and the environment surrounding me. I would like to thank everyone who knowingly or unknowingly helped me through my masters and this graduation project. I would explicitly want to thank my family, my friends and fiance for their unconditional support.

I would also like to thank my supervisory team whom without, this project wouldn't be possible. The bi-weekly meetings formed a highly valued systematic push for the project and have fuelled the project with both expertise and practical experience.

To Derek, through your enthusiasm and highly energetic meetings you've managed to get the most out of me. I wouldn't have stood a chance without your in-depth knowledge within this niche research domain.

To Jos, through your calm and structured way of working you've managed to balance us as a team throughout the journey. Your patience and analytical reflections during our fuzzy-front-end coaching sessions helped to structure my thoughts and prioritize my findings. Together, we were able to unravel the right-colored puzzle pieces from the large stack at the table!

I'm looking back at a path of steep learning, however, I'm enjoying the view from up here! I'm confident about the results and hope to continue this project in a future startup. Furthermore, I hope this project can become a source of inspiration for others who stumble upon it.



Executive summary

Keeping a healthy work/life balance can be a daunting task in today's overstimulated society. For many of us, a regular day can feel like running on a treadmill. This results in fast, restricted and shallow breathing throughout the day. Whereas, the right breathing rhythm can have a profound impact on our (mental) well being and overall happiness. It is argued that habituating deep breathing exercises is a promising solution to increase stress resilience.

This explorative study aims to find a productisable solution for habituating breathwork meditation. The proposed solution (Sensescape) is supported with a novel, yet 'grounded' theory. The working principle of the product is validated with several small scale user tests and experiments. Furthermore, market potential was explored via market analysis, business modelling and strategic roadmapping. It is argued that Sensescape is able to differentiate itself from the competition by building a closed-loop-system in horizon 2 and a focus on first-responders in horizon 3. A brand identity was crafted based on those insights.

Sensescape, is a handheld meditation device to guide breathing, through haptic and light feedback. Soothing vibrations will bounce between two handheld pulsators, to orchestrate the right breathing pattern. This will help you to 'get out of your head' and unwind from everyday stress. On top of that, the immersive tactile effect will naturally grab your attention and sustain focus during a meditative session.

An extensive literature review was performed on the areas of neural entrainment, tactile vibrations, rumination and the art of breathing. These areas formed the foundation for the building of the novel grounded-theory.

It was found that; bilateral tactile phantom sensations lead to easy neural entrainment. This phenomenon is exploited in the working principle of the product to create a natural point of focus. The physical sensations will help disrupt negative thought flow.
Through some experimental sound engineering and an iterative approach, soothing phantom vibrations were designed. The user experience was shown in a live demonstration. See video here: https://youtu.be/VfWNLbKRofI

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MY DESIGN PROCESS

GROUNDED THEORY

Research

Overarching Theory

Literature Claim 1	Literature Claim 2	Literature Claim 3
Design Goal 1	Design Goal 2	Design Goal 3

PROTOTYPING

Sound engineering

Experiment / Validate / Iterate

Product design UX design

MARKETIZATION

Strategizing

Market analysis Brand Identity Roadmapping

Business modelling

Pitch

Glossary

AD /MD /PD = Atypical- /Major- /Psychotic-Depression

Aesthetic resonance = Synchronisation between the sender and receiver.

Auditory cortex = Part of the brain that processes audio.

AVE = Audio Visual Entrainment

Beta2 frequencies = High beta brainwave frequencies (15-22Hz). Associated with mental processes such as; problem solving decision making.

Bilateral = On both sides/hands, vibrating in alternating fashion.

Binaural Beats = Type of focus music,
based on neural entrainment.

COGS = Costs of Goods Sold

DMN = Default Mode Network
Network of brain regions, active during rest.

EEG = Electroencephalogram

EMDR = Eye Movement Desensitization Reprocessing

Haptics = any form of interaction involving touch

HRV = Heart Rate Variability

Neural entrainment = Brainwave synchronization.
The natural phenomenon of synchronization between the electrical activity of the brain and an external stimulus.

Neural salience = How the brain divides attention capacity among different stimuli.

Phantom sensation = illusory (tactile) sensation between the two real actuation points.

Productize = to make into a product which can be sold

PSS = Product Service System
A business model that sells/leases it's (physical) product as a tool to provide a service.

PTSD = Post Traumatic Stress Disorder

Pulsator = Vibration motor

Resonant breathing = Breathing exercise based on biofeedback

Rumination = Overthinking or worrying

SaaS = Software as a Service, business model

Sensescape = Name of proposed product.
Portmanteau word for 'Escaping' the mind, by the use of the human 'senses'.
It's derived from 'Soundscape', a collage of sounds.
Sensorimotor = involving both the sensory and motor system

Tactile = Perceptible by touch
In this project, tactile stimulation refers to applying vibrations in both hands

Tactile Beats = Musical vibrations (beats) perceived through tactile vibrations only

Techno / Breakbeat / Ambient = music genres

VAT = Vibroacoustic Therapy

Vibe = As a social construct, the mood or atmosphere produced by a particular person, thing or place.

Vibrotactile = The perceptions of vibrations through touch

Sensescape

Mental Health

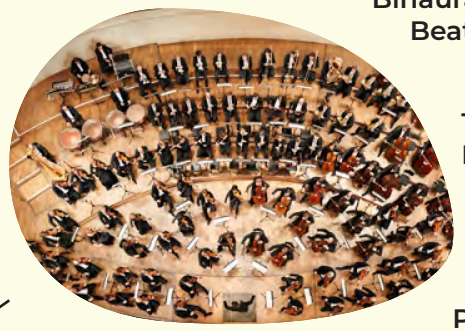


Destigmatisation

Rumination

Everyday Stress

Music Theory



Binaural Beats

Auditory Salience

Techno // Breakbeat

Harmony Perception

Cognition

Aesthetic Resonance



Neural Salience

Neural Entrainment

Brain Waves

Haptics



Phantom Senations

Bilateral Stimulation

Vibro-tactile stimulation

Psychotherapy



AVE

EMDR

VAT

Breathwork



Meditation

HVR

Resonant Breathing

Figure 0: Reseach Map

Frame of Reference

1

Why would you read this report?
The following chapter will provide a frame of reference to better understand the executed literature study. It will shine light on some of the trends at play within society, influencing the problem at hand. The formed perspective will function as a fundamental layer for the execution of this project and provides relevance for the proposed product offering in general.

Introduction

What is real? Is a sunset real?
Or the meltwater in a mountain lake? When we see something amazing, unexpected, or just plain surprising, we can sometimes be quite puzzled about its very ‘reality’. And what is it that we normally do in order to convince ourselves of its actual existence outside the realms of our own mind (or imagination)? That’s right, whenever possible; we touch it.

In the bible, Saint Thomas is said to have put his fingers into the chest of Jesus in order to be sure that he really had been resurrected (see Figure 1.1). Touch, then, is often depicted as the sense that cannot be deceived or fooled. It is the sense that makes the world real to us!

Because of this important role in our daily lives; the surface of the human body (the skin) is actually created as one huge sheet of tactile receptors. It provides us with the means to connect with our surroundings. It is the skin that constitutes the largest of our sense organs. The skin protects our body from the external world and, at the same time, informs us about what occurs on its surface.



Figure 1.1 - ‘Doubting Thomas’ checks if Jesus is truly resurrected. (Caravaggio)

This project will explore the relationship between our tactile receptors and our mental wellbeing. The literature study will provide evidence from many different fields (see Figure 0) to establish a grounded theory. Consecutive, validation will be sought by testing with a self-made prototype. Ultimately, these findings will be translated in the design of a product named ‘Sensescape’ to explore market potential.

The importance of mental health

“HUMAN HEALTH IS A STATE OF COMPLETE PHYSICAL, MENTAL AND SOCIAL WELLBEING AND NOT MERELY THE ABSENCE OF DISEASE OR INFIRMITY.” - WHO

Looking at this definition of the World Health Organisation, concepts of mental health should also include ‘subjective wellbeing, perceived self-efficacy, autonomy, competence, intergenerational dependence and recognition of the ability to realize one’s intellectual and emotional potential’.
Mental health has also been defined as “a state of wellbeing whereby individuals recognize their abilities, are able to cope with the normal stresses of life, work productively and fruitfully, and make a contribution to their communities.“ (WHO, 2003)
Mental health is about enhancing competencies of individuals and communities and enabling them to achieve their self-determined goals.

This broader definition of mental health shows that the matter should be a concern for all of us, rather than only for those who suffer from a mental disorder. On a global scale, the financial burden of mental health disorders is enormous. Worldwide, as many as 450 million people suffer from a mental or behavioural disorder (WHO, 2003). Within some countries of the European Union, treatment costs of these disorders are estimated to amount to up to 4% of the gross national product (Chen et al., 2020). In 2015, depression specifically resulted in a cost burden for the USA of $210 Billion (Analysis Group, 2015). Nonetheless, recent studies suggest that there are currently more depressed people, than ever before (Blue Cross, 2018).

This data is relevant for this project since it shows the relevance for enetering the market with a product offering tackling this growing issue.

Figure 1.2 - Destigmatisation of mental health (Rita Quattrocchi)



Racing thoughts in a racing society

The trend research executed in the following chapters represent some of the ‘threads’ which are interwoven in our societal weaving loom. All play a role in our lives, without any direct control of our own. Nonetheless, they do affect us in various ways. It is argued that these different actors contribute to themes alive to rumination and enhance everyday-stress.
Therefore, they should be adressed and understood, before a product tackling these issues can be designed.

Figure 1.3 - Multiplication of lifestyle choices (Unsplash)



INDIVIDUALISATION

Globalisation, digital connection and, not least, the growth in prosperity over the last few decades have multiplied the options for self-fulfilment. Lifestyles and life choices are becoming more flexible and differentiated. Everything now seems possible for everyone (TrendOne, 2019). But what to choose?

People are increasingly projecting themselves as a brand and curate their own identity exhibitions in social networks. To be unique, products and services are being individualised to a very high degree. Personally designed clothes, media use and selected lifestyles all show that the motto here is: distinction not convention. Companies have spotted this and are rushing to the aid of consumers, with all their needs, desires and preferences.

Not least due to the growing visibility of different lifestyle concepts in social media, the idea of a flexible identity spectrum for sexuality and gender is becoming more popular among younger people.
Since making these ‘life choices’ often comes with an introspective thought-journey; they form a significant contribution to ruminative themes. Resulting in everyday stress and a variety of mental health concerns.

ATTENTION ECONOMY

In times of clickbait and fake news, people are only willing to reward top-quality content with their attention. In order to stand out, brands are therefore increasingly using emotionalization, authenticity and stances on social issues to scream for attention.

To outvoice the competition, brands try to communicate via innovative platforms, think outside the box and offer their customers high-quality branded content instead of flat claims.

Therefore; attention is one of the most important currencies of the 21st century.
However, with the rise of mindfulness practices, people are becoming increasingly exclusive with this valuable resource. A societal relevant theme wich frequently evokes debate. Since for many of us, this bombardment of impulses causes trouble unwinding from work.



Figure 1.4 - Attention as a currency (Reuters)

"AS THE EXPRESSION 'PAYING ATTENTION' SUGGESTS, WHEN YOU FOCUS, YOU'RE SPENDING LIMITED COGNITIVE CURRENCY THAT SHOULD BE WISELY INVESTED, BECAUSE THE STAKES ARE HIGH."
– WINIFRED GALLAGHER, RAPT.

EVERYDAY STRESS

Lately, the COVID-19 pandemic has altered every aspect of normal daily life for people all around the world. Besides all the medical applications, the pandemic has also a significant and long lasting effect on mental health related issues. Worldwide many people are experiencing considerable stress related to the coronavirus. The American Psychological Association reports that people are experiencing higher levels of general stress than in recent years (especially for parents).

“The average reported stress level for U.S. adults related to the coronavirus pandemic is 5.9. When asked to rate their stress level in general, the average reported stress for U.S. adults is 5.4. This is significantly higher than the average stress level reported in the 2019 Annual Stress in America survey, which was 4.9” (APA, 2020).

Besides COVID-19, everyday stress has increasingly been playing a major role in people's lives for the past decade. Statista’s global dossier on ‘Stress & Burnout’ reported in 2017 that 37 percent of adults in the U.S. stated an increase in their stress levels over the past year, a rise from previous years. (Statista, 2019). These rising stress levels are also greatly contributing to rumination (see chapter 2).



Figure 1.5 - “Work hard, Play hard (Guenter Zimmermann)

What is Rumination?

2

Do you sometimes ruminate yourself?
The following chapter will give insight in the act of rumination, why it occurs and what happens when you do it. Before a product is able to disrupt rumination, it's important to understand the phenomenon itself.
This chapter will tap upon the practical implications, underlying mechanisms and provide some coping strategies.

Chewing on uninvited thoughts

The thought process of rumination is colloquially called ‘over-thinking’ or ‘worrying’. It can best be described as negative thought-loops or depressive thought patterns. Within this project, rumination will always refer to the psychological definition and should therefore not be mistaken for the act of chewing the cud.

Within literature; rumination refers to ‘repetitive thinking and focus on negative mood states’ (Nolen-Hoeksema, Morrow, & Fredrickson, 1993). It’s a dysfunctional self-focussed attention often initiated by intrusive thoughts. This type of thinking activates negative associative memory networks. When these negative networks activated, they interfere with attention, block instrumental behaviour and impair problem solving (Huffziger, 2009). The latter, makes rumination occur in a continuous form and hard to disengage from.

The American Depression and Anxiety Association estimates that around 6 million people in the USA alone are troubled by intrusive thoughts (ADAA, 2018). This implies a significant amount of ruminators in the USA. Intrusive thoughts are thoughts that seem to become stuck in the mind. They can cause distress, as the nature of the thought may be upsetting.

Urges and images contained in these thoughts are of inappropriate things at inappropriate times, and generally have aggressive, sexual, or blasphemous themes (Baer, 2001).

This project will mainly focus on ‘work-related rumination’ because it’s strong and effect on mental health and close relation to everyday stress. Work-related rumination has been defined as a thought directed to issues relating to work, that is repetitive in nature (Cropley & Zijlstra, 2011). For example, a worker may ruminate about an important project deadline, an unfinished task, stress over a future meeting, or they may perseverate about something negative that was said to them by colleague at work (Cropley & Millward, 2009; Syrek et al., 2016).

Figure 2.1 - “I should smile more often to my manager” (Amy Cutler)



Moreover, it was found that rumination has a pivotal role in the onset, maintenance as well as phenomenology of major depressive disorder (MDD) (Nolen-Hoeksema, 2008). Its presence increases the risk of relapse in remitted patients and can exacerbate MDD (Roberts, Gilboa, & Gotlib, 1998). This shows that designing a product which is able to disrupt rumination, can also significantly contribute to the battle against depression.

Lastly, prior work suggests that rumination has two subcomponents: brooding and pondering. Brooding involves passive continuous negative thought about one's emotions. Pondering involves more active reflection and problem solving about one's situation (Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

Rumination vs worry

To better understand the concept of rumination on itself, it's important to make a clear differentiation from worrying. Which might be more familiar to most readers.

The matter is, rumination and worry are significantly correlated with each other (Fresco et al., 2002; Muris, Roelofs, Meesters, & Booms- ma, 2004; Segerstrom et al., 2000; Watkins, 2004; Watkins, Moulds, & Mackintosh, 2005).

Nevertheless, rumination is statistically distinguishable from worry (e.g., they load on different factors; Fresco et al., 2002; Hong, 2007; Muris et al., 2004; Segerstrom et al., 2000; Watkins et al., 2005). And can even be distinguished by comparing HRV data from both worrying and ruminating people (see chapter Heart Rate Variability).
Key features differentiating worry from rumination can be found in Figure 2.2.

WORRY	RUMINATION
Future oriented	Past oriented
Goal: Anticipate threats	Goal: Deeper understanding of (negative) event
Outcome: Prepared for taking action	Outcome: Bad mood

Figure 2.2 - Distinguishing features of worry and rumination. (Nolen-Hoeksema, 2008)

Why do we ruminate?

What is causing us to ruminate? Convergent lines of evidence suggest that the default mode network (DMN) may be the key brain network underlying rumination (Zhou et al., 2019). Rumination can therefore be viewed as the psychological expression of default mode network (DMN) abnormalities. Especially in patients with MDD (major depressive disorder) (Kaiser et al., 2015). Chen et al, has found in a recent study (2020) that DMN region activities are significantly high during rumination.

The DMN is a set of brain regions showing reduced activity during 'active attention-demanding tasks' (Andrews-Hanna et al., 2010; Buckner and Carroll, 2007; Buckner and DiNicola, 2019). Systematic reviews and meta-analyses implicated the involvement of DMN in a number of different processes. These include "autobiographical memory, self-referential thinking, scene construction and theory of mind" (Buckner and Carroll, 2007; Qin and Northoff, 2011; Spreng et al., 2009). These processes are all related to ruminative thought content. Since the processes are posited to be forms of self-generated thought, the mental content mostly consist of internally constructed representations (Buckner and DiNicola, 2019; Christoff et al., 2016).

In practice, this means that most of these (self-generated) thoughts aren't necessarily true. Because of this ruminative way of thinking, they tend to be overly negative and therefore useless. The increased activity within the DMN regions (causing rumination) has therefore a negative effect on our way of thinking.

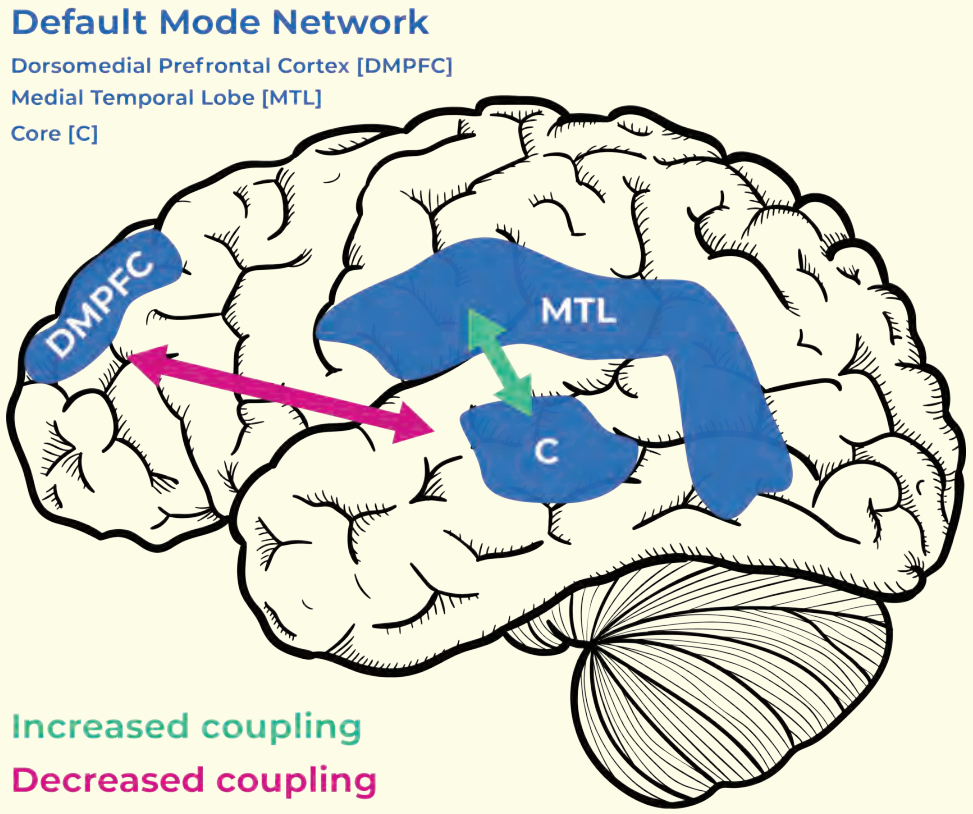


Figure 2.3: Coupling mechanisms during active rumination

Underlying mechanisms

If we focus on the DMN in more detail, it can be delineated into three subsystems; the core (C), the dorsomedial prefrontal cortex (DMPFC) and the medial temporal lobe (MTL) (Andrews-Hanna et al., 2010b, 2014) see figure 2.3.
When Chen et al, analyzed how the DMN communicates at the subsystem level, it was found that active rumination is driven by enhanced functional coupling between the core and MTL subsystems. This process goes hand in hand with a weakened coupling between the core and DMPFC subsystems.

This over-constrained communication between the DMN regions may lead to the key phenomenological features of rumination: repetitive, self-focused and negative valence. While in ruminative state, the DMN is 'reinforcing communication among regions supporting autobiographical memory processes, self-focused thoughts, and affective appraisal' (Christoff et al., 2016; Fox et al., 2018; Marchetti et al., 2016). This is not beneficial since, this causes other unrelated regions to uncouple so more information can be processed (Chen, et.al, 2020). This process causes rumination to be experienced as a 'negative downward spiral'. The coupling mechanisms between the brain areas at play during rumination can be seen in Figure 2.3

Ruminative Response Scale

To study and asses different forms of rumination, Nolen-Hoeksema and Morrow developed in 1991 a list of questions. When reading these questions, one can get a good sense of how ruminators think, and how they are 'caught up' in these lines of thinking. The eight questions below are part of a shorter version of the RSS (Brose et al., 2020).

		Almost never	Sometimes	Often	Almost always
	Depressive brooding				
1	I think about how only I feel this way.	○	○	○	○
2	I wonder why I have these problems and others don't.	○	○	○	○
3	I think about how sad I feel.	○	○	○	○
4	I think about my failures.	○	○	○	○
5	I try to understand my depressed feelings.	○	○	○	○
	Reflective self-regulation				
6	I write down what I am thinking and analyze it.	○	○	○	○
7	I go out alone and think about why I am feeling this way.	○	○	○	○
8	I go somewhere on my own to think about my feelings.	○	○	○	○

Figure 2.4: short-RSS in questionairre form. (Brose et al, 2020)

How to cope

To explore for the best productizable solution, the main existing coping mechanisms will be covered. Most consist of 'self help' in the form of tips and advice. A description of the five most common 'tips' (derived from literature) can be found below. The given advice will be interwoven with some common knowledge.

DISTRACT YOURSELF

Short periods of positive distractions improve not only depressed people's moods, but also the quality of their thinking and problem solving (Nolen-Hoeksema, 2008). This suggests the importance of teaching people prone to depressive rumination to engage in neutral or pleasant distractions as a short-term strategy. Afterwards, it will become easier to think of strategies to solve the problem. However, Nolen-Hoeksema explicitely states that it's important to encourage people to do so.

Please note, distraction is different from suppressing. Since suppressed thoughts will actually become more intense over time (Wegner & Wenzlaff, 1996). As with a snowball rolling downhill; it's important to act upon a ruminative thought as soon as possible.

Jogging and getting together with friends are found to be effective methods to counter rumination. As you may recognize, these are similar to acting upon depression (Jacobson et al., 1996; Lewinsohn, Antonuccio, Brekenridge, & Turi, 1984).

Nevertheless, depressed people, particularly depressed ruminators, find it difficult to inhibit negative thoughts and tend to choose the wrong cognitive activities to distract themselves (i.e., they focus on negative thoughts and memories rather than positive ones. (Joormann & Siemer, 2004; Wenzlaff et al., 1988). Besides, research shows that ruminators sometimes turn to maladaptive behaviors as distraction, such as binge eating/drinking (e.g., Nolen-Hoeksema et al., 2007).

MEDITATE

"Meditation can be defined as a set of techniques that are intended to encourage a heightened state of awareness and focused attention. Meditation is also a consciousness-changing technique that has been shown to have a wide number of benefits on psychological well-being" (NCCIH,2019). During meditation one should focus on achieving a 'mindful' state.

Since mindfulness is a promising solution area on itself, chapter 6 'Mindful Breathing' is fully dedicated to the science and application of meditation practices within psychotherapy.

QUESTION YOUR THOUGHTS

Since rumination is often started by intrusive thoughts. It's important to understand that intrusive thoughts are actually the opposite of one's character, and how a person sees itself (Winston, 2019). Wegner reasons that 'neutral unimportant thoughts can be suppressed, but the more important or emotional the thought, the more it gets stuck and returns.'
Building further upon the mindfulness philosophy, it's important to view your thoughts as outside and distant from oneself (Segal et al., 2002). Thus questioning the validity of one's thoughts can help decrease the emotional load.

Ruminators are also quick to interpret ambiguous events in a negative way. Hertel showed that this tendency contributes to rumination since it contributes to an overall (growing) negative bias (Hertel et al. 2014). The good news is that training ruminators to ignore negative material can reduce subsequent memory bias (Daches et al. 2019).

Cognitive therapy tries to tap into this coping mechanism. Since you often can't change the content of negative thoughts on itself; Barber and DeRubeis (1989) and Teasdale et al. (1995) suggest teaching depressed people methods for standing apart from those negative cognitions, and questioning them when they occur.



WORK ON YOUR RELATIONSHIPS

Interpersonal therapy (IPT) (Klerman & Weissman, 1986; Weissman & Markowitz, 2002) is a method of treating depression and is therefore closely linked to rumination. IPT is a form of psychotherapy that focuses on you and your relationships with other people. It's based on the idea that personal relationships are at the center of psychological problems (Healthline, 2018). IPT have been shown to be helpful in depression and may have positive effects on rumination.

People prone to rumination report more interpersonal conflict, even when they are not currently depressed (Nolen-Hoeksema & Davis, 1999). Interpersonal conflict may both contribute to and result from rumination. Ruminators can make great progress by understanding and improving their role in close relationships. Furthermore, by improving their social skills, interpersonal problems might be overcome (Nolen-Hoeksema, 2008).

UNDERSTAND YOUR TRIGGERS

Although rumination can be triggered at any time by apparent random intrusive thoughts, some external factors might have a significant influence as well. Once a person finds oneself ruminating, making a mental note about the current situation might help understand what triggered it (eg. where am I, what time is it, who's around me, what else did I do today). If one can find a pattern, avoiding or managing these triggers will reduce rumination. Besides, labeling a thought as 'rumination' will put it in perspective and helps to observe with no-interest.



TIMEBOX RUMINATION

Scheduling a moment (±5 minutes) during the day in which a person allows oneself to ruminate helps for keeping off the pressure. A complete stop with rumination after a long period of habitual rumination can feel like an enormous task. When time's up, one should make sure to move on.

MAKE AN ACTION PLAN

While rumination, briefly writing one's thoughts down can help to clear the mind. Afterwards, one should deliberately shift focus towards a step-by-step solution. Thinking of small steps to overcome the problem can help steer solution-focussed thinking.

Figure 2.5 - "Do my friends actually like me for who I am?" (Amy Cutler)



Neural Entrainment

3

What is the phenomenon of 'neural entrainment' and can it be productized?
The following chapter will provide you with the necessary information to understand this concept within the current project context. Different claims will be made how this phenomenon can be harrased for good.

Brain waves

The brain has billions of neurons, and each individual neuron connects (on average) to thousands of others (Muse, 2019). Through small electrical currents, communication travels along the neurons and throughout enormous networks of brain circuits. When all these neurons are activated they produce electrical pulses – think of a wave rippling through the crowd at a sports arena – this synchronized electrical activity results in a so called "brainwave".

The various brainwaves can best be seen as different musical notes - the low frequency waves are like a deeply penetrating drum beat, while the higher frequency brainwaves are more like a subtle high pitched flute. Like a symphony, the higher and lower frequencies link and cohere with each other through harmonics.

Five different predominant neural oscillatory rhythms (brainwaves) can be linked to a specific mental states (Bartel et al., 2017). See Figure 3.1 for an overview. It is good to know that the stated brainwaves only describe the current most dominant frequencies. In practice, there's a constant 'chatter' of many different brainwaves.

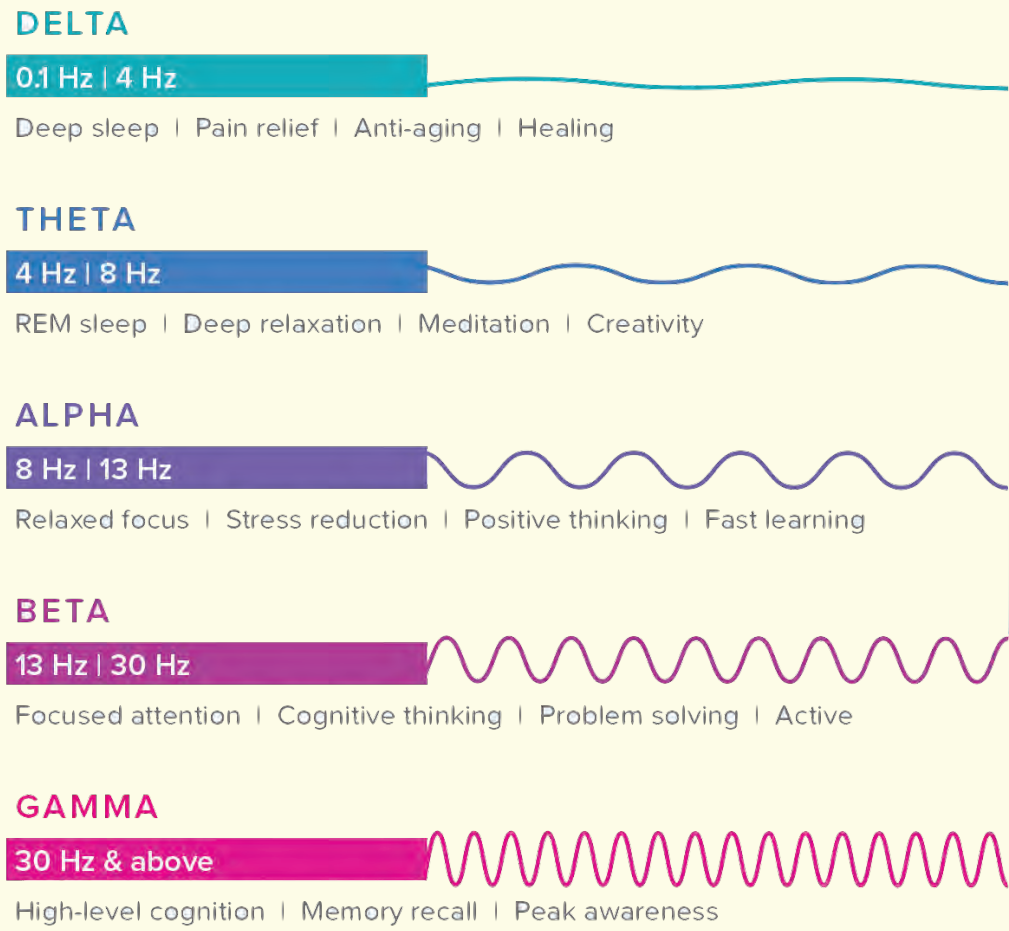


Figure 3.1: Five categories of neural oscillations and their functioning

On a functional level, neural oscillations are likely responsible for the dynamic routing (or 'gating' as Jensen calls it) of information, by synchronizing multiple groups of neurons (Salinas and Sejnowski, 2001; Jensen and Mazaheri, 2010). "From such a network perspective, lower frequency oscillations in the theta- to alpha-bands (4–12 Hz) have been related to long-distance, area-to-area interactions, and higher frequency gamma-oscillations (20–100 Hz) to local neuronal communication" (von Stein et al., 2000),

When many neurons interact in this way at the same time, this activity is strong enough to be detected even outside the brain. By placing electrodes on the scalp, this activity can be amplified, analyzed, and visualized. This is called electroencephalography (EEG), see Fgure 3.2 for an idea how this looks in practice.

(HIGH) ALPHA BRAIN WAVES DURING RUMINATION

In simple terms, ruminating thoughts are "stuck" in the Alpha brain state. This frequency band includes all high-alpha frequencies ranging from 11-13 [Hz] (see figure 3.3). Ruminators have been found to perform poorly on task-switching tasks (Altamirano, Miyake, & Whitmer, 2010) which is related to one profound characteristic of rumination; cognitive inflexibility (Davis & Nolen-Hoeksema, 1999).

Figure 3.2: Brainwaves can be detected via EEG

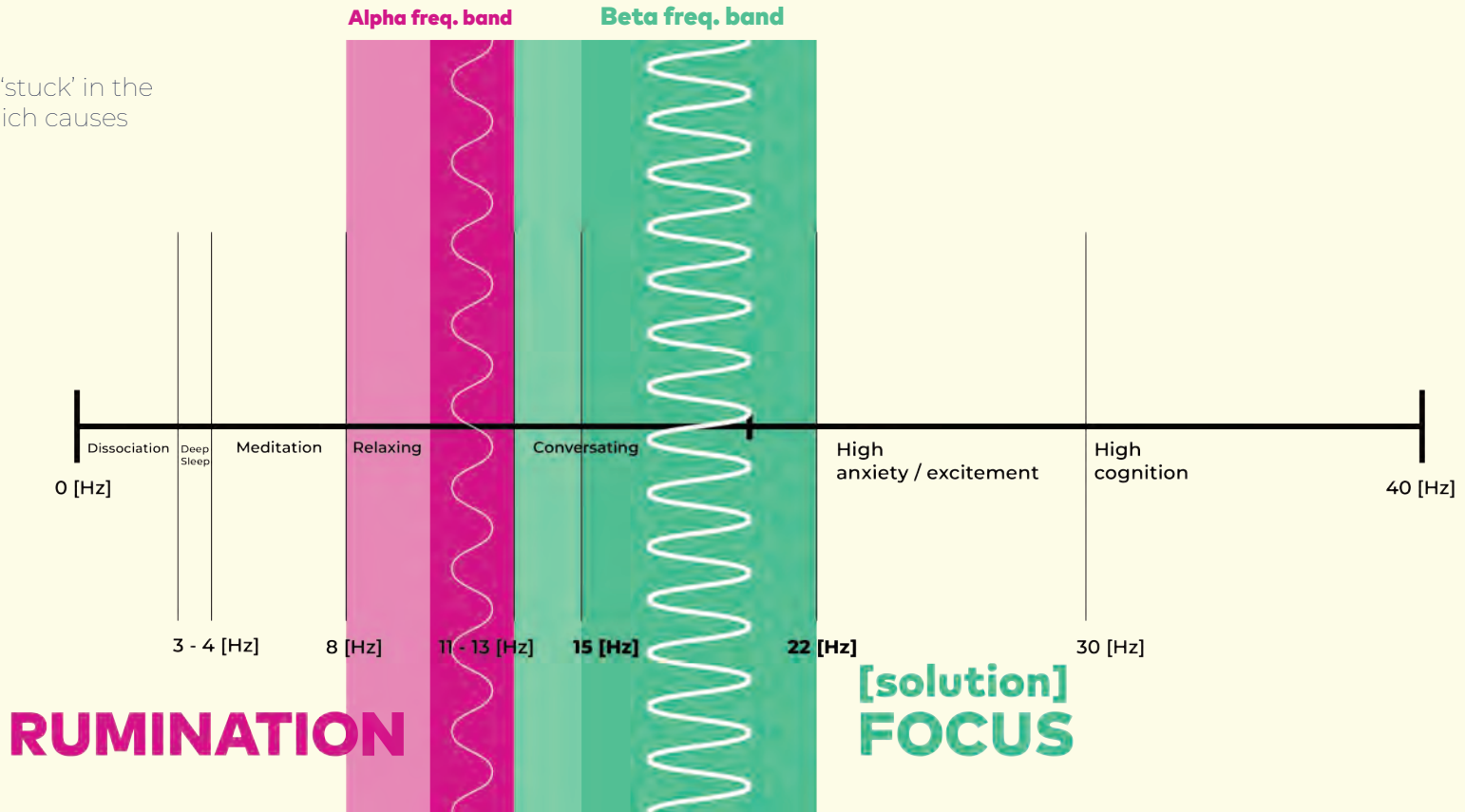


During normal functioning; task-switching tasks are associated with cognitive flexibility and show a decrease in Alpha power. Ruminators find it hard to ‘switch’ between these different states and do not easily move to the Beta zone while a solution is necessary for moving on. This is also due to the fact that rumination interferes with attention, as mentioned earlier.

Furthermore, Putnam and McSweeney (2008) showed that “clinically depressed individuals exhibit greater alpha power bilaterally in the prefrontal cortex while at rest. Additionally, he found that ruminators also share this increased Alpha power.

Ferdek, Van Rijn, and Wyczesany (2016) observed similar patterns in their study in which healthy young adults engaged in rumination of different valences (negative, neutral, or positive). Participants higher in trait rumination displayed “elevated alpha power in the anterior cingulate cortex, increased low beta power within all brain regions examined (including posterior regions), and lower power in high beta in the dorsolateral prefrontal cortex for all conditions (Ferdek et al., 2016).” These studies suggest that ruminators might be helped by inducing so called ‘disruptive (high) beta waves’.

Figure 3.3: Ruminators are ‘stuck’ in the high-alpha brain state. Which causes trouble to focus.



DISRUPTIVE BETA WAVES

When the brain is aroused and actively engaged in mental activities, it generates beta waves. For example a debater or a talk show host would be in 'high-beta' (Beta2, 15-22Hz). This tempo of thought contributes to problem solving and guides decision making processes. Therefore, it is hypothesized that beta waves are 'naturally' opposing ruminative thought loops. The frequency band associated with this solution focussed thinking can be seen in Figure 3.3. Ruminators would benefit greatly from a natural push towards this solution space. This can possibly be achieved by making use of the principle of 'neural entrainment'.

NEURAL ENTRAINMENT IS THE EFFECT OF SYNCHRONIZATION BETWEEN THE BRAIN AND AN EXTERNAL STIMULUS.

Tactile entrainment

Neural entrainment (aka brainwave synchronization or brainwave entrainment) is the effect of synchronization between the electrical activity of the brain and a periodic external stimulus. The synchronization can be seen in an EEG, while people are listening to speech, music or feeling tactile vibrations. A well-documented example of this neural entrainment is when people are exposed to flashing light. If this light flickers at a particular rate, this same frequency can be seen in a spectrogram of their EEG.

Uri Hasson has even demonstrated neural entrainment effects occurring when people listen to a story. Neural responses in all of the listeners began to synchronize. In the individual waveforms could be seen that they moved up and down at the same rate. The brainwaves of the speakers brain lead these movements. (Hasson et al., 2004)
Interestingly, this phenomenon also occurs if meaning is removed from the words (for example, playing an audio recording backwards). Hasson et al. concluded that the auditory cortex can become entrained to sounds, regardless whether the sounds convey any meaning.

This experiment contributes to the hypothesis that other ‘meaningless vibrations’ such as tactile vibrations can also lead to neural entrainment. By effectively entraining the user, the product offering can be improved.

Understanding these neural oscillations can have great impact. Since disturbances or dysrhythmia of the oscillatory activities in the brain are related to several health conditions including AD, PD, pain, and depression (Bartel, 2017). Furthermore, Bartel argues that specific frequencies of sound in its vibratory nature can serve as a means for brain stimulation. He continues by stating that “vibrotactile stimulation can contribute to regulation of specific oscillatory activity.”

Once again, this research shows the possibilities of extending the use of vibrotactile stimulation to regulate oscillatory activity. Regarding the disruption of rumination, battling everyday stress or guiding breathwork meditation.

The next paragraph will investigate how this tactile realm can be exploited to do so. In chapter 13, this concept will be demonstrated in an experiment.

“VIBROTACTILE STIMULATION CAN CONTRIBUTE TO REGULATION OF SPECIFIC OSCILLATORY ACTIVITY”
- BARTEL, 2017

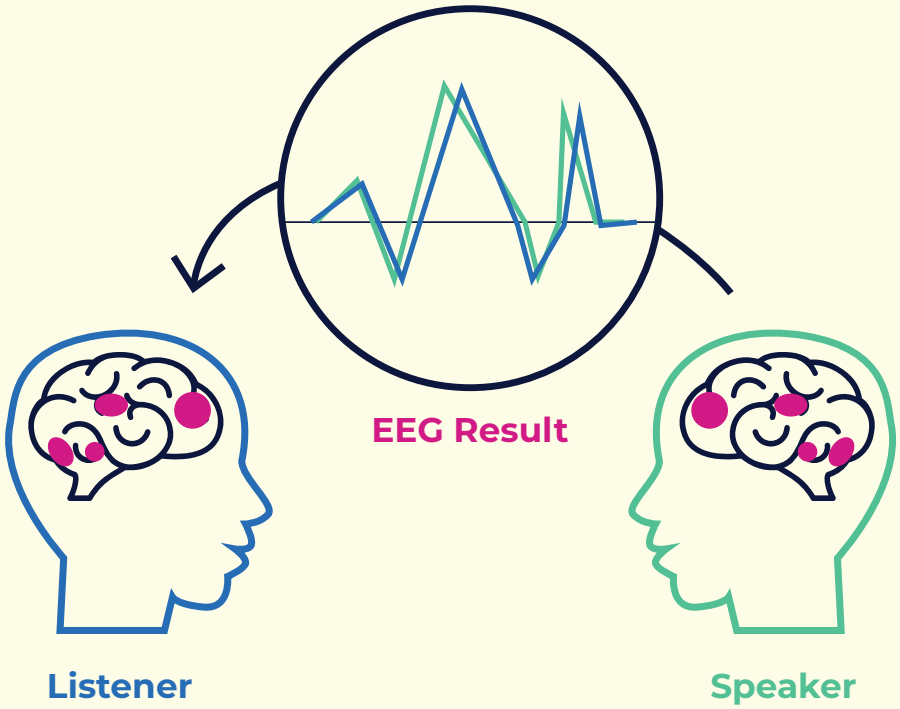


Figure 3.4: neural entrainment occurs while listening to a story

Tactile Vibrations

Can pleasurable 'vibes' be deduced to actual (tactile) vibrations?
The following chapter will dive into the current therapeutic use cases for tactile vibrations and neural entrainment. Some existing and promising applications will be shown. These will all contribute to the scientific backup needed for product development and will form the building blocks for the grounded-theory.

4

#GoodVibes

“A vibration is a periodic back-and-forth motion of the particles of an elastic body or medium” (Encyclopedia Britannica, 2020). Obviously, the physics phenomenon is well understood, however the word “vibe” is informally used in a more complex psychological matter. As a cultural and social construct, the Oxford Learner’s Dictionary defines a ‘vibe’ as a mood or an atmosphere produced by a particular person, thing, or place (Oxford Learner’s Dictionaries, 2020). Within the design realm, a designers often aims to find the “right” vibe for a website, brand, community or physical space. Most people seem to have an intuitive understanding of what vibes are, this broad understanding is even present across age groups (Vibe Research Labs, 2020).



Figure 4.1 - Although a clear definition is lacking, as a collective we know what is meant here.

Although the strong qualitative nature of vibes, this project hypothesizes; there’s also an explicit link with the physical sensations of vibrations ‘moving through air’ (or other mediums). In this way, the social construct of ‘vibe’ comes together in the physical realm in the concept of vibrotactile (pleasurable) stimulation.

This effect is commonly seen within music events such as festivals, concerts or club nights. The vibrotactile stimulation in clubs - feeling the bass - is part of pleasurable experience and contributes significantly to the experienced ‘good vibes’. Todd and Cody stumbled upon a scientific way of addressing this. They found that when the balance organ in the ear is stimulated by loud music we experience pleasurable sensations similar to the feeling of sitting in a rocking chair or playground swing (Todd & Cody, 2000). On top of that, they state that the vibrotactile stimulations of the moving air (boosted through the club by the loudspeaker), contributes to the pleasure.
It is therefore hypothesized that ‘tactile music’ forms a good source for inducing the ‘right’ vibes.

“AS SOCIAL CONSTRUCT; ‘VIBE’ IS A MOOD OR AN ATMOSPHERE PRODUCED BY A PARTICULAR PERSON, THING, OR PLACE.” - OXFORD DICTIONARY

Aesthetic resonance

The word ‘resonance’ originates from the latin word ‘resonantia’, meaning “echo”.
Within physics, resonance is defined as the moment when the frequency of an external oscillation or vibration matches an object its natural frequency. As a result, it causes this other object to vibrate along (wikipedia, 2020).
The resonant frequency is therefore the exact right frequency applied by an external source, so it adds up to the already existing energy within the system.
However, just as the social construct of vibes, we use ‘resonance’ to describe states of amplification (of energy) with people, music, art or even environments. In these instances, one can speak of a synchronisation or even harmony between the sender and receiver.

Within this project, the goal is to establish aesthetic resonance between user and product. Aesthetic resonance could occur if the brainwaves of the user become fully entrained with the vibrational pattern of the product. However, this is a novel proposition and should therefore be validated through experiments.



Figure 4.2 - The experiene of aesthetic resonance with a ‘thing’ (Jackson Pollock)

Therapeutic usage

(Tactile) Vibrations have found many uses in a therapeutic context, some of which exploit the underlying mechanisms of neural entrainment. The most direct link can be found in vibroacoustic therapy (VAT); this is defined as a treatment method based on low frequency pulsed, sinusoidal sound vibrations and music (Grocke & Wigram, 2007).

Depending on the choice of sound vibrations, the effect is either relaxing or stimulating, which allows the therapy to be used for general relaxation, or for the purpose of more specific psychotherapy. The vibrations are mostly administered by (tactile) loudspeakers attached on a chair or bed (Rüütel et al., 2018).

These vibrations are designed to incorporate specific frequencies that are not only emotionally effective, but also can create the necessary physical and tactile sensations that will help for pain relief. In some case, audible low frequency sound vibrations, are even integrated with Virtual Reality to help patients reduce their pain levels, achieve a sense of relaxation, and lower stress levels (Boyd-Brewer, 2004). It has been documented that low-frequencies produced between 30 Hz and 120 Hz are ideal for therapeutic use (Skille, 1989). However, 40Hz is mostly used in a wide variety of studies.

For example, 40Hz vibration stimulation sessions have been found effective for; improved mental status for mild- and moderate-stage Alzheimer's disease patients (Clements-Cortes et al., 2016). Improved motor function for treating Cerebral Palsy. (Kantor et al., 2019). And improved quality of sleep, mood and pain relief for Fibromyalgia (Janzen et al., 2019).



EMDR therapy and bilateral stimulation

Eye Movement Desensitization Reprocessing (EMDR) is a widely recognized psychotherapy designed to alleviate the distress associated with traumatic memories (Shapiro, 1989). The therapy is developed by the American psychiatrist Francine Shapiro and is currently used to process traumatic experiences of patients suffering from PTSD (Posttraumatic Stress Disorder). The therapy facilitates the accessing and processing of traumatic memories and rewires these memories to a new meaning for the patient. After successful treatment with EMDR therapy, affective distress is relieved, negative beliefs are reformulated, and physiological arousal is reduced.

During EMDR therapy the client attends to emotionally disturbing material in brief sequential doses while simultaneously focusing on an external stimulus. Therapist directed lateral eye movements (see Figure 4.3) are the most commonly used external stimulus but a variety of other stimuli including hand-tapping, audio or tactile stimulation are often used (Shapiro, 1991).

This bilateral stimulation is assumed to be instrumental for the alleviation of the memory symptoms of PTSD patients (Montgomery and Ayllon, 1994; Lee and Drummond, 2008; Lilley et al., 2009). Other studies have reported that Eye Movement also decrease the vividness and distress of emotional autobiographical memories in healthy adults (Andrade et al., 1997; Kavanagh et al., 2001; van den Hout et al., 2001, 2010; Barrowcliff et al., 2004; Kemps and Tiggemann, 2007; Gunter and Bodner, 2008; Maxfield et al., 2008; Schubert et al., 2011).

However, scientific studies show that bilateral stimulation through tactile vibrations applied on the skin can also reduce the SUD (subjective units of distress) score during EMDR therapy (Harper & Rasolkhani-Kalhorn & Drozd, 2009). On top of that, it was found that bilateral stimulation in general may enhance comfortable feelings about pleasant memories (Amano & Toichi, 2016). In simple terms, stimulation from both left-brain (emotional) and right-brain (logical) provides interhemispheric interaction, which enhances retrieval (Nieuwenhuis et al., 2013). Furthermore, Nieuwenhuis shows in an experiment similar results betweens bilateral tactile stimulation and eye-movements.

Some therapies revolve mainly about the human experience of touch, such as ‘Sensorimotor-Focused EMDR’ where hand-held buzzers play an important role (O'Malley, 2018). In his book ‘The body keeps the score’ Van der Kolk describes trauma as something which is for 90% manifested in places where words can’t reach, the body (Van der Kolk, 2014).
This shows a promising opportunity for solely using tactile vibrations for general everyday stress reduction and validates the focus on the vibro-tactile realm.

Figure 4.3: EMDR therapists often use a light-tube as bilateral stimuli



Audio Visual Entrainment

Our senses are constantly bombarded by random audio and visual stimuli. For example when watching TV or sitting on a street corner watching traffic go by. These situations will not contribute to any therapeutic effect. However, it was found that audio visual stimuli can have such effects when applied in a controlled environment. This principle is called audio visual entrainment (AVE).
AVE is a technique in which lights flash into the eyes, while tones are pulsed into the ears. Within this procedure the frequencies of the lights and tones are in the most common brain wave frequencies, typically ranging from 1 to 40 Hz.

AVE is one of the most intriguing stimulation technologies. AVE devices (see Figure 4.5) have been shown to have a myriad of influences and effects on brain activity (Siever, 2017). However, never took of with any big commercial succes.

AVE has been reported to provide a significant clinical impact when it is applied randomly at ±1 Hz (for instance, a 10 Hz light flicker stimulus varying randomly between 9 and 11 Hz), while at ±2 Hz the clinical effect is poor, and at ±3 Hz, the clinical effect is lost. So, it appears that the effect of AVE only occur when the stimulation is kept fairly consistent and rhythmic (Siever, 2017).

These two factors are an important characteristic for enabling entrainment (between user and product).

"THE EFFECTS OF AVE ONLY OCCUR WHEN THE STIMULATION IS KEPT FAIRLY CONSISTENT AND RHYTHMIC"
- SIEVER, 2017.

Figure 4.4: The company Braintap have commercialized self-administered AVE.



Siever et al. provides in his book ‘Rhythmic Stimulation Procedures in Neuromodulation’ a solid overview of the wide variety of applications for AVE (Siever et al., 2017). They describe the following: “over the past several decades, AVE has been associated with several types of beneficial outcomes in a wide variety of clinical studies. It has been found effective for SAD (Berg & Siever, 2009); for improving concentration and memory in college students (Budzynski & Tang, 1998; Budzynski, Jordy, Budzynski, Tang, & Claypoole, 1999; Budzynski, Budzynski, & Tang, 2007; Wuchrer, 2009; Siever, 2003c); for reducing worry in college students (Wolitzky-Taylor & Telch, 2010); for the treatment of ADHD and behavior disorders; (Carter & Russell, 1993; Joyce & Siever, 2000; Micheletti, 1999); for regaining motor control in post aneurysm (Russell, 1996); for treating depression and risk of falling in seniors (Berg & Siever, 2004); for treating Alzheimer's (Budzynski, Budzynski, & Sherlin, 2002); for improving brain function and memory in seniors (Williams, Ramaswamy, & Oulhaj, 2006; Palmquist, 2014); for reducing chronic pain from occupational injury (Gagnon & Boersma, 1992); for reducing symptoms of fibromyalgia (Berg et al., 1999); for reducing symptoms of temporomandibular dysfunction (Manns, Miralles, & Adrian, 1981; Morse & Chow, 1993; Thomas & Siever, 1989); for reducing anxiety during dental procedures (Morse & Chow, 1993; Siever, 2003b); for treating PTSD in war veterans (Trudeau, 1999); and for improving sleep (Tang, Riegel, McCurry, & Vitiello, 2016).”

This variety of application provides a glimpse of the promising contribution AVE can possibly make in this current project. Especially Sievers findings about the need for rhythmic and consistent input will be exploited in later product development.

Phantom vibrations

Already in 1958, Békésy described the phenomenon of apparent tactile movement. “The human brain perceives two nearly synchronous vibrations in close spatial proximity as one stimulus from a single source. As a consequence, we perceive an illusory tactile sensation between the two real actuation points, which is known as ‘funneling illusion’ or ‘phantom sensation’ (Kim et al., 2020). Application of this phenomenon has been found in the creation of realistic VR environments. Supplementary it can be used as a way to transmit non-audiovisual information to users. Additionally, a congruent visual cue (like a blinking light) will improve localisation and perception of the tactile illusion (Berger, 2018).

Phantom sensations can also be established in a continuously moving form. This can be done by alternating the intensity of two vibrating motors. Cha et al. has found this works best if placed 60 mm apart, with a velocity of 60 mm/s (Cha et al., 2008).

Within the medical field, the concept of phantom sensations has been widely reported in cases where people can still 'feel' non-existing limbs after limb amputations. Kawashima & Mita found in their research with forearm amputees that bilateral tactile stimulation increases these phantom perceptions (Kawashima & Mita, 2016). This is illustrated in Figure 4.5.

Within this project, it is hypothesized that the experience of phantom sensations are more engaging than other forms of stimuli. Moreover, it is thought that these types of vibrations will lead to easy entrainment since they are imaginative. This is comparable to the easy entrainment effect of binaural beats.

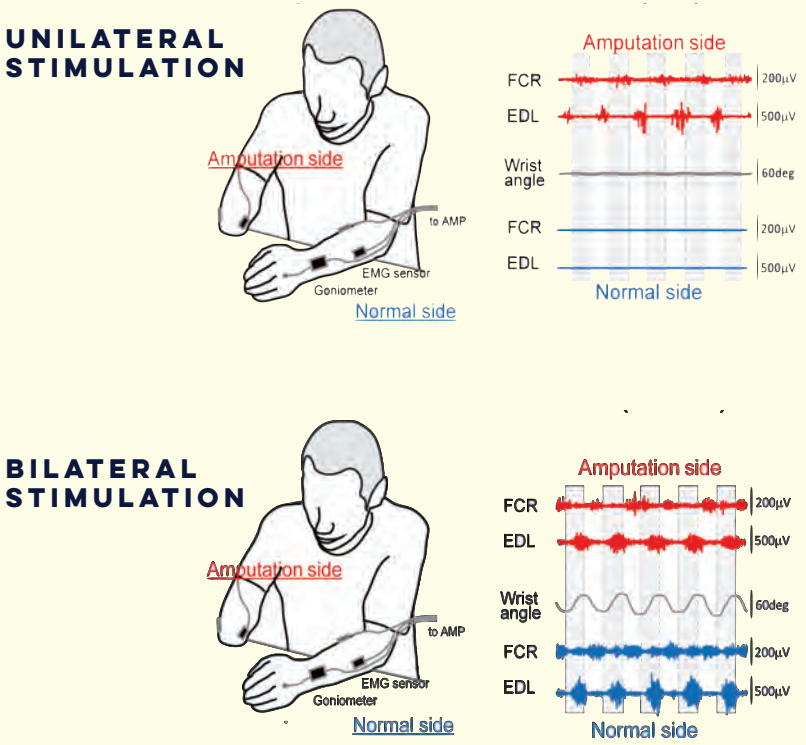


Figure 4.5: EMG results of muscle contractions (FCR/EDL) (Kawashima & Mita, 2016)

Musical Vibrations

Music is a potent phenomenon in human auditory perception and cognition. Music can make us laugh or cry. It can spark us awake or put us to sleep. But can we purposefully design music to help us reliably shape our behavior?
And if so, can the same emotional load be conveyed through the tactile medium?

5

The perception of harmony

To find the link between the tactile and muscial perception of vibrations, it's important to understand the structure of music itself. Harmony is a perceptual property of music, and along with melody, one of the building blocks of Western music (Wikipedia contributors, 2020a). The harmonicity of chords is a complex process encoded by the brain in a number of areas, including the inferior colliculus and the cortex (Bidelman, 2013). Within this process, the inferior colliculus is responsible for binaural auditory integration (Bishop & Oliver, 2016). This involves the localisation of an audio source in a room.

The perception of a 'harmonic sound' is based on consonance, a concept whose definition has changed various times throughout Western music history. Physiologically, consonance is a continuous variable. "Consonant pitch relationships are described as sounding more pleasant, euphonious, and beautiful than dissonant relationships which sound unpleasant, discordant, or rough" (Wikipedia contributors, 2020a).

Besides, the terms dissonance and consonance are often considered equivalent to tension and relaxation (Parncutt et al., 2011).
This raises the question, how do these terms translate in the tactile realm?

Will a user experience a form of relaxation if consonant vibrations are applied via a product?

A study into whole body vibrations found that consonant combinations of vibrations tended to be ranked more highly than dissonant combinations (Vibe Research Labs, 2020).
The unpleasantness of the dissonant vibrations might form a trustworthy factor for disruption of ruminative thoughts and to grab strong attention of the user.



Figure 5.0: An harmonic experience can bring people to ecstasy (Vienna Orchestra)

Neural salience

For a deeper understanding of how vibrations are neurologically processed, the term neural salience will be introduced. The salience (also called saliency) of an item is the state or quality by which it stands out from its neighbors. Neural saliency therefore relates to how the brain divides attention capacity among different stimuli. Within music, if a chord is in 'perfect harmony' this will also be visible on EEG data. This principle is called neural salience, it shows the existence of (perceived) harmony within the brain. In response to harmonic intervals, cortical activity also distinguishes chords by their consonance, responding more robustly to chords with greater consonance (Bones & Plack, 2015).

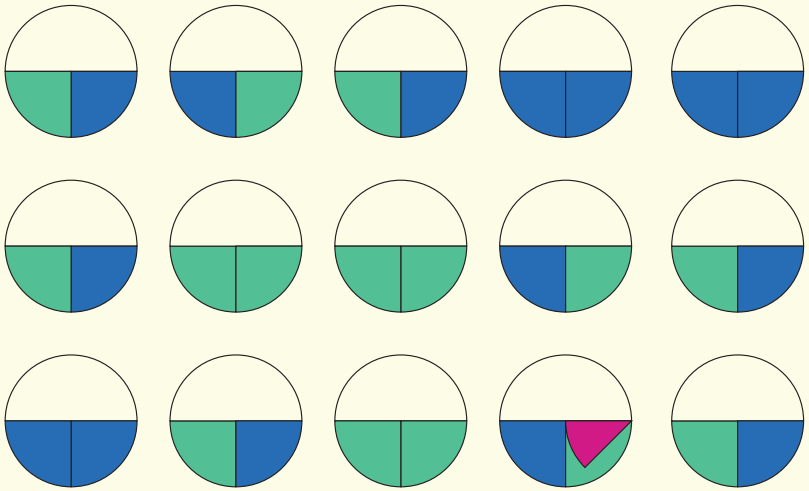


Figure 5.1: The concept of salience.

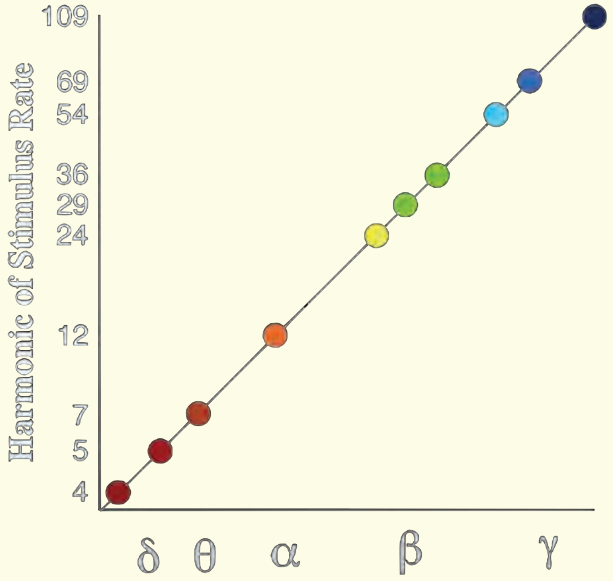
This principle can also be translated beyond music.
It has been found that different brain regions form dedicated networks for specific behavioural tasks (Gilley, 2014). For example when a person is trying to hear the intercom announcement at a noisy train station, two temporary dedicated functional networks are created. The first network tries to focus on the voice of the announcement, the other one tries to analyse the background noise and at the same time suppress it's saliency. In this way the announcement is perceived more clearly.
One can say, both temporarily created networks have to function in harmony, in order to work.

"THE DYNAMIC FUNCTIONING OF BRAIN NETWORKS CAN BE DEFINED AS HARMONIC COUPLING"
- GILLEY, 2014

Harmonic coupling

Gilley defines this dynamic functioning of brain networks as ‘harmonic coupling’. The fascinating fact is, that this isn’t merely a figure of speech but actual harmonic series can be found within these brain state oscillations. An example of a harmonic series was found in children learning speech. The peak frequencies in auditory processing in the childrens brains can be found in Figure 5.2. The response frequency (measured through EEG) corresponds clearly with the harmonic scale.

Figure 5.2: During auditory processing, different brain regions oscillate in harmonic frequencies (Gilley, 2014)



Musical harmony

Musicians can use ‘harmony’ as a vehicle to convey their emotions. As the famous british singer and componist Jacob Collier explains in a video fragment about harmony; “[..] harmony is my way of creating the right narrative to convey emotion. [..] Complex harmonies therefore provide us with tools to express complex feelings [...] it’s the tension between the notes which touches the heart”.
If we translate Colliers’ interpretation of harmony to the tactile medium, it’s plausible to state that the tension between two vibrational ‘beats’ can also provide room for emotional expression or reflective thought. This hypothesis will contribute to the grounded-theory.

“THEREFORE, COMPLEX HARMONIES PROVIDE US WITH TOOLS TO EXPRESS COMPLEX FEELINGS”
- JACOB COLLIER, 2018

The disruptive harmony of Breakbeat

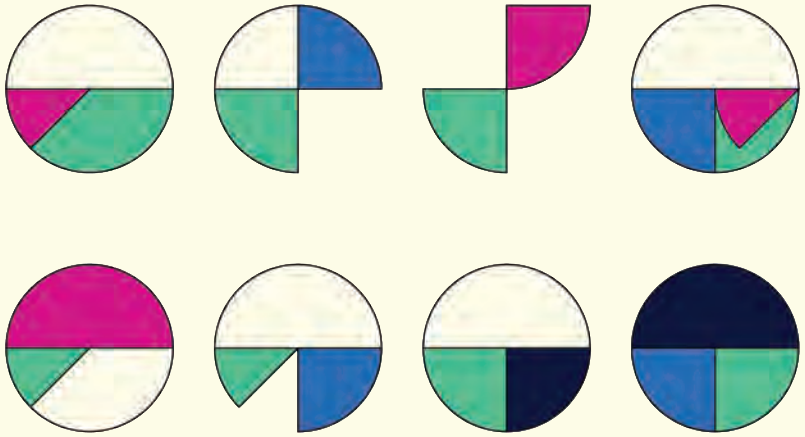
Since different music genres express harmony in a wide variety of ways. It's important to consider the right music genre (and right vibrational patterns) for the development of the product. Two music genres were studied in depth and will be discussed below.

Breakbeat is characterized as a broad type of electronic music style that utilizes 'breaks' for the main rhythm. These breaks are often sampled from earlier recordings in funk, jazz and R&B. (Wikipedia contributors, 2020c). The 'breaks' in this definition refer to the drum-solo's commonly used in the mentioned genres, to fill up the space in between verses. The percussives are often energetic and exciting of character and clearly differentiate from the original beat and tempo of the song.
Since a BreakBeat song mainly revolves around these complex and fast-changing drum patterns, the overall 'beat' of the song can be perceived as 'broken', hence the name. This 'brokenness' makes the music hard to 'grasp' and therefore needs one's full attention to listen too. Listening to this kind of music can soak one's attention and provides a chaotic (but harmonious) focus point. It is argued that this chaotic character can overstimulate ruminative thoughts so people naturally disengage.

This makes Breakbeat a suitable genre as a source of inspiration for (tactile) vibrational patterns.

Often, the used drum-patterns are complex in such a way that one has to listen carefully and for a longer time to really grasp the conveyed 'vibe' of a breakbeat song. This need for full focus might assimilate all brain capacity so the disengaging effect will linger on.
On top of that, BreakBeat leverages the building of tension between beat intervals. As Jacob Collier described, this can be ideal for 'opening-up' reflective thoughts.

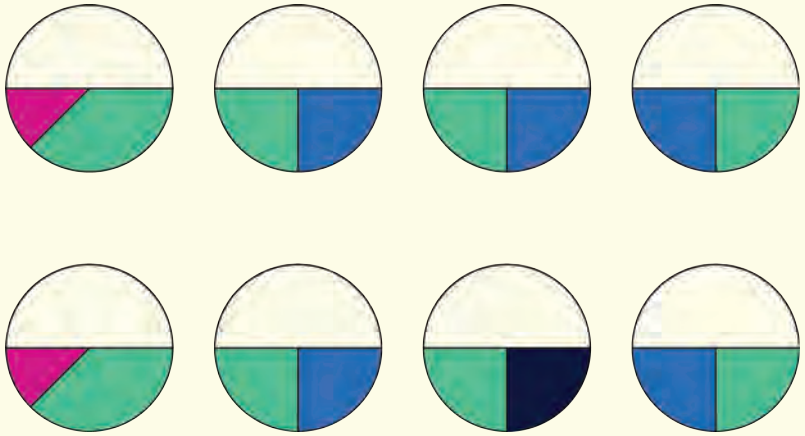
Figure 5.3: A visual representation of Breakbeat.



The organizing harmony of Techno

Another promising source for vibrational patterns applicable within this project context is the infamous trance-inducing genre called Techno. This bass-driven music style originated from Berlin music culture around 1980. The central rhythm is often in ‘common time’ (4/4), while the tempo typically varies between 120 and 150 beats per minute (bpm). The music revolves around dominant and repetitive grinding bass-rhythms, consisting of layered and ‘deep’ industrial noises.

Figure 5.3: A visual representation of Techno.



The music is specifically designed so it contains a vast amount of energy and is able to contain this throughout the track. If any melodies are used, it’s core purpose is to support the monotonous rhythms. All the interwoven elements are not made to be ‘catchy’ nor to distract the listener. In ‘good’ techno, all the elements add on in a subtle manner to establish ‘flow’. Consequently, this will bring the listener in a focussed state of mind. These elements add to the characteristics of techno being highly danceable and trance-inducing. It’s reported that repetitiveness and predictability help to focus (Techno Reddit, 2020).

Techno found it’s appraisal mainy in night-clubs during live continuous dj-sets. True techno lovers don’t necessarily define it as ‘music’ but more as a continuous experience; “something which has to be experienced ‘live’, before it can be understood” (Techno Reddit, 2018). This ‘physical quality’ of techno makes the genre suitable for experiencing it through the means of tactile vibrations.

Concluding, besides techno it’s capabilities to bring the users into a state of focus, it is argued that techno can help disrupt negative mental processes.

Focus music

Brain.fm, an organization centered around ‘focus-music’, found similar results in their research into auditory saliency. In their whitepaper they mention the following: “a particularly strong finding was that beta-rate modulation (12-20Hz, between beats and roughness) appears effective for reducing attentional lapses, and this is now a core part of Brain.fm’s Focus music technology” (Brain.fm, 2020). Within their product offering they use an AI to generated music in a constrained manner. The generated melodies will only vary within a specifically set range. Brain.fm claims that this range is in tune with beta brain states. Experiments suggest that Brain.fm can enhance attention by increasing 30 Hz and decreasing 10 Hz activity in the brain (Brain.fm, 2020). A suprinsingly effective and easily accessible technology, stooled on the principles of neural entrainment.

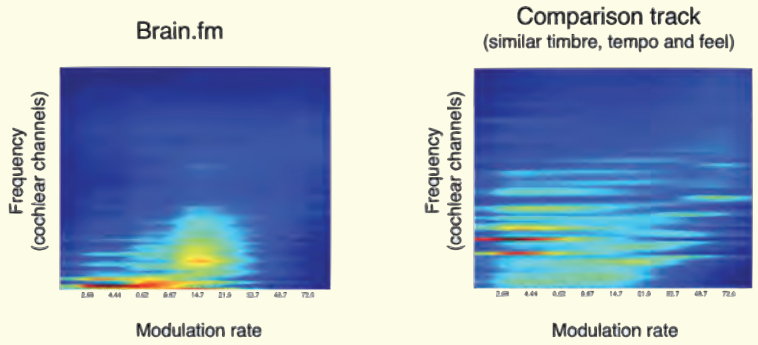


Figure 5.4: Brain.fm modulates tracks so they only resonate with the user at beta frequencies (derived from their whitepaper)

Similarly to the algorithm of Brain.fm, the techno genre is constrained in this way by its own definition. As Stolzenburg states it “Techno is likely perceived harmonious because it’s strong rhythmic periodicity within the harmony” (Stolzenburg, 2015). Because of its linear flow, people are not prone to attentional lapses. As Siever stated (see paragraph about AVE) earlier; this rhymicality leads to interhemispheric connectivity.

On top of that, ‘periodicity’ means “easy sensory processing” and gives therefore a more pleasurable experience (Reber, 2004).

Figure 5.4: A complete crowd can become ‘entrained’ to music at a (techno)festival.



Binaural Beats

Humans use music and rhythm as mood enhancers. Be it in social gatherings or late study nights, we use audio stimuli to set the “right mood” and improve our cognitive performance (Mammarella et al., 2007; Schellenberg et al., 2007; Tarr et al., 2014). Especially binaural auditory beats have aroused the interest of research in psychology. Binaural beats have been a source of speculation and debate within the scientific community. It has been hypothesized to affect cognitive performance (Vernon et al., 2019) and has reported beneficial effects in a wide variety of applications (Garcia-Argibay et al., 2019; Jirakittayakorn & Wongsawat, 2018; Le Scouarnec et al., 2001; Orozco Perez et al., 2020).

‘Binaural Beats’ is a specific form of music grounded on the following principle:
By presenting two tones of different frequencies to each ear, a perception of a single illusionary tone is created. This tone has a frequency equal to the difference between the two tones (Oster, 1973).

For example, a tone with a frequency of 200 Hz is played in a persons left ear and a tone of 205 Hz at the right ear.
These two tones will both travel separately to the brain's inferior colliculus (the part of your brain that gathers auditory input). There, the tones ‘squelch’ together into a so-called ‘binaural beat’ at a perceived new frequency (In this case, it would be 5 Hz).

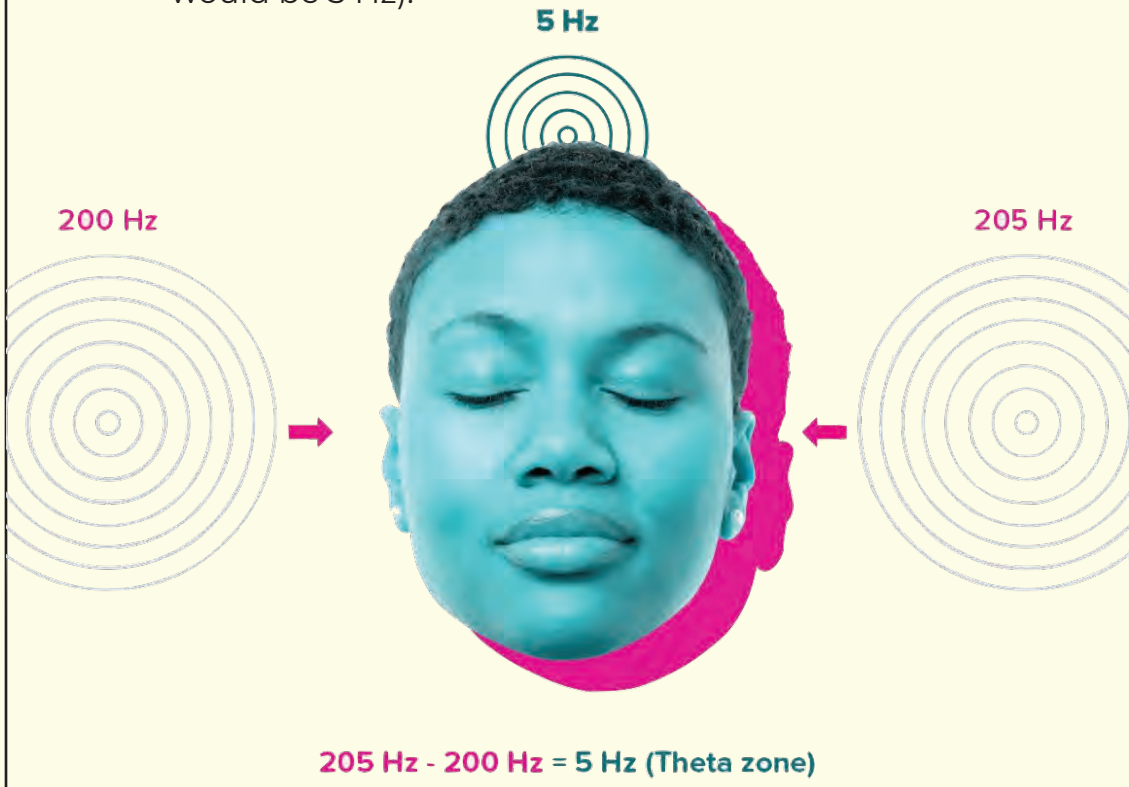


Figure 5.3: An illustionary overtone is produced by hearing two different frequencies

WILD APPLICATIONS

Although there is not much proof of the effects of binaural beats. The possibility of modulating cognitive states without prior training speaks to both healthy and mentally troubled people.

The popularity of binaural beats has been consistently present over the years. Thousands of 'binaural beats' videos can be found online with many different wild claims such as; anxiety reduction, happiness boost or even anti-aging and DNA repair. The most popular videos have over 20 million views and mostly use harmonious binaural tones with multiple layered frequencies (aka solfeggio frequencies). An example can be found here: https://tinyurl.com/y7wn4cyx (PowerThoughts Meditation Club, 2017).

The underlying theoretical assumption is that our brainwaves synchronize to the frequency difference between the two tones. Since this frequency difference is represented by a third illusionary tone, the brain will entrain (see Chapter 3) to this specific frequency. It appears to be the 'illusionary' nature of this tone which leads to easy entrainment. Atwater states this this specific entrainment leads to changes in cognition (Atwater, 1997). If the 'right' tempo is applied, this might enhance the 'right' mood.

INTERHEMISPHERIC COHERENCE

Binaural beats are thought to originate subcortically in the medial nucleus of the superior olivary complex, the first nucleus in the auditory pathway to receive bilateral input (Wernick and Starr, 1968; Kuwada et al., 1979). The 'illusory' third binaural tone is lateralized between the left and right ear of the listener (Ross et al., 2014). Binaural beats can entrain cortical activity at both the specific frequency of the beat (Pratt et al., 2010) and cross-frequency modulations, such as theta beats driving interhemispheric coherence (Solcà et al., 2016).

They also seem to modulate mood (Wahbeh et al., 2007), pain perception (Zampi, 2015), and cognitive performance in memory tasks (Kennerly, 1994). The cognitive effects of binaural beats are attributed to their capacity to drive neural oscillations at the (illusionary) beat frequency. This results in strong hemispheric synchronization. The reported cognitive modulations, however, appear inconsistent and seem to depend on several mediating factors. (Garcia-Argibay et al., 2019a).

As argued in Chapter 4 (EMDR therapy) and shown in ‘hamonic coupling’, interhemispheric coherence is beneficial for (re)processing thoughts. This principle of binaural beats will be eploited in the sound design of the vibrations in the product.

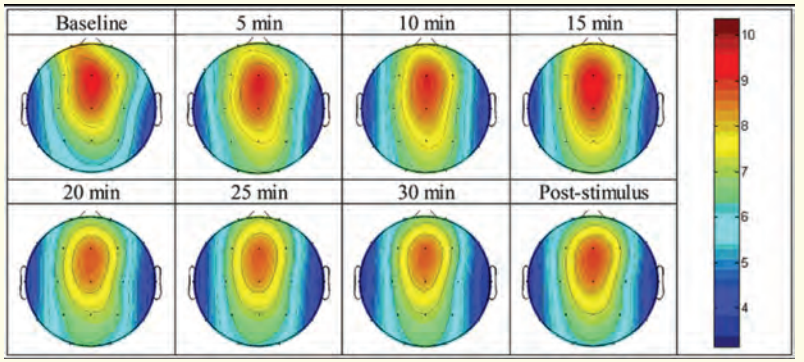


Figure 5.4: Topographic mapping of Theta activity.
Control group, no stimulus.
(Jirakittayakorn & Wongsawat, 2017)

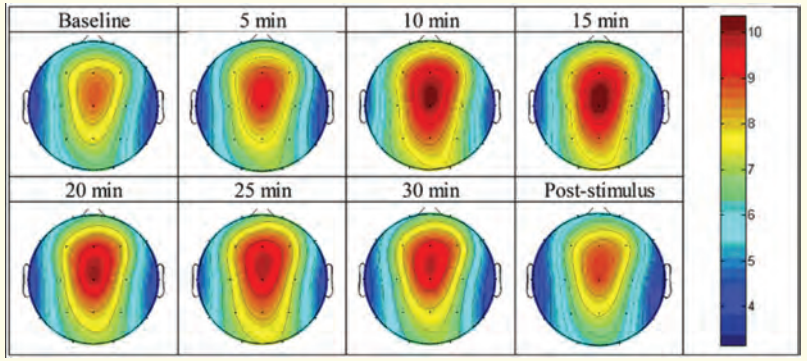


Figure 5.5: Topographic mapping of Theta activity.
Experimental group, 6Hz Binaural Beat stimulus
(Carrier tones: 250 Hz left ear // 256 Hz right ear)
(Jirakittayakorn & Wongsawat, 2017)

Mindful Breathing

6

Can one find resonance within their own breathwork? Mindful breathing is a powerful and accessible way to help direct our mood. This chapter explores breathing as an additional measure to direct desired mind states in the context of disrupting rumination and increasing stress resilience.

Mindfulness

Around 15 years ago, nobody talked about mindfulness as we know it today. As can be seen in Figure 6.0, popularity has been rising sharply throughout recent years. In this graph, the popularity of the Google searchterm 'mindfulness' (blue) is compared to the amount of searches for 'globalization' (red). A true paradigm shift happened when it became known that 'mindfulness' could actually be studied as a proper science. The discovery of neuroplasticity and the insights made possible by new brain imaging techniques helped revolutionise this idea (Fuchs & Flügge, 2014). Especially the easy accessibility of, for example, EEG sparked research popularity. (An example of an easy research setup can be seen in Chapter 13)

On top of that, when it was found that mental activity can change the physical structure of the brain (Davidson & McEwen, 2012). Mindfulness as an actual lifestyle took flight. This new science speaks to people cause it goes further than fundamental lab studies. It's an easy yet impactful way to directly improve your life, wellbeing and overall happiness. Mainly, since Mindfulness teaches practical tools to do so.

"MINDFULNESS IS THE BASIC HUMAN ABILITY TO BE FULLY PRESENT, AWARE OF WHERE WE ARE AND WHAT WE'RE DOING, AND NOT TO BE OVERWHELMED BY WHAT'S GOING ON AROUND US." - MINDFUL.ORG, 2020

Therefore, mindfulness is a quality that every human being already possesses, it's not something you have to conjure up, you just have to learn how to access it. However, many people report that it's hard to habituate a mindful lifestyle. This has opened up the market for productizable solutions.

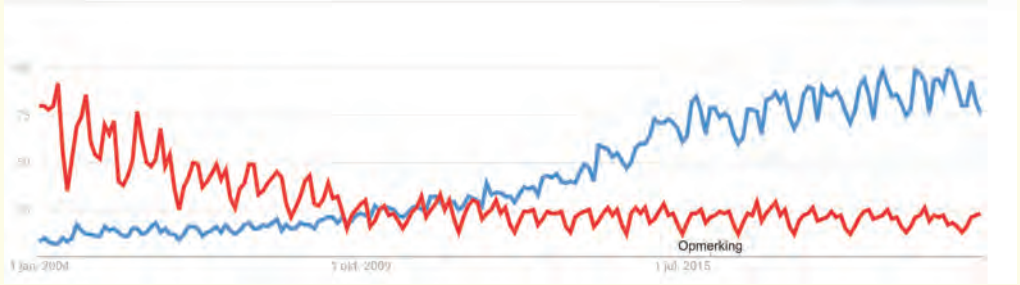


Figure 6.0: 'Mindfulness' has seen a sharp rise in popularity the last 15 years.
Blue = Mindfulness // Red = Globalization

The core concept of mindfulness includes receptive attention to and non-evaluative and sustained moment-to-moment awareness of mental states and processes (Huffziger, 2009). A mindful mode of processing involves a receptive state of mind in which attention is kept to register internal and external events as phenomena in a non-judgemental, accepting way (Brown, Ryan, & Creswell, 2007a). In this context, even unpleasant thoughts and feelings are openly accepted with the notion that they are transient.

Within psychotherapy, mindfulness interventions have been shown to reduce relapse in people with recurrent depression (Teasdale et al., 2000). Brown et al. was able to show that people who have (developed) mindful character traits, tend to be more extrovert and are in control over their emotions. (cf. Brown et al., 2007a). Habitual mindfulness also predicted pleasant emotional states and behavioural motivation in two longitudinal studies (Brown & Ryan, 2003; Levesque & Brown, 2007).
On a neuroscientific level, high mindfulness can even be linked to 'greater affect regulation' through enhanced control over amygdala responses (Creswell, Way, Eisenberger, & Lieberman, 2007).
Especially improved amygdala responses seems promising since it counteracts on the fact that rumination appears to involve an inability to modulate amygdala activity in response to negative stimuli. Similarly, depressed patients show amygdala hyperactivity in response to negative stimuli (Young et al., 2016).

Figure 6.1: "Mindfulness is a way of befriending ourselves and our experience" - Jon Kabat-Zinn (Owen Gent)



The art of breathing

One of the most overlooked — yet very effective — stress management tools is something we involuntarily carry with us throughout every second of the day: our breath.
A wide variety of breathing techniques can be found stemming from hinduism and buddhism culture. Four examples are provided at the end of this chapter. Since the breathing mechanism of the body itself is an autonomous process regulated by areas within the brainstem, it's highly related to cognitive functioning. Several studies show that breathing exercises can actually improve cognitive function, encourage positive thought processes, and reduce symptoms of anxiety (Zelano et al., 2016; Brown et al., 2015).

The rate of breathing is directly related to the response of the autonomic nervous system. The body's breathing rate is either stimulating the sympathetic or parasympathetic nervous system (Zaccaro et al., 2018).
Respectively, these two systems correspond with the 'fight-flight' reflex and the 'rest & digest' body state. In simple words, this means you're either 'stressing yourself' or making yourself feel 'relaxed' by the way you breathe.



Figure 6.2: Many breathing techniques are considered as 'lost arts' (Victor Amirabile)

BREATHING AFFECTING EMOTIONS

In addition, it was found that breathing can even impact a variety of emotions.
A study in the university of Quebec analysed how different emotional states come with different breathing patterns. They found that if someone performs the breathing pattern associated with an emotion, for an extended period of time, they will actually start to feel that emotion (Philippot et al., 2002).



Slow breathing

In recent years, this knowledge has found its way in helping the military during extremely stressful situations. So called “combat tactical breathing” was found to reduce stress and regain focus (Grossman & Christensen, 2011). Furthermore, these simple self administered ‘slow breathing’ techniques are found to be beneficial in the treatment of e.g. stress, anxiety, insomnia, panic disorder and many other health and well-being-related conditions. (Pirhonen & Tuuri, 2011, p. 66)
Furthermore, in comparison to meditation, breathing exercises were found to provide the greatest mental health, social connectedness, positive emotions, stress levels, depression, and mindfulness benefits. (Seppälä et al., 2020)

However, the majority of people is actually breathing too quickly. Breathing via the chest in a fast and shallow manner; inhaling through our mouth, holding our breath and taking in less air.

Over time our breathing patterns have shifted as a reaction to environmental stressors, like temperature, pollution, noise, and other causes of anxiety. Cultural expectations, including the desire to have a flat stomach, encourage holding our breath and sucking in our stomachs, further tightening our muscles. (Headspace, 2020)

Alternate nostril breathing

Alternate nostril breathing (ANB) is a breathing exercise in which you inhale exclusively through one specific nostril (either left or right) and exhale to the other. The technique is stemming from the Sanskrit term ‘Pranayama’ which stands for ‘the art of breath control’. Pranayama is considered to be the heart of yogic exercises and therefore important to study in depth. It is suggested that breathing through the left nostril facilitates the activity or the right hemisphere and vice versa (Telles et al., 2012). It is therefore suggested that ANB has a balancing effect on the functional activity of the left and right hemisphere (Stančák & Kuna, 1994). Moreover, an EEG study by Kuna showed an increase in interhemispheric connectivity and enhanced activity in the beta frequency band.

This shows once again the relationship between an alternating stimuli (in this instance, nostrils) and interhemispheric connection. It was found that ANB has a significant influence on the activation of the parasympathetic (rest & digest) nervous system (Sinha et al., 2013).
Moreover, a study with 20 healthy young adults engaging in ANB showed a significant increase in HRV (see chapter below) (Ghiya & Lee, 2012).

Comprehensively, following the ‘right’ breahting pattern can have great impact on one’s overall health and wellbeing. However, in practice this turns out to be difficult. A productizable solultion will be sought for helping people to stop restricting their breath.

The following paragraphs will give a brief overview of some breathing techniques which can possibly be aided by a product.

Figure 6.3: On average a human breaths ±26.000 times a day. (Victor Amirabile)



RESONANT BREATHING

The ‘resonant breathing’ technique seems promising within this project scope.
During training, biofeedback is provided to guide the user during the breathing process. This naturally occurring breathing tempo is most frequently found in persons in a relaxed mental state with a positive emotional tone. Besides, Moss states that “people are engaged in smooth full diaphragmatic breathing at their resonant frequency breathing rate of ~5–7 breaths per minute (BPM)” (Moss, 2004). An experiment in 2012 with manufacturing operators showed that only after five training session of approximately 45 minutes, a reduction in negative emotional states can be found (Purwandini et al., 2012).

How? Breathing rhythm guided by biofeedback.

WATER BREATHING

When you breathe 4-6 breaths per minute, it has an adaptogenic effect on your nervous system (Panossian & Wikman, 2010). If you’re up, it will bring you down; if you’re down, it will bring you up (Rockwood, 2019). You can practice Water Breathing standing, seated, lying down, and even while driving.

How? Inhale for 4 seconds > exhale for 4 seconds. Repeat at least 10 rounds.

WHISKEY BREATHING

When you reduce your breath below 4 breaths per minute, it triggers a strong parasympathetic (rest and digest) nervous system response, reduces your heart rate, reduces activity in skeletal muscles, and improves digestion. (Jerath et al., 2006).

This type of breathing is great after meals, in the evening, and most commonly, right before bed. This practice should be done seated or lying down, and never while driving or doing anything standing or active.

How? Inhale> hold & count 1-2-3-4 > exhale, hold & count 1-2-3-4. Repeat at least 10 rounds.

COFFEE BREATHING

When you breathe at the rate of 20 breaths per minute or more, it stimulates your sympathetic nervous system (Jerath et al., 2006). This is ideal before exercise, or in the morning. It should be practiced briefly, with care, and only at appropriate times. Never practice while driving (Rockwood, 2019).

How? Exhale sharply through your nose as if sneezing > practice 20 short sneezes. > Rest (2 minutes). Repeat for at least 3 rounds.

Heart Rate Variability

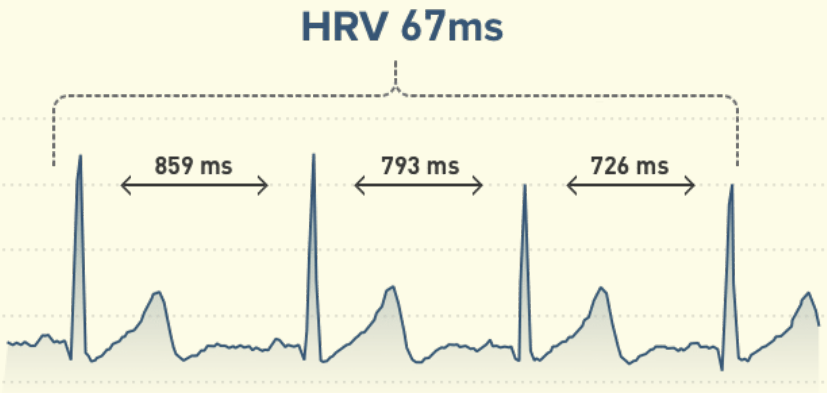
The biofeedback provided during ‘Resonant Breathing’ sessions is based on a person's Heart Rate Variability (HRV). Which is defined as the beat-to-beat changes in the interbeat interval (time between two successive heart contractions) (EACPR, 2012). The beat-to-beat variability is affected by the activity of the autonomic nervous system. It has been suggested that decreased HRV is evidence of vulnerability to physical and psychological stressors, and disease (Lehrer, 2007). Lehrer actually claims that maximal control over HRV can be obtained in most people after approximately four sessions of training (Lehrer, 2007). The provided biofeedback within the resonant breathing technique are currently either audio or visual, vibro-tactile ways should therefore be explored.

Additionally, Purwandini states that the biofeedback is particularly helpful for incorporating the mind–body connection into a training program. “Providing real evidence for clients that what they think and how they feel is integrally connected. As people become more aware of their physiology, they can control it better” (Purwandini et al., 2012).
This internal control can be an important step in batteling rumination.

Biofeedback along with breathing exercises has been proved successful in the treatment and prevention of many stress-related problems, such as PTSD and work-related rumination (Zucker et al. 2009; Siepmann et al., 2008, Cropley et al., 2017). Compared to the low ruminators, high affective ruminators demonstrated lower HRV. This indicates a lower parasympathetic activity, which is responsible for stimulation the "rest-and-digest" or "feed and breed" activities that occur when the body is at rest. A higher HRV is generally considered an indicator of a healthy heart and improved psychological well-being and quality of life (Castaldo et al., 2015).

The use of HRV as biofeedback in combination with resonant breathing seems promising for application within the current project frame since the mental state of rumination has a distinct HRV. An experiment even found that rumination can be differentiated from worry by looking at the HRV (Aldao et al., 2013).

Figure 6.2: HRV is a clear indicator for psychlogical well-being



Grounded Theory

7

This chapter will try to establish a novel overarching (grounded) theory based on the claims and knowledge of the previously collected literature. These claims will be translated to design goals for the to be designed product.

Building blocks

Concluding the literature study, the overarching theory was build on four different research domains (shown in Figure 7.1).

Four novel claims could derived from this literature. Each novel claim will be briefly discussed and translated to a design goal for the product to be designed (Sensescape).

Figure 7.2 shows the working principle of phantom vibrations. Portrayed by it's similarities to binaural beats.

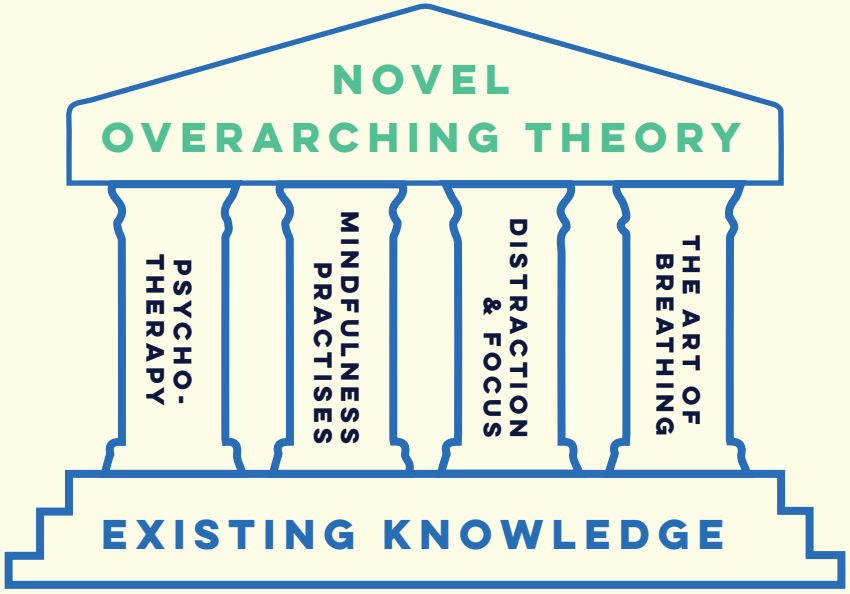


Figure 7.1: A visual representation of the overarching (grounded) theory.



Figure 7.2: A phantom sensation is experienced by bilateral tactile stimulation.



‘TACTILE PHANTOM SENSATIONS LEAD TO EASY NEURAL ENTRAINMENT.’

The widely sought after ‘binaural beats’ give the basic proof for easy entrainment to an illusionary overtone stimulus. This project hypothesizes the existence of a direct relation with the tactile realm. Tactile phantom sensations will lead in a similar way to easy neural entrainment. In the executed small scale experiments, it has been found that especially the phantom sensations ‘travelling between’ both pulsators held the attention of the participants.

Design goal

The product should maximize the perception of phantom sensations.

→ Two pulsators will simulate this sensation (Horizon 1)



RUMINATION CAN BE DISRUPTED BY COMPLEX TACTILE VIBRATIONS.

As seen within some small scale experiments, tactile vibrations are suitable for grabbing one’s attention. These experiments showed that especially the Breakbeat patterns were able to hold one’s attention since it’s hard to directly grasp the music structure at once. This is due to it’s complex nature.

Design goal

The product should be able to generate a wide variety of vibrational patterns

→ An constrained algorithm can generate specifically designed ‘Sensescapes’ (Horizon 2)



THROUGH RESONANT BREATHING A CLOSED-LOOP-SYSTEM CAN BE ESTABLISHED TO IMPROVE OVERALL (MENTAL) WELLBEING

Mindful breathing excersizes, such as resonant breathing form a great opportunity to tackle a wide variety of (mental) health issues.
A closed-loop-system can bring effective guidance to do so.
Some doors can only be opened from the inside, breathing can open those doors.

Design goal

The product should guide the user towards specific breathing rhythms.

→ Biofeedback can be measured through an HRV sensor inside the product (Horizon 2)



MODERN DAY EDM CAN BE TRANSLATED TO ENTRAINING TACTILE BILATERAL STIMULATION

Nowadays club-culture leverages vibrotactile entrainment to create states of 'focus'. This rich source of vibrational patterns (like Techno and Breakbeat) can create an unique differentiating user experience. In the long-run new forms of self-administered therapy can be created through induced tactile vibes.

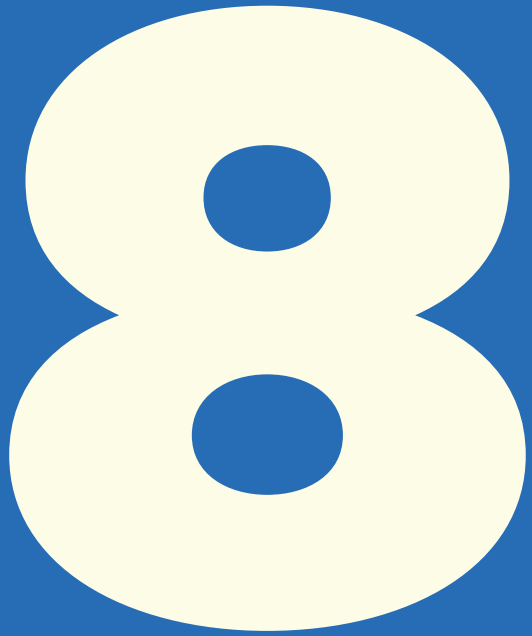
Design goal 4

The product should enable the user to 'get out of his head'.

→ Different 'Sensecapes' can be created by the use of different music genres as vibrational input (Horizon 2)

Value Proposition

This paragraph will show the translation to the final proposed product, Sensescape.
The product has been crafted to tackle the previously formed design goals and exploits the grounded theory as scientific backup for it's working principle.
A fitting problem frame and brand identity was created to attain product/market fit.



The product

Sensescape is a handheld breathwork meditation device which helps to unwind, right at the moment your mind is full.



GUIDED BREATHING
THROUGH HAPTIC AND LIGHT FEEDBACK

GUIDED BREATHING,
THE MOMENT YOUR MIND IS FULL

Ever felt you needed a meditative session, at your work?

Unlike your yoga/meditation classes, Senscape will help you unwind right behind your desk. Breath-along with the soothing vibrations and let yourself escape from everyday work stress.

MEDITATION SUPPORT,
A NATURAL POINT OF FOCUS

Ever felt distracted during a meditative session? or even bored...

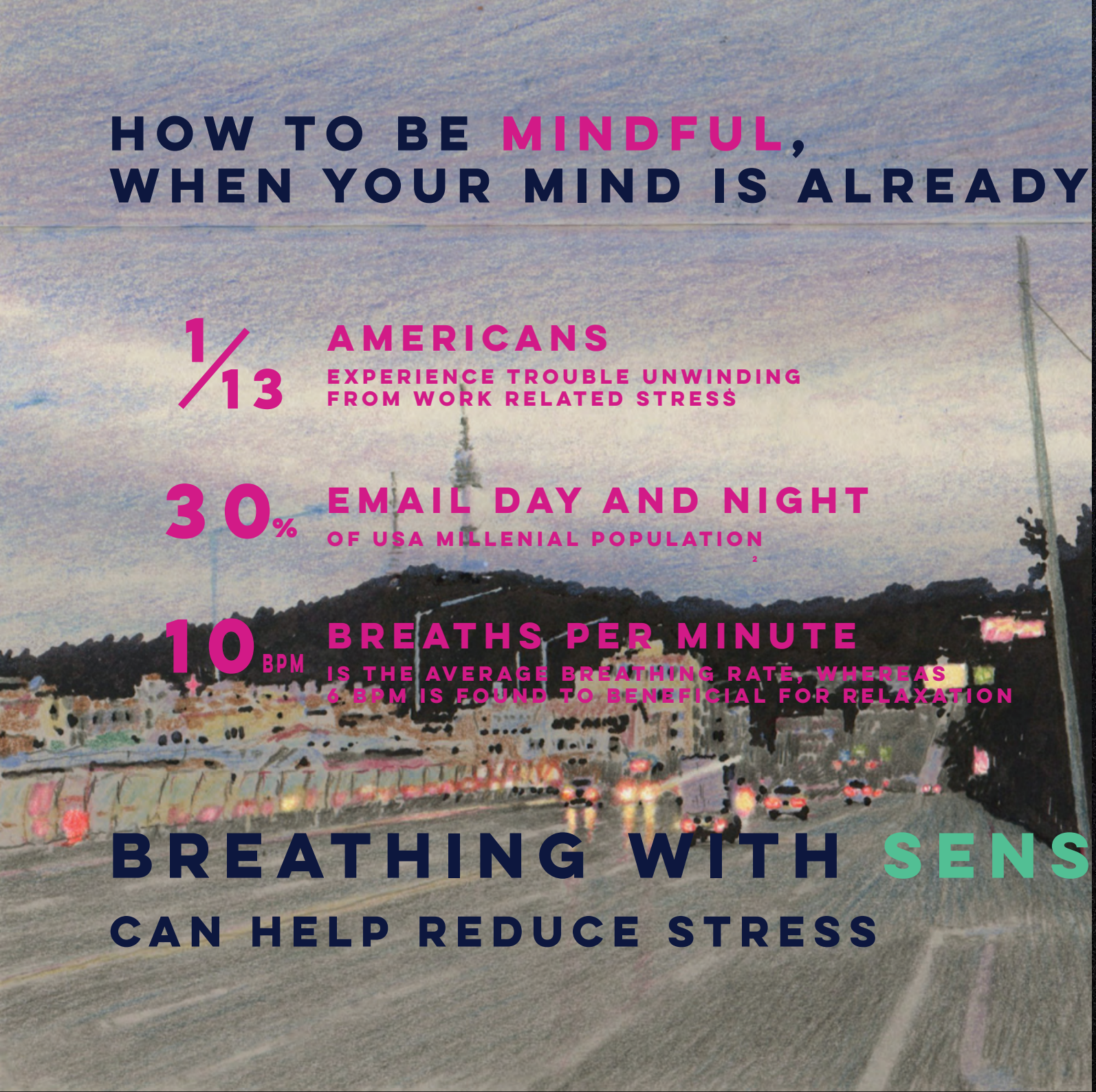
Sensecape provides carefully crafted vibrations to support your breahtwork meditation experience. If your mind wanders of, the vibrations will naturally grab your attention and help sustain focus!

GET OUT OF YOUR HEAD
DISTRACTING BILATERAL VIBRATIONS

Ever felt like your thoughts couldn't stop racing? distract yourself!

Having a pulsator in both hands, the vibrations will 'bounce' inbetween. This immersive effect will overule all other thoughts.

HOW TO BE MINDFUL, WHEN YOUR MIND IS ALREADY FULL



1/13 AMERICANS
EXPERIENCE TROUBLE UNWINDING FROM WORK RELATED STRESS

30% EMAIL DAY AND NIGHT
OF USA MILLENIAL POPULATION[2]

10 BPM BREATHS PER MINUTE
IS THE AVERAGE BREATHING RATE, WHEREAS 6 BPM IS FOUND TO BENEFICIAL FOR RELAXATION

BREATHING WITH SENSESCAPE CAN HELP REDUCE STRESS

Revised problem frame

Keeping a healthy work/life balance can be a daunting task in today's overstimulated society. For many of us, a regular day can feel like running on a treadmill. This results in fast, restricted and shallow breathing throughout the day.

This makes it more challenging than ever to find a moment to unwind. Even proven practices, such as meditation and mindfulness, struggle to become habits.

However, there is a profound stress-management tool, we were all born with.
It was the first thing we did when we entered this life....taking a deep breath.

Deep breathing exercises form the foundation of every mindfulness practice. It's a key component to good (mental) health and will increase your stress resilience.

OVERTHINKING
MINDFUL BREATHING CAN STOP RACING THOUGHTS

A common, yet ineffective, coping mechanism of dealing with everyday stress is 'overthinking'. This bad habit can have an impact on your mental health, and even onset depression. If you recognize such a moment, the distracting vibrations of Sensescape can break these negative thought-loops. Even more, the breathing exercises will help you to find peace of mind.

HIGH PACED BREATHING
DEEP BREATHING WILL INCREASE HRV

Studies show that slow breathing (bpm<10) is found to be beneficial for many health implications. It will improve your HRV (Heart Rate Variability), which is a key marker for good health and wellbeing. The right breathing rate will activate your 'rest & digest' nervous system and can even make you more mentally resilient against stress.

MEDITATION IS NOT INTERNALIZED
MAKE MINDFUL BREATHING A HABIT

Sensescape is effective and simple tool to engage you in commitment and consistency of breathwork meditation.

FIND
YOUR
INNER
RESONANCE



Figure 8.1: Sensescape brand identity: Left page //Purpose, Right page //Vision

SENSESCAPE

Escape the moment,
when your mind is full.





Figure 8.2: When your left hand vibrates, breaht in. When your right hand vibrates, breath out.

AT HOME

Sensescape is simple to use anywhere. Find a comfortable place to lie down, put on your headphones and turn on the Sensescape by pulling them apart from each other.

Choose a session in the app, and allow yourself to be relaxed by the immersive experience. The product can be used solely or compliment breathwork meditation sessions.





ON THE GO

Sensescape is designed to be portable. You should be able to use it anywhere you want. They fit right in your pocket.

It's small size even allows you to use sensescape unnoticed. For those moments when life can suddenly be overwhelming.

"SENSCAPE IS UP FOR GRABS, THE MOMENT YOU ACTUALLY NEED IT" - FUTURE USER

HABITUATE MINDFUL BREATHING



VALUE PROPOSITION



Customer

Consciously mindful workaholics

- Are prone to daily stress
- Engaged in a mindful lifestyle
- Practice meditation to unwind

Pain

Trouble with unwinding from everyday stress, due to work or personal matters

- Weakens mental health
- Difficult to hold focus during meditative sessions
- Breathing excersizes not internalized

Benefit

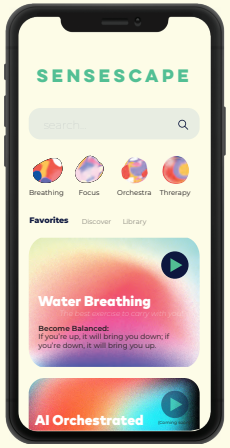
Natural focus point during meditative sessions

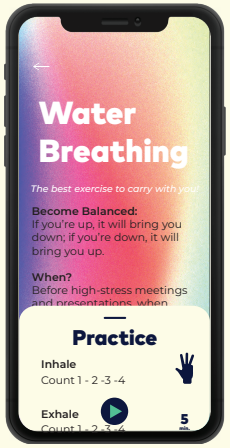
- Product available when needed
- Vibrational stimuli to breath along
- Reach desired breathing rhythms
- Provides a mental state of clarity
- Helps to ‘get out of your head’

Product

Guided breathing, through vibrations.

Soothing vibrations will bounce between two handheld pulsators to naturally grab your attention and sustain focus.



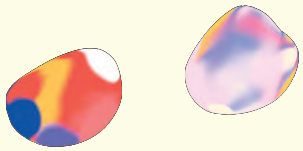


How does it work?

2) CHOOSE YOUR BREATHWORK

Open the Senscape Library and select your desired breathing exercise.
These will range from energizers in the morning,
to unwinding at work or even to fall asleep with in bed!
*For first time use, connect your pulsators in the app via bluetooth.

10 min. Breathwork Meditation session



1) UNCOUPLE PULSATORS

The pulsators click together by the use of magnets.
Once uncoupled, they will automatically turn on!

3) MAKE YOURSELF COMFORTABLE

Hold the devices in both hands and close your eyes.
Make sure to relax your faces and shoulders beforehand.
Try to sit somewhere quiet or put on your headphones
for an extra emerging experience.



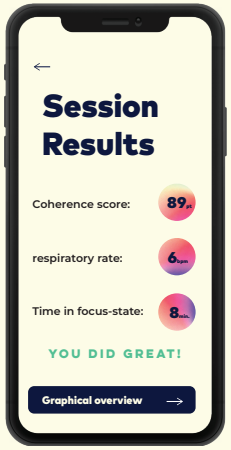
Figure 8.3: Overview of customer journey, using Sensescape.

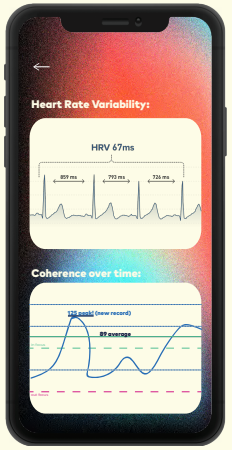
4) BREATH-IN, BREATH-OUT

The pulsators will start vibrating alternatingly, in your selected rhythm.
Breath-in, when the left pulsator starts vibrating.
Breath-out, when the right pulsator starts vibrating.



Simple as that!
The lights inside work together with
the pulsators and will
slowly light-up accordingly
for extra guidance.





6) CHECK YOUR SCORE!

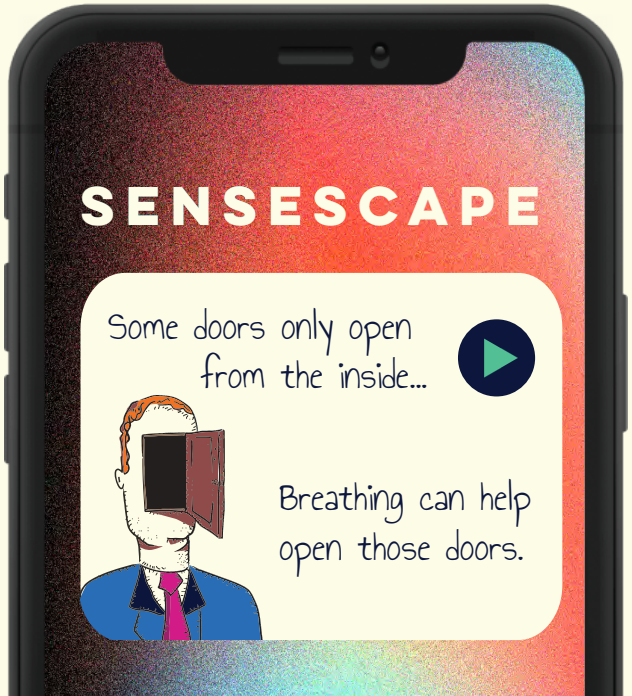
We will calculate an Heart Coherence
score for you, so you can track your process.
Swipe right for more in-depth information



5) ENJOY THE SESSION!

Once the session is over,
the pulsators will give a long soft buzz.

Every month a new breathing technique!



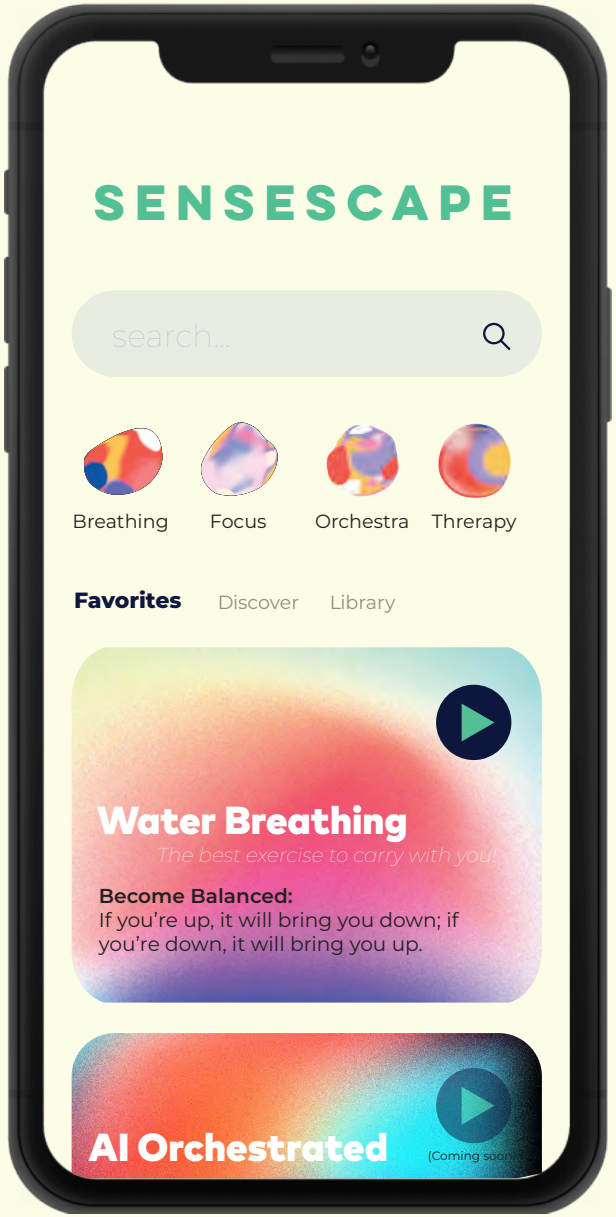


Figure 8.4: Sensescape library // select your desired excersize

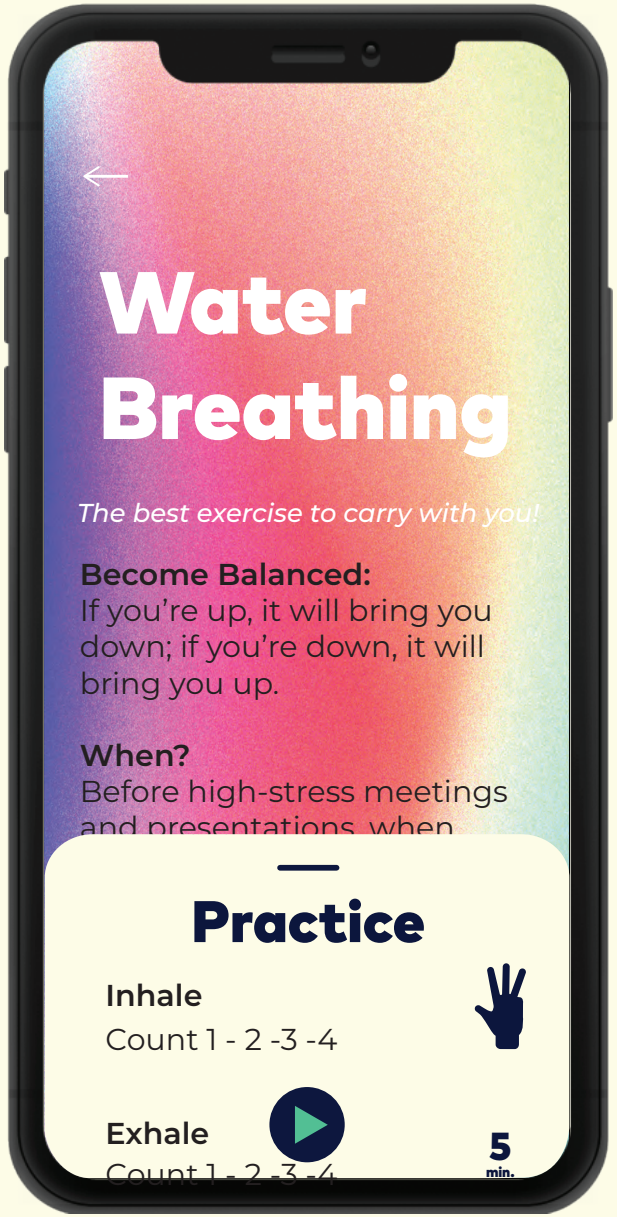


Figure 8.5: Example breathing excersize // swipe up for practice

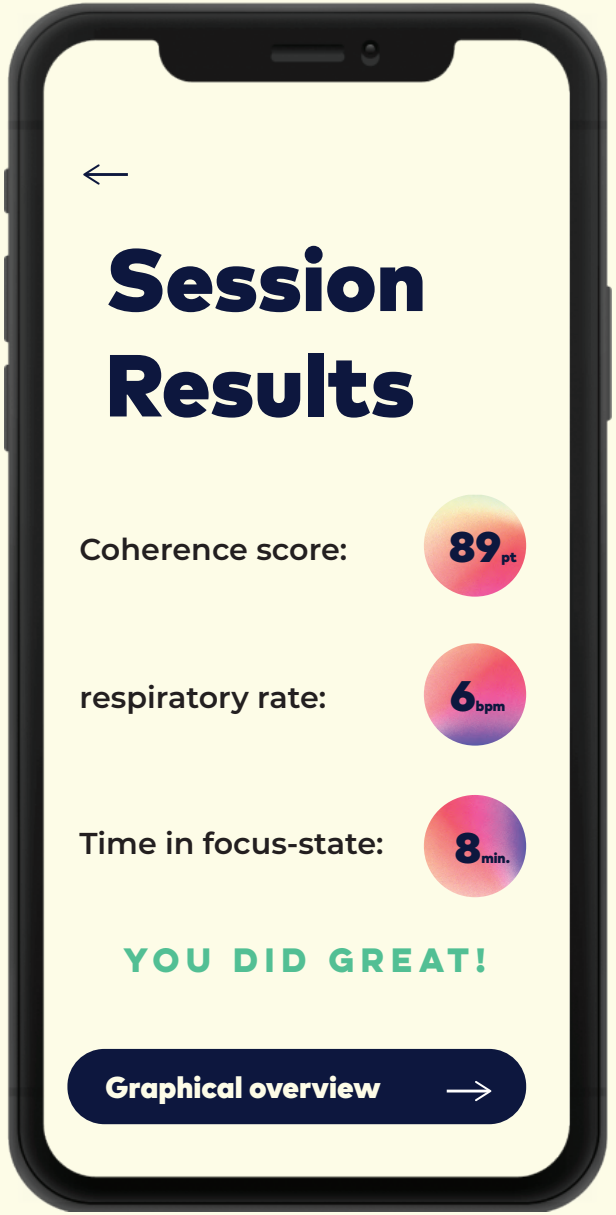


Figure 8.6: Overview after session // scores will be logged

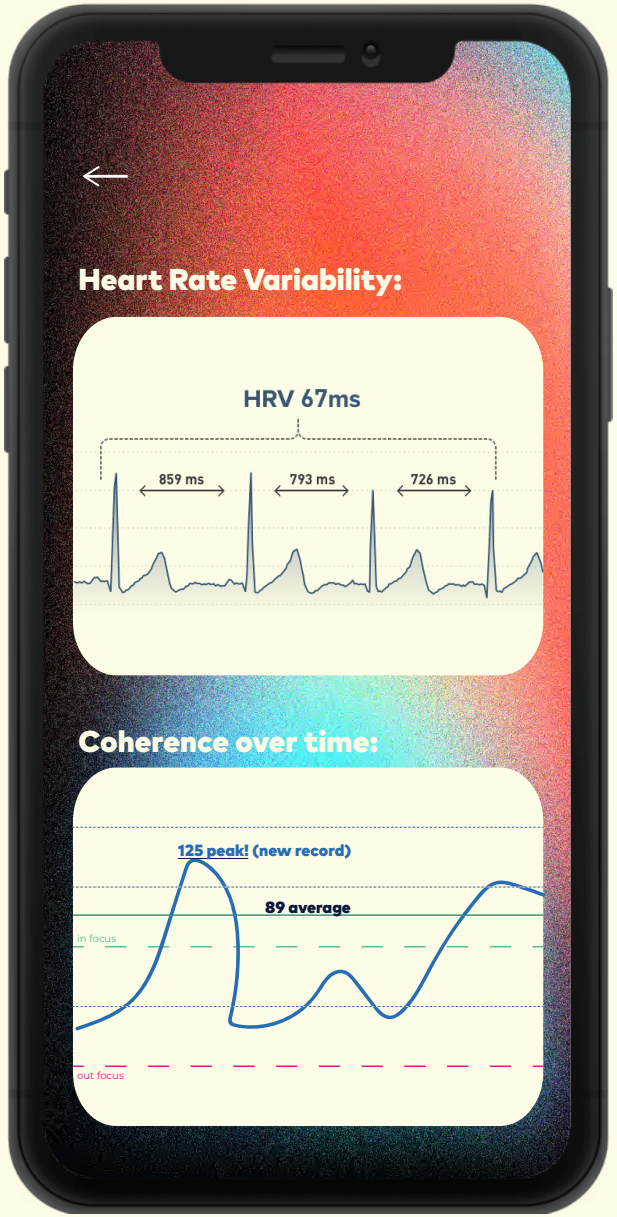


Figure 8.7: Analytical insight // keep track of session to improve

Launch Strategy

Within the Mindful Market, workaholics form a well established target segment to enter the market.
A launch strategy is written to successfully target these customers and to assure profitability.
The market analysis will shine light on the differentiating factors of Sensecape within its industry.
Lastly, strategic partnerships will be investigated for future product development.

9

Customer

Although many paths can lead to success, the ‘beachhead market’ theory states that choosing one path (and sticking to it) will significantly increase your changes (Aulet, 2013). Especially for entrepreneurs, this turns out to be difficult. Dan Ariely shows this in his book Predictably Irrational (2008) with an experiment. According to his research, when people are given (what appear to be) multiple paths to success, they will try to retain all the paths as options; even though selecting one specific path would have guaranteed them the most success.

The Beachhead market theory states: “...by choosing one market to focus on, it will be easier for a company to establish a strong market position“ (Aulet, 2013). Future expansion to other markets can be done strategically over time. For this project the beachhead market will be the so-called ‘Mindful Market’. Within this market we will focus on the segment; ‘consciously mindful workaholics’ (within the millennial generation).

Already in early 2014, TIME magazine had declared the ‘Mindful Revolution’, this movement has been growing rapidly ever since. This revolution revolves around the idea that living in a ‘mindful’ way can be beneficial for a wide variety of aspects in life. For details about mindfulness in general, see paragraph XX. The target group within focus is either part of this movement or willing to change their behaviour in a mindful manner. They are familiar with the term ‘mindful’ and/or actively pursuing it. However, they struggle to implement it in their daily lives because they are prone to ‘workaholism’.





Figure 9.1 - “Consiously mindful workaholics” (Timo Kuilder)

“Workaholism, also called work addiction, is referred to as a compulsive desire to work. It is characterized by working excessive hours, by thinking continually about work and by a lack of work enjoyment.” (Aziz, 2020). Within our 24/7 culture, workaholism may be seen as a prerequisite for success, as a consequence some individuals may find it difficult to release themselves from work, even when they are given the opportunity to do so. Workaholism is associated with reduced physical health and with various psychiatric disorders, including anxiety, ADHD, depression and OCD (Aziz, 2020).

Since it’s given that the mindful-market is already well established, some advantages and disadvantages should be considered. In general, demographics are commonly available, therefore they can easily be targeted by social media campaigns. On top of that, since they are a currently active and growing community, mouth-to-mouth marketing can spread fast. Nonetheless, current marketing campaigns basically claim ‘mindful-everything’, so proper scientific backup is needed. Lastly, since the target group is already familiar with the lifestyle for some years, it’s likely they already have certain products/services or habits in place to pursue mindfulness. This consideration is dealt with in the calculation of the TAM size (see paragraph: Business plan).

A good example of an activity of consciously mindful workaholics is following yoga classes. To get a sense of this market size; in The Netherlands there are 1.6 Million people doing Yoga, which is ±12% of the population. This contributes to a Dutch market of €325 Million, which means the average yogi spends around €90 per month. Yoga is mainly popular among women (74% of total) between their 40-70’s. (Yoga Magazine, 2020)



Figure 9.2 - Yoga schools can form a robust network of sales channels

We should stop wearing ‘workaholic’ as a medal of honour

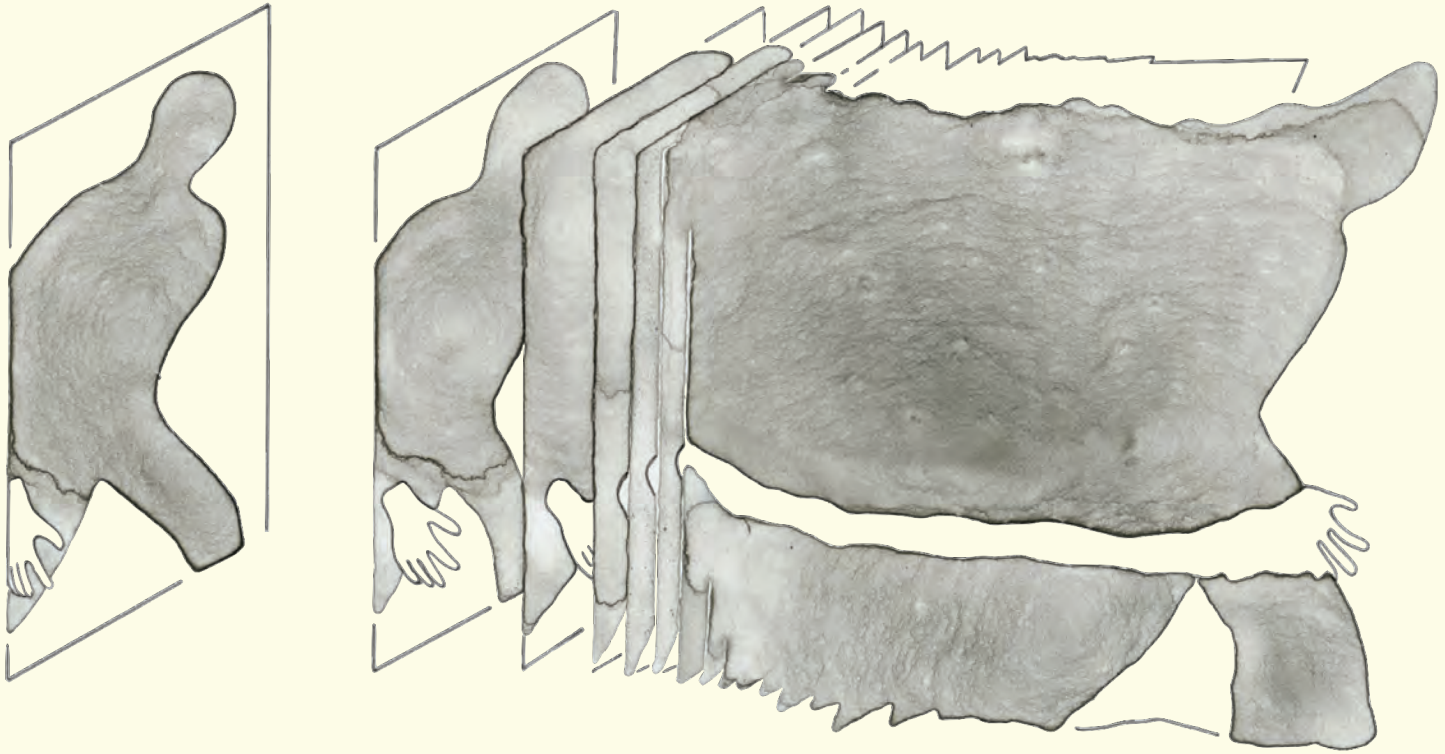


Figure 9.2 - Statement of author, to motivate focus on target segment.

"I'm often still thinking about work, in my free time"



Figure 9.4 - Quote compilation from (small) user research among target group.

"I regularly check my email in the weekends"

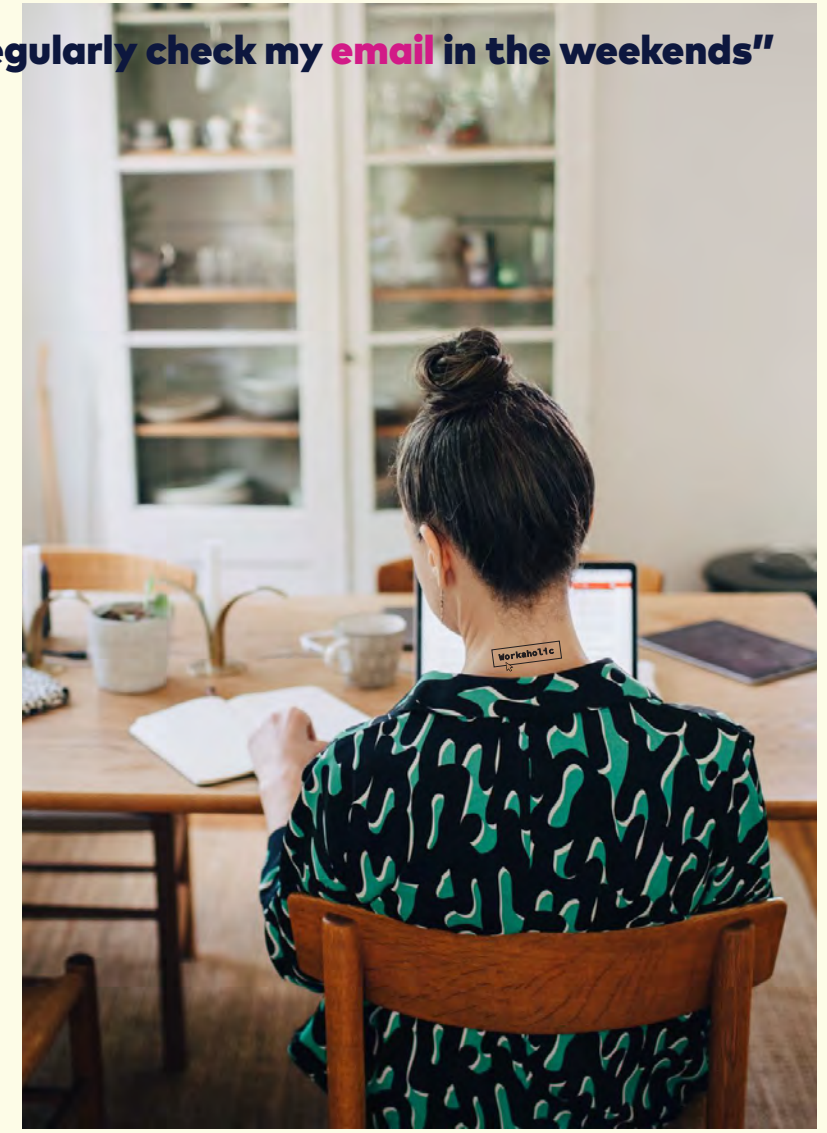


Figure 9.5 - 'wokaholism' is seen as a prerequisite for success.

LIFE ISN'T ALWAYS LIKE THIS...



Figure 9.6 - A peace of mind.

AND EVEN IF IT IS...



HABITUATION IS DIFFICULT



Figure 9.7 - Sensescape can form the needed commitment to habituate breathwork.

Market size

The following chapter will give insight in the calculated decisions related to the market penetration strategy, as presented in the roadmap.

To get a good sense of the size and possible revenue I've used the TAM/SAM/SOM method to calculate market share. The retail price will be calculated in the last stage.

The Total Addressable Market would be every person who encounters everyday stress. One out of four Americans experiences everyday stress (Statista 2019). However, since the product can easily be used as an addition to a meditative session. It is more likely that people will buy the product whom are already implementing a meditation habit in their daily lives. In 2018, a large scale questionnaire found that 40% of the Americans meditate on a weekly basis.So for the USA alone this would give the following TAM calculation:

TAM = Population of USA *%Experiencing stress * %meditates = 330 * 0,25 * 0,4 = ±33 Million People



Figure 9.8 - A strategically chosen beachhead market will increases chances for success

However, a more reasonable number can be considered using 3 extra limiting factors; trouble unwinding from the stress, willingness to meditate and cooping methods. The amount of people who actually experience trouble unwinding from everyday stress is considered to be 13% of the population of the USA (Statista, 2019).
On top of that, it should be considered that these people might already have cooping methods (such as exercising) or already invested in a competitors offer (such as Headspace). For this estimate it is considered that 75% of the people will find trust their own cooping method, so 25% will buy the product. This leaves the Serviceable Available Market (SAM) with the following calculation:

*SAM = TAM * %trouble unwinding * %meditates * %competition = 33 * 0.13 * 0.25 = ±1 Million People*

Nevertheless, these people won't all be in reach (especially in the USA). So if we would translate this number to The Netherlands the following Serviceable Obtainable Market (SOM) can be established with the current value proposition:

*SOM = (SAM * population NL)/ Population USA = 50 Thousand people*

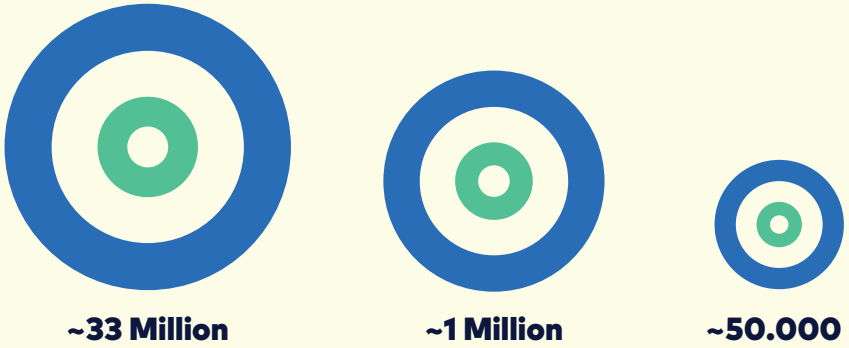


Figure 9.9 - TAM // SAM // SOM (amount of potential customers)

For a retail price of €250,- this would deliver in 12,5 Million turnover. With a revenue margin of 10% this would approximately result in **1,25 Million revenue**. The turnover per year, can be found in Appendix B-I.
It is plausible to reach this market within 5 years. As seen within the Technology Adaptation Cycle (Figure 7.2) the first 2,5% of the customers can be labeled as Innovators. In practice, this would be the amount of backers you could attract in a Kickstarter project. In this case that would be 1250 backers which will generate a first investment of ±1.7 Million.
In comparison, Sensate reached 4000 backers and generated and reached ±0.8 Million (IndieGogo, 2020).

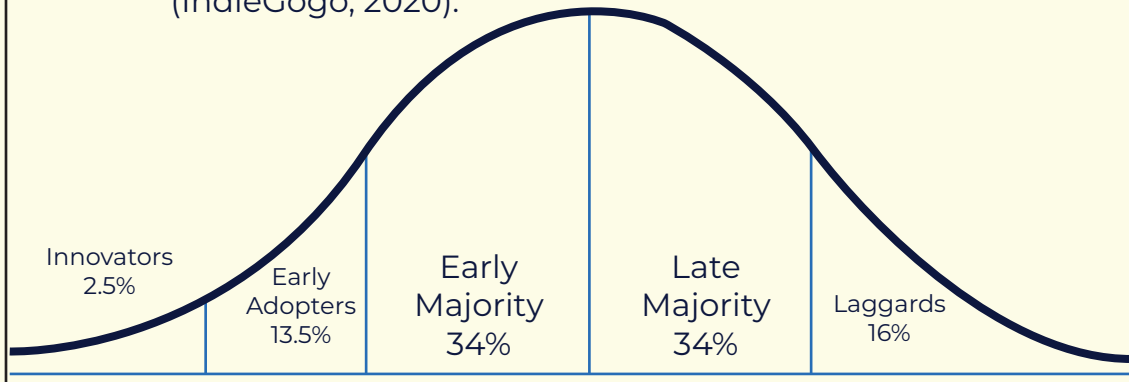


Figure 9.10 - Technology Adoption lifecycle (Moore, 1991)

Industry

Founded in 2010, Headspace can be seen as one of the leading players in the mindfulness industry. In a respectable 10 years they've gained worldwide popularity and they are on it's way to reach 100 Million users by 2022 (BusinessOfApps, 2020). Calm, another major player, have a customer base of over 60 million users and reached an valuation of 1 Billion (BusinessOfApps, 2020a). This shows a strong market pull, and validates customer need.

Another interesting competitor is Muse, a meditation guiding headband. They have been able to productize meditative sessions by providing direct feedback via a brain sensing headband. Since this is a relatively new technique, the product is still in full development and is widely trusted by investors. This shows in their latest investment round, raising $13.1 Million (Pitchbook, 2017).

Especially in the app market, companies are trying to capitalize this upcoming trend. According to the CDC, "meditation was in 2018 the fastest-growing health trend in America. Meditation studios, brands and apps are spawning worldwide—with Apple naming mindfulness apps the #1 app trend of 2018." (Clarke, 2018). A recent report of Prophecy Marketing Insights, expects this rapid growth to continue steadily: "The global mindfulness meditation apps market accounted for US$ 153.6 Million in 2019 and is estimated to be US$ 341.9 Million by 2029 and is anticipated to register a CAGR of 8.3%. (Compound Annual Growth Rate)". "Meditation is mainstreaming now, and it's just in time to counteract the epidemic of stress that threatens our society." - Prof. Gerry Bodeker, 2018

A similar player in the industry would be the startup 'Sensate', a relaxation device which also makes use of haptic feedback. They have run a successful Indiegogo campaign and have a similar value proposition: "the shortcut to reduce stress and anxiety". They attracted ±4200 backers and have raised around ±€800.000,- (Indiegogo, 2020). If these ±4200 backers are considered to be 'innovators' (2,5% of market), their potential customer base can be extrapolated to ±168.000. This gives them a future revenue of €42 Million (retail price is €250,-). It is likely that Sensescape can at least reach the same order of magnitude.

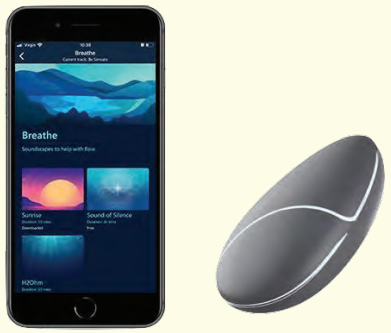


Figure 9.11 - Sensate, a similar product offering, raised 800.000 via crowdfunding.

COMPETITOR MAP

Figure 9.9 shows a clear differentiation in product characteristics compared to current competitors on the market. Two key differentiating aspects of The Memory Jogger are its capabilities to orchestrate a desired mood. Just as a professional orchestrator (conductor) the device 'listens' to the body and adapts it's stimuli accordingly. The device even forms a closed loop system by sensing HRV and can adjust by real-time feedback. This is different from WaveKit (top left corner) since this device is only 'orchestrating' the desired mood but does not read any (bio)feedback.
Furthermore, The Memory Jogger uses guided sessions to reach a clear goal. Unlike other meditation focused devices, the goal is to reach clarity instead of calmness.

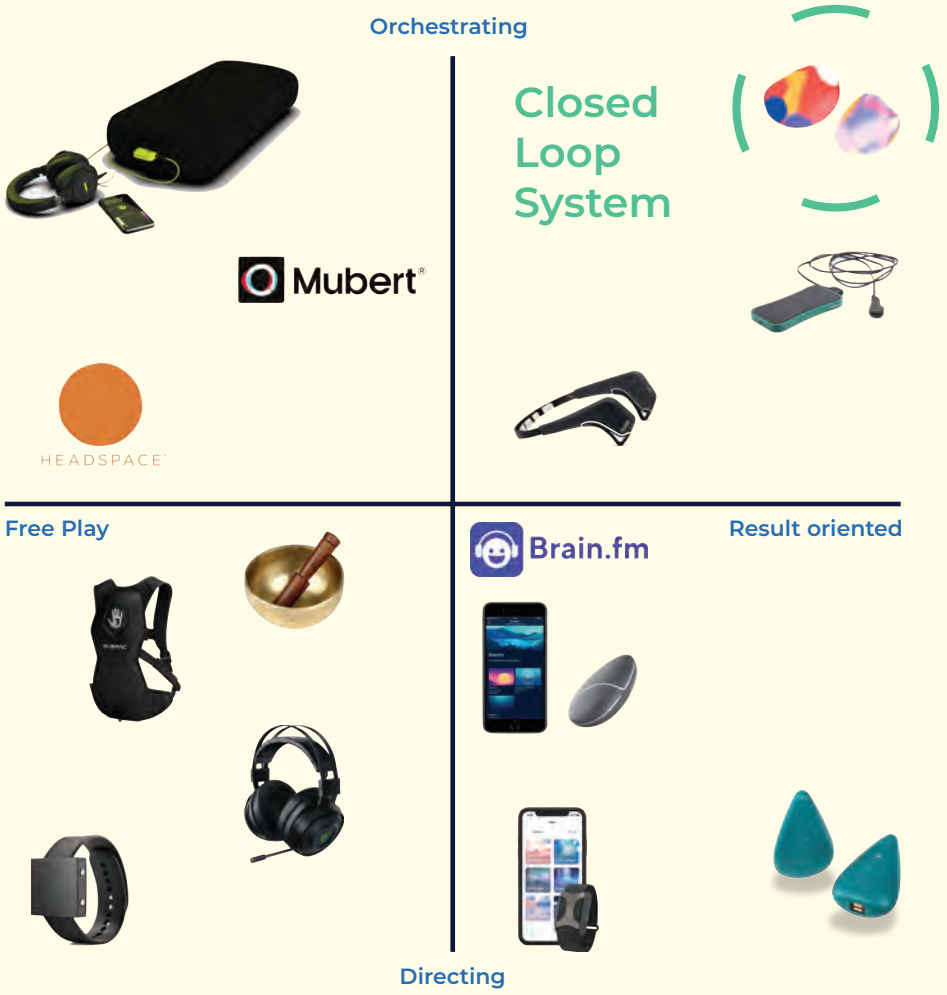


Figure 9.12: Space for market entrance via closed-loop-system PSS.

Strategic Partner: LOFELT

The current prototype makes use of the LoSound Engine, designed by Lofelt. As they state on their website; “The high precision of the LoSound engine (L5 actuator) results in a deep sound experience.” (Kickstarter, 2017). These vibration motors are especially suitable for this project since they can be easily controlled by sound files. Using actual audio as vibration patterns gives room for creative freedom in the crafting of the imagined sensescapes and can easily be linked to the Mubert AI. In future extensions of the ‘sensescape library’ collaborations with audio engineers could be sought which contributes to the unique experience the product can deliver.

Lofelt	Sensescape
Opportunity to sell a significant amount of L5 Actuators	**Leverage existing actuator technology**
Recommence of R&D investment in Lofelt Basslet	**Use sound files as input for vibrational patterns**
Straightforward manufacturing role for already existing product	**Leverage experience and expertise of Lofelt**

Figure 9.13: Overview of benefits for strategic collaboration.

In later stages, the Lofelt team could even work on a new actuator especially designed for this purpose. Future user feedback should learn if this is actually worth the investment.

A strategic partnership is sought since the L5 Actuator is a ‘one of a kind’ product. There are no other vibrational motors out there, which can be controlled with the same ease or use sound files as input. This shows the neccesity of their expertise.

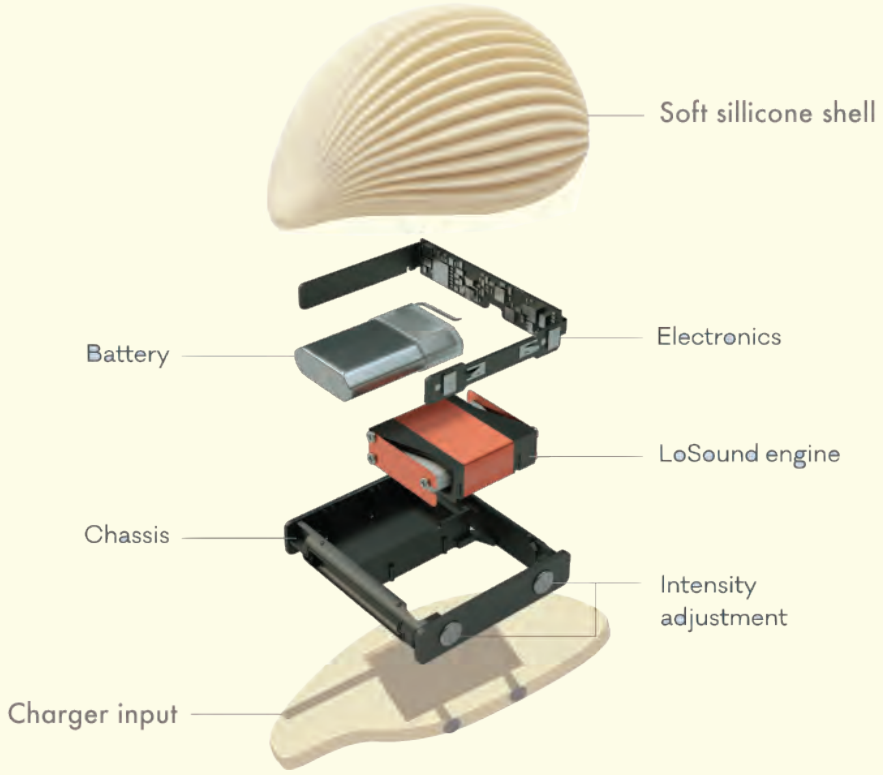


Figure 9.14: Incorperation of the Basslet design in the Senscape pulsator.

Strategic Partner: Mubert®

Mubert is a music-tech startup (founded 2016) who enable AI-created music. Their AI creates an endless stream of original music based on audience preferences. Via the app they are capable of offering different genres of music, including Techno, Ambient and music similar to Breakbeat.
I've approached them as a strategic partner to create a 'Bilateral Beats' channel within their app to be used during or alongside psychotherapy. Since Sensescape works with music files as input, they could easily be coupled. A strategic partnership would offer the following benefits for both parties involved.

Mubert	Sensescape
Vehicle to leverage purpose-driven innovation	Leverage existing AI technology
Brand identity boost because of collaboration for good cause	Build brand identity by 'cool' collaboration
Significant new customer base, which would have been unreachable otherwise	Reach existing customer base of Mubert
Steppingstone for entrance into meditation market	Use existing promotion channels
Realizable product extension within current expertise	Leverage existing app

Figure 9.15: Overview of benefits for strategic collaboration.



Figure 9.16: Like/Dislike specific moments during the track to personalise the AI.

Business Model

10

The capability of basic business modelling is important for every entrepreneur.
This chapter will analyse the viability of the proposed concept. Several aspects of the business proposition are covered such as; income structure per year and Costs of Good Sold.
An evolving business model is proposed with a combination of B2C hardware selling & Saas solutions.

Hardware + SaaS solutions

Since the strong rise of the 'subscription economy' around early 2015. Subscription business models are the norm nowadays. This is driven by the search of most Millenials for experiences instead of commitment (buying a product). A subscription provides freedom for the customer and companies enjoy a robust and predictable income. The recurring income makes it easy to predict revenue growth for the future and track how customers' perception of value changes over time. It's a mutually beneficial system, which will also form the basis for the suggested business model below.

By offering a premium subscription on the supportive app, a SaaS model (software as a service) can be established. The hardware (pulsators) is necessary for the app to function. Especially for the current value proposition a subscription model is fitting since it allows customers to switch the service on/off if they are in a more or less stressful phase in life. On top of that, the service will be updated over time, which will also make the service of more value over time. Value will be added by adding new sensescapes to the library, this justifies the subscription fee. Lastly, subscription models are highly popular within the Millenial target group (Retail Dive, 2017).

The business model can be studied in detail in Appendix B-I. This dynamic excel sheet includes information per provided number. Apendix A will also give a quick overview of the cashflow and Breakeven point(s).
Two different exemplar years are provided in the following paragraph, including explanation for it's key figures.

Year 1: Crowdfunding

Retail price: €250,-
During the crowdfund stage, the vibration motor will be a buy-in product, which pushes the product price. In this product category, prices are around €350 (Sensate, 2020).

Expected crowdfunding backers: ±1250
This figure includes the innovators, 2,5% within the SOM market segment

Total paying subscribers: 0
In the first two years, the company can't update/improve their product offering on a monthly basis. So a regular sales model will be used.

Gross margin per product: €79,-
The relatively high price covers for the variable costs and leaves some room for expanding the company team.

Customer Acquisition Cost: €20,13,-
Kickstarter and Indiegogo (crowdfund platforms) charge per pledge.
Total profit: €37.938,-

In year 1, all money will be invested in the development of the AI and HRV sensor. This new product will be released in year 4.

Year 3: Subscription model

Retail price: €79,-
The hardware is sold as cheap as possible to stand out from the competitors. In this product category, prices are around €350 (Sensate, 2020). On top of that, since the strong rise in mindfulness devices and the progress in sensor development, a hefty price drop should be anticipated.

Expected sales: ±17000
This figure includes the early majority, 34% within the SOM market segment

Total paying subscribers: ±6800
Since the product is sold for a low price it is expected 75% of the backers will pay for subscription.

Subscription cost p/m: €5,99-
If used weekly, this results in the cost of a cup of coffee per session. In comparison, Headspace charges €11 per month.

Subscription cost p/y: €39,-
It is encouraged to take a year subscription right away for a fast cash flow.
But moreover, the data input of the customers can be used right away for improvement of the product and development of the AI needed in the 2nd horizon.

Gross margin per product: -€29,-
The hardware will be sold with loss, to grab the biggest portion of the market share. The subscription fees compensate for the loss made.

Total profit: -€331.416,-
In year 3, the company will still be doing heavy investments in the building of the AI and HRV sensor. These will be released in year 4.

Cost Of Goods Sold

The Cost Of Goods Sold (COGS) value will drop heavily throughout the 5 year plan. This has few main factors;

Economies of scales
Within the first years, the low sales volume will bring high investment costs and the production and distribution channel will be relatively expensive. As production increases, average costs will fall. On top of that, low brand recognition causes high CAC.

Improvements in technology
Whereas the Lofelt L5 Actuator is currently a state of the art pulsator, this will become mainstream in a few years. Driven by the mega-trend

of VR, the haptic field has been in rapid development for the last few years. It is anticipated that the Lofelt pulsators can be bought-in cheaper every year (see price construction below).
The same principle applies for the (to be built) HRV sensor, since the rise of fitness products is not expected to stop any time soon. In this scenario, this will mainly have it's influence on the price drop of the components used inside the HRV sensor and the needed know-how for development.

Competition
As a startup, it's of high importance to stay ahead of competition by keeping low prices and trusting investors to cover for the startup costs. In the first five years, the hardware will be sold as cheap as possible, since the main income will be generated via the subscription model. This will especially be true for the second horizon. A low price will also provide competitive advantage.

Price skimming
In its first years, Sensescape will have a certain 'new gadget feel'. This will attract customers with an inelastic demand. Once these customers are saturated, the price will drop to gain appeal from a wider audience.

Investing in development of AI and HRV sensor
In the current 5 year plan, a new product will be released in year 4. This new product offering will enable the entry of horizon 2. This product will embody a in-house designed HRV sensor, which can sense HRV through the hand palms. The development of such a sensor is costly and requires a knowledgeable team. Similarly, the imagined AI system, which will orchestrate 'sensescapes' in H2, also needs high investments for its development. In this case, early development is important since the AI will need a significant period of time to learn from the customer's usage data.

COGS Year 1: €145,-
2x Lofelt L5 Actuator + 2 BT receivers = €120,-
This price calculation incorporates a strategic partnership with Lofelt. The retail price of a Lofelft Basslet is €130,- this includes 1 L5 Actuator and 1 BT receiver. In later stages, a strategic partnership with Lofelt will be tried to establish, to drive prices down.

KYTO HRV earclip = €15,-
In the 1st horizon the KYTO HRV earclip will be sold as a solo product, next the pulsators. In later horizons the HRV sensor should be built in the product itself and should be able to read HRV through the handpalms.

Embodiment/ packaging/ assembly = €10,-
The soft shell on the outside will be made from 'Silopren™ Matrix 70 LSR', inside there will be a hard PC case for the L5 Actuator and BT receiver. Packaging and assembly are based on a rough estimate of €5,-

Horizons

As a Strategic Designer, I try to see the bigger picture of the current minimal viable product (Sensescape).
A strategic roadmap is presented to show the true depth of the product concept. As the value proposition grows over time, the product will establish within the medical sector for purposeful impact. Besides, it is argued that B2B sales in Horizon 3 can greatly increase market penetration. A brief sketch of the possible product functions in these future stages is provided.

11

STRATEGY IS JUST LIKE CURLING. SOMETIMES YOU HAVE TO THROW A CURVEBALL TO LAND AT THE WINNING SPOT - AUTHOR, 2020

The roadmap presented on the following 2 pages was created in line with this philosophy.
The green curveball represents Sensescape. In the coming 10 years, it follows a deliberate curved path to spin around some major competitors in the industry. These are represented by the opposing team's red stones.
The value proposition will change along the way, to be able to penetrate new markets.

Mindful market
GUIDED BREATHING

Within the first five years, the value proposition will solely be 'guided breathing'. This will help 'Consciously Mindful Workaholics' to habituate breathing during or alongside there meditative sessions. For more information about this beach head market, see Chapter 9 - Customer.

The profit made within H1 will be used for in-house development of an HRV sensor and build-in AI. This will enable a change in value proposition for entry to H2.

Everyday stress
DESIRED MOOD

Starting from 2025, the value proposition will change to 'Desired Mood'. A closed-loop-system will enable the device to boost mood in a wide variety of ways. The personalized and self-learning AI will be able to guide the user towards different mood states. This will speak to a wider audience and can already help people with 'silent' mental disorders. In the paragraph - Horizon 2, an examples is given of this working principle.

The profit made in within H2 will be used for organizing clinical trails. To prove the working principle and make the step towards the mental health therapy market.

First responders
THERAPY ASSIST

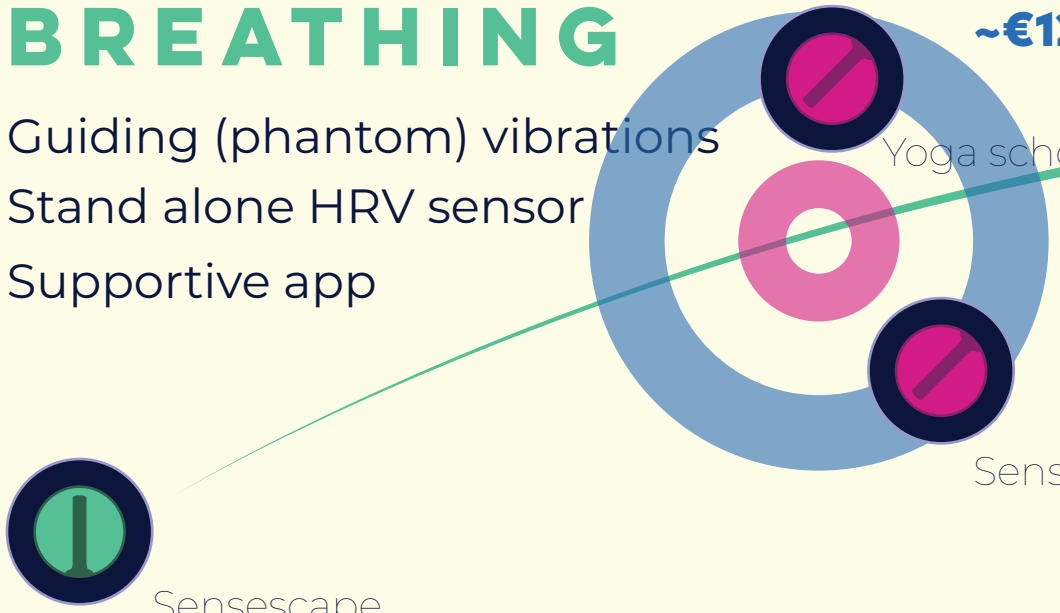
Once clinical trails are initiated, operations will be shifted towards Business-to-business sales. Besides the normal sales channels, the product will be sold to (Dutch) first responder organization as a 'product service system'. The system will collect user data to provide insight in the overall mental wellbeing of the organization.

In this horizon, the goal will be to:
'Increase employability, by providing insight in stress related health issues'.

STRATEGIC ROADMAP

2021
GUIDED BREATHING

Guiding (phantom) vibrations
Stand alone HRV sensor
Supportive app

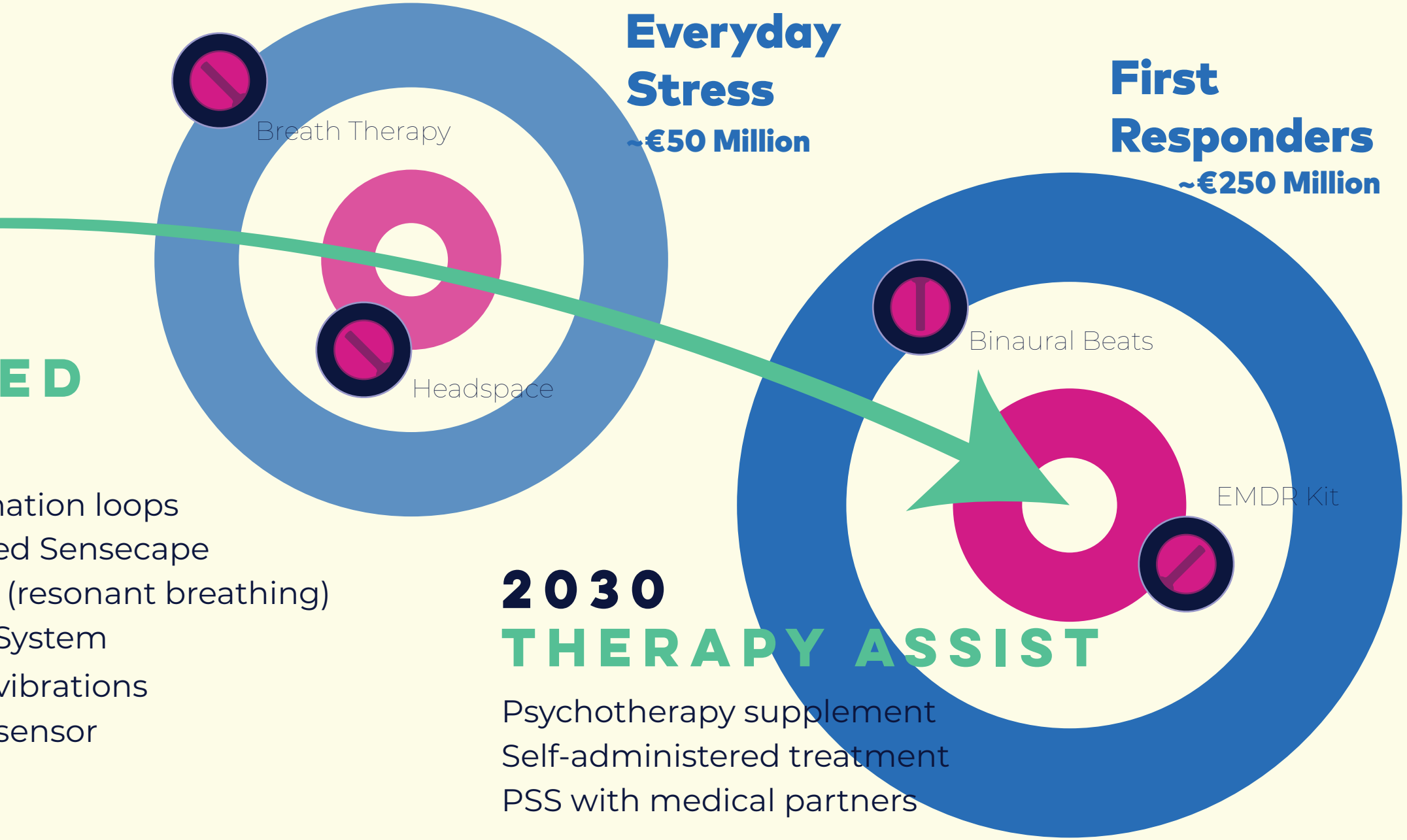


Mindful Market
~€12,5 Million

Muse

2025
DESIR MOOD

Dirsupt rumin
AI Orchestrate
Bio Feedback
Closed-Loop-S
Personalized v
Build-in HRV s



ED

nation loops
ed Sensecape
(resonant breathing)
System
vibrations
sensor

2030
THERAPY ASSIST

Psychotherapy supplement
Self-administered treatment
PSS with medical partners

Horizon 2
DESIRED MOOD

In Horizon 2;
Sensescape is a set of two handheld stabilization devices, which can direct you towards desired mood states. When one finds himself in a depressive state, panic attack or just low in energy.
Sensescape will provide distracting vibrations to disrupt your negative thought flow. After successful distraction, the build-in AI will orchestrate a vibrational 'sensescape', which will guide you towards a solution-focussed state of mind. Your brain will be drawn towards this focus-state by synchronising (neural entrainment) with the bouncing vibration between both pulsators.

RESONANT BREATHING

To help find your focus, the pulsators make use of Heart Rate Variability sensors to provide feedback to guide breathing. A balanced breathing rate will help you stay calm and focused during the practice. In this way, a closed-loop-system is established to continuously monitor and improve your focus. If used correctly, you will experience a form of resonance with the device, since it reflects back both your mental and body state.

AI ORCHESTRATED SENSESCAPES

The vibrational patterns used in the pulsators are created by an AI which generates these rhythms based on the input of the HRV sensor. The AI will listen to your body and adjust the tempo of the vibrations accordingly. If you experience high stress, this can be sensed through a low HRV; in this situation the AI will generate 'fast' alternating beats so you're able to synchronise with the beats before slowly winding down the tempo.

Sensors inside the product will feed the AI with information to establish the closed-loop-system. Some other examples of input can range from; 'intensity of vibrations' to 'firmness of grip' or even the 'measured distance' between the pulsators. For example; a firm grip would translate to a prolonged session and more intense vibrations.

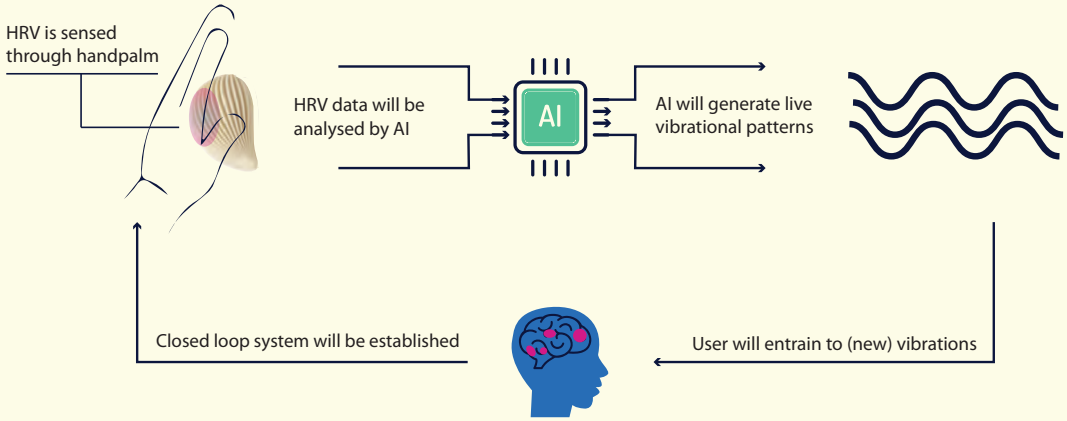
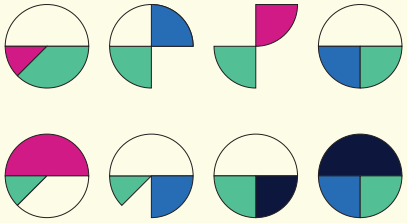


Figure 11.1: Overview of AI regulation process (Closed-Loop-System)

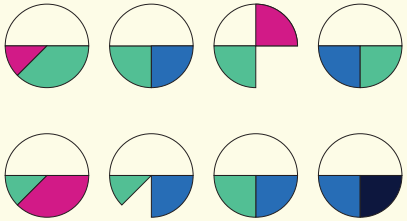
RUMINATION ‘SENSESCAPE’

The following example describes how a session to counteract rumination would look like. Once the user clicked ‘Stop overthinking’, the described three phases will start playing. They all have different goals.
The device will try to continuously try to find neural resonance with the user. Behind the scenes, it will make use of the neural entrainment principle to achieve this.



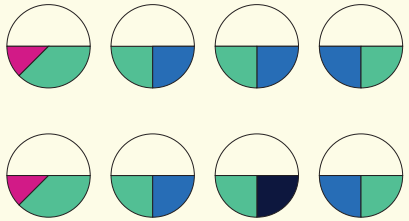
PHASE #1 - DISTRACTION

As described in the paragraph ‘How to cope’, the most effective way of coping with rumination is to distract yourself. This is the core purpose of the first phase and will help the user to be ‘present’ in the room instead of ‘locked-up’ in his head. The (small scale) experiments showed that complex rhythmic vibrational patterns are mostly perceived as distracting. Therefore the AI will be constrained in generating vibrations by the parameters of the Breakbeat genre.



PHASE #2 - TRANSITION

Although distraction is an effective counteract on stopping rumination on the moment itself, the product should also help the user in the long run. Therefore, the next phase will help the user transition towards solution focussed thinking, related to his/her ruminative themes. The vibrations will slowly be directed towards High Beta brain states, this is associated with problem solving and focus (see paragraph ‘brainwaves’). The AI will orchestrate a gradual transition to not lose the users neural entrainment. The Ambient genre is suitable to do so.



PHASE #3 - FOCUS

In the third phase, the product will help the user obtain a focussed state of mind. The bilateral stimulation will be mostly apparent during this phase, since the phantom sensations help focusing. Moreover, the character of the Techno genre is suitable for a strong perception of phantom sensations because of it’s bass-drive.

Horizon 3
THERAPY ASSIST

In the third horizon, year 2030, Sensescape is imagined to be suited to be used alongside or during psychotherapy.
In this horizon the target group will form: ‘first-responders’, prone to PTSD (Post Traumatic Stress Disorder).

First-responders

A first responder is a person with specialized training who is among the first to arrive and provide assistance at the scene of an emergency, such as an accident, natural disaster, or terrorism. First responders typically include law enforcement officers, Paramedics, EMT's and firefighters. (Wikipedia, 2020d).
PTSD rates are high across all these segments (AEF, 2011). PTSD forms a major player in daily (mental) wellbeing of thousands of the lives of our societal care-takers.

Self-administered sessions

In consultation with their therapist, daily self-administered sessions can be prescribed on top of regular treatment. Bilateral tactile stimulation is proven to be effective for reducing stress and anxiety (O’mally, 2018).

Currently, there are already some products on the market offering tactile bilateral stimulation in therapy context. An example is EMDR-kit which is used during EMDR therapy sessions. However, these products all lack ‘smart’ connected functionalities such as measuring bio-data through sensors or any user data insight. On top of that, they are not not meant for self-administered use and do not offer a closed-loop-system.



Figure 11.2: First-responders within the military (Andrés Guerrero)

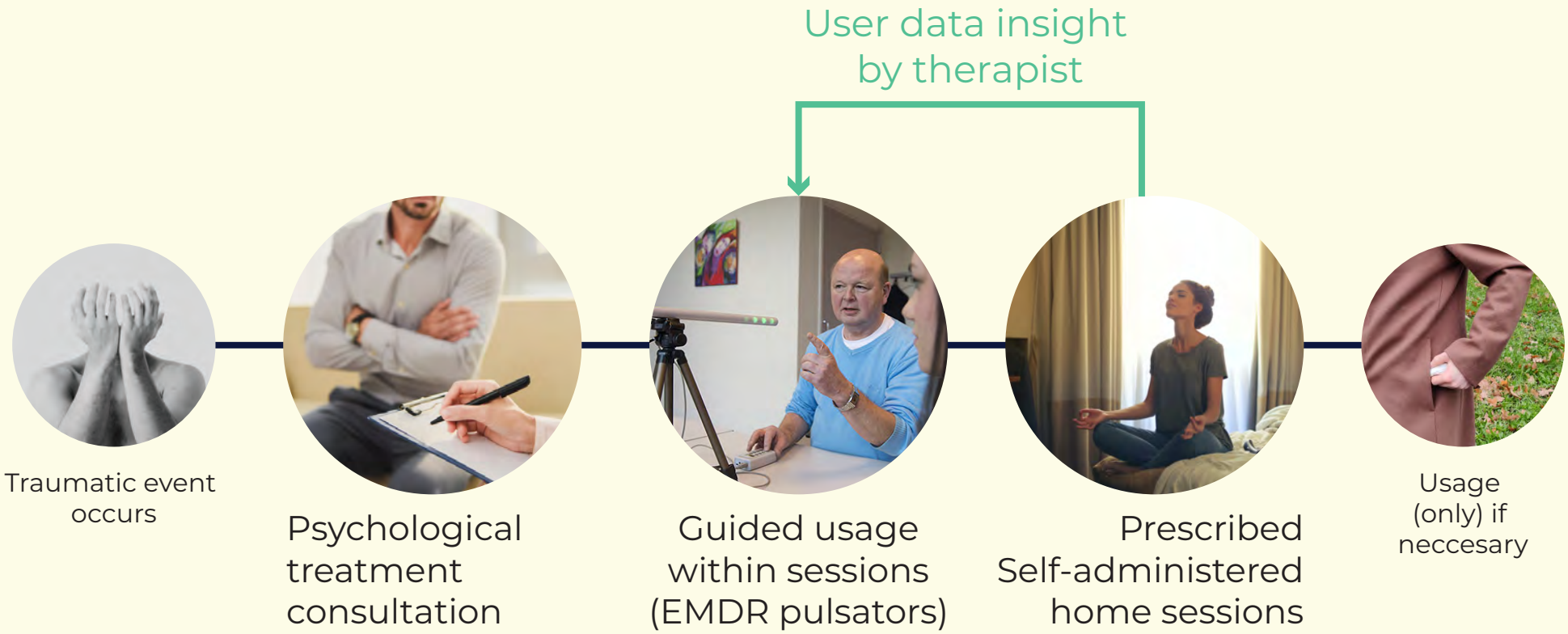


Figure 11.3: Process overview of product touchpoints in Horizon 3.

Form & Material

A quick overview of the process and reasoning for the chosen product form and material.

12



Figure 12.1: Author's free expression of design process to arrive at chosen product form.

Form

Derived from literature and small scale user testing, there are seven form factors which should be taken into account.

- Product form should stimulate exploration
- Product should have ergonomic and natural shape for holding in the hands
- Product should have a dedicated spot to place the thumb
- Product form should be portable
- Material should feel soft
- Material should be squeezable
- Colors should be easily customizable
- Vibrations should be able to travel well through material

Material

For the soft shell on the outside of the product the following material is chosen:
Silopren™ Matrix 70 LSR

The manufacturers' website describes the material properties as follows:
"Silopren™ Matrix 70 LSR by Momentive Performance Materials is a non-combustible, fiber-reinforced, two-component liquid silicone rubber. Exhibits excellent processing properties, excellent stability, flexibility at low temperatures, good rubber-like properties and high modulus" ..."It does not melt or drip and it is easily pigmentable with LSR color pastes. Designed for processing by injection molding. Silopren™ Matrix 70 LSR is recommended for membranes, pressure hoses, exhaust hangers, watchbands and belts." (Omnexus, 2018)





Figure 12.2: Silopren feels smooth and soft on the skin.

As can be seen in Figure 12.2, the material is often used for watchbands, this is suited for the product since it will have a soft feel and will feel familiar on the skin. It will also be a little flexible so the material can be squeezed. However, the flexibility won't let down on quality of the texture since advanced forms are possible as well (see embossment of watchbands also in Figure 12.2). Besides, the production process of injection molding will be straightforward and convenient during design phase. It will also come in handy for customizable color pallets.

The embossement possibilites of the material can be exploited to create 'shell-like' ribs on the product. These have a double function; the ribs can guide they lights inside the product to 'swell' in a natural way. Morover, the ribs will stimulate exploration while holding the product. This can help people to focus, using the same principle as a 'fidget spinner'.



Figure 12.3: Similar form & material come together well in the 'Iroha Tenga'.

Validation

Multiple small scale user tests have steered the design process of Sensescape.
The following chapter consists of an overview of two significant experiments with the designed prototype. Notebly, an observable effect of neural entrainment was found during an EEG recording of bilateral tactile stimulation. Secondly, the prototype appears to be helpful in increasing Heart Rate Variability.

13

Experiment 1

Recording (tactile) entrainment via EEG

Neural entrainment (aka brainwave synchronization) is the effect of synchronization between the electrical activity of the brain and a periodic external stimulus. This phenomenon, although it's relatively recent discovery, has been well documented in several experiments using EEG (Hasson, 2004; Timmermann, 1999; Frederick, 1999).

However, these experiments are all centered around the use of AVE (Audio and/or Visual Entrainment). Little studies focus on the occurrence of entrainment using solely tactile vibrations as stimuli.
Moverover, no study (in my knowledge) ever looked at the effect of tactile bilateral stimulation on neural entrainment in the brain. This form of bilateral stimulation seems promising because of its direct link to the bilateral eye movements used in EMDR (Eye Movement Desensitization Reprocessing) therapy.



Research Question:
What form of tactile vibrations leads to the strongest neural entrainment?

Hypothesis:
Bilateral tactile vibrations lead to the strongest neural entrainment.

Stimuli:
- Pure 8 Hz sine wave audio
- Pure 16 Hz sine wave audio
- Constant 8 Hz tactile vibration
- Constant 16 Hz tactile vibration
- Tactile Binaural Beat 8 Hz (138-146 Hz)
- Tactile Binaural Beat 16 Hz (138-154 Hz)

Conditions
- N = 1
- Participant had eyes closed
- 2 minute sessions
- The stimulus device is held in both hands; stimulating L/R hand alternatingly (during bilateral vibrations)

Equipment:
- Headphones (for audio stimuli)
- Two Lofelt L5 Actuators as actuators (build in prototype)
- 8 & 16 Hz Binaural Beat files, retrieved from Mynoise.net (Binaural Beat generator)
- Pure 8 & 16 Hz sine waves
- Neuroelectronics Instrument Controller software (NIC2)
- Enobio 8 wireless EEG recorder

Experiment setup:

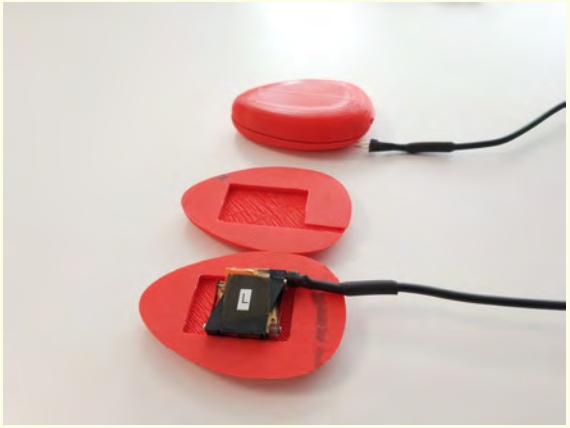


Figure 13.1 - View of the Lofelt L5 Actuator inside the two stimulus devices. They are held in both hands

The EEG electrodes were set up as can be seen in Figure 10.2. The points of measurement are based on a recent (2020), similar paper by Jiao et al. It is stated that these points are best for measurement of haptic sensation through the hands.

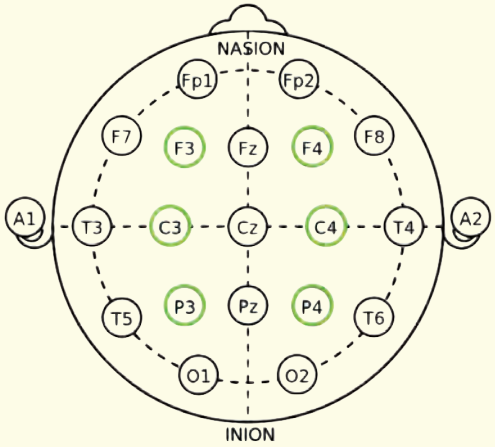


Figure 13.2 - Spatial map of EEG electrode wiring

Procedure:

- Setup EEG recording equipment
- Close eyes
- Baseline EEG recording // 30 seconds
- Hold device in both hands // apply stimulus
- Stimulus EEG recording // 2 minutes

Results:

While applying the 8 & 16 Hz bilateral stimulus; an observable effect was found during the live view of the EEG recordings. As can be seen in Figure 10.3 & 10.4, during the bilateral vibrations a strong consistent peak in brain activity could be observed, corresponding with the bilateral left and right stimulation in the hands via the actuators. This effect could not be observed during the regular constant 8 & 16 Hz stimulation. Both figures show the live recording of electrode C3.

It is striking that the measured brain activity is rather consistent and follows the exact same rhythm as the audio track used to stimulate the actuators. In general, it's rather difficult to get any significant visual response on the live EEG, which makes these results even more striking. Besides the consistent peaks at the 8Hz, vague activity at the harmonic frequency range of 2, 4, 8, 16, 24 could also be observed.

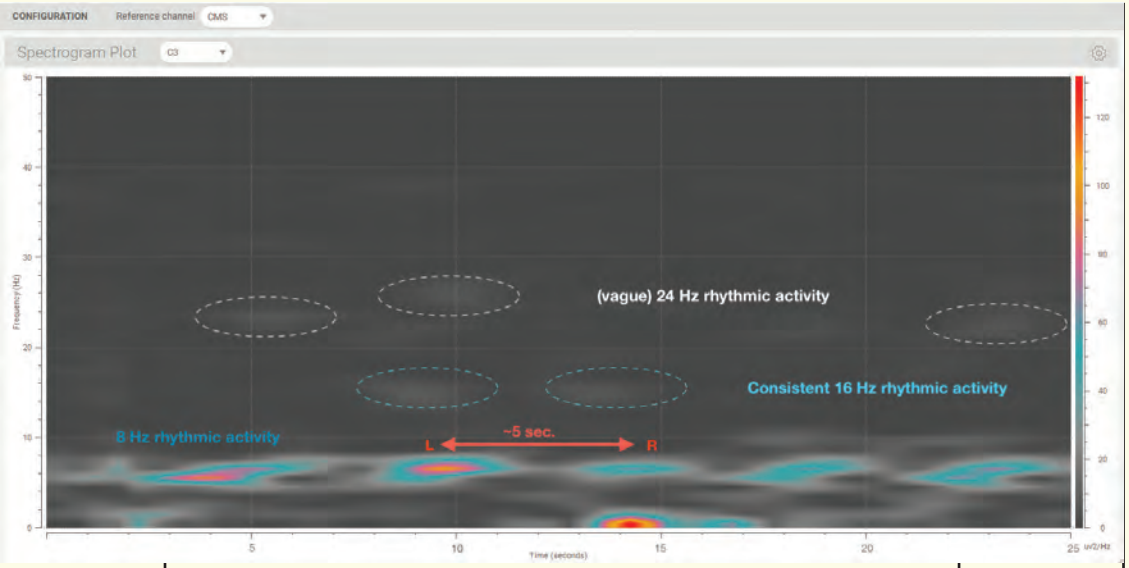


Figure 13.3 - 8 Hz bilateral tactile stimulation shows consistent corresponding brain activity.

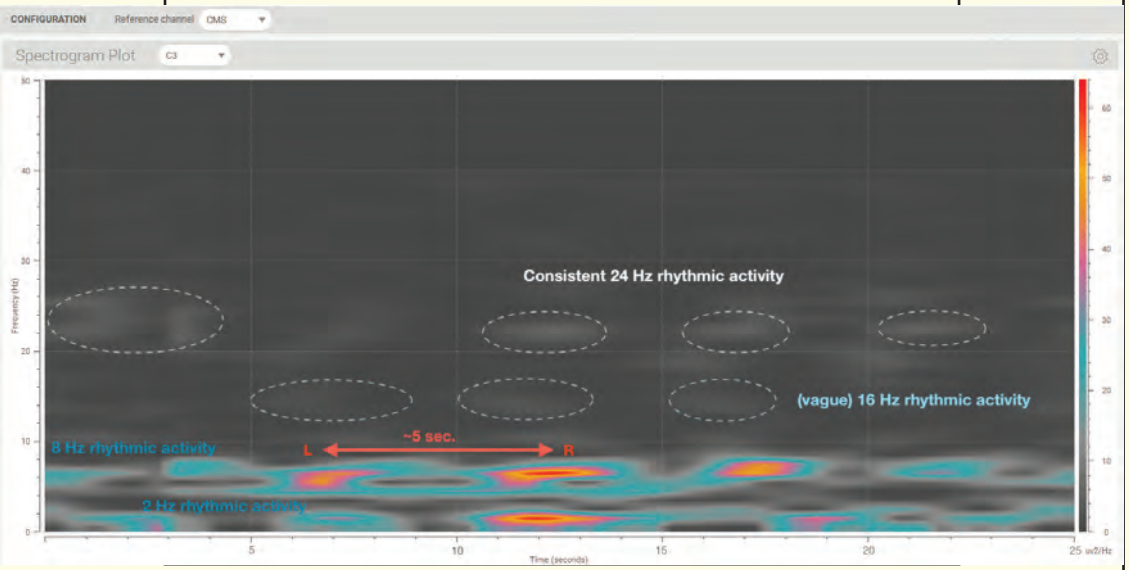


Figure 13.4 - 16 Hz bilateral tactile stimulation shows consistent corresponding brain activity.

Lastly, two PSD plots (Power Spectral Density) were made to gain overview about the development of the complete 2 minute session (Figure 10.3 & 10.4 only give a snapshot of 25 seconds). In both PSD plots, Figure 10.7 & 10.8, it is not directly apparent if there was any neural resonance at the frequency of the stimulus.

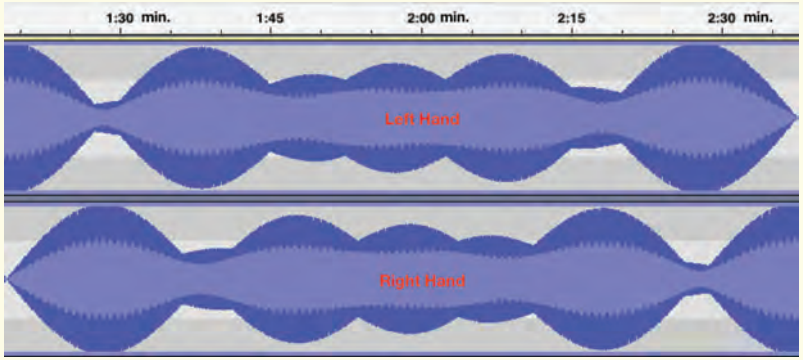


Figure 13.5 - The ten carrier tones contribute to complex beating patterns in both left and right hand.

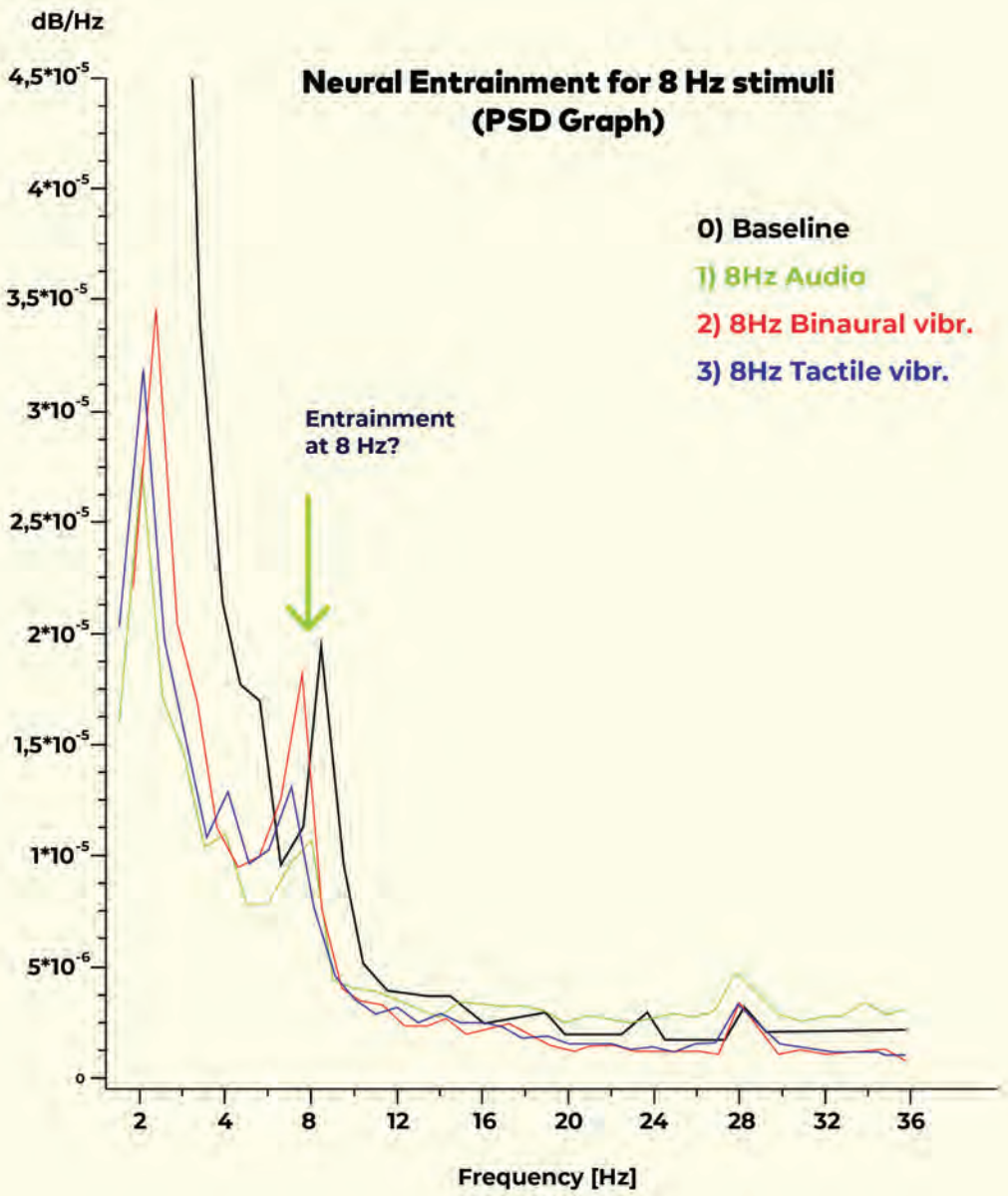


Figure 13.6 - PSD graph comparison between all 8 Hz stimuli.

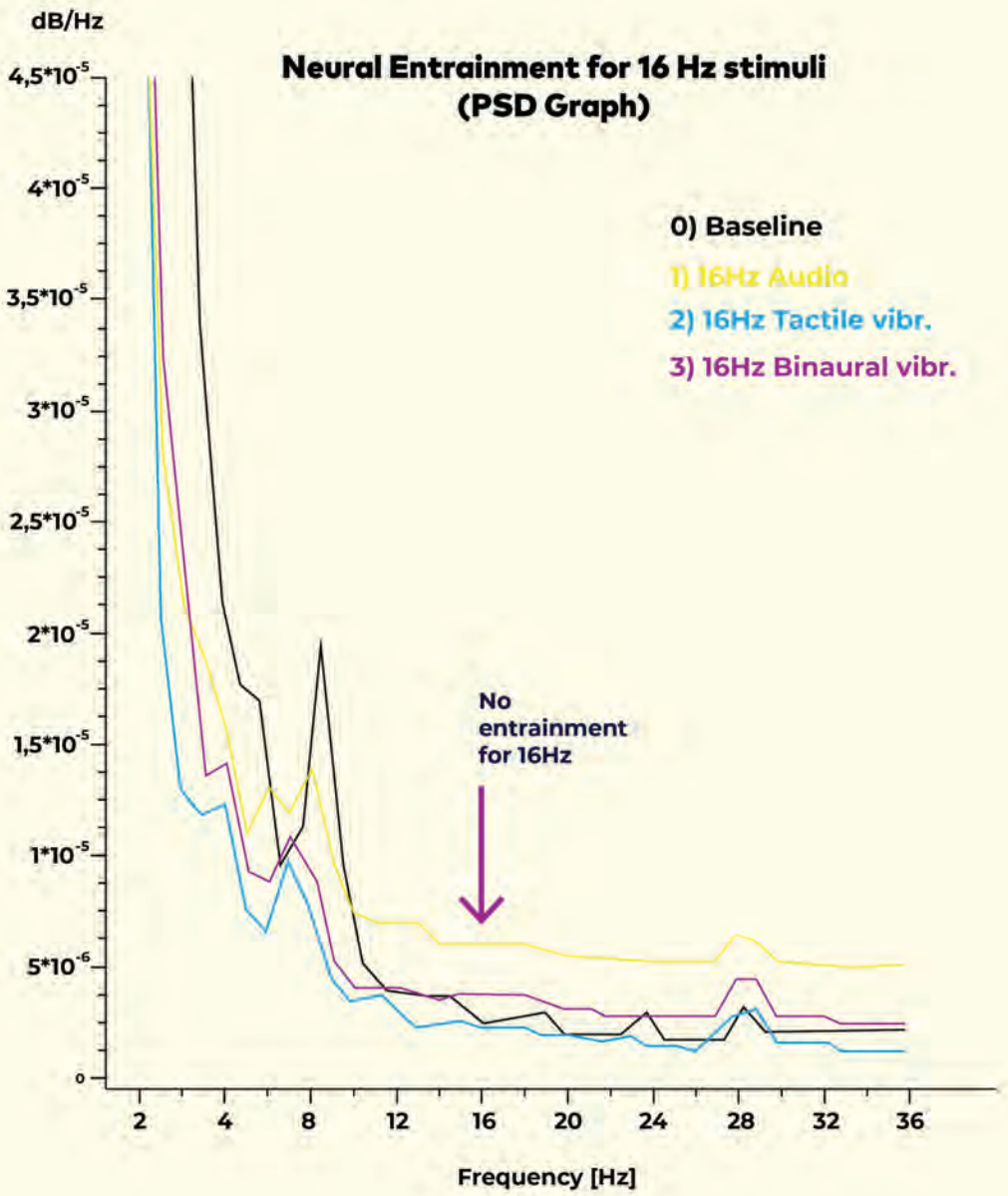


Figure 13.7 - PSD graph comparison between all 16 Hz stimuli.

Discussion:

It should be noted that this was a small scale experiment, with n = 1. Although the results are truly promising, they should be taken with a grain of salt. Furthermore, the following limitations should be considered. As a bilateral vibration; the audio file of a 8 & 16 Hz binaural beat was used. (see paragraph: Binaural Beats). This audio file generated via the 'Binaural Beat Machine' at Mynoise.net (Mynoise, 2020). Although this generator generates pure sine waves, it uses ten carrier waves to amplify the binaural effect. This results in complex beating patterns, which can be seen in Figure 10.5. It is argued that the complex pattern contributes to the entrainment effect since it was perceived as 'interesting' and 'emerging' by the participant. The beating pattern alternated between left and right hand roughly every five seconds (which corresponds with the EEG data).

The noise in the frequency analysis in Figure 13.8 shows that besides the strong peaks at 138 Hz and 146 Hz, the other carrier tones are also perceivable. The same goes for the frequency analysis of the 16 Hz overtone in Figure 13.9. Future research is needed to iterate with different participants and improve the data collection methods.

Conclusion:

Bilateral tactile vibrations have a stronger neural entrainment effect, compared to a regular/constant tactile vibration stimuli.

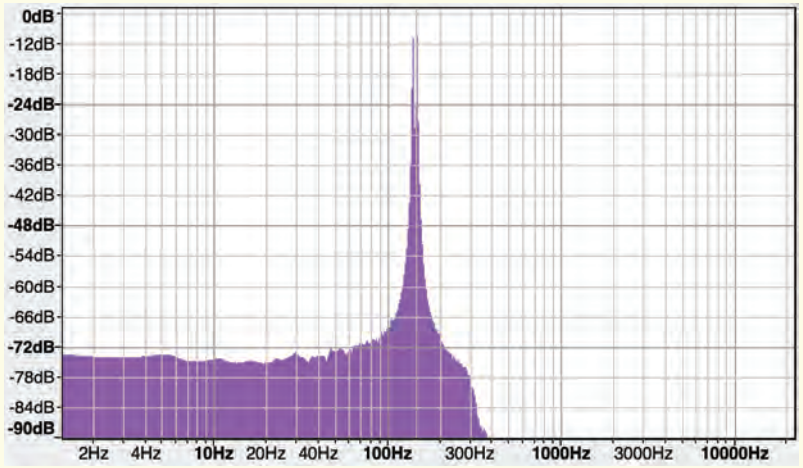


Figure 13.8 - Frequency analysis: peaks at 138 Hz & 146 Hz give the binaural overtone of 8 Hz.

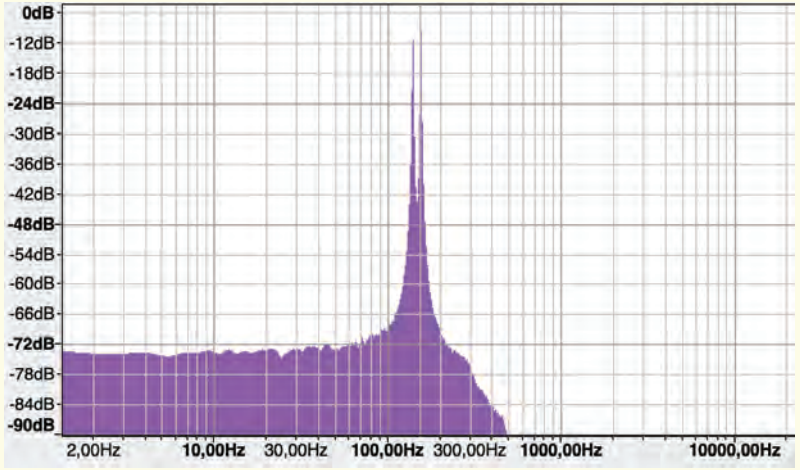
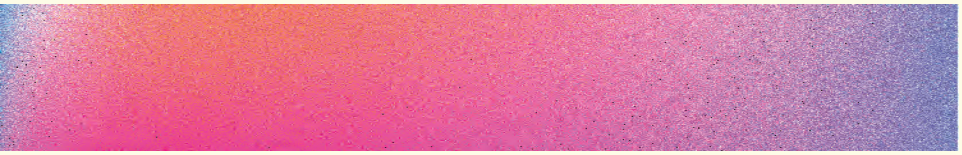


Figure 13.9 - Frequency analysis: peaks at 138 Hz & 155 Hz give the binaural overtone of 16 Hz

Experiment 2
Measuring HRV during product use

Heart Rate Variability (HRV) is defined as the beat-to-beat changes in the interbeat interval (time between two successive heart contractions) (EACPR, 2012). A higher HRV is generally considered an indicator of a healthy heart and improved psychological well-being and quality of life (Castaldo et al., 2015). Besides, HRV is often used during breathwork meditation, to check if a solid mind-body connection is established (Purwandini et al., 2012). For more information, see chapter 6.

For these reasons, HRV is chosen as an indicator if the Sensescape is doing it's job for the user; improved overall wellbeing and high quality mediation. Furthermore, a qualitative interview will be conducted to control the other parameters, such as 'improved focus during meditative session'.



Research question:
Does the usage of Sensescape increase HRV during breathwork meditation?

Hypothesis:
'Breathing along' with Sensescape will help increase HRV.

Stimulus:
- Sensescape pulsators: stimulating L/R hand alternatingly for respectively breathing in/out. A phantom sensation will be experienced during the shift from left to right hand.
- Vibrational pattern: a special audio file was created to function as input for the vibration motors.

Conditions:
- N=6
- Participants are listening to a special created breathwork meditation session with guiding voice prompts
- 10 minute breathwork meditation session
- The stimulus device is held in both hands

Equipment:
- Headphones (for audio guidance)
- Two Lofelt L5 Actuators as actuators (build in prototype)
- Kyto fitness Bluetooth HRV monitor (earclip)
- Coherence Heart Trainer app (for HRV data recording)

Experiment setup:



Figure 13.11:
One of the participants during the session. Holding the product in both hands. while listening to the voice prompts over the headphones.

Procedure:

- Brief explanation of what is going to happen
- Trial run together with participant; to check if the voice prompts are clearly understood (without headphones)
- Setup HRV monitor and camera
- Hold device in both hands // turn on audio guidance
- HRV recording // 10 minutes
- Qualitative interview

HRV Data results:

Besides the qualitative analysis, two different indicators for a successful session could be derived from the collected HRV data; 'average coherence score' and 'time spend in coherence'. The Coherence Heart Trainer app quantifies the HRV into a score ranging from 0-100. A 'good' score is an increased HRV quantified as everything above 60. One can speak of 'time spend in coherence' if a score above 40 is reached.

A surprising effect was found during analysis of the quantitative data. As can be seen in Figure 13.11 & 13.12, novice users performed better overall. They spend more time 'in coherence' and get overall higher 'coherence scores'.

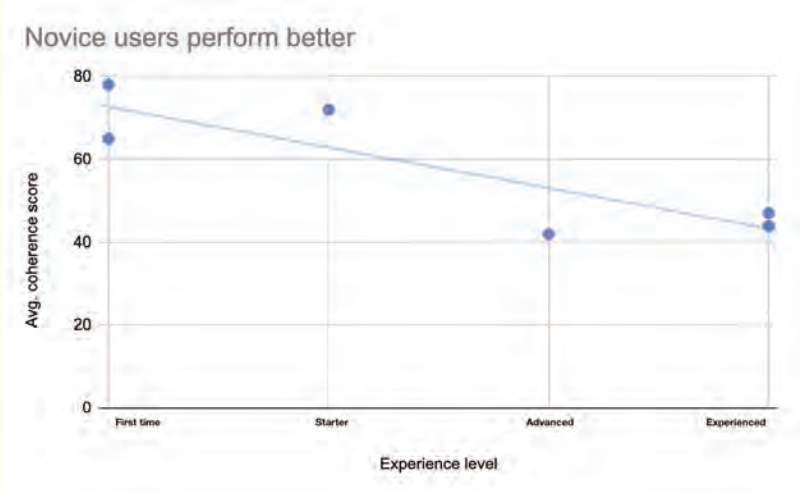


Figure 13.11: Data points for 'coherence score' during session.

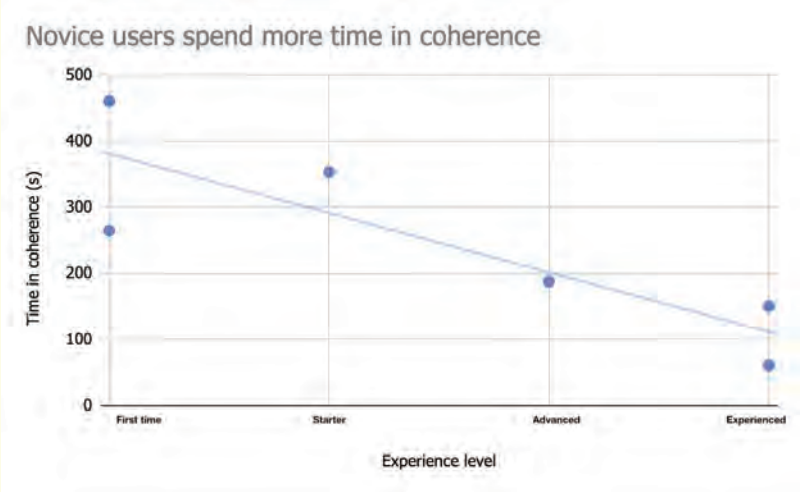


Figure 13.12: Data points for 'time spend in coherence' during session.

Qualitative interview results:
As can be seen in the video deliverable, most users are content with their experience. A brief overview of all the answers can be found in Appendix K. On a positive note, users explicitly noted to feel 'guided' by the vibrations since it was a 'physical sensation'. Besides, 6 out of 6 reported that the vibrations felt intuitive and were easy to 'breath along'. The main critique consisted of two points; for all participants it took time to 'get into' the intended breathing pattern. 4/6 reported that the vibrations felt 'too slow' in the beginning of the session. However, they were all able to 'catch up' later on, this can be seen in the coherence graphs in Appendix M & N. Secondly, the more advanced meditators reported an 'unnatural' breathing rhythm since it was 'different' from what their usual meditation sessions.

Discussion:
It should be noted that this was a small scale experiment, with n = 6. Although a trend could be seen in the graphs (Figure 13.11 & 13.12), they should (once again) be taken with a grain of salt. Furthermore, the following limitations should be considered. The participants were all filmed during the session, this is not beneficial for the meditation(see Hawthorne Effect). Additionally, the product is intended for users who are having trouble unwinding from work and are therefore in (high) stress while using the product. These circumstances were not recreated; all participants started the session with a relaxed state of mind. It's expected to get improved results with 'stressed' participants.

Regarding the critique; an actual closed-loop-system (as described in horizon 2) would prevent the user from 'catching up' with the rhythm. Furthermore, it can be concluded that the product is most suited for novice users to be introduced to the 'art of breathing'. More advanced meditators might have already developed their own breathing patterns, this leads to a 'forced' and 'uncomfortable' feeling while using Sensescape. This might be counteracted by incorporating multiple breathing patterns in the Sensecape Library (see horizon 2).

Conclusion:
Sensescape helps to increase HRV for novice meditators.



Postscript:
For N=1, the effectiveness of Sensescape has also been compared to a regular breathwork meditation session. For this experiment, all conditions remained the same except aside from the participant not using the pulsators.

This dataset is gathered with participant 6, who had the most prior experience with meditation (relative to the other participants). But also reported an uncomftable feeling since the breathing pattern used in the experiment was so different from his regular meditation. In this scenario, the participant should be feeling comfortable during the session and can attend to his usual breathing rhythm.
Nevertheless, the coherence score is significantly lower without the product (see Figures 13.13 & 13.14)

Two conclusions can be derived from this data. The natural breathing rhythm of the participant during meditation does not increase his HRV.

Future research with more participants is needed to study in more depth how the product can be useful for experienced meditators.

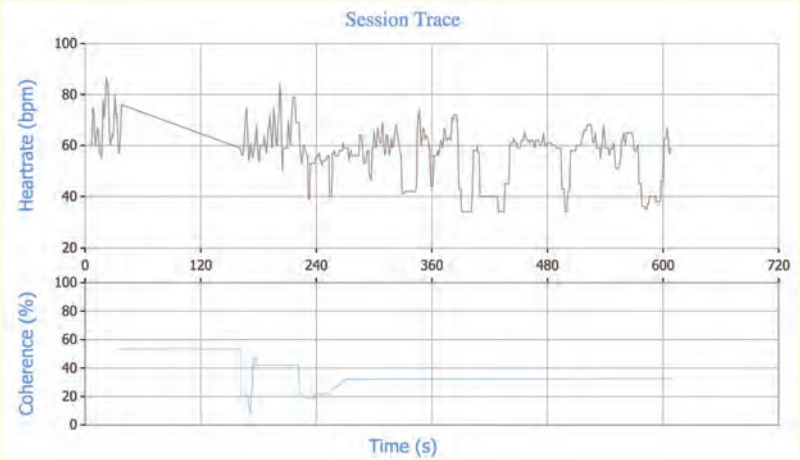


Figure 13.13: Coherence score during session without using Sensescape .

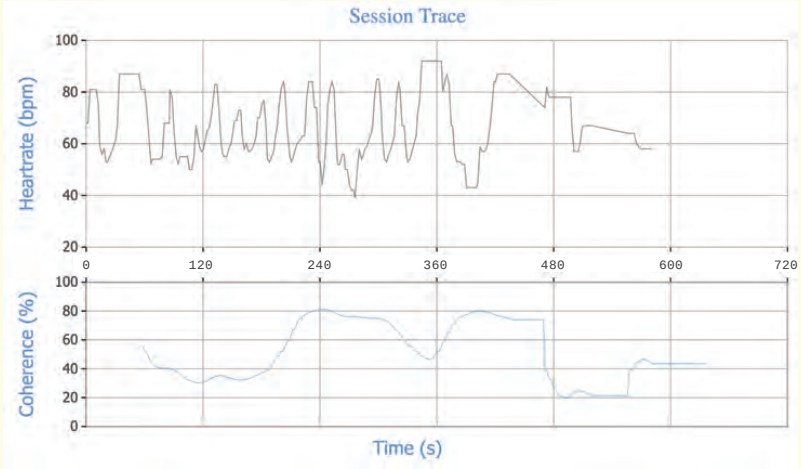


Figure 13.14: Coherence score during session with using Sensescape .

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“If I have seen further it is by standing on the shoulders of giants” - Newton, 1675.

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Appendices

Appendix A - I : Business model sheets
Appendix J: Ethical Implications
Appendix K: Product video deliverable
Appendix L - N: HRV recordings
Appendix O: Business Model Canvas
Appendix P: Favorite artwork of author

15

Appendix A

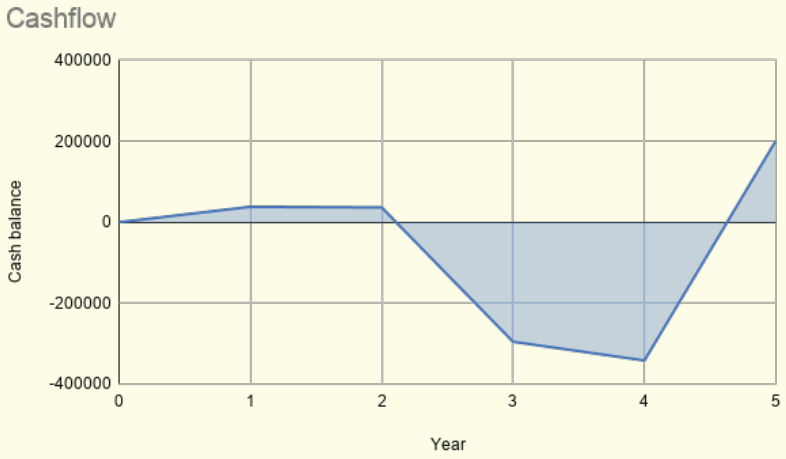


Figure A.1: 5 year cashflow projection

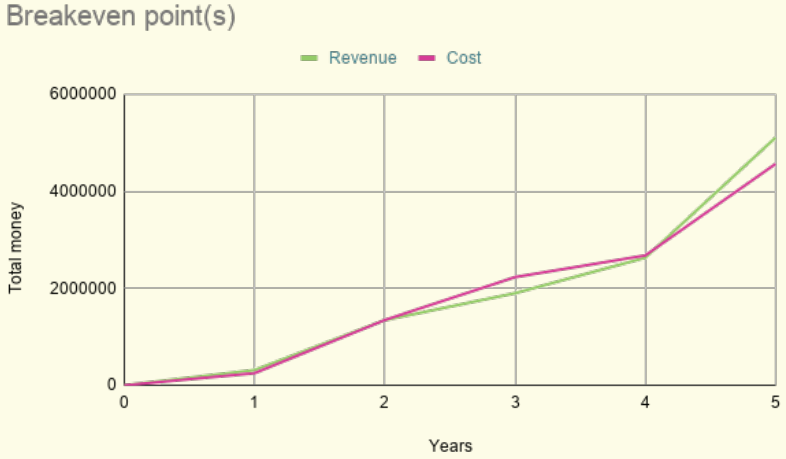


Figure A.2: Because of the AI & HRV development costs, break even will be after 4 years.

Appendix B

Five Year Plan. From H1 to H2 entry	
YEAR 1/ Kickstarter campaign (Innovators)	
Employees (founders)	3
Amount of sales	1250
Variable Costs	€ 171,13
Retail price	€250
Total profit first year	€37.938
Overal bank account balance	€37.938
YEAR 2/ Website sale (Early Adopters)	
Employees	7
Amount of sales	6750
Variable Costs	€ 150,50
Retail price	€199
Total profit first year	-€1.625
Overal bank account balance	€36.313
YEAR 3/ Subscription Model (Early Majority)	
Employees	8
Amount of sales	17000
Variable costs	€ 107,50
Retail price	€79
Subscription p/m	€ 5,99
Total subscription income	€ 555.084,00
Total profit first year	-€331.416
Overal bank account balance	-€295.104
YEAR 4/ Release V2 (including HRV sensor & AI driven) (Late Majority)	
Employees	9
Amount of sales	17000
Variable Costs	€ 140,00
Retail price	€109
Subscription p/m	€ 5,99
Total subscription income	€ 776.730,00
Total profit first year	-€46.270
Overal bank account balance	-€341.374
YEAR 5/ Subscription Model (H2 entry)	
Employees	10
Amount of sales	33000
Variable Costs	€ 129,00
Retail price	€109
Subscription p/m	€ 5,99
Total subscription income	€ 1.507.770,00
Total profit first year	€541.770
Overal bank account balance	€200.397

Appendix C

Total Addressable Market			**Sources:**	
Population USA	330.000.000		(Census, 2020)	
Percentage experiencing everyday stress	25%		(Statista, 2019)	
Percentage practice weekly meditation	40%		(Masci, 2018)	
TAM Size	33.000.000	±30 Million		
Rounded number	*30.000.000,00*			
Service Available Market				
Trouble unwinding from everyday stress	13%		(Statista, 2019)	
No coping method in place	25%		(estimate)	
SAM Size	1072500	±1 Million		
Rounded number	*1.000.000,00*			
Serviceable Obtainable Market				
Population NL	17000000		(CBS, 2020)	
SOM Size	51515	± 50 Thousand		
Rounded number	*50.000*			
If SOM reached within 5 years.	**Percentage of SOM**	**Sales**	(Technology Adoption Lifecyle)	
Year 1: Innovators	2,50%	1250		
Year 2: Early adopters	13,50%	6750		
Year 3: Early majority	34,00%	17000		
Year 4: Late Majority	34,00%	17000		
Year 5: Laggards	16,00%	8000		

Appendix D

Crowdfund campaign only

Money in		**Money out**		**Kickstarter campaign**		**Indiegogo campaign (goal = 150K)**	
Variable costs		*Fixed costs*		*Expected backers*	625	*Expected backe*	625
Retail price	€249	Office	€ 0,00	*Funded*	*€ 155.625,00*	*Funded*	*€ 155.625,00*
Amount of sales	1250	Salaries	€ 0,00	Total fund fee (5%)	€ 7.781,25	Total fund fee (5	€ 7.781,25
	Innovators	Injection Mold	€ 5.000,00	Payment processing fee (3%)	€ 4.687,50	Payment proces	€ 4.531,25
		Prototype costs	€ 1.000,00	20 cent per pledge bonus	€ 125,00	30 cent per pled	€ 187,50
		Software	€ 15.000,00				
		Overhead costs	€ 1.000,00				
		Variable Costs	€ 197,15				
		COGS	€ 171,00	**Total campaign costs**	€ 12.593,75	**Total campaign**	€ 12.500,00
		Packaging	€ 3,00				
		Shipping	€ 3,00				
		CAC	€ 20,15				
Total money in	€311.250	**Total money out**	€ 261.040,90				
Gross margin per proc	€52						
Total profit first year	**€50.209**						

Appendix E

YEAR 1/ Crowdfunding								
Money in		**Money out**		**Kickstarter campaign (goal = 150K)**			**Indiegogo campaign (goal = 150K)**	
Variable costs		*Fixed costs*		*Expected backers*	*625*		*Expected backers*	*625*
Retail price	€250	Office	€ 3.000,00	*Funded*	*€ 156.250,00*		*Funded*	*€ 156.250,00*
Amount of sales	1250	Salaries	€ 11.000,00	Total fund fee (5%)	€ 7.812,50		Total fund fee (5%)	€ 7.812,50
	(Innovators)	Injection Mold	€ 5.000,00	Payment processing fee (3%)	€ 4.687,50		Payment processing fee (2,9%)	€ 4.531,25
		Prototype costs	€ 1.000,00	20 cent per pledge bonus	€ 125,00		30 cent per pledge bonus	€ 187,50
		Software	€ 15.000,00					
		Overhead costs	€ 500,00					
		Variable Costs	€ 171,13	**Total campaign costs**	€ 12.625,00		**Total campaign costs**	€ 12.531,25
		COGS	€ 145,00					
		Packaging	€ 3,00					
		Shipping	€ 3,00	To reach the widest audience, the Kickstarter campaign will be continued on the Indiegogo website				
		CAC	€ 20,13					
Total money in	€312.500	**Total money out**	€ 274.562,50					
Gross margin per product	€79							
Total profit first year	€37.938	*please note that this includes investment in development costs for future company endeavors						
Overal bank account balance	**€37.938**							
Explanation								
Revenue: price determined for hardware on €250,- (in this product category, prices are around €350 (https://www.getsensate.com/)								
Amount of sales: SOM = 50.000. Kickstarter campaign will likely attract 2,5 of SOM. (innovators)								
Office: based on YESDelft pricing for 30 m^2								
Salaries: the founding team* will initially get a minimaal wage salary of €300 per person, per month, and 33% equity in the business. meaning salaries will be around 11.000								
Injection Mold: the outside soft shell needs to be injection molded in a factory in China, since it's a small and easy product, cost will range between 3-8 thousand euros								
Software: development costs are estimated at 15.000 (see appendix). This will also be used to maintain website/ make brochures.								
COGS (Cost of goods sold): 2 Lofelt motors** & BT receiver €120 + HRV sensor €15 + embodiment €5 + packaging €5 euro + assemble costs (including supplies to assemble) € 5.								
Shipping costs: €3 per device send to backer								
Packaging: €3 material cost for package								
CAC (Customer Acquisition Costs): See Kickstarter Campaign cost calculation.								
*The team will consist of 3 members at start. All sharing 33% equity. 1) Chief Research & Development. 2)Chief Business & Operations. 3) Chief Software & Technology.								
**this is price is based on a strategic partnership deal with them. Retail price Lofelt Basslet = 130 (includes 1 Lofelt motor & BT receiver)								

Appendix F

YEAR 2/ Website sale (start development HRV sensor & AI)					
Money in		**Money out**			
Variable costs		*Fixed costs*			
Retail price	€199	Office	€ 3.000,00		
Amount of sales	6750	Salaries	€ 26.000,00		
	Early Adopters	R&D	€ 200.000,00		
		Software	€ 100.000,00	*strategic partnership with Mubert will be tried to establish	
		Variable Costs	€ 150,50		
		COGS	€ 125,00	*Lofelt motors will be cheaper, becaus of big order	
		Packaging	€ 2,75		
		Shipping	€ 2,75		
		CAC	€ 20,00		
Total money in	€1.343.250	**Total money out**	€ 1.344.875,00		
Gross margin per product	€49				
Total profit 2nd year	-€1.625				
Overal bank account balance	**€36.313**				
Explanation					
Revenue: price determined for hardware on €199,- (in this product category, prices are around €350 (https://www.getsensate.com/)					
Amount of sales: SOM = 50.000. Kickstarter campaign will likely attract 13,5% of SOM. (early adopters)					
Office: based on YESDelft pricing for 30 m^2					
Salaries: In year 2, 4 additional interns* will be hired. Also earning a internship compensation of €300 per month. They will also be offered a few percent equity, diluting our current shares					
R&D: mostly determined as a budget for development of special HRV sensor which measures through handpalm					
Software: This budget will be used for website maintenance, and to make a (small) start in AI development					
COGS (Cost of goods sold): 2 Lofelt motors** & BT receiver €100 + HRV sensor €15 + embodiment €10 + packaging €5 euro + assemble costs (including supplies to assemble) € 5					
Shipping costs: €2,5 per device send to backer (small price drop, since buy-in can be done in bulk)					
Packaging: €2,5 material cost for package (small price drop, since buy-in can be done in bulk)					
CAC (Customer Acquisition Costs): Targeted Facebook marketing and direct selling channels within mindfulnes branche (yoga studios)					
*2 electrician / product design interns who will work full time on development of HRV sensor. 2 AI junior programmers					
**this is price is based on a strategic partnership deal with them. Retail price Lofelt Basslet = 130 (includes 1 Lofelt motor & BT receiver)					

Appendix G

YEAR 3/ Subscription model

Money in		**Money out**	
Variable costs		*Fixed costs*	
Retail price	€79	Office	€ 6.000,00
Amount of sales	17000	Salaries	€ 46.000,00
		R&D	€ 200.000,00
Paying subscribers	6800	Software	€ 150.000,00
price/month	5,99	*Variable Costs*	€ 107,50
Income subscription/month	488784	COGS	€ 85,00
Yearly subscription	1700	Packaging	€ 2,50
Price/Year	39	Shipping	€ 2,50
Income yearly subscription	66300	CAC	€ 17,50
Total money in	€1.898.084	**Total money ou**	€ 2.229.500,00

Gross margin per product	-€29	*Break even point after 4 months subscription
Total profit 3rd year	-€331.416	
Overal bank account balanc	**-€295.104**	

Explanation

Retail: price determined for hardware on €79,- (in this product category, prices are around €350 (https://www.getsensate.com/)
Amount of sales: This figure includes the early majority (34%) within the SOM market segment
Subscription: Most users will likely use the product once per week, which means 1,5 euro per session. It is estimated that 1/2 of the users will choose for a subscription. This will increase when updating product offering.
Office: based on YESDelft pricing for 60 m^2 (bigger office was needed for the new employees)
Salaries: A professional sound designer will be hired to keep updating the sensescape library, plus a raise in salary for all employees
R&D: mostly determined as a budget for development of special HRV sensor which measures through handpalm
Software: Further development together with Mubert to create the AI
COGS (Cost of goods sold): 2 Lofelt motors** & BT receiver €60 + HRV sensor €15 + embodiment €10 + packaging €5 euro + assemble costs (including supplies to assemble) € 5
Shipping costs: €3 per device send to backer
Packaging: €3 material cost for package
CAC (Customer Acquisition Costs): See Kickstarter Campaign cost calculation.

**this is price is based on a strategic partnership deal with them. Retail price Lofelt Basslet = 130 (includes 1 Lofelt motor & BT receiver)

Appendix H

YEAR 4/ Subscription model (Release V2, HRV sensor included)

Money in		**Money out**	
Variable costs		*Fixed costs*	
Retail price	€109	Office	€ 6.000,00
Amount of sales	17000	Salaries	€ 90.000,00
		R&D	€ 100.000,00
Paying subscribers	8500	Software	€ 100.000,00
price/month	5,99	*Variable Costs*	€ 140,00
Income subscription/mo	610980	COGS	€ 120,00
Yearly subscription	4250	Packaging	€ 2,50
Price/Year	39	Shipping	€ 2,50
Income yearly subscript	165750	CAC	€ 15,00
Total money in	€2.629.730	**Total money out**	€ 2.676.000,00

Gross margin per produ	-€31	*Break even point after 4 months subscription
Total profit 4th year	-€46.270	
Overal bank account ba	**-€341.374**	

Explanation

Revenue: price determined for hardware on €109,- price increase due to V2 release
Amount of sales: This figure includes the late majority (34%) within the SOM market segment
Subscription: The subscription model should give access to more vibrational modes. Most users will likely use the product once per week, which means 1,5 euro per session. It is estimated that 3/4 of the users will choose for a subscription.
Office: based on YESDelft pricing for 60 m^2
Salaries: A professional product designer will be hired to finalise the V2 release, plus a raise in salary for all employees
R&D: HRV sensor development should be finished this year
Software: First official version of AI will go online. AI will start learning through user data of sensors
COGS (Cost of goods sold): 2 Lofelt motors* & BT receiver €60 + in-house developed HRV sensor* €40 + embodiment €10 + packaging €5 euro + assemble costs (including supplies to assemble) € 5
Shipping costs: €3 per device send to backer
Packaging: €3 material cost for package
CAC (Customer Acquisition Costs): See Kickstarter Campaign cost calculation.

*The HRV sensor will be (too) expensive at start, but will be neccesary to start data collection, to improve AI

Appendix I

YEAR 5/ entry of H2			
Money in		**Money out**	
Variable costs		*Fixed costs*	
Retail price	€109	Office	€ 6.000,00
Amount of sales	33000	Salaries	€ 100.000,00
		R&D	€ 100.000,00
Paying subscribe	16500	Software	€ 100.000,00
price/month	5,99	*Variable Costs*	€ 129,00
Income subscrip	1186020	COGS	€ 105,00
Yearly subscripti	8250	Packaging	€ 2,00
Price/Year	39	Shipping	€ 2,00
Income yearly su	321750	CAC	€ 20,00
Total money in	€5.104.770	**Total money ou**	€ 4.563.000,00
Gross margin pe	-€20	*Break even point after 4 months subscription	
Total profit 5th ye	€541.770		
Overal bank acc	**€200.397**		

Explanation

Revenue: price determined for hardware on €109,- price increase due to differnt market segment and V2 release

Amount of sales: This figure is based on the innovators (2,5%) within H2 segment + laggards (16%) of SOM

Subscription: The subscription model should give access to more vibrational modes. Most users will likely use the product once per week, which means 1 euro per session. It is estimated that half of the users will choose for a subscription.

Office: based on YESDelft pricing for 60 m^2

Salaries: Customer Care intern will be hired

R&D: HRV sensor development should be finished this year

Software: budget for AI maintenance, AI becoming smarter everyday

COGS (Cost of goods sold): 2 Lofelt motors & BT receiver €60 + in-house developed HRV sensor €25 + embodiment €10 + packaging €5 euro + assemble costs (including supplies to assemble) € 5

Shipping costs: €2 per device send to backer

Packaging: €2 material cost for package

CAC (Customer Acquisition Costs): price increase in comparison to Year 4, because worldwide marketing needed (translation, setup of new marketing channel)

Ethical implications

“IT’S LIKE A FITBIT IN YOUR BRAIN - ELON MUSK (NEURALINK, 2020)

Neuralink Corporation is an American neurotechnology company founded by Elon Musk and others, developing implantable brain–machine interfaces (BMIs). After their recent presentation (Aug. 2020) in which Elon Musk presented the new ‘fitbit for the brain’; they have been valued at an estimation of $509 Million (Forbes, 2020). Their newest “Link” will be implanted directly in the brain tissue via autonomous robotic surgery
(see Figure K.1 & K.2).

Another example is Lumosity who got charged with a $2 Million claim for deceptive advertising. They made the unfounded claim that users who do Lumosity brain-training, “perform better at work and in school, and reduce or delay cognitive impairment associated with age and other serious health conditions.” (Federal Trade Commission, 2016).

Companies such as Neuralink and Lumosity play into an apparent market-pull, called the ‘brain-hacking’ trend (or neuro-hacking). This market-pull is a logical outcome of people failing the societal push for prestige.

Although the trend has many derivatives and therefore has many product forms, it’s all stooled on the principle: self-improvement by stimulating the brain.
Sensescape moves in a field of tension since it leverages neural entrainment, and promises mood changes. On top of that, the breathing exercises can have a profound impact on one’s mental health. Admitting the fact that the proposed project is far from crossing ethical boundaries (right now) it’s wise to consider some ethical applications upfront.

To do so, four promises are made:

1) Sensescape will avert misleading marketing claims

2) Sensecape will not promote with unfair advantages

3) Sensescape will always stay transparent about (possible) risks

4) Sensescape will strive for medical trial approval, as soon as viable.

Appendix J

NEURALINK

Figure K.1 - Elon Musk holding the Neuralink (during live presentation)



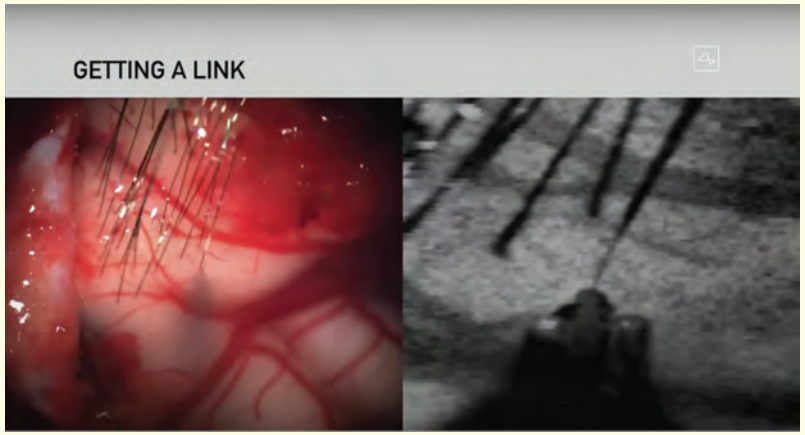


Figure K.2 - With its ultra thin electrodes, the Neuralink will be implanted via autonomous robotic surgery into the brain tissue

Appendix K



Meditation experience 18	WOW-Factor 11	Right rhythm 14	Intuitive vibrations 8	Get out of my head 7	Focus point 14	Weekly routine 12	Other 13
Tristan 15							
First time	Very calming!	Yes	Yes	Yes	Yes	Yes	It relaxed my arm muscles
Time in coherence: 461 sec.		Nice and slow			Purpose for hands	I want to start now!	Normally I felt awkward...
Average coherence score: 78							...placing my hands
Laura 15							
First time	Neutral feeling	No	Yes	Yes	Yes	No	My normal breathing
Time in coherence: 265 sec.		Too slow			Physical sensation :)	No clear benefit	...seems too fast now
Average coherence score: 65		Felt uncomfortable					
Caiseal 16							
Starter	Very calming!	Yes	Yes	Yes	Yes	Unsure	It went better than usual!
Time in coherence: 354 sec.	Very postive	Felt natural	Transition could be clearer	Less bored than usual	Physical sensation :)	Creating habits is hard	
Average coherence score: 72							
Hidde 14							
Advanced	Not calmer than usual	No	Yes	Yes	Yes	Yes	Meditation is different...
Time in coherence: 188 sec.		Different and faster than			Less wandering	During travel	...for everybody
Average coherence score: 42							
Ishit 18							
Experienced	Medium	No	Yes	Yes	Yes	No	I don't like forced breathing...
Time in coherence: 151 sec.	Usual meditation...	Too long breath hold			Did not need it	Only used if stressed	...during meditation
Average coherence score: 44	...is more pleasant				Distraction from...		
					...observing breath		
OB 19							
Experienced	Medium	No	Yes	Yes	Yes	No	I usually breath at...
Time in coherence: 61 sec.	I usually meditate...	To long breath hold,	Transition could be clearer		Don't need it	Only used if stressed	...my own pace...
Average coherence score: 47	...in a different form	Too slow					...during meditation

Appendix L

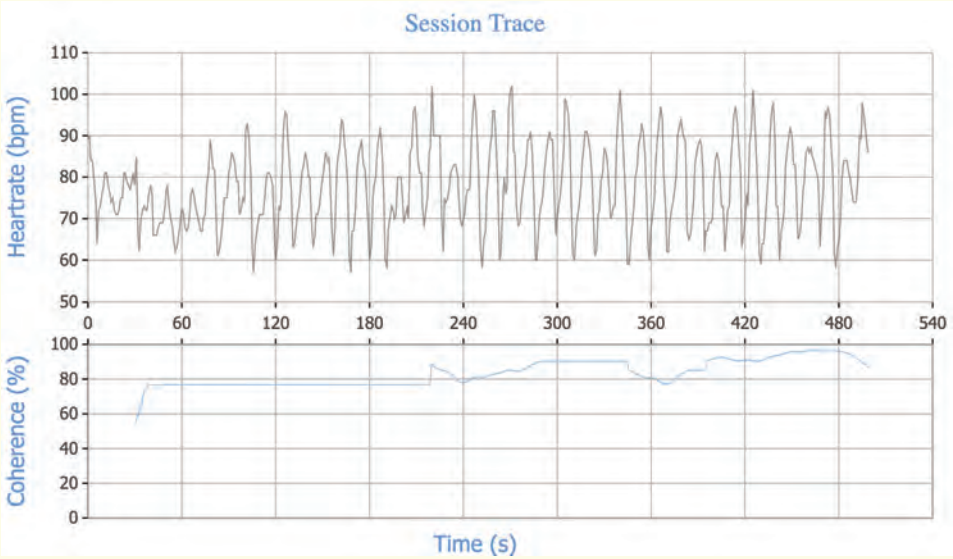
Figure L.1 - Screenshot of video deliverable:



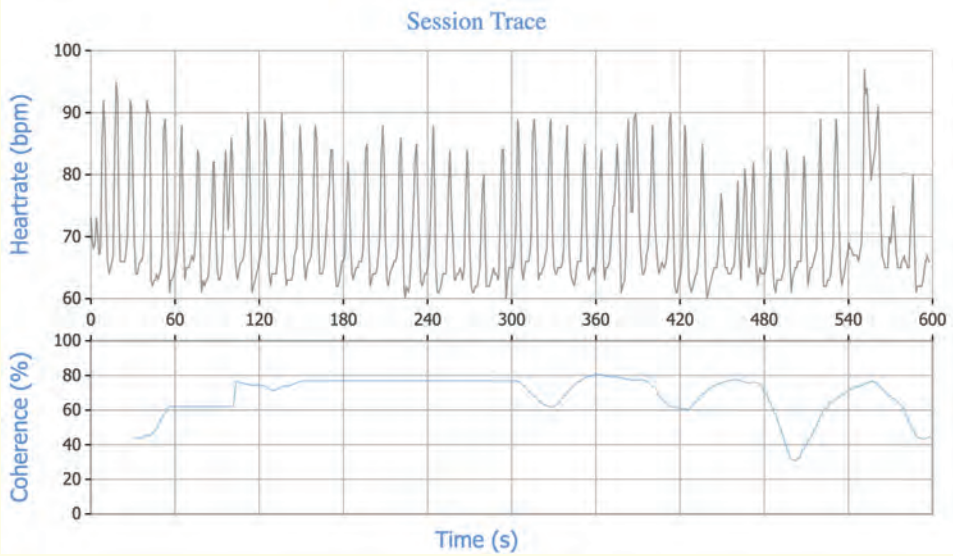
https://youtu.be/VfWNLbKRofI

Appendix M
HRV recordings (P1,2,3)

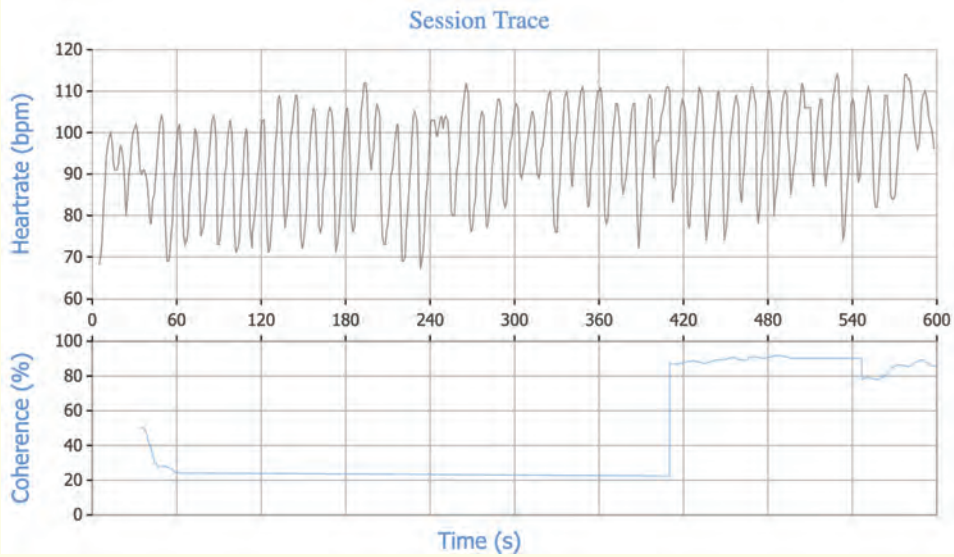
Particpant 1



Particpant 2

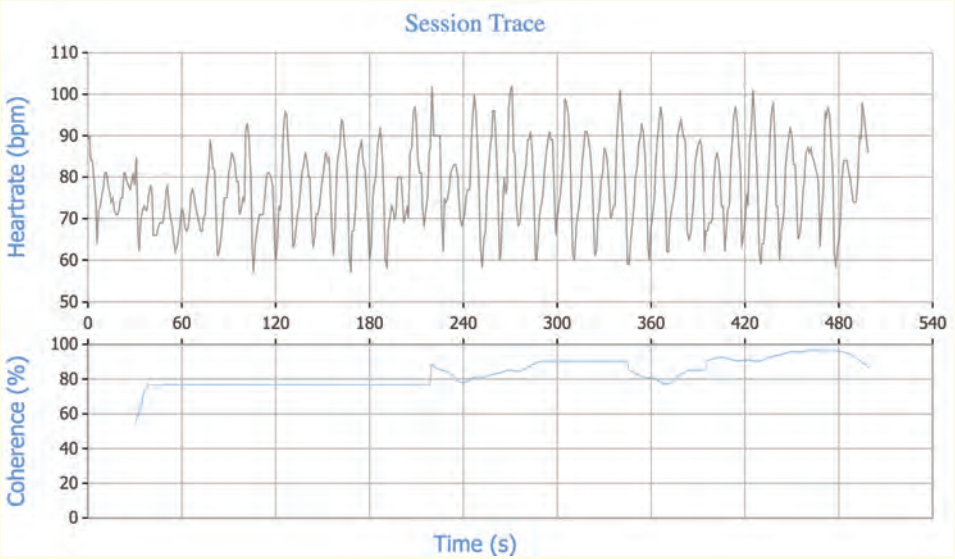


Particpant 3

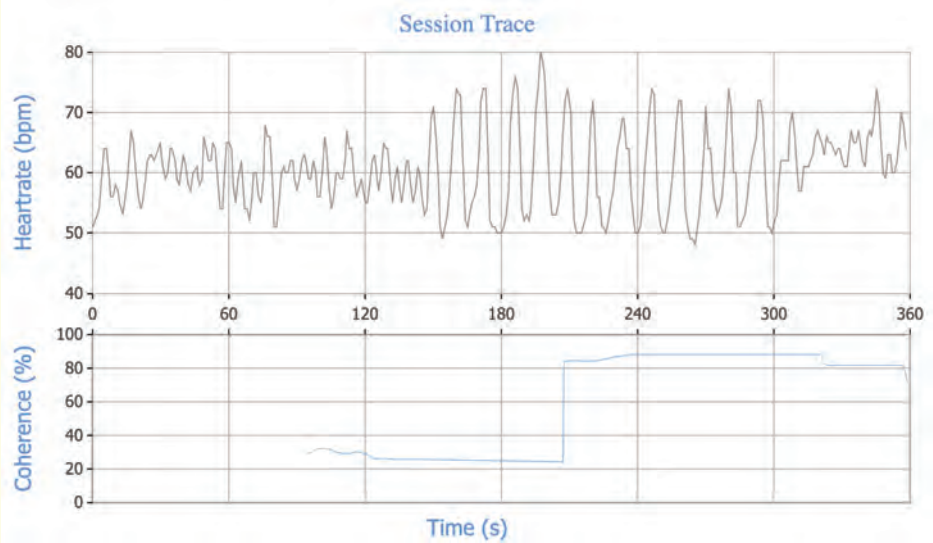


Appendix N
HRV recordings (P4,5,6)

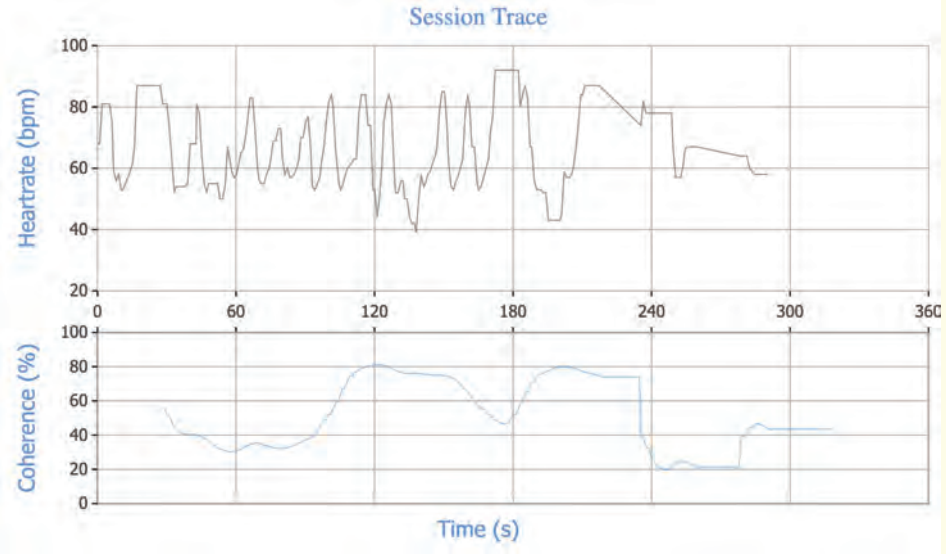
Particpant 4



Particpant 5



Particpant 6



BMI • Business model canvas

Appendix O

Key partners

Who are your most important partners?
Which key resources do you acquire from partners?
Which key activities do your partners perform?

LOFELT

- Supplier of Lofelt L5 actuators. Possibly co-creation partner for next generation products

Mubert®

- co-creation partner for creation of sensescape library. Use of API offering for AI development

In-house

- Product design & development
- Business strategy
- Marketing & graphic design
- Customer relations
- Financial operations
- Software dev. (co-creation with partners)

Key activities

What are the activities you perform every day to create & deliver your value proposition?

- Organization of marketing channels to increase sales
- Supplier management
- Sales channel expension (yoga/breathing studios)
- Crafting new Sensescapes to update library
- In-house dev. of HRV sensor
- In-house dev. of AI
- Improve on product design & UX for new product entry in H2
- General business operations (finance, customer complaints, bug fixes, etc.)

Key resources

What are the resources you need to create & deliver your value proposition?

MOMENTIVE performance materials

- Silicone softshell material supplier.
- Injection mold (€5000,-)

- outsource mvp app dev. (€15000,-)

- Prototyping costs (€1000,-) for product dev. in H1

Value propositions

What is the value you delivery to your customer?
Which of your customer's problems are you helping to solve?
What is the customer need that your value proposition addresses?
What is your promise to your customers?
What are the products and services you create for your customers?

Horizon 1 Guided breathing

Pain: Trouble unwinding from everyday stress
- Difficult to hold focus during meditative sessions
- Breathing excersizes not internalized

Benefit: Point of focus during meditative sessions
- Product available when needed
- Vibrational stimuli to breaht along
- Helps to 'get out of your head'

Product: a handheld meditation device to guide breathing, through haptic and light feedback.

Horizon 2 Desired Mood

Pain: Same as H1

Benefit: Directed towards desired mood state
- Closed Loop system
- AI orchestrated sensescapes
- Same as H1

Product: Similar to H1
- including build-in HRV sensor
- including build-in AI to orchestrate session

Horizon 3 Therapy Assist

Job to be done Customer:
Increase employability by providing insight in stress related health issues.

Job to be done User:
Decrease level of distress after an incident

Customer relationships

What relationship does each customer segment expect you to establish and maintain?

Horizon 1
- Knowledge sharing in community through website / Newsletter / Instagram

Horizon 2
- Monthly update of value offering (through sensescape library extension)

Horizon 3
- Longtime B2B relationship
- Product adaptation to business & customer needs
- Data insight system

Channels

How does your value proposition reach your customer? Where can your customer buy or use your products or services?

Horizon 1 & 2

Website sales through:
- Kickstarter
- Facebook / Instagram targeted marketing
- Yoga / meditation schools

Horizon 3
- B2B: customer specific product
- Product is part of standard equipment for first-responders

Customer segments

For whom are you creating value?
What are the customer segments that either pay, receive or decide on your value proposition?

Horizon 1
Consciously Mindful Workaholics

Estimated market of ±12.5 Million

SOM (NL) in Horizon 1 is expected to be around ±50K

Horizon 2
People with low stress resilience

1/13 Americans is experiencing trouble unwinding from everyday stress (Statista, 2019)

SOM in Horizon 2 is expected to be around ±1 Million

Horizon 3 (B2B)
First-responders

Customer:
First-responder organizations (Police, Army, Ambulance)

NL Police yearly cost burden = 221 - 543 Million (AEF, 2011)

User:
First-responders who experienced a traumatizing event.

120K first responders in NL (20-30 % reduced mentally resillient) (AEF, 2011)

Cost structure

What are the important costs you make to create & delivery your value proposition?

COGS H1 = €171,- (see business model)

In order to enter H2:

Yearly investment of ±€100.000,- in software (for AI development)
Yearly investment of ±€200.000,- in R&D (for HRV sensor development)

Scaling up workforce leads to increasing salary costs (see business model)

Revenue streams

How do customers reward you for the value you provide to them?
What are the different revenue models?

H1: regular sales through kickstarter / website / Yoga studios. Retail price = €249,-

H2: subscripton model (5,99 per month) + regular sales. Retail price = €109,-

H3: Upfront payment for harware (€300,- per device)
Insight in data package per first-responder is estimated at €25,- per year per user



Figure P.1: Favorite artwork of author (Jackson Pollock, 1950)

[The End]

Thank you for reading!