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Gallery of Heartbeats: soma design for increasing bodily awareness and social sharing of the heart rate through sensory stimuli

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Abstract

Elevated heart rate is considered to be an indicator of stress. Thus, noticing one's own heartbeat can have a negative connotation. Yet, the heartbeat is simply a physiological function, neither positive nor negative in itself, that is experienced in diverse contexts, such as medical, athletic, or intimate. This study uses first-person research through design and soma design to increase awareness of the heartbeat from both an individual and social angle and examines the potential benefits of using external sensory stimuli to convey biofeedback information. It also opens up the design space around the heartbeat and sensory stimuli and reflects upon comfort and relaxation, biofeedback and digital mindfulness, the Sensiks sensory reality pod as a tool and space, and the heartbeat as a spectrum and a way of getting to know people. The study results in four deliverables: a design critique of the Sensiks sensory reality pod, a design fiction publication, a design proposal, and an experience prototype.

The study proposes the design for the Gallery of Heartbeats – a sensory experience aimed at externalising and sharing the heartbeat of self and others. The Gallery of Heartbeats supports individual reflections, providing the user with real-time numerical, graphical, and auditory biofeedback on their heart rate. It also encourages social communication of this commonly unnoticed physiological feature, allowing users to record and store their heartbeat to an archive and experience the pre-recorded heartbeats of others in a multisensory way.

The evaluation of the Gallery of Heartbeats prototype shows that the design succeeds in making people more aware of their cardiovascular activity, triggers their curiosity, and increases empathy. However, the Gallery of Heartbeats also makes the users want to control or change their heart rate which goes against the mindfulness principles of presence-in and presence-with the design was inspired by. Sensory stimuli, especially sound and visuals, are assessed as beneficial for creating feelings of immersion, whereas different representations of the biofeedback information have different effects and use cases.

Keywords

Biofeedback, digital mindfulness, mixed reality, multisensory experience, soma design

Sammanfattning

En förhöjd hjärtfrekvens anses vara en indikator på stress. Därför kan en hög puls tolkas som något negativt. Likväl har hjärtats pulserande enbart en fysiologisk funktion, som i sig varken har en positiv eller negativ betydelse, och som kan erfaras under olika omständigheter, såsom i medicinska sammanhang, vid fysisk träning eller under intima stunder.

Denna studie är en forskning-genom-design ur ett förstapersonsperspektiv samt soma-design för att öka medvetenheten om sina hjärtslag, både från en individuell och en social vinkel, samt en undersökning av de potentiella fördelar som kan finnas med att använda ett yttre stimuli för att ge biofeedback. Den öppnar också upp designrymden kring hjärtslag och sensorisk stimuli, reflekterar kring välbefinnande och avslappning, biofeedback och digital mindfulness, Sensiks sensoriska kapsel som ett verktyg och en plats, samt hjärtfrekvens som ett spektrum och ett sätt att lära känna människor. Resultatet av studien framställs i fyra olika delar: en designkritik av Sensiks sensoriska kapsel, en fiktiv design publikation, ett designförslag, och en prototyp av upplevelser.

Detta examensarbete utmynnar i ett förslag på en design kallad “Gallery of Heartbeats” - en sensorisk upplevelse avsedd att ge en yttre form och för att dela hjärtslagen med sig själv och andra. “Gallery of Heartbeats” skapar utrymme för individuell reflektion, och ger användaren i realtid en numerisk, grafisk och ljudmässig biofeedback på sin hjärtfrekvens. Den uppmuntrar också till samtal av detta vanligtvis omärkbara fysiologiska fenomen, den möjliggör användaren att spela in och spara sina hjärtslag i ett arkiv, och användaren ges möjlighet att uppleva förinspelade hjärtslag av andra personer på ett multisensoriskt sätt.

Utvärdering av prototypen för “Gallery of Heartbeats” visar att designen lyckas få människor mer medvetna om sin kardiovaskulära aktivitet, väcker deras nyfikenhet och ökar empatin. Dock gör även “Gallery of Heartbeats” att användaren vill kontrollera eller ändra sin hjärtfrekvens, vilket går emot de principerna inom mindfulness av att vara ‘presence-in’ och ‘presence-with’. Sensorisk stimuli, särskilt ljud och bild, ses som främjande av att skapa känslan av att vara absorberad, medan andra signaler från biofeedback har en annan påverkan och andra användningsområden.

Nyckelord

Biofeedback, digital mindfulness, delad verklighet, multisensorisk upplevelse, soma-design

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Stockholm, September 2020
Eva Maria Veitmaa

Disclaimer

The views and opinions expressed in this study are those of the author and do not represent the opinions of any other agency, organisation, company, or employer including Sensiks BV and KTH Royal Institute of Technology, unless explicitly stated otherwise. Any views or opinions are not intended to malign any organisation, company, or individual. Assumptions made in the analysis are not reflective of the position of any other entity than the author.

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List of acronyms and abbreviations

aka	also known as
bpm	beats per minute
CEO	Chief Executive Officer
ECG	electrocardiogram
HCI	human-computer interaction
HRV	heart rate variability
IBI	interbeat interval
improv	improvisation (e.g. contact improv)
MBSR	mindfulness-based stress reduction
RtD	research through design
SSD	solid-state drive
VR	virtual reality
WPF	Windows Presentation Foundation

1 Introduction

Stress is a natural part of life. It invigorates and mobilises people. Most people affiliate stress with something that causes distress – negative reactions to changes in life. Long-term negative stress has a straining effect on one's health and wellbeing. It can cause headaches [1], lethargy [2], difficulties concentrating [3], and feelings of anxiety [4]. Co-occurring problems include depression [5], heart disease, and increased blood pressure leading to strokes [2]. In 2020, the year of the novel coronavirus pandemic, common causes of stress include worries over health, economy, and employment [1]. However, even insignificant daily incidents, such as being stuck in traffic or sitting for an exam, can induce stress.

There is a variety of methods for handling negative stress. One of them is mindfulness – being present in the current moment in a non-judgemental way. Mindfulness-based therapy has been assessed as an effective treatment for various psychological problems, but especially useful for reducing stress and anxiety [6, 7]. Mindfulness entitles grounding oneself to the present with all the senses, disrupting habitual responses and adjusting one's reactions to mundane worries. Mindfulness practices can take many forms, e.g. meditation, yoga, or body scans [8]. Some of them need a ritual setup, e.g. yoga mat and sports clothes, while others can be engaged with anytime and anywhere, e.g. when tying shoelaces or walking in the street.

Although mindfulness can easily be practised without any tools, digital mindfulness technologies can help with being in the present. Most digital mindfulness artefacts act as a means to an end and help the user achieve explicit goals, such as lowering their heart rate or calming down their mind [9]. An alternative to those instrumental artefacts is mindfulness design that allows one to be present in the current moment without any objectives. Such designs are integrated with daily life and allow the user to reflect on the data instead of the system assigning meaning to it.

Digital mindfulness artefacts can be enhanced with biofeedback to reflect back the user's physiological functions. Biofeedback is especially useful for presenting the user with information on those bodily aspects that are usually difficult to notice as it externalises those hidden bodily functions [10]. Compared to traditional relaxation practices, biofeedback training provides the user with quantified information on their boy. Similar to traditional methods, however, it encourages self-observation and self-reflection [11].

Biofeedback can be presented in various ways. It can be explicit, in the form of graphs and numbers, or more abstract, using colours or movement. An interesting alternative is to present biofeedback information through sensory stimuli, such as heat or airflow. For that, a sensory reality pod by the company Sensiks can be useful. The Sensiks sensory reality pod is shaped like a small dressing cabin and features numerous actuators, such as fans, heat panels, scent dispensers, LED lights, and speakers. These can be used for presenting information or creating immersive relaxation experiences. Since the Sensiks sensory reality technology is novel, it is unclear what the potential uses of it are. Therefore, this study also opens up the design space around using sensory reality for relaxation, mindfulness, and providing biofeedback.

One physiological function that using biofeedback is beneficial for is the heart rate. The heartbeat is something that is always with a person, yet rarely noticed unless it becomes more intense, e.g. after a straining physical activity or when feeling anxious and stressed. The heartbeat is a complex physiological feature and an even more complicated topic. The heart powers a person throughout their life, it reflects one's physical and physiological states [2], and is an essential part of being. Yet, this fundamental part of a person is rarely shared with the outside world, e.g. when getting a medical check-up, using an activity monitor or lying on the chest of a loved one. While everyone can see each other's faces and hear the voices, the heartbeat is in the background, hidden away inside a person. People have a poor perception of the heartbeat of self and others.

This study embarks on an explorative design journey into the domains of relaxation, bodily awareness, and biofeedback. As a result, it opens up a rich and complex design space that revolves around the aspects of individual reflection, social sharing, desire for control and change, the multi-layered nature of the heart rate, and sensory stimuli. It takes the reader through experiences with multiple relaxation practices with the aim of increasing bodily awareness and perception. It looks critically at the current design of the Sensiks sensory reality pod with its incorporated technology. An alternative future is imagined in Misuse Magalogue – a fictional publication targeting the Sensiks pod. Through copious insights into relaxation, bodily awareness, and biofeedback, the study steers towards a design proposal for the Gallery of Heartbeats – a sensory experience aimed at increasing awareness of the heartbeat of self and others. The resulting design prototype is evaluated with users and followed by a thorough discussion on the discovered design space, comfort and relaxation, biofeedback and digital mindfulness, the Sensiks pod as a tool and space, and the heartbeat as a spectrum and a way of getting to know people.

The goals of this study are to increase bodily awareness of one commonly unnoticed physiological feature – the heartbeat – from both an individual and social angle and to examine the potential benefits of using external sensory stimuli to convey biofeedback information. Thus, the research question can be formulated as “How can sensory stimuli be used to increase bodily awareness of the heartbeat?”. The study results in four key deliverables: a design critique of the Sensiks sensory reality pod, a design fiction publication, a design proposal, and an experience prototype. Methods used in this study include first-person research through design, soma design, and experience prototyping. These are chosen as they support designing from a personal, intimate perspective that is important when designing with and for the living body or soma as the centre of sensory appreciation [12, 13]. This study aspires to trigger curiosity towards digital mindfulness, sensory stimuli, and the hidden features of the soma and to inspire other designers to work with these topics.

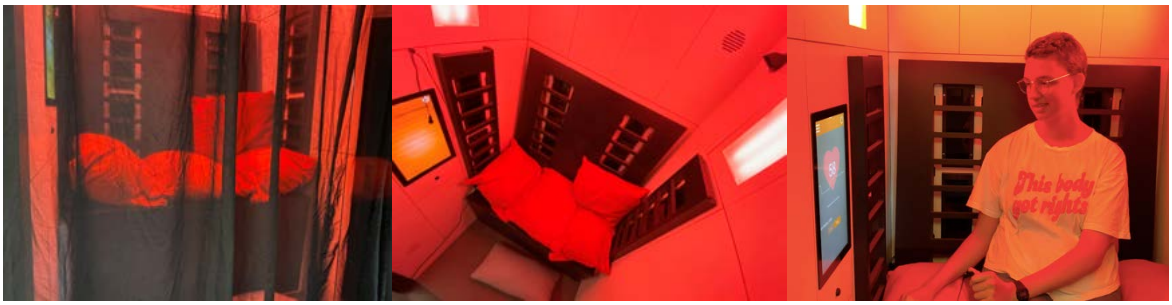

Figure 1-1: The Gallery of Heartbeats uses sensory stimuli to increase bodily awareness and support social sharing of the heartbeat.

1.1 Personal motivation

The author with her influences is a vital part of the design process. Therefore, it is essential to elaborate on her personal motivations for choosing this topic. The interest is twofold. First, the author has experienced the weight of negative stress and anxiety throughout her life, albeit not on a disturbing level. By looking into relaxation and bodily awareness practices, she hopes to discover coping mechanisms that would help her handle stressful life situations better. Additionally, the author has a keen interest in physical interaction design and everything where technology has more of a supporting role than one that captures the most attention. In her mind’s eye, technology should be ubiquitous and unnoticeable with the main focus being on people and their felt experiences.

1.2 Structure of the thesis

Chapter 2 presents relevant background information about soma design, sensory reality technology, stress and anxiety, digital mindfulness, and biofeedback. It also lists a selection of previous works in this domain. Chapter 3 presents the methodology and methods used in this study. Chapter 4 gives an overview of somatic exploration of bodily awareness practices and key insights gathered from the sessions. Chapter 5 looks into ways of enhancing the Sensiks pod to support relaxation. Chapter 6 presents a design proposal for increasing bodily awareness and supporting social communication of the heartbeat. Chapter 7 describes results from evaluating the design prototype of the Gallery of Heartbeats and chapter 8 discusses some concepts that arose from engaging with the design process and the evaluation.

2 Background

This chapter provides background information about sensory reality and the sensory technology by the company Sensiks. Additionally, this chapter describes the principles of embodied and somaesthetic design. Information about stress, digital mindfulness, and biofeedback is presented. The chapter also describes related work in the domains of bodily awareness, digital mindfulness, and stress reduction.

2.1 Sensiks sensory reality pod

This study was done in collaboration with the company Sensiks who produces technology for sensory reality. By the term “sensory reality”, Sensiks means using sensory stimuli (e.g. scent, wind, sound) to create feelings of being present in a remote environment [14]. The Sensiks sensory reality pods enable combining audio-visual experiences with scent, temperature, airflow, and light frequencies (see Figure 2-1 and Appendix A). To do so, the pods are equipped with one big light panel on the ceiling and two smaller ones in sidewalls, infrared heating panels on the back wall and on both sides of the user (depending on the model, there may be an additional one in the front left side of the pod), four small ventilators in each corner near the ceiling, a scent dispenser in one of the sidewalls, surround-sound speakers (two up top on left and right, two speakers down low on each side), and a digital computer screen that acts as a touch-based control panel built in the wall on the right. Additionally, a virtual reality headset can be connected to the system.

The Sensiks sensory reality pods are used for healthcare (e.g. exposure therapy for treating post-traumatic stress disorder), training and experiential learning, and entertainment, for example [14]. The original idea for the Sensiks sensory reality pod came to the founder when he wanted to reproduce the feeling of being at the beach.

For a more thorough overview of the Sensiks sensory reality pod including a design critique, see Appendix A.

Figure 2-1: The sensory reality pod by Sensiks (courtesy of Sensiks).

2.2 Embodied and somaesthetic interaction design

According to one of many definitions of embodiment, the body is dual, meaning that it can be both a subject and an object at the same time [15, 16]. As an object, the body can be measured, quantified, tracked, and changed. As a subject, the body is seen as an ambiguous receiver and creator of aesthetic experiences, an endless source of new knowledge and pleasure. Embodied interaction captures the influence of surrounding social and physical contexts on a person and vice versa.

In [17], embodied design ideation methods were divided into three larger groups based on the knowledge they bring forth. “New Material Forms” revolve around opening the design space around certain (technological) materials. “New Concepts” cover the emergence of social relations and aesthetics. “New (Bodily) Behaviours” build the design on movement potential, patterns and habits. The strategies of embodied design methods include placing a certain material or movement in a novel context, using artefacts to change bodily sensations, using enactments to grow empathy, or altering the material for a better understanding of the situation and potential use cases.

Somaesthetics describe the living body or soma as the centre of sensory appreciation [12, 13]. The concept of soma captures one’s subjective self, both body and emotion, while aesthetics describe the perceptual appreciation of the surrounding world. How people move affects how they think, exist, and understand the world. Bodily awareness can be roughly divided into three tightly-linked categories: “living in the body”, “living in relation to others”, and “living in society” [18]. “Living in the body” is about being aware of one’s inner bodily sensations and, thus, forming a stronger sense of self. Well-developed bodily awareness results in being more empowered and satisfied with oneself. It also increases empathy towards others and involvement with society (see Figure 2-2).

The soma can be trained to be more receiving of various aesthetics. This is done by engaging in various practices, such as yoga, meditation, or Feldenkrais, or by disrupting the habitual responses and movements, e.g. slowing down a gesture [19]. Such practices tend to reveal unconscious, unnoticed movements and the complex coordination of body parts [20], which can act as an input for the design space. Enhanced somatosensory appreciation helps design technology for the mental and physical wellbeing [15, 21].

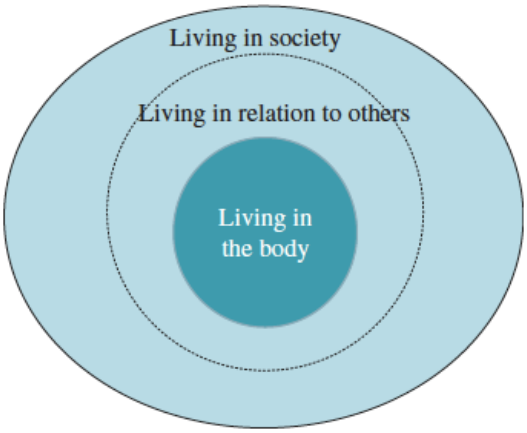

Figure 2-2: Bodily awareness forms the core of living in society (courtesy of [18]).

2.2.1 Somaesthetic appreciation, biofeedback loops, and affective loops

A somaesthetic appreciation design artefact guides attention and focus inwards to the user’s bodily sensations in a subtle, non-distracting way [19]. It creates a safe and comfortable space for the user to take a break both in the physical and psychological sense. The interactive feedback from the

design is immediate, intimate, and in sync with the body. The strong concept of somaesthetic appreciation proposed by [19] emerged from engaging in routine practices of Feldenkrais, material exploration, autobiographical and shared design work. Examples of somaesthetic appreciation design would be the Soma Mat that directed the user's attention to their body parts with heat [19], Breathing Light that reacted to the user's breathing patterns with light intensity [22], and Sonic Cradle where the user's breathing patterns created a soundscape [23].

An alternative concept is biofeedback loops [24–26]. While somaesthetic appreciation aims to guide the user's focus inwards [19], biofeedback loops draw the attention to external visualisations of physiological phenomena. In a way, these concepts are opposites as any technology that uses too much intrusive external stimuli will fail at directing the user's attention inwards. On the other hand, biofeedback can help externalise hidden physiological features (see Section 2.5) and, thus, increase bodily awareness.

In case of affective loops, an interactive feedback loop is created between the user and the system [27]. The user expresses a certain emotion via their physical body (e.g. gestures, facial expression). The system responds to the user's emotions by expressing an affective state of its own. This in turn influences the user's emotions and creates a closer bond with the affective system. Affective loop systems designed in [27] simply reflected the user's inner state and experiences. They did not tell the user whether the experience was positive or negative. The meaning-making of the data was left to the user. By enabling users to reflect on and interpret their experiences, an affective loops system can also motivate behavioural change, although that is not the inherent goal of the system.

2.2.2 Challenges of somaesthetic design

Somaesthetic design is accompanied with various challenges [28]. For one, designers engaging in soma design need to adopt the perspective of feeling and experiencing instead of simply presenting the ideas. It is essential to explore the materials in detail for a period that is long enough to capture nearly every aesthetic experience the material has to offer before deciding on a design to pursue. A designer should let materials and their aesthetics guide the design process, instead of feeling restricted by them.

Since soma design relies so strongly on subjective felt experiences, documenting a soma design process in a way that captures the somatosensory aspects and enables re-experiencing them in the future becomes difficult [28]. Perhaps the biggest challenge with using embodied and soma-based design methods is presenting them in the written language without losing the richness and depth of an experience that is best understood by first-hand involvement. Experiencing soma-based methods always ensures a much deeper understanding than simply reading about them [21].

2.3 Stress, anxiety, and mindfulness

Anxiety and negative stress are some of the many things that affect one's soma. Both can harm health and wellbeing, for example, cause headaches [1], lethargy [2], or difficulties concentrating [3]. Co-occurring problems include depression [5], heart disease, and increased blood pressure leading to strokes [2]. During the novel coronavirus pandemic of 2020, people reported feeling more worried about health, economy, and employment [1]. However, even insignificant daily incidents, such as being late to a meeting, can induce stress.

A variety of methods for handling negative stress exist. One of them is mindfulness or being present in the current moment and acknowledging it in a non-judgemental way. Mindfulness-Based Stress Reduction (MBSR) is one of the formal mindfulness practices founded by Jon Kabat-Zinn [8]. It consists of formal exercises, such as body scan, mindful meditation, breathing, and yoga, and

informal ones, such as mindful eating or listening. While the former usually need a specific routine or a set-up, the latter can be incorporated into every moment of the day, for example, while brushing teeth, washing the dishes, or shopping for groceries.

A study on people with anxiety and panic disorders showed lower self-reported stress and depression scores after participating in an MBSR program [29], even in a longer timeframe [30]. No negative side effects of MBSR have been found as of today. This shows that mindfulness can be an effective treatment for daily stress and chronic anxiety [7]. It was also found that people engaging in mindfulness practices remembered less negative words than people who did not partake in such practices [31], suggesting that mindfulness can reduce the impact of negative events in life and, thus, contribute to the practitioner's wellbeing.

Mindfulness meditation is also believed to increase bodily awareness as one becomes more in touch with their present state. However, despite being conditioned to be more focused on their body, meditators failed to notice their heartbeat better than non-meditators [32, 33]. On the other hand, meditators did report experiencing heartbeat sensations in more numerous areas on the body compared to those who did not meditate.

2.4 Digital mindfulness

There are various ways how technology can support mindfulness and meditation practices. One of them is situated mindfulness with the goal of bringing informal mindfulness practices into everyday life and daily actions [34]. In [34], however, they found that only routine mindfulness meditation was successful in actually creating a state of mindfulness and curiosity. Therefore, it is difficult to design for a situated mindfulness approach that ought to be practiced throughout the day. Designing for a ritual, dedicated practice is comparatively easier.

One approach to mindfulness in Human-Computer Interaction (HCI) classified digital mindfulness technology based on whether it supported presence-in, presence-with, or presence-through experiences [9]. In this case, mindfulness technology was split into four levels. Digitalised Mindfulness is a text-, audio-, or video-based replacement for traditional face-to-face mindfulness instructions. Personalised Mindfulness tailors the experience according to the user, their preferences, or context. Quantified Mindfulness technology supports interactive exercises that rely on biofeedback (see Section 2.5). These first three levels of digital mindfulness technology provide the user with goals, tools, and techniques for achieving mindfulness and are, thus, referred to as presence-through artefacts.

Level 4 presence-in and presence-with applications enable the user to simply be present without any goals, just like one would be present in and with nature when taking a walk in the woods or watching fish swim in a pond [9]. Such mindfulness technology allows the user to direct their attention to the current moment without judging it. It does not rely on routines, rituals, or tools, but is seamlessly merged into daily life. It presents the information about our constantly changing bodies in a neutral way that does not elicit the need for control or alteration. Examples presented in [9] include a digital fishpond that changed visual parameters based on the physiology of the observer, a glass that reacted to the temperature of the liquid inside it, and digital screens that reflected the seasons or breathing (see Figure 2-3). An important aspect is that "digital mindfulness apps are designed for presence [...], not for immersion without mindful presence or for escapism" [9]. Therefore, one should aim to ground the user with a design for mindfulness instead of "teleporting" them to another place or moment in time.

Figure 2-3: Presence-in and presence-with digital mindfulness technology allows the user to be present in the current moment without any goals [9].

2.5 Biofeedback

Biofeedback provides a way of reflecting back the user's physiological aspects. In its clinical meaning, biofeedback is a method of improving the user's health by measuring the often difficult-to-notice physiological states (e.g. heart rate, respiration, muscle, brain, or electrodermal activity) and presenting them to the user in a way that supports behaviour change [10]. For example, studies using heart rate variability (HRV) biofeedback have reported reductions in self-reported stress and anxiety which indicates biofeedback's potential in treating stress and anxiety with wearables [35].

Biofeedback training is somewhat similar to traditional meditation and mindfulness as it encourages self-observation and self-reflection [11]. However, biofeedback training provides the user with quantified indications on their progress which traditional practices do not. Ironically, focusing too intensely on relaxation may have the opposite effect of increasing stress levels instead [36]. It is similar to when someone tells you to not think of a pink elephant – one cannot but imagine a pink elephant. As a result, biofeedback technology supporting relaxation should be designed in a way that does not further agitate the user.

While common affective health solutions translate user's physiology into emotions, a somewhat alternative design approach for a real-time stress feedback application avoids assigning positive or negative valence to the data and lets the user themselves interpret the bio-signals [37], akin to affective loops (see Section 2.2.1). Such systems also result in increased bodily awareness [38]. Khut as a practitioner of this approach has used biofeedback for creating interactive artworks [24].

With biofeedback, a trade-off exists between accuracy and comfort [38]. The commercial wearables (e.g. activity monitors or smartwatches) are comfortable, but not very high on accuracy. Current high-tech sensors, however, are mainly still too invasive or uncomfortable to be used in daily life. Therefore, when designing with biofeedback, one must often choose between comfort and precision.

2.6 Previous works on bodily awareness, digital mindfulness, and stress reduction

Previous works on digital mindfulness, increased bodily awareness and stress reduction can roughly be divided into two groups – those using virtual reality and those using tangible artefacts. Some solutions use biofeedback on physiological features, such as brainwaves, heart rate, breathing, body temperature, or skin conductivity, to externalise hidden physiological or psychological states. This section will first present some virtual reality solutions and then have a closer look at tangible artefacts.

Many previous works have used interactive virtual reality to make users focus on their soma (see Figure 2-4). RelaWorld was an immersive virtual reality environment enhanced with

neurofeedback designed to aid users in practicing body scan and focused attention exercises [39]. The visibility of the surroundings and the hover level of the virtual platform were used to reflect the user's relaxation and concentration levels in real time. These were being measured via electroencephalography (EEG).

The Meditation Chamber used biofeedback combined with auditory, visual, and tactile cues to support the user's meditation experience [40]. The Meditation Chamber tracked the user's galvanic skin response, heart rate and breathing. One of the exercises featured a virtual sunset triggered by the user's relaxation level while others supported muscle tension and breathing practices. Results showed that the users experienced increased relaxation and were more aware and in control of their physiological parameters when using the Meditation Chamber.

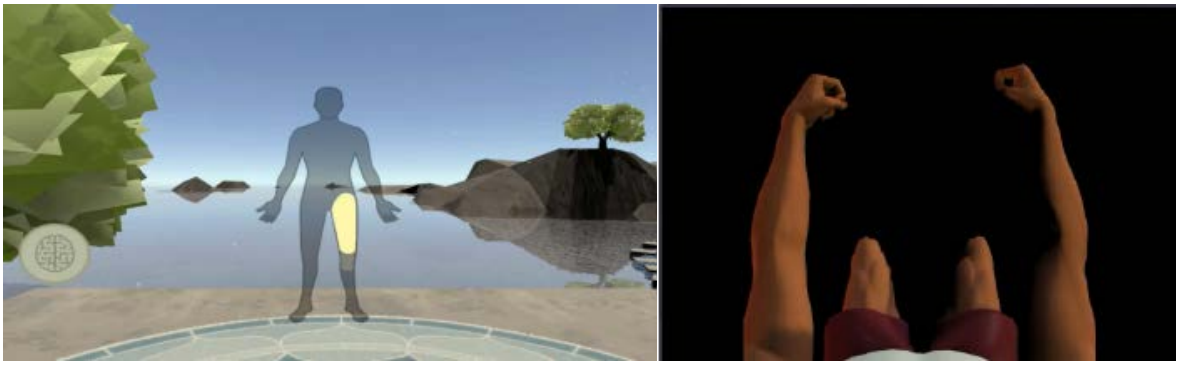

Figure 2-4: RelaWorld [39] (left) and Meditation Chamber [40] (right) used virtual reality and biofeedback for body scan and muscle tension exercises.

Paying attention to breathing and changing breathing patterns are common ways of reducing stress, e.g. with Breathe Deep [41] that used an adaptive virtual coach guiding the user through breathing exercises. Some have taken a more gamified approach, for example, DEEP [42] or ChillFish [43], where users could explore virtual underwater environments using their breath, or Life Tree [44], where respiration was used to grow a virtual tree (see Figure 2-5).

Life Tree [44] also summarised some key aspects for designing engaging biofeedback solutions. First and foremost, the used hardware has to be comfortable and non-obstructive so as not to distract the player. They also noted that minimalistic interactive visuals in the game assisted in focusing on breathing and that hearing their breathing sounds was pleasant and could further increase awareness of one's own respiration.

Figure 2-5: A selection of breathing games. Left: DEEP [42]. Right: ChillFish [43].

While the aforementioned projects used virtual reality, various alternatives also exist, for example, mobile applications or tangible artefacts (see Figure 2-6 and Figure 2-7). Some projects have used stimuli other than audio-visual virtual reality. For example, [45] experimented with thermal stimuli and how heat could be used to bring attention to one's body. They found that heat acts as a much more pleasant and subtle stimulus for directing focus than touch or light. However, preferred heat levels were very subjective, heat tended to come and go slowly, linger on materials,

and could sometimes distract the attention as an external stimulus. Others have also used lights [46–48], mechanical movement [46, 49], or water [50, 51].

AEON [52] and TANGAEON [50] helped users in thought distancing exercises by visualising thoughts as written ink under water. The user could then dissolve their thoughts in water by moving their fingers, either on a digital screen (AEON) or in actual water (TANGAEON). Both solutions externalised thoughts, showed the gradual disappearance of a thought, and gave the user control over the process while relying on natural element visualisations and sounds.

Figure 2-6: AEON [52] (left) and TANGAEON [50] (right) used physical interactions for thought distancing exercises.

Lotus [46] was an actuated plant-like device that detected stress based on heart rate and guided the user through mindful breathing exercises aimed at lowering the heart rate and, thus, reducing stress. LightStress [47] and DeLight [48] were tangible artefacts that reflected the user's stress levels using changes in colour. A cooler colour tone was presented when high stress levels were detected. As the user relaxed and their body temperature rose, the colour shifted to warmer tones. LightStress measured changes in body temperature and DeLight detected stress levels from heart-rate variability (HRV).

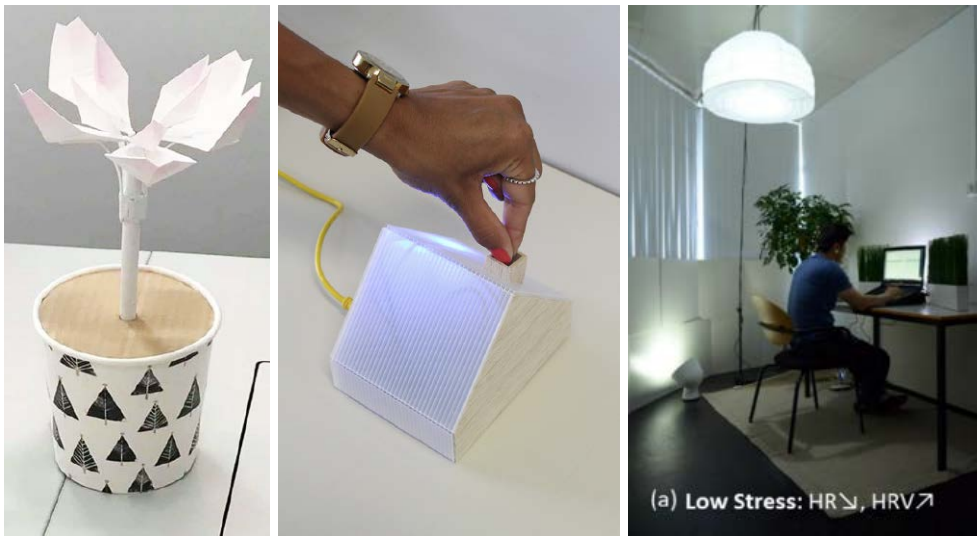

Figure 2-7: Lotus [46] (left) used mechanical movement to guide the user through mindful breathing exercises. LightStress [47] (middle) and DeLight [48] (right) indicated user's stress levels with colour.

While more palpable than virtual artefacts, tangible artefacts tend to pull attention away from the user's body, shifting the locus of attention to the artefact outside the body [53]. This happens even when the object visualises the user's inner physiology, such as heartbeat or respiration. While

such designs may not be the best aids for an inward-focused meditation practice, they are good for training and for externalising and sharing hidden bodily information. The remaining solutions are presented in two categories based on their intended use – either for internal awareness or as a communication channel between people.

2.6.1 Biofeedback for internal awareness

The following works used biofeedback to increase the user's awareness of their soma, either for simple information sharing or for changing a physiological feature (see Figure 2-8). In case of the latter, it could have been to reduce one's heart rate or to change a breathing pattern with the goal of calming down or lowering feelings of anxiety.

Sonic Cradle [23] was a slightly more abstract version of the aforementioned Meditation Chamber [40]. The user sat in a completely dark room without any visual input. Their breathing patterns affected the spatial soundscape of the room. Sonic Cradle's main goal was to draw the user's attention inward, thus supporting mindfulness. Many users reported the desire to explore how to control the sounds at first but fell into a more relaxed and meditative state later on. Participants described Sonic Cradle as a relaxing experience that could trigger visuals, feelings of floating, distortions in how time is perceived, positive emotions, a dream-like state, reduced thinking and a clearer mind [54]. The authors themselves pointed out that while Sonic Cradle creates states of relaxation, the experience might not have been fully aligned with achieving complete mindfulness as they failed to capture non-judgemental focus on the present moment.

TOBE [55] was a Tangible Out-of-Body Experience which means that an external artefact gave the user information about their inner states, such as heart rate or cognitive load. The authors analysed how users visualised their usually abstract internal states and discovered that there were many different ways to represent a single physiological feature. They proposed an educational biofeedback toolbox that could measure electrodermal activity, heart rate, eye blinks, and mental states and projected this data to a tangible avatar based on the user's custom representations of their internal states. Potential uses the authors pointed out were medical treatments, social communication, representation of the aggregated physiological states of a group, or communication between people over time and space. The main goal, however, was to encourage users to get to know their body and mind and practice self-reflection.

Inner Garden [56] was an augmented toy sandbox that visualised the user's physiological states using an electroencephalograph (EEG). Although influenced by the user's stress levels and meditation frequency, this modern zen garden did not explicitly aim at affecting the user's inner states. Instead, it acted more as a tool for reflection and contemplation while doubling as a fun interactive toy. With Heart Waves [51], the user's heart rate controlled the speed of a water fountain. The device used a one-to-one mapping –more water flowed with higher heart rate and less with lower. The ambient sound of falling water was hypothesised to create a relaxing atmosphere and have a stress-reducing effect.

George Khut has created multiple artworks revolving around biofeedback [24, 25]. In the Heart Library Project and the Mobile Mood Lab, the visitors lay down and were shown a mirror image of themselves enhanced with abstract sounds and visualisations that changed according to their heart rate. Distillery: Waveforming and the BrightHearts App used changes in sounds and colourful visuals to help patients cope with pain and anxiety that goes along with medical procedures.

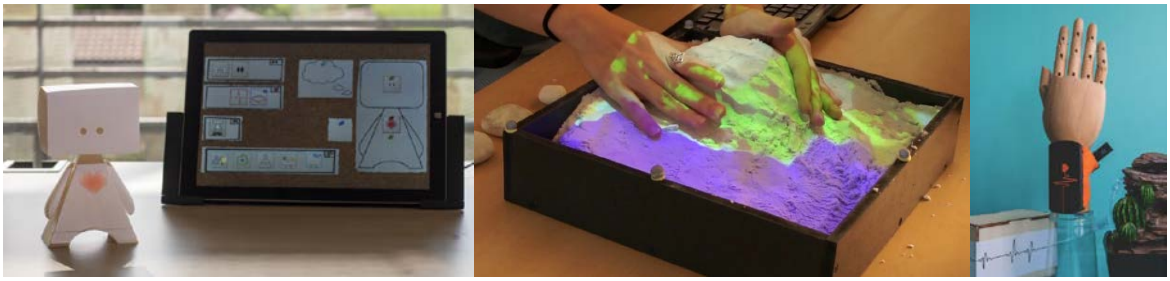

Figure 2-8: TOBE [55] (left), Inner Garden [56] (middle), and Heart Waves [51] (right) increased the user's awareness of their soma using biofeedback.

2.6.2 Biofeedback for social communication

Another category externalises physiological features that are commonly unnoticeable by others, such as heart rate or breathing, as a means of supporting communication between people (see Figure 2-9). It is argued that publicly sharing such intimate information creates stronger bonds between people and increases empathy [57].

Breeze [57] was a custom-made biofeedback necklace that measured and guided the user's breathing via visual, auditory, and tactile cues. Work on Breeze pointed out the highly descriptive language of breathing and its potential use in social communication. The authors argued for using breathing biofeedback both for internal awareness and as a communication tool between people. The latter was also the goal of BreathingFrame [49] which used an inflatable frame to share the breathing of relationship partners.

The live stream #FOLLOWMYHEART [58] broadcasted Shia LaBeouf's heartbeat to everyone who followed it on a public web page. It was an exploration on personal connection and intimacy over distance [59]. Heart Calligraphy [60] mapped real-time heart rate data into pen movements, creating unique drawings based on the user's cardiovascular activity. It used a more abstract way of presenting biofeedback than a traditional numerical or graphical interface. The resulting artwork captured the visitor's heart rate during the period they were connected to the machine.

Breathing Watercolours and Breathe With Me were completely non-technological art projects by Jeppe Hein and ART2030 [61]. Visitors to the exhibition were encouraged to pick up a paintbrush and paint their breath on a canvas. This resulted in a sharable representation of the visitor's breathing as an otherwise hidden physiological modality. Additionally, while doing this exercise, the person was focused on their physiology and the present moment, thus, being mindful.

Figure 2-9: Breeze [57] (left) was a necklace that made the wearer's breathing visible from afar. BreathingFrame [49] (middle) allowed partners to share their breathing while being physically separated. Heart Calligraphy [60] (right) produced an artwork from cardiovascular data.

2.7 Summary

As seen above, various guidelines for using sensory stimuli to increase bodily awareness and support reflections emerged. First, sensory technology in the form of the Sensiks pod is relatively novel and can provide new interactions and new ways of representing information. Since this study was done in collaboration with the company Sensiks, the design would be for their hardware. However, virtual reality headsets are avoided as they "teleport" the user away from the present moment into another environment which goes against the principles of mindfulness.

Additionally, the study uses soma design as a research method. The design process is guided by materials and insights from bodily awareness practices. The study aims to create a presence-in or presence-with digital mindfulness artefact that grounds the user to the present moment and enables them to be present without any goals. The resulting design aims to not assign any meaning to the user's states, not telling them whether high heart rate is positive or negative. It is to simply reflect back the user's inner state, leaving the meaning-making to the user. This way, the user is encouraged to look deeper into themselves and become more somatically aware.

The resulting design aims to both increase internal bodily awareness by reflecting information back to the user, and to support social communication by enabling sharing a commonly hidden somatic aspect with people other than the user. To do so, biofeedback and Sensiks sensory technology are used to measure and externalise a physiological feature. All the while keeping in mind that external stimuli holds the threat of being distracting and pulling the user's attention away from their soma.

3 Methods

This study used the methods of autobiographical research through design (RtD), embodied and somaesthetic design, experience prototyping, qualitative interviews, and contextual inquiry. The research process included exploring selected bodily awareness and relaxation techniques, exploring the technological materials, establishing a design proposal and evaluating a design prototype. This chapter describes which methods were used and how.

3.1 First-person research through design

While science commonly analyses what is, design looks at what could be instead [62]. In research through design (RtD), the researcher engages in design practices, such as thoroughly understanding a complex situation, ideating on potential solutions, and creating prototypes that address the situation and mould the experience to what it could be instead of what it is now. By iteratively engaging in such design processes, discovering opportunities, overcoming constraints, observing the effect of the created artefacts on the target group, and reflecting on the decisions, insights are gathered [63]. Thus, new knowledge is produced through designing.

First-person perspective is an approach to research where the researcher is also in the role of the research subject – research and design activities rely strongly on the researcher's own perceptions and experiences. First-person perspective is increasingly common in HCI research focused on the body and mind [64]. Using autoethnographies, autobiographical design, and autobiographical research through design sheds light on how the author (and, inductively, more people) relates to technology. First-person perspectives are often useful for gathering deeper insights into ethically complicated topics, such as intimate relationships. They are also valuable in domains which set the soma as their main focus. By training to notice their somas, designers are more capable of documenting their felt experiences than somatically untrained external participants. As a result, designers can better capture the nuances of felt experiences and use them as inspiration for their design [13].

The Sensiks sensory reality technology that lay in the centre of this study requires physical presence to experience fully. Since first-person methods lack the need for other participants than the author, they were also ideal to use during the novel coronavirus pandemic to comply with social distancing regulations and avoid endangering people when designing with and for the Sensiks technology.

In this study, first-person perspective was used in the form of the author being the main participant in the design process. The author was the one who increased her own bodily perception, analysed the materials, created a design proposal and a design prototype. External participants were only included during the evaluation of the design prototype to test the design on a larger target group than a singular person. By being so deeply included in the process, the author developed a more thorough experience with the design and its goals than any external participant could by participating in a selected number of design sessions. Therefore, the result was a more nuanced design that took into account felt experiences throughout every step of the process. On the other hand, a single person is unable to capture the perceptions of everyone else, especially on such a personal topic as awareness of one's own soma. Thus, not all discoveries and insights of this study are applicable to the whole general public.

3.2 Embodied and somaesthetic design

Embodied and somaesthetic design (also see Section 2.2) consider a person's soma and their senses to be at the centre of lived experiences [13, 17, 65]. Engaging in various practices and deliberately

paying attention to one's soma trains one to be more receiving of various aesthetics. Higher somatic awareness helps reveal novel interactions [20] and design directions. In this study, three methods from embodied and somaesthetic design were used: estrangement [17] or defamiliarization [66], bodystorming or embodied storming [67, 68], and slowstorming [13].

3.2.1 Estrangement

Estrangement or defamiliarization means adopting a novel perspective for something regular and routine, e.g. doing a movement with a different tempo than is common [17]. Estrangement from the habitual included the author engaging in various bodily awareness exercises and relaxation practices novel to the author. The practices explored in this study were meditation, mindfulness, body scanning, contact improvisation, and yoga. By engaging in these practices, the author defamiliarized herself with her own soma and her habitual movements.

This exploration of bodily awareness techniques and estrangement from the habitual helped the author become more somatically aware. As a result, the author was more sensitive to felt experiences. Additionally, by engaging in existing practices, the author aimed to discover specific interactions or movements that she was oblivious to before. Both increased bodily awareness and novel interactions provided input for the design process.

The experiences with various relaxation practices were documented in written text, photographs, and sketches. It was acknowledged that such media did not fully capture the personal and highly subjective experiences of the author. However, it was still useful for sharing obtained insights.

3.2.2 Bodystorming

Bodystorming or embodied storming stands for engaging in design activities in the original context [67, 68]. This means that ideally everything would be done while present at the situation or location one is designing for. This study mainly revolved around the use of Sensiks sensory reality pod. Therefore, bodystorming took place in or near a Sensiks pod.

However, the closest available Sensiks pod took 40 minutes of cycling for the author to reach. Thus, not every design activity was carried out as part of embodied storming. Instead, some of the design work was done away from the pod. Photos and videos of the pod were used to help keep the context in mind during those situations.

The technological materials in the form of the Sensiks pod and its sensory stimuli (ambient lighting, airflow, heat, scent, sound, touchscreen) were explored to map out the technological capabilities and allowances and to analyse the effect of the sensory stimuli on the soma. The exploration of the incorporated sensory stimuli was done via the built-in control panel of the Sensiks pod and custom computer programs based on the Sensiks API. These approaches enabled controlling each of the sensory stimuli both individually and in combinations and observing perceptions of the sensory stimuli.

Photographs, videos and written text were used for documenting the setup and functioning of the technology. The material exploration resulted in a design critique that described the behaviour of the Sensiks sensory technology and the effects on the author using the pod. The design critique was mainly constructed from the perspective of how well the Sensiks pod supports users in relaxation.

3.2.3 Slowstorming

Slowstorming enables coming up with more thoughtful designs by engaging in somatic practices before any design activities [13]. Therefore, slowstorming is a method of grounding oneself in their soma. It helps recall bodily sensations and using those insights when coming up with a design.

In this study, slowstorming looked as follows. When engaging in design activities at the office space where the Sensiks pod was located, the author did a session of mindfulness meditation and body scanning before any design activities. Yoga as an activity that requires more space and preparation was practised before engaging in design activities at home.

The study also takes advantage of "staying in the undecided" [28]. This means that design decisions were not made rapidly but after careful consideration and repeated engagement with the materials. This resulted in a slower design process, yet more refined outcomes for the final experience.

3.3 Experience prototyping

Experience prototyping in this work was used for exploring and evaluating design ideas to create and refine the design proposal [69]. Prototypes that support bodily awareness were designed, implemented and tested iteratively using the Sensiks pod technology.

First, the author looked into ways of making the Sensiks pod more comfortable and relaxing. This included adding non-technological artefacts, such as blankets or pillows. Brain- and bodystorming in the Sensiks pod were used to find which artefacts elicited feelings of relaxation and in what way they could be used in the context of relaxation. Photographs and written text were used for documentation. The result of this stage was an artefact of design fiction [70]. The artefact described how the Sensiks pod's hardware should look and feel like to be more comfortable and support achieving a state of relaxation.

Experience prototyping relied strongly on discoveries from the phases of material exploration and engaging with bodily awareness and relaxation practices. Insights from those stages were used to create a software application for the Sensiks pod and its sensory technology. The goal of said application was to increase bodily awareness of the user. In addition, the role of biofeedback was analysed. Relaxation experiences enhanced by incorporating biofeedback were compared to those without biofeedback to observe in what way biofeedback affected how the experience was perceived. The main point was to investigate whether real-time biofeedback assisted in increasing bodily awareness or relaxation.

3.4 Evaluating the design prototype

The resulting design prototype was assessed through summative user testing. An evaluation session consisted of briefing, informed consent procedure (see Appendix F and Appendix G), an oral in-person pre-test interview, testing the design prototype by engaging with it, and a post-test interview in the form of a contextual enquiry. The length of one evaluation session was 30 minutes in total. The protocol for the session can be found in Appendix H.

The participants for the evaluation session were recruited via an email (see Appendix D) sent to the mailing list of XRBase co-working space and from a local community of young professionals living in Wasa Village, Amsterdam. These groups were selected for two reasons. First, both groups experienced higher mental workload in their work or studies. Second, people in those groups already shared their living or working spaces with the author. This avoided the exposure of external people to those spaces and reduced the spread of the novel coronavirus.

Participants needed to be physically able to enter and exit the Sensiks pod. Due to the confined space, darkness, and bright lights that could flash, suitable participants could not be claustrophobic or epileptic. These requirements were part of the information sheet and additionally emphasised immediately before the user test.

Before testing the design prototype, the participant was asked general questions about their previous experience in the domain of relaxation and bodily awareness. To make it easier to talk about their bodily feelings, participants were asked to fill out a soma body sheet [28] by marking down various sensations in their body (see Appendix I).

After testing the design prototype, feedback on the design and experience was gathered via a qualitative semi-structured interview. A semi-structured interview means that although there is a selection of prepared questions (see Appendix J), the researcher may probe the participant for clarification or deviate from the planned structure depending on the participant's responses [71]. During the post-test interview, participants were asked to fill in another soma body sheet to encourage discussions and observe changes in bodily feelings.

The pre-test interview was done in a separate meeting room (see Figure 3-1). The post-test interview took place with the participant sitting inside the pod at XRBase. Such a contextual inquiry made it easier for the participant to refer to certain features of the pod and the experience.

Figure 3-1: Pre-test interviews were done in separate rooms. Two interviews were conducted with the setup on the left and three interviews with the setup on the right. In both photos, the researcher would be sitting on the right and the participant on the left.

When engaging with the design prototype, the participant was allowed to freely explore it at their own pace without any interference from the researcher. No explicit tasks or guidelines were given to the participant, apart from telling them beforehand to try out the design prototype as they saw fit. This approach was taken to see how the participants behaved when seeing the design for the first time.

No notes were taken during the session to guarantee a smooth interaction between the participant and the interviewer. Instead, the evaluation sessions were recorded in audio and video for later analysis using an iPhone 11. iPhone's native camera application was used to record the audio and video inside the Sensiks pod during the contextual inquiry and while the participant was exploring the design independently. VoiceRecorderLite* application by LiveBird Technologies and QuickTime were used to record the audio during the interview parts of the evaluation session. The recordings and data were stored in a safe location at the contact researcher's private password-protected iCloud and the password-protected Google Drive of the University of Twente. The data was kept confidential, meaning that any personally identifiable data was kept separately at an offline

* https://apps.apple.com/us/app/voice-recorder-lite-record-hd/id955000203

data storage and unique identifiers were used instead [71]. The recordings were presented as summarised transcripts. Key ideas and quotes were presented on individual cards. An affinity diagram was then used as a tool for grouping together analogous concepts and findings. Such thematic analysis enabled identifying common themes in the qualitative interview data [72].

No observers or notetakers were present at the evaluation sessions. A session featured a single participant and the contact researcher only. However, since the post-test interview took place when sitting in the pod located in a stairwell at XRBase, there might have been disturbances from occasional passers-by. A pilot session was conducted to assure the correctness of the procedure. The pilot session took place a week before the real evaluation sessions.

Due to the novel coronavirus pandemic, the surfaces of the Sensiks pod were disinfected before and after each participant. Close contact was avoided as much as possible. Participants were asked to disinfect their hands upon arrival. Providing food was avoided, but participants were free to fill in a glass of water themselves.

4 Somatic exploration of bodily awareness practices

Designing for one's soma asks for heightened somatic awareness of the designer. Engaging with bodily awareness practices enables discovering nuances that might otherwise go unnoticed and establishing a basis for a design proposal. To support this goal, the author of this study experienced various bodily awareness practices herself. Mindfulness, meditation, and yoga were practised over a longer period of time whilst contact improvisation and the Grinberg Method were engaged with in single sessions. The following chapter first describes in detail how these practices were done and then looks at what the key findings were.

4.1 Mindfulness and meditation

The mobile application Headspace [73] was used for guided meditation. "A Mindfulness-Based Stress Reduction (MSBR) Workbook" [8] was used as an introduction to the basic concepts of mindfulness and meditation. The workbook features written text about the background and origins of mindfulness, references to scientific work, transcriptions of guided exercises and worksheets. It is accompanied with audio files of guided exercise recordings. The formal exercises include Mindful Eating, Mindful Breathing, Body Scan, Mindful Meditation, and Yoga, amongst others. In addition, focus lies on integrating mindfulness into everyday actions, such as doing the dishes or walking.

Daily mindfulness (aka present moment awareness) was practised in various settings throughout the study, e.g. when cycling outside or taking a shower. Body scans were often conducted during or immediately after a yoga session or when a strong bodily sensation, e.g. an ache or an itch, was present. Meditation was often ritual and included sitting on the bed in a cross-legged position with a folded pillow under the buttocks and hands loosely resting on knees, palms downwards (see Figure 4-1). During the meditation session, the author was facing the window, although her eyes were closed for most of the time. For two times, a session occurred outdoors on a pier near the Amsterdam Central Station. Meditation sessions ranged from 5 to 20 minutes at a time and were done when the author felt like she needed a break from her daily activities or when her thoughts became overwhelming.

The mindfulness and meditation practices resulted in increased bodily awareness, more sensitized perception of the surrounding environment, a calmer mind, and appreciation of the current moment.

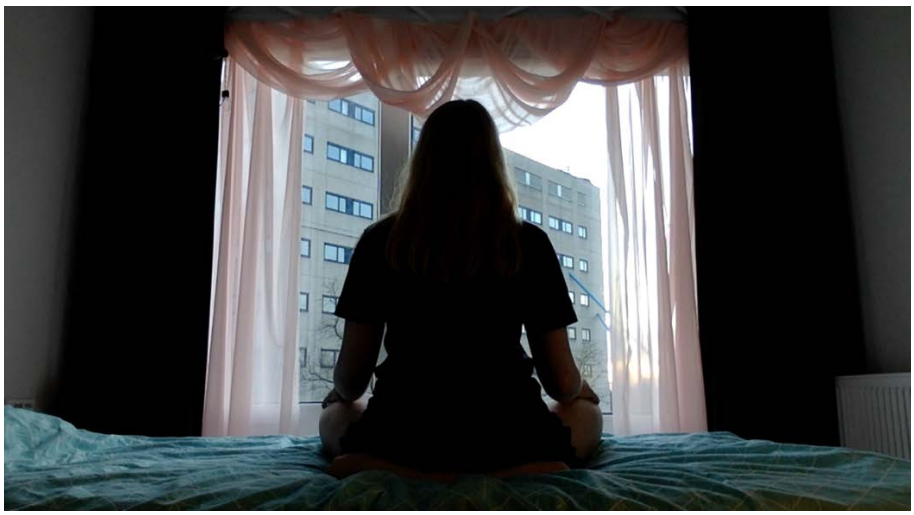

Figure 4-1: Meditation was commonly practiced whilst sitting on a bed and facing the window.

4.2 Yoga

Yoga was practised by following along with the guided videos by Adriene Mishler on her YouTube channel Yoga with Adriene [74]. These videos were chosen due to the pleasant personality and professional approach of the instructor and their free-of-charge nature.

Yoga was practised daily in a small studio apartment with limited space. Often, the furniture partially blocked the movement or the possibility to fully extend the body in a position. For example, when sitting on the ground and moving hands from the sides upwards to the sky, the table would block the movement of the arm. The poses or body orientation had to be adjusted occasionally to match these spatial restrictions (see Figure 4-2), e.g. turning sideways or moving the hands diagonally instead.

As a result, the flow of a yoga session was sometimes interrupted, and some poses differed from the ones in the instructional video. Fortunately, the instructor in the chosen video routines stresses the importance of adaptation and encourages everyone to explore the alternatives for poses. This helped to see the modifications caused by spatial restrictions as growth opportunities instead of a nuisance.

Figure 4-2: Due to spatial restrictions, some yoga poses had to be adjusted accordingly. The stretching pose shown in this picture originally requires the right arm to be extended to the side.

4.3 Contact improvisation

Contact improvisation (or contact improv) is a form of improvised dancing that focuses on bodily awareness and exploration, sharing touch, weight, body contact, and movement [75]. The author participated in a workshop held by the contact improvisation group Kahbam [76] with Loby Lam as

the instructor. Altogether there were eight people attending the session. This was the first time for the author to engage in contact improvisation activities although she had done improvisational theatre before. The topic of the workshop was “How to catch yourself while falling?” and it revolved around balance, leaning, falling, rolling, sliding, support, and weight distribution. Exercises were done individually, in pairs, or together with the whole group.

The movement was perceived best when not thinking about it and letting other participants guide the process (“going with the flow”). When the author deliberately focused on what she was doing or why, she felt unnatural, stuck, or uncomfortable.

The contact improvisation session increased body awareness, loosened up the body and refocused the mind away from daily worries, amplified the comfort and satisfaction of being in one’s own body, enabled the estrangement of habitual movement patterns and the discovery of alternative ones.

4.4 The Grinberg Method

The Grinberg Method is another way of increasing awareness of bodily sensations [77]. It is commonly done in person under the guidance of a professional practitioner. Due to restrictions posed by the novel coronavirus, this was not possible during this study. However, the author discovered a post [78] on the Reddit website looking for people interested in an online Grinberg session.

The session was done via the conference call platform Zoom and lasted for approximately one hour. The coach gave oral instructions to guide attention to specific areas of the body. He received visual feedback through the web camera pointed at the author. When engaging in the exercises, the author’s eyes remained closed to make it easier to focus on felt experiences. The topic of the Grinberg session revolved around guilt and how it manifests in the body.

During the session, the author was either standing up or sitting in a cross-legged position without back support. This turned out to be counterproductive as the tension in the body caused by keeping it upright was often not distinguishable from bodily sensations caused by emotions which were the main focus. Often, the instructor proposed certain feelings which he thought the author might be having. Sometimes, there was a mismatch between what was proposed and what the author actually felt. Due to being unable to put the actual feelings into words, the author often agreed with the proposed sensations to keep the session going. Occasionally, it felt as if certain bodily sensations were being forced upon the author despite them not being accurate.

The session was successful in raising body awareness and demonstrating the connection between mental states and bodily sensations as certain feelings associated with the guilt became very apparent when they were intentionally focused on.

4.5 Key findings

Engaging in the aforementioned relaxation practices estranged the author from the habitual, increased her bodily awareness and revealed various interactions and sensations that commonly go unnoticed in daily life. The following sections describe these findings in detail.

4.5.1 Increased bodily awareness

By engaging in the aforementioned practices, the author learned to deliberately listen to her soma and intentionally direct attention to it. This included, but was not limited to, recognising her posture and facial expressions (see Figure 4-3), the weight and weight distribution of the body, or the

temperature of various areas on her body, and noticing various inner functions, such as pulse, digestive activity, or muscle tension.

As a result, the author felt more in touch with her soma. Although fully feeling the soma still needed deliberate attention in the form of a body scan, it happened more often than before. Additionally, various bodily sensations, such as pain, hunger, or a rush of adrenaline, were recognised and acknowledged more easily.

Figure 4-3: Sensing facial expressions happens more often thanks to increased bodily awareness.

4.5.2 Connection between the physical body and mind

The indications of many mental states were recognised as physical sensations in the body. The Grinberg Method was especially useful for learning to make these connections. During that session, guilt as an emotion and the corresponding bodily sensations were looked at. The main symptom of guilt was tightness in the abdominal muscles. They were clenched and it felt as if the muscles were trying to collapse into themselves so as to create a black hole (see Figure 4-4).

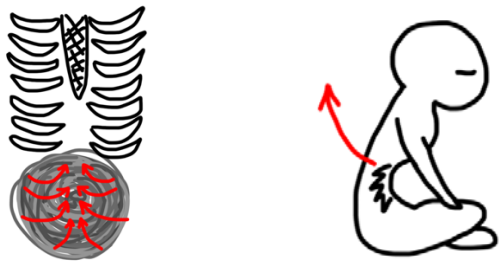

Figure 4-4: Guilt manifested as a black hole.

Shoulders experienced a variety of sensations (see Figure 4-5). They were heavy and being pressed down as if there were weights on both arms pulling downwards, yet it also felt like they were being lifted upwards instead of hanging loose. The most prominent feeling was alike to when someone grabs one from the arms with their hands and squeezes both shoulders, shaking the whole body as if to say, “Are you an idiot?!”.

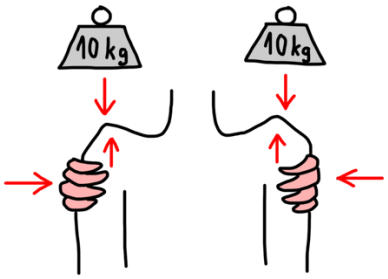

Figure 4-5: Shoulders experienced a variety of sensations.

In daily life, a feeling that sometimes appeared was anxiety, which was felt mainly in the chest. The sensation felt like there was a string wrapped around the sternum and an external force pulling up and backwards towards the spine.

Strong emotions, such as anger or annoyance, but also excitement and nervousness, were connected to an increase in heart rate and adrenaline secretion. Negative emotions were accompanied by tension in muscles and the jaw, complemented by shivering and the need to constantly keep the body in motion. Positive emotions created a lighter, more floaty feeling, and forcefully staying still was perceived to be restricting in this state as well.

All in all, the physical body and mind were found to be strongly connected, although bodily sensations were experienced more as symptoms of emotions, not vice versa. They were usually triggered by external events, e.g. an unpleasant phone call. However, by disrupting the physical body's habitual response to an emotion, e.g. by deliberately taking slower and longer breaths, the emotion could be reduced or stopped completely. This was useful when strong negative emotions were perceived as too overpowering and stressful.

4.5.3 Peculiar bodily sensations

Due to increased bodily awareness, the author was able to capture and describe the emergence of a variety of peculiar bodily sensations. These differ from regular sensory experiences because they appeared most commonly during meditation and other moments of stillness where the author was motionless. Despite not changing her position, she sometimes perceived changes in her posture, body shape, or the surface her body was touching. Thus, these sensations originated from inside, not as a result of any environmental changes.

After the contact improvisation session, the air felt thick when moving around in it, creating a sensation of floating in water whilst standing firmly with two feet on the ground. By imitating swimming motions with arms, the author felt like she was swimming through the air.

Body morphing was another distinct sensation. When sitting still in meditation, the author experienced her upper body change shape twice (see Figure 4-6). This first happened during the Grinberg session where the author felt her head and neck elongate and bend to the right into what felt a spiral. The second time was during a guided Headspace meditation session when the author got a similar feeling of her upper body lengthening and curling into a spiral, this time forward and down. During one guided body scan exercise, the author experienced a sensation of legs melting and bending away, as if they were boneless or like soft spaghetti curling into a backwards C-shape.

Sitting or floating on a cloud was experienced often. This could not have been due to the fact that most meditation sessions happened on a soft bed because the same feeling was also experienced while sitting on a hard, rocky asphalt surface. During one meditation session, clouds were felt underneath the palms placed on top of the knees (see Figure 4-6). The actual touchpoint of the limbs seemed to disappear, and the clouds created a feeling of hands being lifted upwards. Often, the author felt like a ball of warmth and light wrapped inside cotton or a soap bubble.

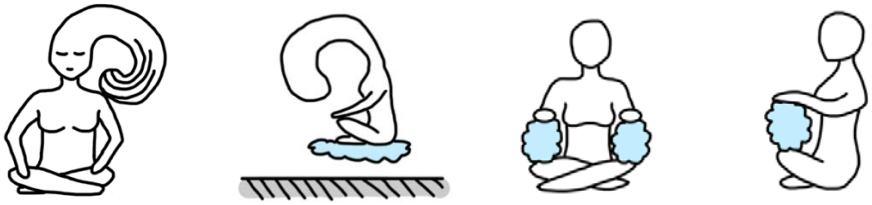

Figure 4-6: Peculiar sensations were experienced during the sessions, e.g. body morphing or floating.

4.5.4 Heartbeat and pulse

Many observations were made regarding heartbeat and pulse. Due to the increased bodily awareness, pulse was felt in various ways and places in the body (see Figure 4-7), such as hollow tension in the chest near the heart, stimulating pulsations near the groin, fingers, and neck, rhythmic beating in lower abdomen when lying on the stomach and in both upper and lower back when lying on the back, distinct pressure in the touch points of legs when sitting in a cross-legged position, and intervallic rush of blood in the back of the head during a headache. Occasionally, the heartbeat was so strong that it gently swayed the whole body when sitting still.

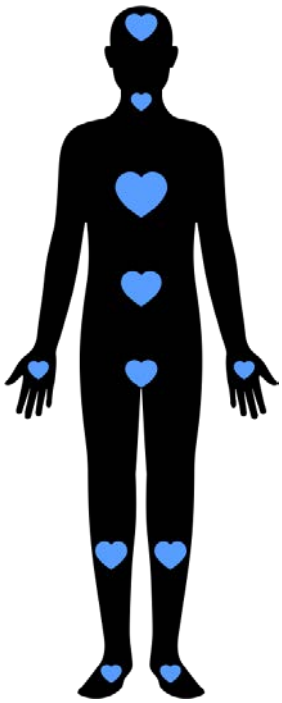

Figure 4-7: Pulse can be felt in various areas of the body.

A scientific installation at the Nemo Science Museum in Amsterdam revealed differences in heart rate between people. The installation used touch plate sensors and a speaker. Pulse was measured from hands positioned on the plates and a recording of the user's heartbeat was played back in a corresponding tempo from the speakers. The author visited the installation with a male friend. The author's heart rate was noticeably faster than that of the male friend.

Additionally, the author could distinctly feel how her heart beat faster when breathing in and slower when breathing out. This was a very peculiar and somewhat confusing sensation that alarmed the author at first. After repeated experience, however, it became very comforting.

Noticing the heartbeat created contradicting feelings. On the one hand, recognising the heartbeat showed how aware the author was of her inner bodily functions. It was an indicator of being alive and a direct reflection of activities and feelings. For example, heart rate was elevated during physical activity or excitement. On the other hand, the author's heart rate was often high, creating feelings of angst when noticed. For example, hearing high-tempo bass-intensive music often reminded the author of rapid heartbeat and induced anxiety, causing feelings of discomfort.

4.5.5 Increased perception of the environment

In addition to noticing the inner functioning of the body better, the senses which are used to perceive the surrounding sensory environment were also heightened. This included but was not

limited to feeling the pressure from the surface one is sitting or standing on, sensing fabrics, wind, sunshine, or moisture on the skin.

The mindful eating exercise was excellent for learning to pay attention to the environment. In that exercise, one had to notice all sensory aspects of a food item they were eating (see Figure 4-8), for example, its colour and patterns, light reflection and shades, texture, smell, or crunchiness. Habitually, one does not focus on food on such a level and does not notice the details. Intentionally focusing on all these sensory aspects of a seemingly trivial item made the author see it in a completely new light and enhanced the overall experience. This practice taught the author to notice and appreciate the present moment more.

This carried on to other situations in daily life. On the habitual route to the supermarket, stores that had been passed by multiple times before were noticed for the first time. The view from the window was taken in with a more curious gaze, discovering new sights. Wind or sunshine on the body was appreciated more. Focusing on the present moment enabled pushing away worries about the past or the future, thus calming the mind and creating a more relaxed feeling in the body.

Figure 4-8: During the mindful eating exercise, the author noticed all the sensory aspects of the food.

4.5.6 Eyes as the gateway for turning inwards

Humans are highly visual creatures. We get most of our information through sight. Meditation is often recommended to be done eyes closed or with a soft unfocused gaze. The Headspace app recommended shutting the eyes at every session. Closed eyes made it easier to direct attention inwards and to focus on the soma by eliminating the visual stimuli from the surroundings. Both bodily sensations and thoughts became more apparent and intrusive due to the lack of distractions.

Numerous patterns and visual effects appeared in front of the closed eyes. They were akin to a static television screen, a kaleidoscope, or a steady flow of water from the showerhead that is reflecting light (see Figure 4-9). The patterns were in constant change and appeared to be completely random (see Figure 4-10). The colour of the mental screen in front of closed eyes was dependent on the surrounding light. In a bright or sunny environment, it had an orange or pink shade. In the dark, the visuals appeared in shades of grey.

Closed eyes created a barrier between the soma and the surrounding world, eliciting a feeling of an individual entity wrapped in a bubble or a cotton capsule. The environment was still there and could be perceived, but there seemed to be a slight disconnection from it and a distinct boundary between the soma and the surroundings. It was akin to a hamster in a plastic exercise ball.

Having the eyes shut for some time seemed to reset the environment the author was in. When opening the eyes again, the world appeared to be brighter, clearer, and more vivid. Despite a visual impairment and not having the glasses on, the author perceived the environment as sharper, more detailed.

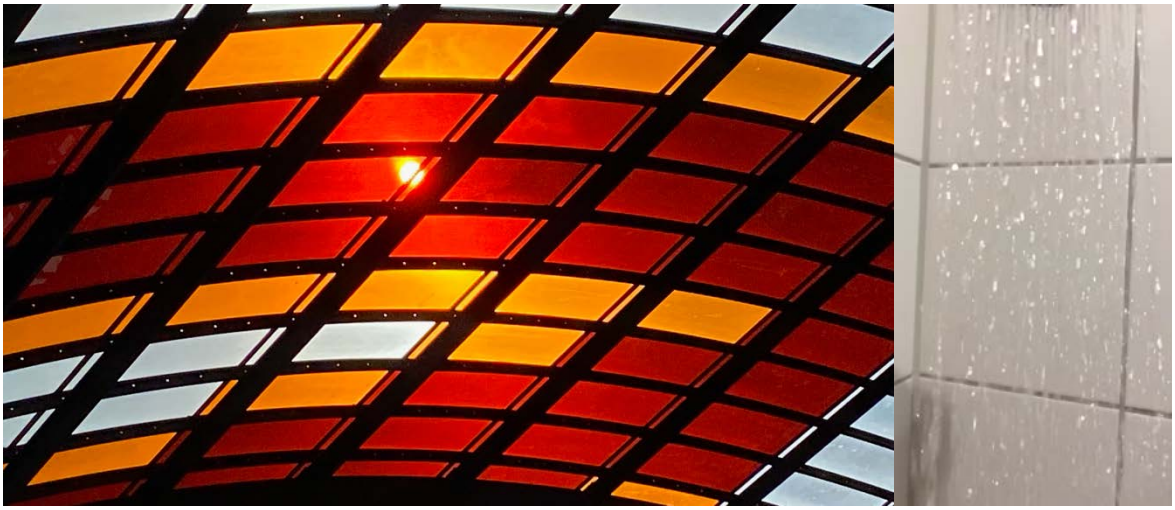

Figure 4-9: Visual effects that appeared when eyes are closed were similar to existing phenomena. Left: the glass roof of Amsterdam Central Station had the same colours and patterns as closed eyes during a sunny day. Right: water falling from a shower created a pattern alike the ones in front of closed eyelids.

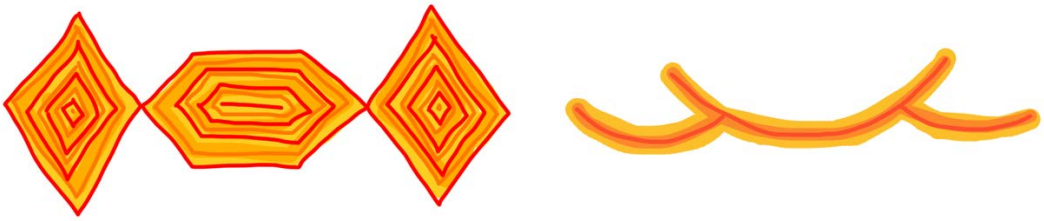

Figure 4-10: Examples of visuals that appeared in front of closed eyelids during meditation sessions. Left: an angular pattern. Right: an abstract pattern that reminded the author of a nose.

4.5.7 Pros and cons of guided sessions

Guided sessions of meditation and yoga are engaging and ensure that one remains focused throughout the session. The voice or video recordings lead the practitioner through the process, helping one direct attention to the appropriate places or reduce the cognitive workload of coming up with the next yoga pose.

On the other hand, they provide little freedom and possibility of exploration to the practitioner. Occasionally, misalignment occurs between the recording and the practitioner when the latter desires to remain at a certain stage for longer whilst the instructions keep progressing. This creates pressure to continue along with the recording instead of listening to one's soma.

Because of this mismatch between the pre-recorded instructions and the current state of the practitioner, some sessions were perceived to be either excruciatingly long and difficult or painfully short and easy. A perfect alignment between what the author expected and how the session actually looked like was rare.

4.6 Summary

Engaging with bodily awareness practices was successful in increasing the author's somatic awareness. It estranged the author from habitual and revealed novel experiences and interactions. It made the author pay more attention to her soma, for example, where and how she could feel her heartbeat.

As a basis for the design, the following points can be articulated. First, the soma experienced a large variety of feelings, both emotional and physical. Psychological and physical feelings were sometimes connected and influenced each other. Therefore, the design should allow for reflections on both types of somatic experiences. For making the user feel even more connected to their soma, it is hereby proposed that the meaning-making is left to the user instead of the system telling them what their felt experiences entitle. Therefore, the design itself is to present no right or wrong interpretations of someone's felt experiences but act as a medium for externalising them instead.

Eyes are a great way to separate oneself from the surroundings. Eyelids act as a gateway between the environment and a person. With closed eyes, focusing on one's bodily sensations becomes easier. Opening eyes again resets the environment, making it look more vivid. The design could take advantage of this effect and use a similar separation from the surrounding distractions to make it easier for the users to focus on their somas.

Due to the mismatch between individual progression and the pace of guided sessions, the author hereby decided against using any time-based guidance in the design. The users have to be given the chance to freely explore the design and move on at their own pace.

5 Misuse Magalogue

Somaesthetics is a combination of two: soma as one's body and mind and aesthetics as one's perceptual appreciation of the surrounding world [12, 13]. While the bodily practices analysed in the previous chapter were mostly oriented inwards to the author's soma, the following chapter focuses on the author's experience with sensory appreciation of the surrounding environment, namely the Sensiks sensory reality pod. Doing the somatic exploration both before and iteratively with the material exploration made it easier to notice the effects the environment had on the author's soma. It inspired the author to engage with the technology in a more open manner and to find creative non-habitual ways of both analysing and using the Sensiks pod.

When assessing the current design of the Sensiks sensory reality pods (see Appendix A), it appears that they are not sufficiently comfortable to elicit strong feelings of relaxation. The seating is hard and lacks affordances for alternative positions, the see-through glass door makes the user visible to passers-by, and there are disturbances from both the internal and external noise. By looking at the existing design, it can be claimed that the pods are mainly meant to be used for a short period of time and with strong audio-visual input.

To mediate the lack of comfort, this stage of the study looks into ways of using the pod that are different from how the design currently implies it should be used, i.e. how the Sensiks pod could be improved to support relaxation and somatic exploration. Therefore, this section is about misusing the pod – using it in a wrong or improper way [79]. The results of this material exploration stage were organised in a periodical design fiction publication called the Misuse Magalogue (see Appendix B). Design fiction enabled imagining an alternative approach, focusing strongly on the what-if aspect of design. Therefore, it was a great tool for presenting design modifications aimed at making the Sensiks pod more comfortable. A product catalogue format was also chosen for the reason that it can be added to any existing Sensiks pod as a manual, independent of the general design and content of the pod.

The following chapter presents excerpts from the Misuse Magalogue alongside with an analysis on why such modifications were chosen and how they influenced the author. The complete Misuse Magalogue is presented in Appendix B.

5.1 About the magalogue

Misuse Magalogue (see Figure 5-1) is a mix of a promotional catalogue and a high-quality magazine [80]. It is a fictional independent periodical publication released four times a year. Each edition focuses on a single company and its product offering but is not officially affiliated with any of the featured companies. The Sensiks edition of Misuse Magalogue revolved around the Sensiks sensory reality pods.

The main goal of Misuse Magalogue is to look into how the company's existing offering could be improved. The products sold in the magalogue are fictional and designed by Misuse Magalogue, not the featured company. They are the formulated results of material exploration. In some cases, the products themselves appear in an unmodified state, but with a different use case than what they have been designed for. Therefore, they can still be considered fictional. The Sensiks edition of the Misuse Magalogue features product offerings that make the pod more comfortable and customisable, e.g. pillows or curtains.

Additionally, Misuse Magalogue features content other than product offerings, such as articles, interviews, or tutorials. This content is about the subject relevant to the featured company and its product offering. Each edition of the magalogue is a holistic set of novel design ideas and accompanying content. The cover story of the Sensiks edition, for example, elaborated on various

positions one can take in the pod. The goal of this was to provide inspiration to the reader on how to position themselves in the Sensiks pod.

Figure 5-1: The cover of Misuse Magalogue Sensiks edition.

5.2 Concealing the pod with fabric hung on the door

This product offering of Misuse Magalogue targeted the see-through glass door of the Sensiks pod which could elicit unpleasant feelings of being on display if the pod was used without the virtual reality headset (see Appendix A). To make it more difficult for people to see into the pod, half see-through day curtain fabric was hung over the door (see Figure 5-2).

Two colours were compared - black and white. Originally, it was hypothesised that the black fabric would create strong feelings of claustrophobia. However, this did not happen. Although both white and black colour were represented in the interior of the pod, the black fabric looked more aesthetically pleasing than white. The black curtain contrasted with the white walls of the pod the same way as the existing black detailing of the seat, ventilator, and heater covers.

The fabric's opacity was tested in layers. With the black fabric, a single layer proved to be too thin to effectively conceal anything inside the pod when observed from outside. A double layer placement was optimal for providing a concealing effect while not appearing too grim as happened when the fabric as hung in three layers. A single layer of the white fabric was slightly thicker and, thus, less transparent than that of the black one. The white fabric hung in a single layer was already effective in concealing the inside of the pod while still enabling visibility from the inside to the outside. A double layer made it difficult to see through the door and with triple-layer placement only bright light spots originating from the windows of the room in which the pod was placed were visible. For reducing the feelings of being completely enclosed in a small space which could trigger claustrophobia, partial transparency was important. Therefore, an ideal setup featured either two layers of the black fabric or a single layer of the white one. This can and will deviate depending on the fabric and the subject.

With the fabric hung on the door in a way that it was completely outside the pod, the reflection of the user sitting inside was visible on the glass door. This created a slightly uneasy and unpleasant feeling. Having the fabric only on the inside of the pod further increased the concealing factor as the door mirrored the surroundings of the pod to anyone passing by it. However, having fabric on both sides of the door looked the most aesthetically pleasing and inviting.

The texture of the hung fabric also played a role in how it felt to be inside the pod. When placed as a flat panel, the door looked less like a passageway and more like an additional wall creating feelings of being trapped in a place with four surrounding walls. When placed like a curtain in a way that createed waves in the fabric, it looked more like a pathway that afforded to be walked through. With such ruffled fabric hanging on both sides of the door, one could even forget that there was a glass door underneath it and run right through it.

All in all, semi-opaque fabric placed in ruffles on both sides of the door was deemed as ideal for drawing in the people passing the pod while providing privacy to the user inside it.

Figure 5-2: Product offering from Misuse Magalogue: curtains to cover the glass door of the pod.

5.3 Providing softer seating with cushions

The original plywood board seat in the pod is hard and uncomfortable, especially if one sits there for an extended period of time. To make sitting more pleasant, adding cushions was explored (see Figure 5-3). Decorative pillows from the couch at XRBase were used for this purpose.

At first, a single thin pillow placed under one's buttocks seemed enough to make sitting more comfortable. After a while, however, the pillow was flattened and did not provide enough buffer. The hard seat became apparent again. Two pillows on top of each other provided more bolster but tended to slide off each other. Therefore, a thick pillow worked best. A cushion placed under the feet on the floor of the pod elevated legs so that the author could not feel the edge of the seat cut into the backside of her thighs. This could be helpful for users with shorter legs that do not comfortably reach the floor otherwise.

Having pillows between the back and the backrest of the bench is another option. A pillow positioned in the lumbar curve provided support to the whole back if fit snugly between the backrest and the lower back. Adding a pillow behind the upper back lost that support and added nothing. Holding a pillow in front of the stomach with arms wrapped around it elicited feelings of safety and warmth. The intertwined arms rested on each other and no effort was needed for keeping them elevated. Alternatively, it provided a solution to the unpleasant tension one got in the shoulders when trying to place hands on a bare bench next to the hips instead as the seat was too far to be reached.

Cushions definitely made sitting in the pod more convenient as a softer surface as less straining for the buttocks. For the author, the optimal placement in regard to comfort appeared to be with a single thick pillow under the buttocks, one behind the lower back, one under the feet, and one held in a hugging position in front of the stomach.

Figure 5-3: Product offering from Misuse Magalogue: cushions for softer seating.

5.4 Positions in the pod

Although the pod is mainly intended to be used while sitting, there are multiple variations of how one can position themselves inside the pod (see Figure 5-4). These positions do not come naturally as the pod lacks the necessary affordances in its original state, i.e. there is currently just one distinct backrest. The author had to take various poses intentionally to discover alternative positions in the pod.

The bench was slightly too narrow to comfortably sit on it with crossed legs. This position was possible, but it felt like legs might slip off the bench at any moment. Putting a pillow under the hips helped a bit as it lifts up the lower body and makes the position narrower, thus using less of the bench's depth.

Sitting sideways on the floor felt surprisingly nice. Being surrounded by wall-like structures on all sides elicited feelings of being enclosed and held. Although the body appeared small and

compressed, sitting like that still felt safe and secure. Despite the surrounding hard surfaces, it reminded the author of being wrapped in a soft cloud, much like meditation did (see Section 4.5.3). As the back was positioned directly in front of a speaker, lower frequency sounds could be felt with the body. The sound, however, lost its spatiality as all sounds appeared to originate from either behind, in front of, or high above the user.

Figure 5-4: Exploring alternative ways of sitting in the pod.

Sitting in the same sideways position on the bench felt more open and less secure. The emptiness on the side towards the door created the effect of sitting on the edge of a canyon. Due to the slight tilt in the bench, bent legs and torso tended to sink sideways towards the backrest. The covers of the heating panels provided an excellent means of modifying this position as they could be used for elevating the feet on various levels.

Lying on the bench was nearly impossible and depended mainly on the height of the person. When lying on the side with hips and torso flat on the bench and legs extended towards the ground one felt crouched and pressed together. The body was twisted under weird angles, especially at the hips. When lying on the back, legs tended to fall downwards due to gravity. Keeping them extended at a 90-degree angle against the wall needed conscious effort.

Sitting with legs on the ground seemed to be the most intuitive position to engage in. However, sitting sideways either on the floor or on the bench was the most comfortable for the author.

5.5 Estrangement of sitting positions

One of the articles in Misuse Magalogue is a guide to sitting positions. This is a result of defamiliarizing interactions that are commonly habitual and engaged in unconsciously. Such interactions often go unnoticed. The corresponding section in Misuse Magalogue brings out a variety of the nuanced ways people might sit in the pod and describes them in a humorous key.

When writing these descriptions, it was discovered that ways of sitting are sometimes influenced by culture and norms. For example, the position Unladylike which portrays the female author sitting with legs slightly parted indicated how the author was influenced by the norm of men sitting with legs spread apart and women expected to keep their legs closed (see Figure 5-5). Remarkably, taking a "manly" photo of sitting with legs spread apart was even experienced as uncomfortable and unnatural while the cross-legged poses where the groin is also exposed did not elicit such feelings.

Additionally, as the pods are contextually situated, one always enters the pod with some pre-existing mindset. Entering the pod does not erase what has happened to the user before. The author, for example, had to cycle for 40 minutes before reaching the pod, often either admiring the beautiful route or getting frustrated with the traffic. These emotions, bodily feelings, and previous events are not left outside the pod but taken inside as they are an integral part of the user. Thus, the sitting positions one engages in by default might also be influenced by the previous experiences, e.g. crouched positions, such as the Bent Pretzel or the "O", could be preferred when feeling tired or sad while spread and extended positions, such as the "W", could feel more natural when experiencing positive emotions (see Figure 5-6).

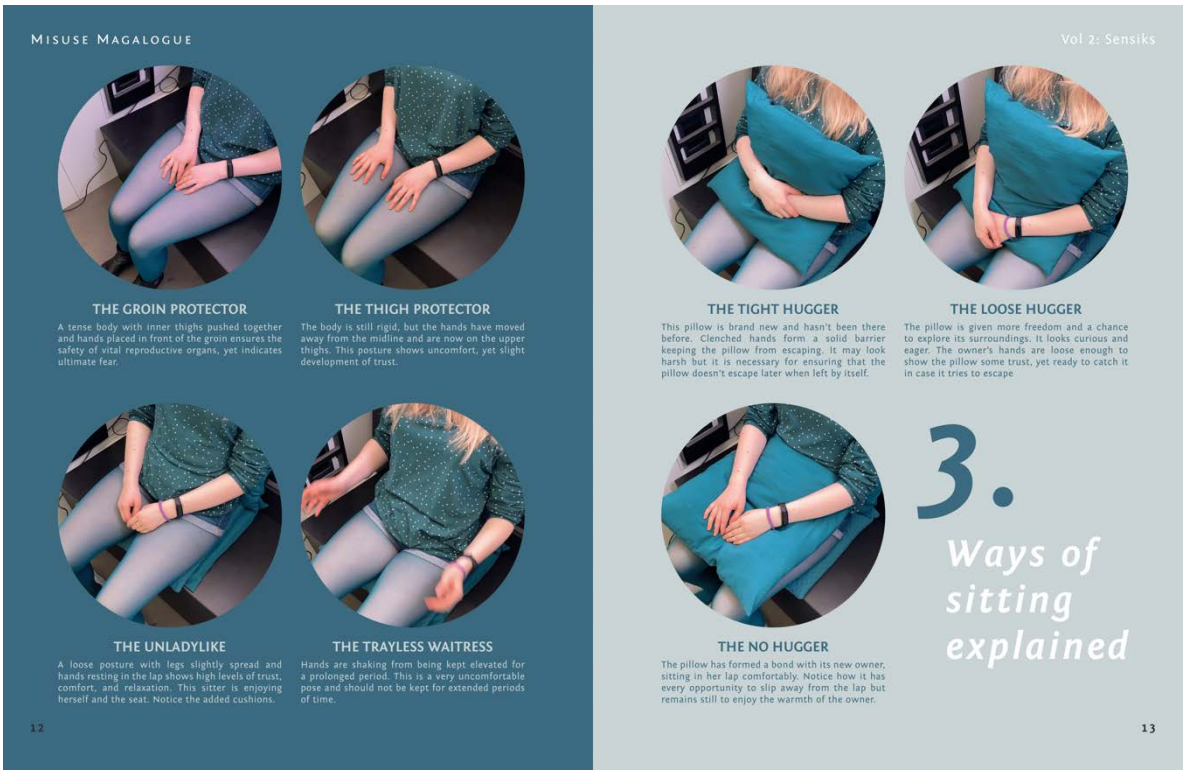

Figure 5-5: Sitting positions were influenced by cultural norms, such as the Unladylike in bottom left corner.

Interestingly, more positions were discovered and found to be more comfortable when wearing loose clothing as opposed to shoes and jeans which might have restricted movement. Discarding the footwear made it more inviting to try out various positions as the author no longer worried about making the surfaces dirty. This shows that wearing suitable clothing is a prerequisite for perceiving the interactions as comfortable.

Descriptions on page 13 of Misuse Magalogue are examples of personification (see Figure 5-5). The pillow as an inanimate object is given lifelike characteristics, such as free will and a desire to escape. The poses show symbiotic character development where a bond is created between the pillow and the user of the pod. As a result of this personification, the author began to look at the objects inside the pod differently and in a more empathetic way, seeing the pod more like a living

organism than a piece of inanimate technology. This can be used to show the pod as an extension of the user's soma or as a constantly changing environment that is partially influenced by the user and their actions, e.g. through temperature exchange or breathing.

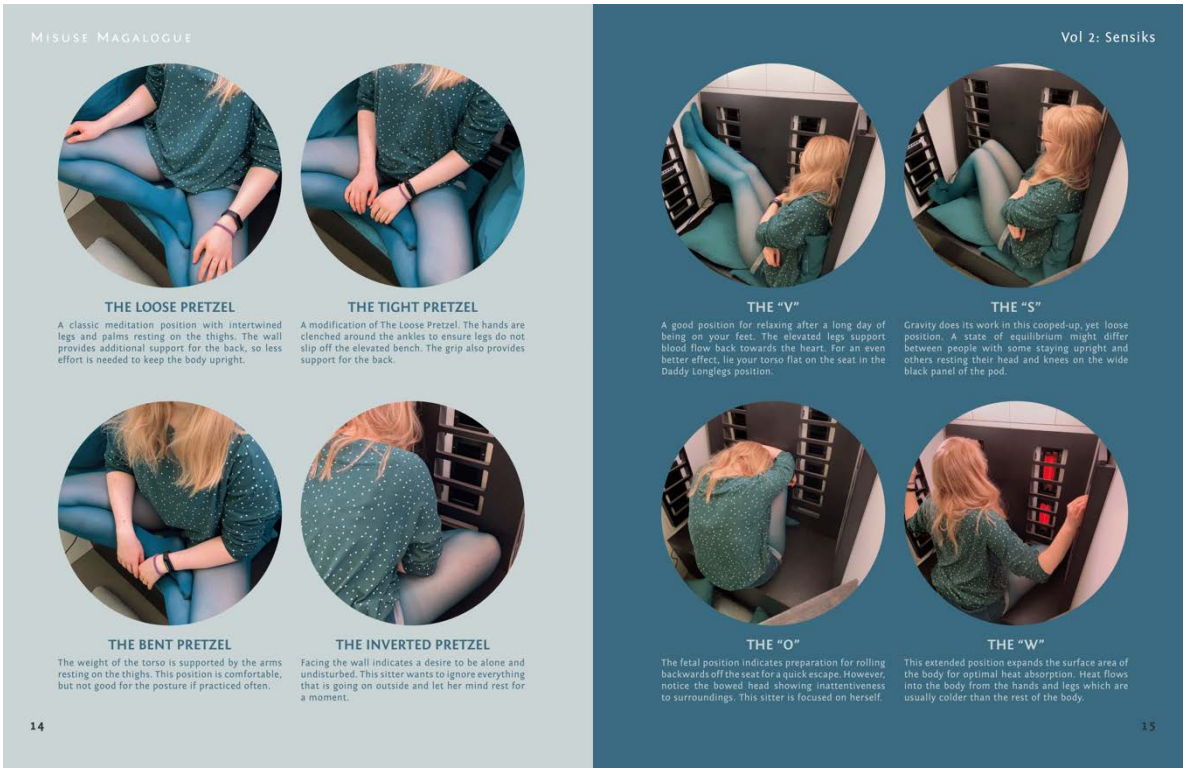

Figure 5-6: The positions might be dependent on previous experiences that happened before entering the pod.

5.6 Custom olfactory landscape

The author did not find the scents incorporated in the Sensiks pod particularly pleasant. This preference for scents, of course, is highly subjective as some people enjoy sweeter scents and others fresher, more sour ones. Unfortunately, the Sensiks pod did not enable replacing their scents easily at the time of working on this study as they were closely tied to pre-designed experiences and hardware.

However, to demonstrate how easy it is to make the pod more pleasant when it comes to scents, Misuse Magalogue features a tutorial on making custom scents using common household products, such as a spray bottle and shampoo (see Figure 5-7). The main idea is to use a mixture of a scented product and water that is dispensed from the nozzle of a spray bottle. Such low-fidelity prototype was already usable in the pod as it was separate from the existing system and relies on manual operation. This alternative way of incorporating scents was just as effective as using the built-in scent dispenser albeit spraying the liquid from the bottle created more moisture.

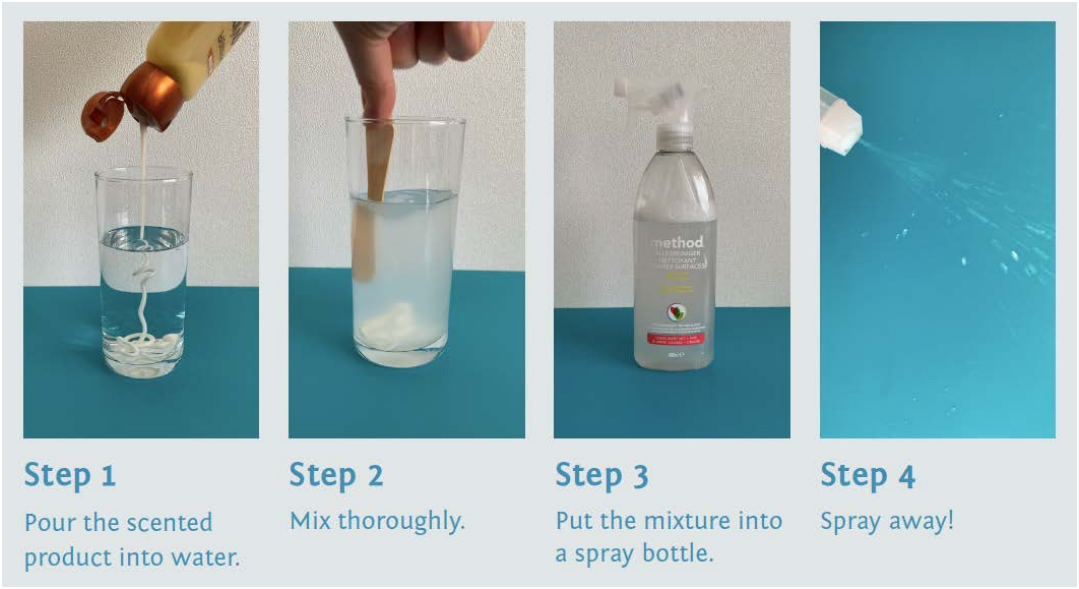

Figure 5-7: Excerpt from Misuse Magalogue on how to make custom scents using a mixture of an existing scented product and water in a spray bottle.

5.7 Extended control panel

As mentioned in the design critique (see Appendix A), the built-in control panel was not ergonomic to use for longer interactions. As a workaround, the remote-control application TeamViewer* was used to make a connection to the pod computer. Such a setup enabled using the pod's control panel and changing the settings of the sensory stimuli at a distance. Any device supporting TeamViewer could be used for this purpose. The advantage of a laptop is its big screen while a smartphone excels with its portability. A tablet computer was hypothesised to be the most comfortable mobile replacement for the built-in computer screen as it combines the larger screen size of a laptop computer with the compact measurements of a phone. This hypothesis was not tested due to the lack of a tablet computer.

5.8 Summary

There were many learnings this section revealed that were summed up in the Misuse Magalogue. First and foremost, there were ways of making the Sensiks pod more comfortable and supportive of relaxation. Covering the door with fabric increased the privacy and reduced the intrusiveness of the gazes of passers-by. Custom scents enabled tailoring to individual preferences. Controlling the pod through TeamViewer running on an external device made using it more ergonomic and flexible. Engaging in various sitting positions and incorporating soft cushions made the seating less formal and more relaxing.

The way one sits is often habitual and not consciously focused on. Most sitting positions experimented with here did not come naturally as the pod had only limited affordances for supporting alternative sitting positions. Moreover, comfortable clothing played a role in discovering a multitude of possible positions. Removing one's footwear was already helpful in encouraging position exploration. Personifying the pod and objects in it increased empathy towards the pod as a living organism instead of an inanimate object. The design could, for example, be a representation of a live creature or physiological feature.

* https://www.teamviewer.com/

6 Design proposal for the Gallery of Heartbeats

Based on the somatic and material explorations (see Chapters 4 and 5, Appendix A, Appendix C), a design proposal for using sensory stimuli to increase bodily awareness and social communication was formulated. The design has multiple goals. First, to increase general bodily awareness of the user. Second, to make them think closely about the heartbeat as a commonly unnoticeable aspect of their somas and its meaning. Third, to provide a way of sharing a hidden physiological feature that is commonly unnoticeable by other people. Fourth, to create an immersive sensory experience in the context of relaxation using the Sensiks sensory reality pod.

This all results in the Gallery of Heartbeats – a sensory experience aimed at increasing awareness of the heartbeat of self and others. Gallery of Heartbeats supports individual reflections, providing the user with real-time multisensory biofeedback on their own heart rate. It also encourages social communication of this intimate commonly unnoticed physiological feature, allowing users to record and store their heartbeat to a gallery and experience the pre-recorded heartbeats of others in a multisensory way. The design is an abstract external representation of the human heart with focus on its concealment, pulsations, warmth and constant flow of energy. The following chapter describes the features of the experience and connections between the features and the aforementioned explorations.

6.1 Motivation

Humans know and recognise each other mostly by visual or auditory appearance, i.e. faces and voices. In more intimate relations, other modalities, such as body temperature, scent, or breathing, can also be present. Yet the first thing the world knows a person by is their heartbeat. A heartbeat can be observed as early as the fourth week of prenatal development [81]. Until facial features finish developing, the heartbeat is the only thing that describes and identifies a person. It is an indication of a new life and watched very closely throughout the prenatal development.

Once the baby is born, recognising them by their heartbeat suddenly stops. From that moment onwards, the person is identified by their appearance and voice. The heartbeat of another person is only noticed in a medical context or when lying on the chest of a loved one. The heart becomes hidden and unnoticed by others, despite being such an integral part of a person. The Gallery of Heartbeats takes one back to a mother's womb where the heartbeat was the first thing notifying the world of a new life. The Gallery of Heartbeats allows one to record, compare, feel and share their heartbeat to make this hidden physiological phenomenon more explicit.

The heartbeat as the target feature was chosen due to its contradicting nature. When engaging with the somatic exploration, the heartbeat was noticed in various locations on the body both during moments of tranquillity and strain (see Section 4.5.4). It was experienced as strong and scary, yet captivating and hypnotic. The heartbeat differed both between people and within the author herself depending on her emotions, activities, or time of the day. The heartbeat was also perceived differently in different contexts, e.g. medical or intimate. Thus, it became clear that the as isw multi-layered and worth designing for.

6.2 Views

The Gallery of Heartbeats can be divided into two distinct parts: the outwards appearance (including the interior of the pod) aka hardware and the software*. The design of the outwards appearance aims to create feelings of seclusion, separation from the outside world and comfort.

* https://github.com/3v4m4r14/msc-pod

The main goal of the software is to use biofeedback to show the user their heart rate. The software is divided into four main views and an idle screensaver (see Figure 6-1). The “recording” view provides real-time biofeedback through the heart rate sensor (see Appendix C) and enables the user to record the data from the sensor.

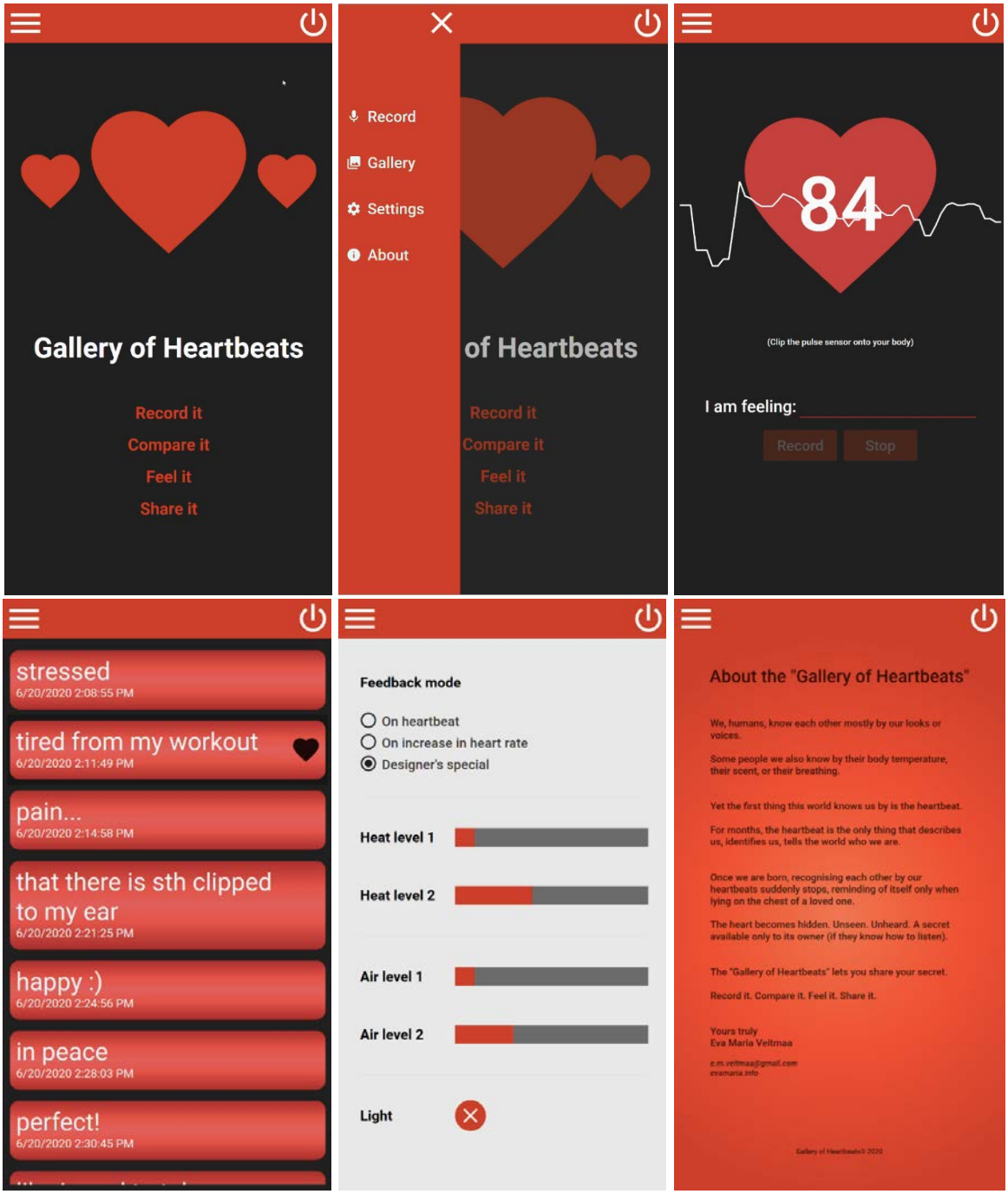

Figure 6-1: The software application has five views. Up left: idle view. Up middle: idle view with menu panel open. Up right: recording view. Down left: gallery view. Down middle: settings view. Down right: about view.

The “gallery” view contains all previous recordings taken with the Gallery of Heartbeats. The user can scroll through the list of heartbeats and play them back using heat, airflow, lights and sound. The gallery enables experiencing the heartbeats in a multisensory manner to create a more immersive and tangible experience.

The “settings” view enables controlling the mode of feedback and levels of the sensory stimuli. Each user can create a custom experience tailored to their own preferences. The default settings are created by the author as a result of her explorations (see Appendix C). While the auditory feedback is present in both recording and gallery views, in the prototype, the heat and airflow are only present at the gallery view to avoid signal disturbances during real-time feedback (see Appendix C). Ideally, the multisensory feedback would also happen during live biofeedback.

The “about” view presents a manifesto for the Gallery of Heartbeats. It explains the reason for designing it (see Section 6.1) and includes the author’s contact information.

6.3 Haven for retreat

From the material explorations (see Chapter 5 and Appendix A), it became apparent that the aesthetics of the environment are important for creating a pleasant atmosphere. The Gallery of Heartbeats aims to be comfortable and seclusive, providing a place to retreat to when one wishes to be with themselves.

One of the key factors for feeling comfortable was not having an impression of being on display (see Section 5.2). To achieve that, the pod’s door is covered with a long black half-opaque curtain (see Figure 6-2). The curtain acts akin to eyelids, separating the interior of the pod from the surrounding environment (see Section 4.5.6). When the door and the curtain are closed, the user is slightly disconnected from the external world. One can still see the surroundings through the curtain, but they are more distant and concealed. Such a separation further induces the feelings of being back inside a mother’s womb. The pod is a small and confined space. The user is surrounded by all sides with either walls or a curtain, creating feelings of safety and being held. Such design also supports withdrawing from the habitual daily life and simply being with oneself.

Additionally, as was noticed during meditation sessions, having the eyes shut for a while seemed to make the environment brighter and more vivid afterwards. The dim interior of the pod combined with the curtain as a gateway ensures that the surrounding world appears to be richer and clearer after experiencing the Gallery of Heartbeats.

Figure 6-2: The curtain separates the interior of the pod from the outside world.

The need for comfortable seating was another factor that emerged from the material exploration (see Section 5.3). For the Gallery of Heartbeats, the pod features some loose cushions on the seat

(see Figure 6-3). This is to make the seating softer and, thus, encourage staying in the pod for longer. Loose pillows also afford being moved and repositioned. That way, the user can play around with cushion combinations and seating positions to find what feels the most comfortable to them.

The pod is to have a pair of slippers outside, right next to it. This encourages the user to take off their footwear and leave it outside the pod. The aim is to have the user try out alternative sitting positions in the pod (see Section 5.4), experimenting with what feels good to them. However, the user should not feel forced to remove their footwear. Perhaps they do not have presentable socks or have been keeping their shoes on all day. Hence, taking the footwear off is not a requirement and the Gallery of Heartbeats can be successfully used nevertheless. Because of the novel coronavirus, close contact and item sharing is avoided. Therefore, the design prototype used in evaluation sessions (see Chapter 7) does not feature any slippers.

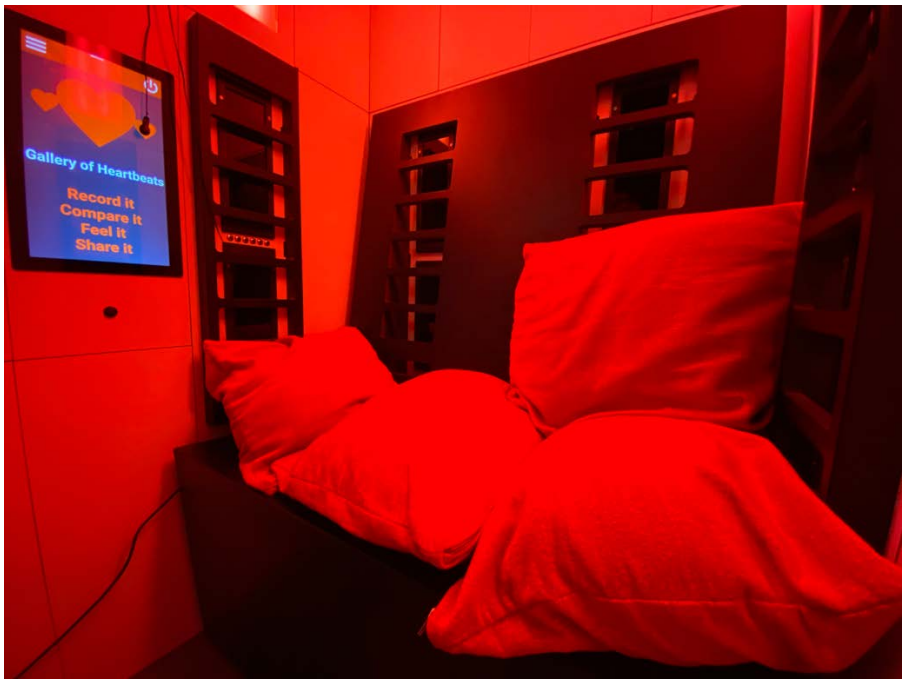

Figure 6-3: Cushions provide a more comfortable seating and can be moved around freely.

6.4 Red and orange as symbols of the heart and meditation

Red and orange are chosen as the main colours of the experience. In Western culture, hearts are usually represented using the red colour. Dark red is also the colour of blood. In that way, the pod is a representation of the organ investigated. Orange is chosen because of the patterns behind closed eyes that the author experienced during meditation (see Section 4.5.6). Thus, the colour scheme is also inspired by the act of looking inward. In software, these colours are accentuated with the use of black as a background or text colour. Black provides a neutral background and brings the bright colours out well.

The lights inside the pod are a lighter shade of red, almost orange (see Figure 6-4). To give users a better sense of their environment, the lights within the pod are on when no playback is activated. Having the lights on is safer and less threatening than no lights. If the lights were off, the users entering the pod from a bright external environment would need some time for their eyes to adjust to the darkness of the pod. During the moment of adjustment, the user has no idea what is inside the pod and that can feel unsafe. With lights on, they have an overview of the contents of the pod. The lights are also partly visible through the opaque curtains and make the pod inviting, yet mysterious.

Figure 6-4: The light inside the pod is a lighter shade of red, although the phone camera captures it as bright red.

6.5 Supporting somatic explorations and introspective reflections

Ideally, the pulse would be measured non-invasively without any effort from the user, e.g. by using an infrared camera from the distance or, alternatively, by having the pulse sensor embedded in a pillow that the user holds or sits on. However, such technology was not available when making the prototype. Therefore, an ear clip pulse sensor is used instead (see Appendix C).

To support independent explorations with the sensor, no explicit guidelines are given about where to position it on the body. The prompt simply states, “Clip the pulse sensor onto your body” (see Figure 6-5). This way, the user is encouraged to think of places on their body where they could attach the sensor. They are expected to experiment with the sensor placements to find out what works and how (see Appendix C). As a result, they consciously pay more attention to their soma.

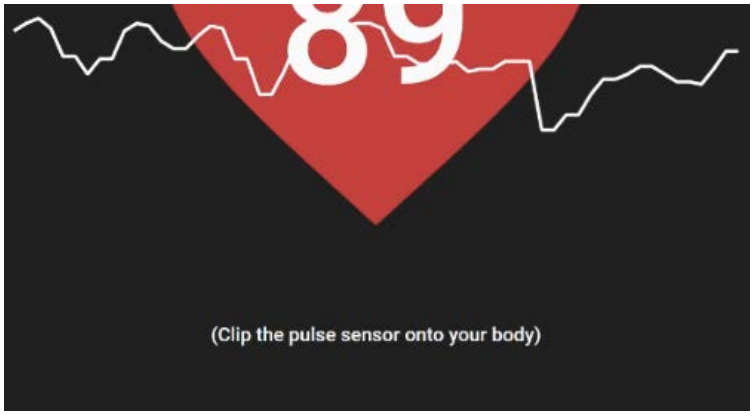

Figure 6-5: A vague prompt about sensor placement leaves room for somatic exploration.

Recordings have identifiers which consist of a timestamp and a title entered by the user. The prompt states, “I am feeling” and allows the user to enter their own freeform input (see Figure 6-6). Such a prompt allows for both mental descriptions (sad, happy) and bodily sensations (pain, itchiness). It makes the user focus on their soma by taking a moment for introspective reflection before the recording. The prompt is inspired by body scans that the author engaged in during

mindfulness meditation and is a technique for systematically scanning through the body to notice various sensations.

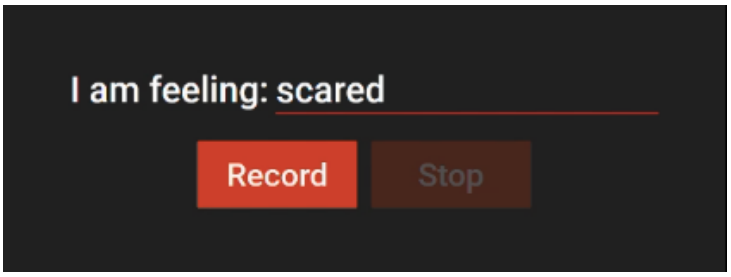

Figure 6-6: The title prompt makes the user pay attention to their soma and allows for both physical and psychological feelings.

The "recording" view of the Gallery of Heartbeats provides the user with real-time biofeedback on the heartbeat and enables recording it (also see Appendix C). Ideally, the real-time feedback would be given using sensory stimuli, such as heat pulses. However, due to the interference from the heat panels, the pulse sensor cannot be used at the same time as the infrared panels. Therefore, in the prototype, the feedback is provided in three distinct ways (see Figure 6-7).

First, the view presents the numerical value of the current heart rate in beats per minute (bpm). This allows the user to make mental connections between their current heart rate and previous knowledge, such as their previously measured heart rate. Numerical data also quantifies the heartbeat and makes it easier to describe afterwards. Second, the heartbeat is represented as a graph with the horizontal axis being time and the vertical axis being bpm. The graph line enables the user to observe subtle changes and irregularities over time. It visualises the dynamics of the heart, for example, how breathing or movement influence the heart rate.

The previous two are complemented by an audio recording of a heartbeat. The auditory feedback makes the heartbeat even easier to observe as the user does not have to look at the screen at all. The audio is also the most comprehensible and direct mode of feedback as people are used to experiencing their heartbeat as tangible vibrations (e.g. measuring pulse with fingers on a wrist, throbbing in chest) or rhythmic sounds (e.g. drumming in ears, blood rushing through the head during a headache). With the aforementioned numerical or graphical feedback, the user would have to convert the numerical data to a rhythm to compare it to their felt pulse at that moment or vice versa. Audio guidance in the form of instructions is avoided for two reasons. First, that would provide the user with a goal which goes against the presence-with digital mindfulness principles (see Section 2.4). Second, it may not be perfectly aligned with the user's expectations (see Section 4.5.7) and, thus, be counter-effective.

Figure 6-7: Real-time biofeedback is provided through a number, a graph, and audio.

The heartbeat can also be recorded. It is saved as regularly polled heart rate values. The length of the recording is determined by the user. This way, the user is given the freedom to decide how much they want to share the personal and intimate aspect of their heartbeat. All recordings are added to a gallery.

The gallery part features recordings from people who have previously used the Gallery of Heartbeats and decided to add their heartbeat. There are two options for the gallery – to store and show the information locally or globally. In the first case, the gallery includes recordings from the specific pod it is running from. This ties the recordings to a tangible location and creates a feeling of closeness over time. By showing recordings from all pods, more people are reached and included, creating an additional feeling of closeness over distance. The prototype used in evaluations (see Chapter 7) features recordings from a single pod.

Two or more recordings can have the same title as the users are given freedom to name the recordings after their experienced feelings. Timestamps are used to differentiate between recordings. In case of a globally connected pod, the pod's name or location is also used. Time and location also give some additional context about the author of the recording.

A heart icon is used to indicate the currently selected track (see Figure 6-8). It is essential to show the user which track is currently active as recordings can sound the same. When the recording is playing back, the heart icon is pulsating. When the recording is paused or stopped, the icon remains static. A progress bar in the background indicates the length of the recording. Since recordings do not have a predetermined length and depend completely on how long the user decided to record, they can differ in length. The prototype does not have the progress bar implemented.

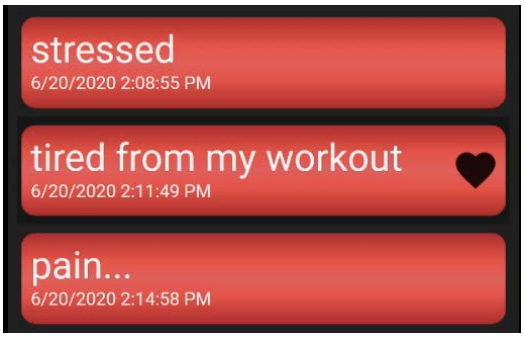

Figure 6-8: A heart icon shows which recording is selected.

6.6 Customisation of sensory stimuli

Since the author could not establish a single perfect combination of sensory stimuli that would work for her independent of the situation (see Appendix C), a need for customisation became vital. The settings panel gives users the freedom of selecting which sensory stimuli they want present during playback, in what mode, and how intensely (see Figure 6-9). That way, everyone can create their own ideal sensory experience and tweak it to their preferences at any given moment.

The pod provides four main stimuli: heat, airflow, light, and audio. Heat essentially wraps the user into a nice warm casing while airflow acts as an opposite and cools the user down. These two complement each other. They also act as an extension or representation of the human body: heat panels as an analogy to body temperature and ventilators as an analogy to breathing. Scent and virtual reality are omitted from the experience as they were perceived as too distracting by the author. Screen use is aimed to be minimised by having fewer and more basic features and a simple user interface.

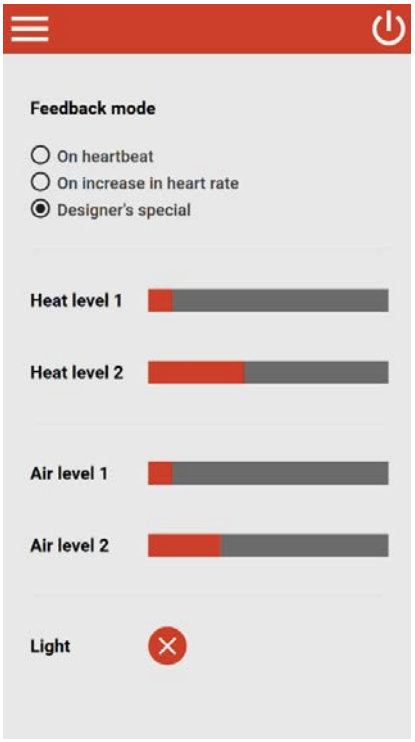

Figure 6-9: The settings panel enables tailoring the experience to each user's preferences.

There are three modes for how sensory actuators behave during playback (see Figure 6-10). The stimuli are either on when heart rate increases and off when it decreases, the stimuli are on as pulsations that correspond to each heartbeat, or a mix of those two modes. The latter is referred to as the "designer's special" and originates from experimenting with various sensory stimuli combinations (see Appendix C). The "designer's special" has heat as pulses in accordance with heartbeats and airflow turned on during inhalation and off during exhalation.

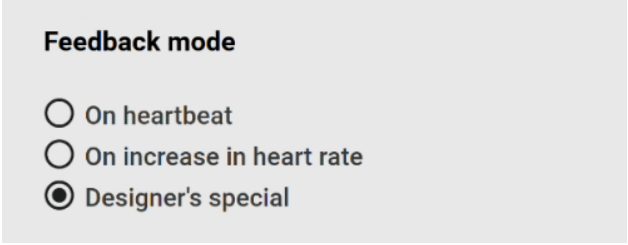

Figure 6-10: There are three different feedback modes.

The sensory stimuli's intensity can be set between 0 to 100% (see Figure 6-11). This posed a problem with naming the settings. Originally, it was proposed to name the stimuli "[stimulus] on" and "[stimulus] off". However, "off" does not necessarily have to be on a lower level than "on", e.g. the "on" setting can be set to 0% and "off" to 100%. A naming like that would cause a mismatch between the mental model of the user and the behaviour of the pod. Therefore, the settings are instead named as "[stimulus] level 1" and "[stimulus] level 2" to separate the two different intensities.

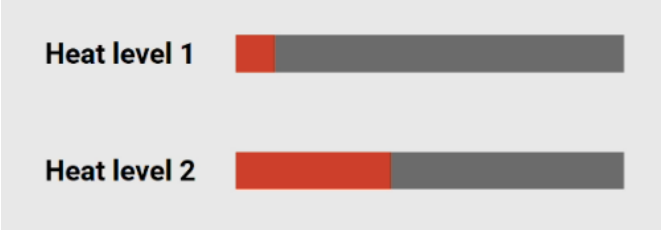

Figure 6-11: The intensity of the sensory stimuli can be set between 0 and 100%.

6.7 Summary

The Gallery of Heartbeats presents a design for increasing bodily awareness and supporting individual reflections by externalising a selected biosignal – the heartbeat. It acts as a means for social communication, allowing the user to share their heartbeat either in real-time or by recording and storing it into an archive. The physical design with its red colour gamma and concealed space represents the human heart and life. That analogy is further reinforced through sensory stimuli, especially the pulsating heat.

The Sensiks pod that is converted to the Gallery of Heartbeats becomes a secret haven, a place to retreat to with the goal of relaxation and being with oneself in the present moment. It provides seclusion and separation from the outside world, its troubles and nervousness. The Gallery of Heartbeats offers the possibility of moulding it to every user's individual preferences by allowing the users to change the settings of sensory stimuli and experiment with the positioning of the cushions inside the pod. That way, each user can create the environment they feel the most comfortable in at that present moment.

The Gallery of Heartbeats is also an archive of people that have visited it and recorded their heartbeats. It collects snapshots of people throughout time. The recordings capture how the user felt, but not necessarily who they were. Cardiovascular activity is tied to what each user assessed themselves to feel at the time of recording. Through this, the Gallery of Heartbeats triggers curiosity and raises empathy – users are given endless free space to wonder who the previous people using the pod were, what they were feeling at the time of their visit, and why. As an archive, the communication channel has a time delay, separating current users from the ones that came before.

7 Results

To evaluate the design proposal, the prototype was tested with people other than the author through interviews and contextual inquiry. The goal was to find out how the users perceive the Gallery of Heartbeats from the perspective of increasing bodily awareness and supporting social communication of the heartbeat. Five people participated in the evaluation: one at a pilot session (Mary) and four as official participants (James, Mike, Peter, Oliver*). There were one female and four male participants. The age of the participants ranged from 22 to 27 years. The participants had international backgrounds, coming from the Netherlands, Ireland, Germany, and New Zealand. The sessions were conducted in English. All participants had high levels of proficiency in English, although expressing their bodily feelings and opinions might have been more restrictive for non-native English speakers, including the researcher, due to less eloquent vocabulary. All but one participant consented to having photo- and videographic material of them used publicly. None of the participants had previous hands-on experience with the Sensiks sensory reality pod, although two of the participants (James and Mike) work at XRBase and pass by the pod regularly.

The results were thematically structured using affinity diagrams (see Figure 7-1). General feedback varied a lot amongst the participants. James and Peter perceived the design as relaxing and peaceful, although Peter was not completely sure what the purpose of the Gallery of Heartbeats was. Oliver needed some time to figure out how everything works. Mike wished for clearer instructions of use, such as where to position the pulse sensor, how to use the Gallery of Heartbeats and for what purpose.

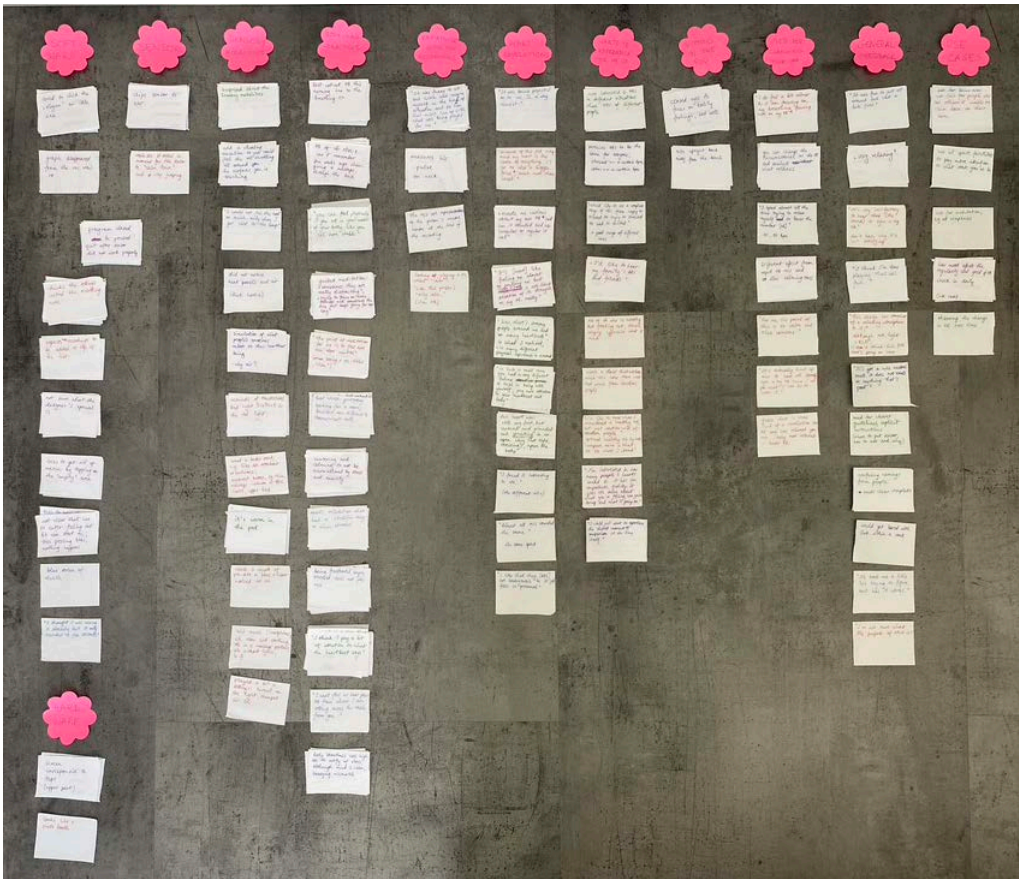

Figure 7-1: The affinity diagram enables thematic sorting of the data from all five interviews.

* All names changed.

Mike and Oliver also desired a more concrete framework for adding the recordings, e.g. templates of feelings to choose from. They pointed out the inconsistency caused by free-form input, difficulties grouping and comparing the data. Oliver expressed doubts about whether the recording titles actually correspond to the feelings experienced by the authors of the recordings. He expected to see universal truth instead of people's own interpretations of their experiences.

Various usability issues were also discovered, such as the sensitivity of the pulse sensor or unresponsiveness of the touch screen. Since the main focus of this study is on experience design, these usability issues are presented separately (see Appendix L). The following chapter elaborates on feedback on the experience with the main emphasis on the perceptions of the heartbeat and sensory stimuli.

Overall, the Gallery of Heartbeats made participants more aware of their heartbeat and experienced body. They discovered hidden dynamics of their own heartbeat and empathised with other people whose recordings they experienced. They noticed effects on their own soma caused by the recordings and sensory stimuli. However, only a few participants explored the settings and possibilities of sensory customisation which was hoped to be one of the key values of the design. The following sections elaborate on these findings in detail.

7.1 Encouraging discussions with the soma body sheet

The soma body sheet was used to encourage discussions about physical sensations and bodily awareness. Participants captured a variety of bodily feelings, such as feeling warmth, coldness, heaviness, lightness, high heart rate, hunger, tension or pulsating in various areas of the body (see Appendix K). Some participants marked down a large variety of sensations while others relied mainly on the list of suggested feelings. One participant used a multitude of different colours to separate the feelings (see Figure 7-2). Another used symbols to connect the suggested words to areas of the body.

Mary pointed out how she never really focuses on her body unless something is wrong:

> *"Generally, I'm not very consciously aware of my body when I am feeling okay, when there's no need to be, I guess it's because it's functioning as normal."*

The motivation for using the soma body sheet was to encourage participants to focus on their experienced body and to initiate discussion about bodily feelings. Therefore, the results from the soma body sheets should not be used as indicative of any effects of the pod. Nevertheless, compared to pre-test, participants reported more distinct feelings of warmth and pulsating after test (see Figure 7-3). James, Mike, and Peter claimed to feel calmer and more balanced, both mentally and physically.

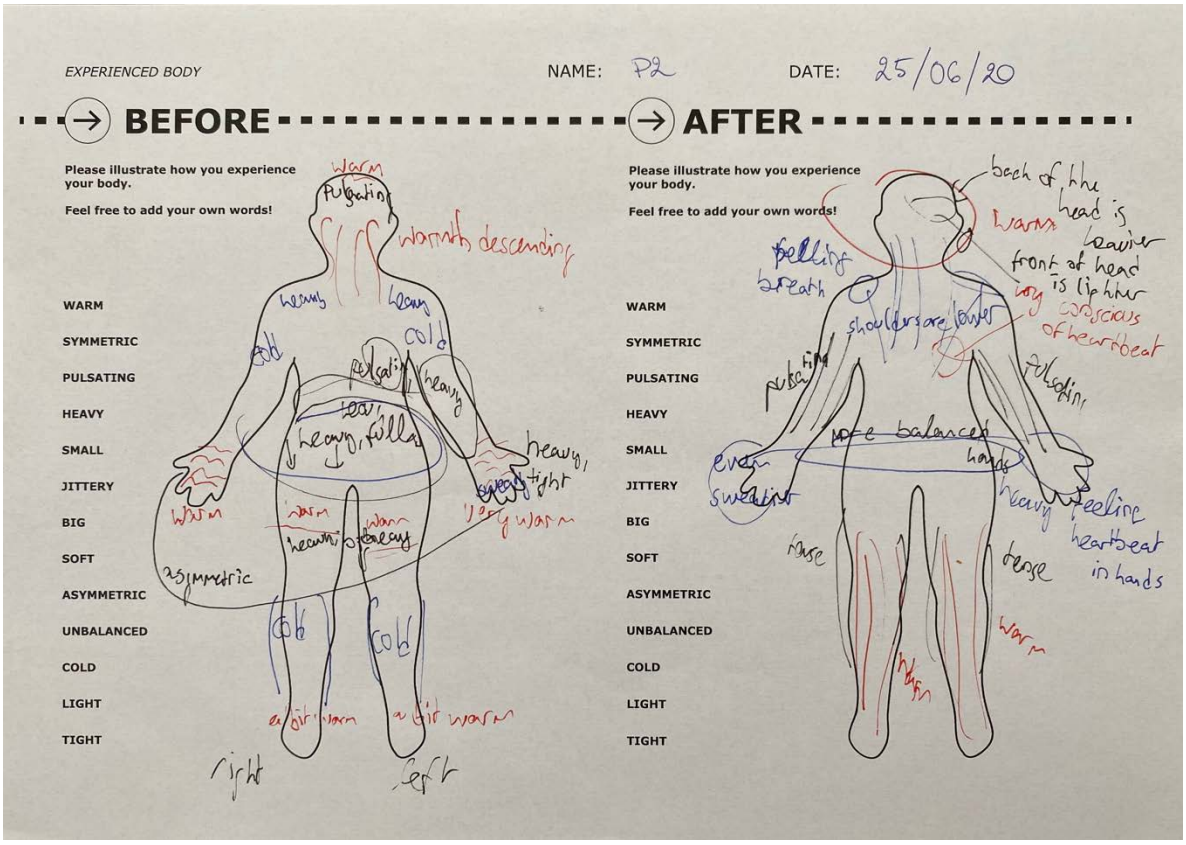

Figure 7-2: The soma body sheet enabled capturing a variety of bodily feelings.

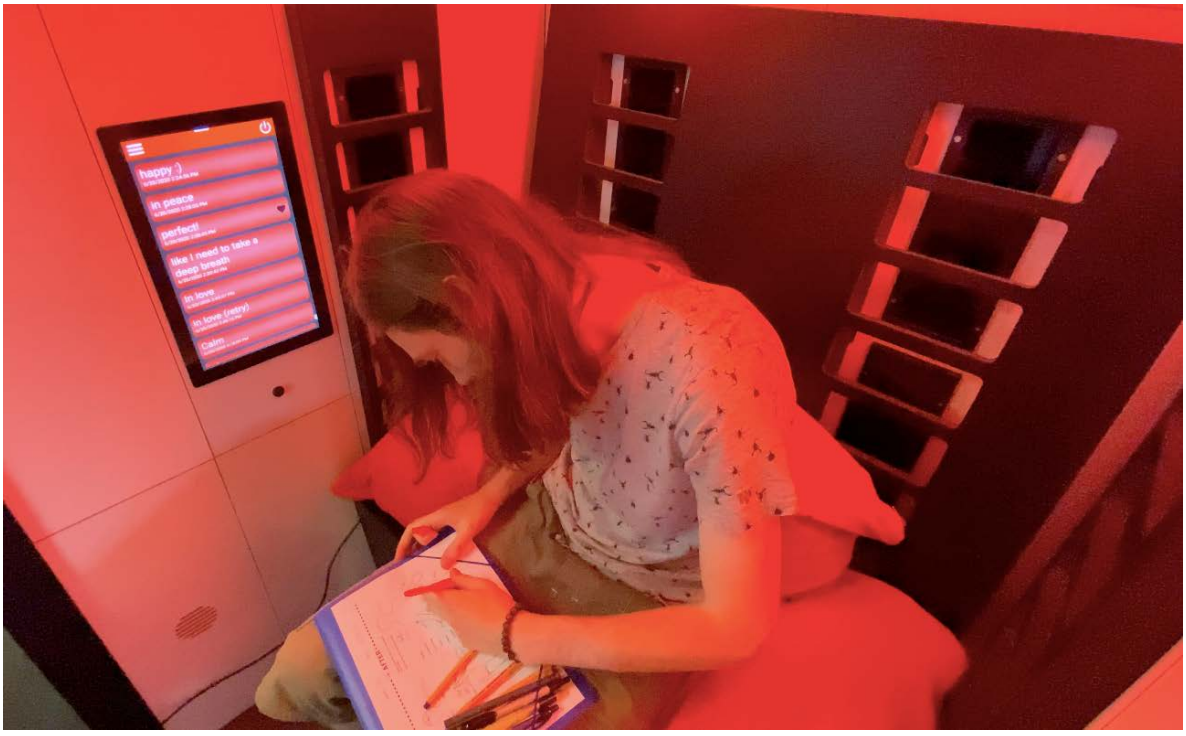

Figure 7-3: Participant filling in a soma body sheet after having explored the design prototype.

7.2 Previous experience with bodily awareness practices

During the pre-test interview, participants were asked about their experience with bodily awareness practices, stress and relaxation, and perceptions of heartbeat. Participants had different ways of coping with stress and were familiar with a variety of bodily awareness practices including meditation, yoga, and martial arts. Discussions also arose around the heartbeat and heart rate, both one's own and other people's. The following sections elaborate on the previous experiences of the participants.

7.2.1 Stress and relaxation

All participants reported having felt stress at some point. They pointed out both mental and physical manifestations of stress. Participants described feeling agitated, frustrated, angry, or unable to sit still.

Mary: *"[Stress] bleeds into other things I'm trying to do. [...] Everything I do seems to go wrong and that's very annoying."*

From bodily symptoms of stress, participants listed muscle tension, especially in neck, back, and jaw, and a noticeable heartbeat that makes the whole body vibrate. Oliver perceived being able to notice his heartbeat as an especially annoying sign of stress.

Participants had various different preferences for relaxing and reducing anxiety. Mary and Oliver preferred talking to a friend or going for a walk. Peter dealt with stress by structuring his thoughts and writing them down. He pointed out that having more control is what calms him. Other ways included drinking tea or beer, taking a warm shower, sleeping, listening to music, or sunbathing. One participant uses marijuana regularly to keep himself calm.

7.2.2 Bodily awareness techniques

All participants had previous experience with certain bodily awareness techniques although that was not a requirement for participating in this study. James had been practicing mindfulness meditation for one year and the Wim Hof Method [82] since February 2020. The latter is a breathing technique that focuses on long inhalations and exhalations intertwined with keeping the air in. James engaged in his practices daily and stated that the practices had caused him to have higher bodily awareness than before. James also pointed out how audio guidance from Headspace app can often be distracting:

> *"Sometimes they [= the guided meditation recordings] are really distracting. [I am] trying to focus on some feelings and sometimes the voice just keeps going for too long. [...] Sometimes it's nice to just silence it and sit in there."*

Mike had been practicing Aikido for two years as part of his studies in the theatre domain. Mike pointed out how that martial art practice has made him more aware of the effects of touch, especially the connection between the mind and physical touch and how they influence each other.

Peter was relatively new to meditation, having started only a week before the evaluation session. He used no external tools during his sessions, focusing only on his breathing and a mantra – a word or phrase repeated for keeping attention. Peter usually meditated sitting upright with closed eyes. The reason for him to start meditation was to feel more relaxed during the day and, as a result, improve his reaction time and reflexes:

> *"The point of meditation for me is to feel more zen, more neutral."*

Oliver was doing no bodily awareness practices at that time. Oliver had previously practiced yoga to improve flexibility and engaged in mantra meditation at a Hare Krishna centre:

> *"Mantra meditation is very much a sensory experience rather than trying to shut off the mind and just sit still."*

Oliver considered the goal of meditation to be an empty, thoughtless, silent mind:

> *"I know meditation is a lot about silencing the mind and trying to control your thoughts, push them away. […] The ultimate state of mind would be to have no more thoughts and just be completely present. That's the ultimate goal."*

7.2.3 Noticing one's own heartbeat

Participants claimed to be the most aware of their heartbeat both at moments of serenity and at stressful periods, e.g. when Mary was cycling fast to reach a destination in time. The former happened when they remained physically still in a quiet environment with little to no external distractions.

Participants pointed out various locations on the body where the heartbeat could be felt, for example, chest, limbs, neck, head, stomach, hands, and fingers. Heartbeat was noticed as various sensations. Oliver could usually feel his heartbeat as a rhythmic throbbing feeling. James had a visible heartbeat that could be seen with a naked eye as movement on his chest. He had also been able to notice it as a pulsating sensation in his fingertips if he put effort and focus in it. Mike described his heart during the post-test interview as:

> *"[…] still very fast but centred and grounded and spreading in an open way. Opens the body. […] Feels like warmth spreading from the centre of the body, more flowing to different body parts."*

Oliver described a peculiar phenomenon where he was reminded by his body to be anxious even though there is no apparent reason. Occasionally, in tense or important situations, he experienced an annoying mismatch between a high heart rate indicating stress and a calm mind, essentially a dualism between mind and body:

> *"My body is actually the one telling me to feel stressed. It's like, 'Come on! You're supposed to be anxious, do something! Be anxious!" […] It's like my heart and my mind are in different places. I'm perfectly happy, relaxed, chill, but I'm still feeling that something. So I find it quite weird."*

Some participants connected high heart rate to stress and discomfort, e.g. Oliver: *"High heartbeat is a sign that I have to take a bit more care."*

Peter admitted that his heart was constantly beating fast: *"I just feel like my heart beats a bit quicker than others'."*

7.2.4 Noticing the heartbeat of others

All participants had difficulties recalling when they last noticed the heartbeat of someone else. Mary had experienced it when having intercourse, James had felt the heart vibrate through the ribs when giving a back massage, and Mike had felt the pulse in someone's arm at a theatrical performance. Peter was in a situation where a friend acted as a buffer by tapping out the heartbeat of the third person with them. Hearing the rhythmic tapping then enabled Peter to compare his heart rate to the friend's. Oliver could not recall when he last noticed the heartbeat of someone else.

The participants described feeling someone else's heartbeat as something surprising and peculiar, portraying it as confirmation of closeness and shared intimacy between two people.

James: *"Feels like life."*

Mary: *"I can't feel or hear your heartbeat from where I am sitting across the table from you."*

7.3 The heartbeat is not what it seems to be

From the pre-test interviews, it became apparent that participants were somewhat aware of their own heartbeat. Noticing the heartbeat of others happened more rarely and was perceived as something intimate. Throughout the evaluation sessions, participants had various revelations about their own heart. Participants expressed how they did not usually pay attention to their heartbeat, although it was an essential part of themselves (see Figure 7-4). The Gallery of Heartbeats with its feedback made the heart activity explicit and enabled the participants to observe it better.

James: *"I realised I don't really listen to my heart rate that often. [...] It's [= the heart] like fuelling me almost or powering me but I don't have a very direct sensation of its strength or my heart rate really."*

Peter: *"[...] this [= heartbeat] is constant but you don't pay attention to it. [...] Because of this pod, in my mind, my heart is the centre of everything. It's for me also a bigger focus, much more than usual. [...] It's very satisfying for me to have this whole pod double down on my heartbeat and let me control it with my own body; it's very satisfying."*

Mary: *"It's very different having a heartbeat played back to you like that from how you perceive it to be when you're in your body. [...] It's just a whole different experience. [...] Normally, your heartbeat feels like a background process, but to have it happen in a way that you can't NOT focus on it is very interesting."*

Mike: *"In such a small room you had a very different feeling of focus in being with yourself, [you] pay more attention to your heartbeat and body."*

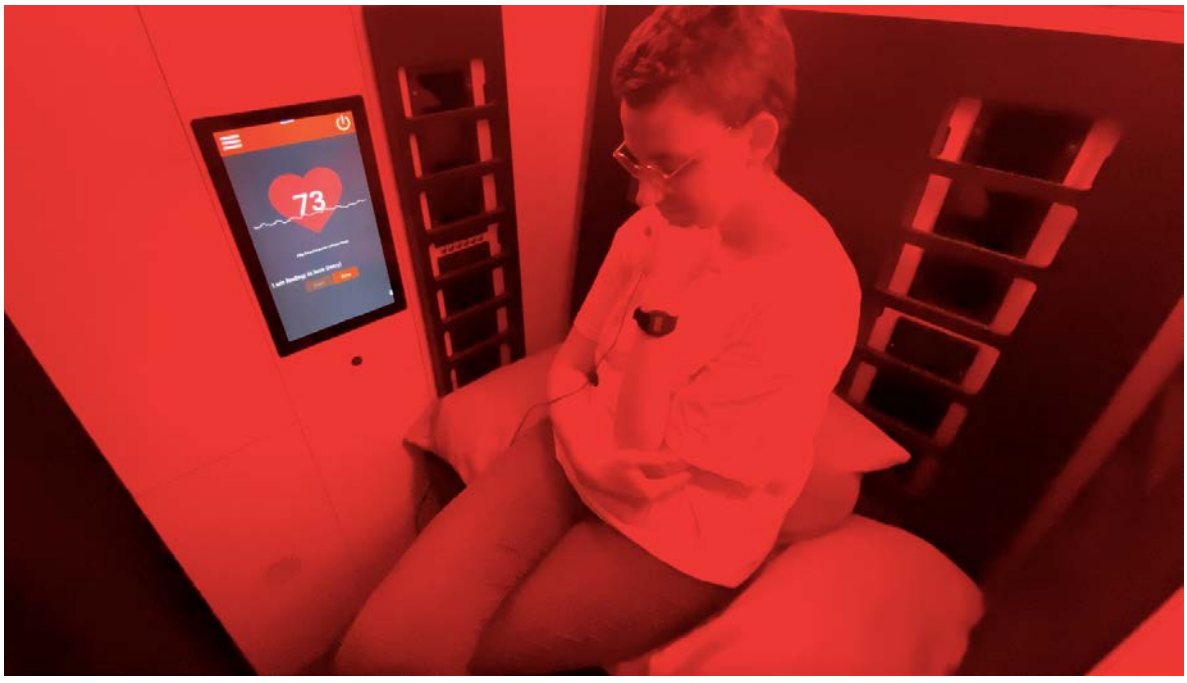

Figure 7-4: The visual and auditory feedback enable the participant to observe the dynamics of her heartbeat.

In the gallery section of the Gallery of Heartbeats, participants could experience the pre-recorded heartbeats of the author and other participants who added their recordings in previous sessions.

Participants described their experiences with the heartbeats of others as intense and focusing (see Figure 7-5).

Mary: *"It was being projected onto me in a way almost."*

Mike: *"'Wow, there's so many people around me and so many heartbeats,' is what I realised. [...] so many different physical experiences in a moment."*

Oliver: *"I found it [= the different heartbeats] interesting to see."*

Mary also commented on the titles and relative anonymity of the recordings: *"I like that they [recordings] are anonymous because it [= heartbeat] feels so personal."*

Oliver, however, desired to see more variety in the recordings: *"Almost all recordings sounded the same."*

Many participants were surprised to see how nuanced and variable the heartbeat actually is.

Mary: *"It's [= heartbeat] less regular. I always thought it was super rhythmic, but there's just jumps and bits, it seems. Or there's something horribly wrong with me."*

James: *"[Listening to the recordings] made me curious about my own heartbeat and how it sounded and how irregular or regular it was."*

Peter expressed doubt about the irregularities being caused by either a malfunctioning sensor or the heart itself.

Figure 7-5: A participant is experiencing the recordings of others.

7.4 Desire to control the heart rate

All participants expressed desire to use the pod for changing their heart rate. Many participants aimed towards a lower heart rate, using the feedback from the recording view as a guide. Peter hypothesised that there exists a correlation between heart rate and how relaxed one is, namely that lower heart rate indicates higher levels of relaxation.

Peter: *"For me, the point of this is to calm and relax someone."*

Oliver: *"I spent almost all the time trying to relax myself to lower the number [= heart rate]."*

Mary and Peter were interested in seeing how changing the surrounding factors, such as the sensory stimuli, affects the state of relaxation. Especially Peter perceived the goal of the stimuli to be to change the heart rate of the user. James and Mike also reported feeling the effects of recordings. Experiencing recordings with slower heart rate was more relaxing than those with a more rapid heart rate.

Some participants tried to control their breathing to observe the effect on their heart rate. James did a round of Wim Hof Method [82] and stated that his heart rate seemed pretty consistent (see Figure 7-6). Peter was more amazed about the direct impact of breathing on heart rate. Before, he was unaware of how a slightest change in breathing changes the heart rate.

Peter: *"[I] noticed that when I control my breathing that has an effect on what goes on. [...] With a certain breathing I can have my heart rate down at 89, otherwise it's 95+. [...] Damn! Breathing is everything!"*

He also claimed to have observed a calming and relaxing effect of having his heartbeat presented in such an explicit manner: *"I do feel a bit calmer because I am focusing on my breathing, focusing more on my heartbeat."*

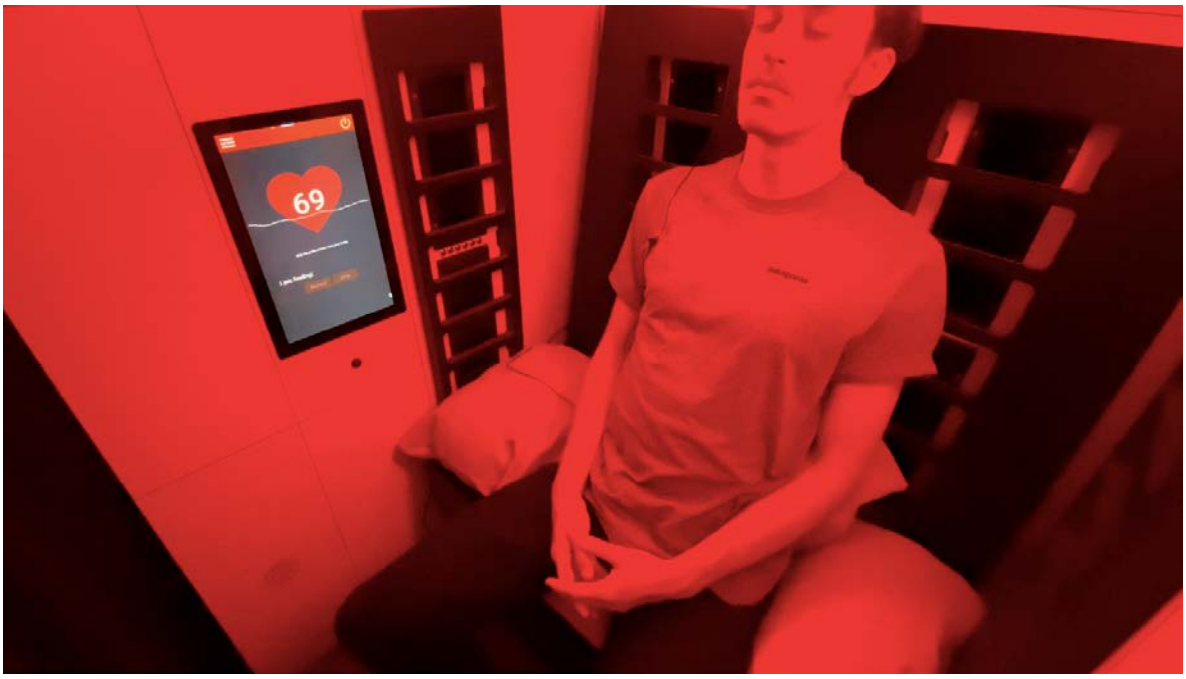

Figure 7-6: Participant is holding his breath as part of a breathing technique. The graph is showing a very stable heart rate.

7.5 Empathising with previous recordings

Participants mentioned developing feelings of empathy and curiosity towards the people whose recordings they experienced. The only thing they knew about the people in other recordings was the time of recording and how the person felt at the time of recording. Yet, this already gave them some information and a basis for comparison. Participants perceived the recordings to be representations of a person's mental and physical state at the time of recording. They tried to imagine what the people were feeling by reading the titles and experiencing the previously recorded heartbeats.

James: *"I was trying to empathise with the people whose heartbeat it was."*

Oliver: *"It [= the title] tells me a little bit about how they were feeling when they were in that situation. [...] I could see what it would be like from the heartbeat perspective for me, if I was in pain right now."*

Mary: *"It was funny to sit and listen and imagine myself in the kind of situation and see how that might line up with what was being played for me."*

Peter, whose own heart rate was constantly rather high, was surprised about one of the slow recordings titled "[I am feeling] calm": *"Wow. This person's really calm."*

When listening to the gallery recordings, participants were observed to measure their own pulse by positioning a finger on their wrist or neck (see Figure 7-7). Participants reported the recordings having a physiological effect on their own heart rate, although Mary was doubtful whether it is a true effect or a placebo fabricated by her imagination.

Mary: *"[I] felt my own heartbeat almost adapting to what was being played."*

Participants described feeling tense or stressed when experiencing high-tempo recordings. Slower recordings, on the other hand, caused Mary's and Mike's to also slow down. James explained perceived changes in his mood caused by experiencing heartbeats with different tempos.

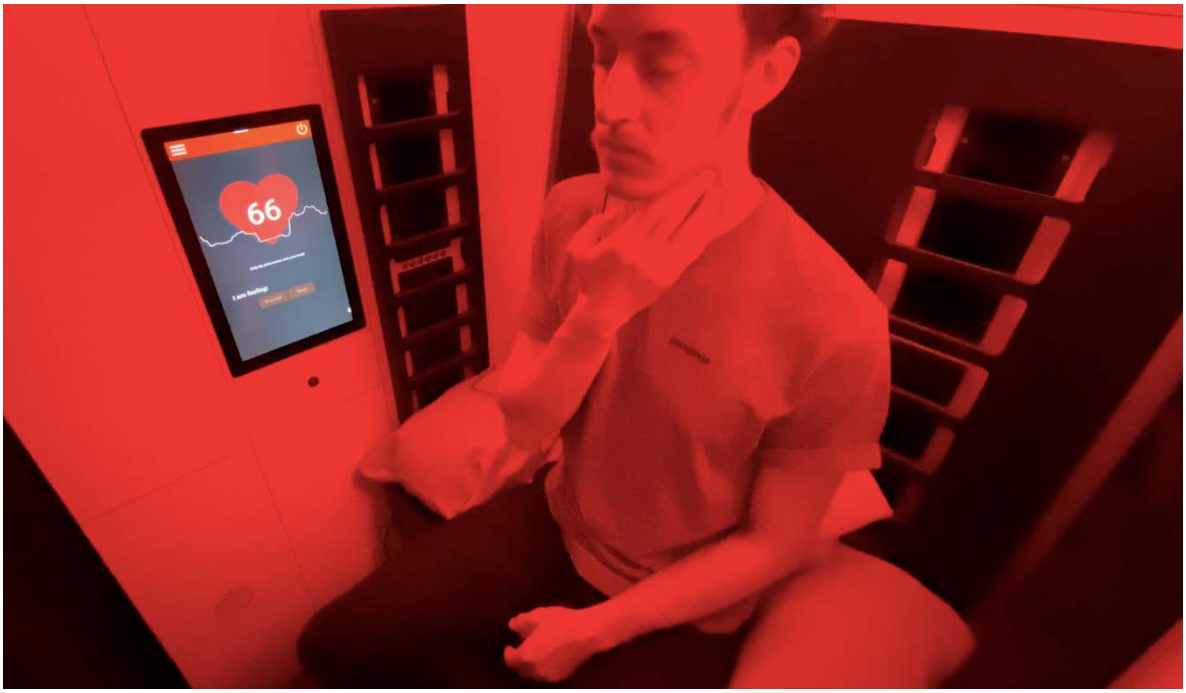

Figure 7-7: A participant is measuring his pulse to compare it with the pod's auditory feedback.

7.6 Mirror, mirror on the wall, how's the heartbeat of a…?

When asked about which heartbeats they would like to experience in the Gallery of Heartbeats, opinions divided roughly into two. Mary and James wanted to hear heartbeats of people they know, such as family members or friends.

James: *"I'm interested in how many people's hearts sound because it has an empathetic quality. It gives something away about what you're feeling, how you're doing and what is going on."*

A more popular request was not for a specific person, but for a large variety of different situations, mental states, and physical activities. Mike wanted to see the heartbeat after playing squash or a long night of drinking: *"You realise how exhausting an activity can be when listening to heartbeat from that situation."*

Both Peter and Oliver found having a curated list important. Peter wanted to see a clear distinction about which recordings come from World Health Organisation and which ones from random people: *"I'd like to know what is considered a healthy heartbeat, not just emotion-wise of random people. [...] compare mine with that to see where I stand."*

Oliver perceived the heartbeat almost as a universal truth that ought to be the same for every person. He was convinced that all people have the same heart rate when stressed and a certain bpm rhythm when calm. It almost seemed that Oliver expected all human hearts to be the same and behave in an analogous way. He did not like that recordings with the same tempo (bpm) could be for a variety of different emotions and feelings. He yearned for a curated list instead of people's own custom titles: *"If people self-identify with an emotion, you're probably not going to get very reliable results because it is such a self-conscious thing."*

7.7 Sensory stimuli

One of the key design features of the Gallery of Heartbeats is the possibility to experience heartbeats in a multisensory way through heat, airflow, audio, and lights using the Sensiks technology. Participants had mixed feelings of the sensory stimuli. Mike was positively surprised about the sensory modalities and had not expected them. Oliver, on the other hand, was wearing a thick hoodie and sitting away from the back of the wall where the fans were targeted. As a result, he noticed no other stimuli than lights and audio.

Mike, Peter, and Oliver struggled with figuring out the reason for the sensory stimuli. Oliver perceived it to be a simulation of people's emotions and their heartbeat, e.g. feeling warmer when angry. He was confused about what the airflow represents in that case. Mike expected the sensory stimuli to change depending on the heartbeat. He was searching for the logic behind the gallery and the connection between stimuli and different heartbeats. Peter expected the stimuli to be perceivable while recording to see how different stimuli setups influence his heartbeat. Note that having live multisensory feedback was originally the idea, but not implemented due to technical limitations.

Peter also recommended adding some slow and soothing music to further induce the relaxing effect of the pod. Mary considered vibration the ultimate way of feeling a heartbeat and would have liked to have the surfaces throbbing along with the audio.

7.7.1 Lights

Mary preferred brighter lights while Peter wanted the lights to be even dimmer and suggested adding a dimmer switch.

Mary: *"I didn't think the light was very bright, but I also didn't think that was a bad thing."*

Peter: *"I'd like to dim the light."*

When a recording in the gallery part is stopped or changed, the lights come on for a moment. Mary considered this to be a good indicator of a recording changing. Peter was the only one to point out that the red light inside the pod reminded him of the infamous Red-Light District of Amsterdam.

7.7.2 Heat

Four out of five evaluation sessions took place on days with extremely hot weather. The closed, almost airtight pod was also slightly warmer than usual. This might have caused some discomfort for the participants. Nevertheless, heat stimulus was perceived as relaxing. Mary also pointed out how she associates warmth with relaxing environments and would have liked to have even higher levels of heat.

Mary: *"This is quite nice and warm."*

James: *"[...] very warm, relaxed."*

Mike: *"It's warm in the pod."*

Thanks to the visual feedback of the turned-on heat panels, Mary assessed the heat as easy to observe. However, she also stated that with the default settings the heat is slightly difficult to notice: *"I could not feel the heat so much, only when I got close to the lamp."*

7.7.3 Airflow

Participants seemed to enjoy the added airflow feedback and pointed out the relaxing effects of it.

Mary: *"I liked the air! I liked the air a lot. But it did make some of the stressy recordings [with faster bpm] more relaxing to me."*

Peter: *"Definitely the air can help me feel more relaxed."*

Mike desired a more explicit indication of the airflow. He pointed out that visual feedback exists with lights and infrared heat panels. He would have liked to have visual feedback indicating when the fans were on as well.

7.8 Expected use cases

Three main use cases arose from participants' feedback. First was to intentionally calm oneself down using the sensory modalities and the biofeedback from the pulse sensor. In this scenario, the goal was to change the soma towards a desired state.

Second usage was for passively observing the state of the soma and the heartbeat. Participants recommended using the pod for check-ins throughout the day. This would enable paying more attention to what state one is in. Additionally, by recording and storing information about their heart rate in connection with their feelings or activities, one could observe the changes and correlations over time.

A third use case was presented by Oliver who pointed out that it would be interesting to compare his own heartbeat with someone else while they are both at the pod, e.g. by using two pulse sensors at the same time. This use case was more about accepting the heart rate as-is instead of changing it.

8 Discussion

The purpose of this study was to increase bodily awareness of one commonly unnoticed physiological feature – the heartbeat – from both an individual and social angle. In addition, an aim was to examine the potential benefits of using external sensory stimuli to convey biofeedback information. The evaluation of the Gallery of Heartbeats showed that the designed experience succeeded in making people more aware of their cardiovascular activity, triggered their curiosity, and increased empathy towards others. However, the Gallery of Heartbeats also made the participants want to change their heart rate to a "better", "healthier" one which goes against the mindfulness principles of presence-in and presence-with that the design was based on. Sensory stimuli, especially sound and visuals, were assessed as beneficial for creating feelings of immersion, albeit not essential to conveying the biofeedback information.

8.1 The opening of a rich design space

The Sensiks sensory reality technology is relatively novel. Therefore, concrete use cases are still to emerge and mature. Even the company itself is currently advertising their products for various markets, such as healthcare, education, and entertainment, for example [14]. The potential of the Sensiks sensory reality technology is also apparent from this study. A large number of possible interactions and potential reasons to use the system emerged from both the design exploration leading to the Gallery of Heartbeats and the resulting design itself. Consequently, a rich design space of sensory stimuli, relaxation, and bodily awareness has been opened up.

The potential uses for the Gallery of Heartbeats are as follows. First, as the participants of the evaluation session also pointed out, it could be suitable for emotion regulation. Real-time biofeedback teaches the user about the connection between their activities, somatic states, and the heart rate, e.g. how physical activities, such as exercise or sitting still, influence their heart rate and emotions. By reflecting back the heart rate in real time, the design enables the user to consciously adjust (i.e. lower) it. That, in turn, can lead to feeling calmer, less anxious, and less stressed. It can also act as a stepping stone for independent regulation of emotions, i.e. being able to calm oneself without any assistance from the technology. For this use case, the numerical representation of biofeedback seems to work best (see also Section 8.2).

Participants also pointed out how experiencing the recordings of others seemed to have an effect on their own heart rate, e.g. feeling calmer when presented with slower heart rates and more anxious with faster ones. These claims lie purely on the participants' self-observation and have not been double checked by measuring their heart rate whilst listening to heartbeat recordings. However, it indicates the potential to use the design for deliberately influencing the users. While the first use case is more passive and leaves the decision to change their heart rate to the user, in this one, the system has a more active role. This effect could be taken advantage of in various situations. For example, presenting slower recordings to users who feel anxious and wish to calm down or higher ones to those who wish to invigorate themselves, e.g. to prepare for a running race. One participant pointed out how she felt the design project the heartbeat recording onto herself. Therefore, feedback through sensory stimuli, especially audio, could work best for this use case.

Since the Gallery of Heartbeats enables recording one's heartbeat, it can also be used for data collection and analysis, either individually or across a population. The desire to use the design over a longer time period was also pointed out by the participants who explained that saving their heart rate at various times of day or when doing different activities could help them understand the effects of their behaviour on their heart rate. In turn, they could adjust their life accordingly, i.e. by engaging more with activities that result in their desired heart rate patterns. Alternatively, data gathered from multiple people can be used to compare the heart rate between people and within a

population. This could either shine light on the general health of people or demonstrate the variation in cardiovascular activity. The latter could have already been useful when evaluating the design to counter the false belief of the uniformity of the heart rate held by one of the participants. The archive feature of the design is best for data collection. For presenting the variations between heart rates, additional design is needed that enables comparing and contrasting heart rate recordings. The graphical representation could work best for that purpose as it also shows the subtle changes in heart rate.

Finally, the Gallery of Heartbeats can also be used as a haven for meditation or relaxation, a place to go to when one wants to be by themselves. The settings screen that enables controlling the sensory stimuli is beneficial for tailoring the pod's environment to one's preferences. As a result, one can create an environment they feel most comfortable in. The same goes for the physical additions to the pod, i.e. the curtains and pillows. For this use case, the Gallery of Heartbeats provides a place for retreat whereas the technology, e.g. the pulse sensor, can even become redundant.

As seen above, the Gallery of Heartbeats is multifaceted and does not lack potential uses. It is akin to a smartphone which enables the user to take photos, set alarms, browse the internet, and play games. However, while the main function of a phone – calling – has already been established, the specific reason for which to use the Gallery of Heartbeats has yet to emerge. This is natural for designs that take advantage of novel technology and opening the design space as was done in this study, is the first step towards that.

8.2 Biofeedback for increasing bodily awareness and supporting somatic exploration

The participants of the evaluation sessions had no problems with discussing bodily feelings, especially when using the soma body sheet for support. However, before experiencing the Gallery of Heartbeats, their heartbeat had been one of the lesser noticed features. The Gallery of Heartbeats succeeded in making the cardiovascular activity explicitly noticeable and revealed aspects the participants had been oblivious to before. One of the most commented-on was the dynamics of heart rate and its connection to breathing. The Gallery of Heartbeats provides numerical, graphical, and auditory feedback on the heart rate. The design intentionally uses such explicit representations as the subtle dynamics of the heart rate are difficult to notice otherwise. The graph of heart rate over time is especially fruitful in demonstrating the changes as they can be seen as increases and decreases on the graph line.

Many previous works have taken advantage of more abstract ways of biofeedback, for example, coloured lights [46–48] or changes in soundscapes [23]. While these may perhaps be more interesting or engaging ways of providing biofeedback, they often fail to capture the subtle nuances of a dynamic physiological feature. They largely only focus on the bigger picture, i.e. the increase or decrease in average heart rate over time instead of constant cyclic changes triggered by respiratory activity. The explicit feedback of the Gallery of Heartbeats lets the users see how their heartbeat is influenced by their activities in detail.

The Gallery of Heartbeats uses biofeedback loops [24–26] and sensory stimuli to make users more aware of their bodily behaviour. They can experiment with how their activities change their heart rate and, consequently, the sensory feedback. Such a design has the danger of pulling the user's attention away from their soma. By focusing on the external representation of their body, the user stops looking inwards [53]. That was also apparent from people engaging with the design. They were focused on finding the meaning for the stimuli and understanding the connections to their bodies. This might indicate that the stimuli used in the Gallery of Heartbeats was too intrusive or powerful. Future design iterations could look into using more subtle stimuli.

On the other hand, the design acts as a stepping stone towards an inwards-looking practice. By externalizing a hidden physiological feature that is commonly unnoticed, it makes people think

more about their heartbeat, not only when they are engaging with the design, but at a later time. In that sense, the effect of the design lingers. Although the Gallery of Heartbeats may fail to direct the user's focus inwards at the time of use, it can make them more aware of their bodily functions and sensations and increase bodily awareness for the future.

8.3 Somaesthetic appreciation and digital mindfulness

The Gallery of Heartbeats uses some, but not all qualities of somaesthetic appreciation [19]. For example, it does not use subtle guidance to support introspective somaesthetic appreciation. However, it complies with the second quality of somaesthetic appreciation design which is providing space for reflection. The enhanced physical design of the pod environment conceals the user from the outside world. The curtain on the pod's door creates an enclosed atmosphere and a secluded space for being with oneself while providing enough openness to not feel too encapsulated. Since using the pod is ritual – one needs to go to the pod to use it –, it also slows down the pace of life and disrupts the habitual routines of the user.

Another quality of somaesthetic appreciation artefacts is providing immediate feedback that is in sync with the body [19]. The Gallery of Heartbeats is a representation and an extension of the user's body by externalising the heart rate using sensory stimuli affiliated with the heart – heat and heartbeat sounds as representative of the biodata and airflow and lights as representative of the affective states tied to changing heart rate [27]. On its own, the Gallery of Heartbeats supports articulating the experience [19] when the user enters a title for their heartbeat recording and is encouraged to think about what they are feeling. However, during evaluation sessions, articulation was further stimulated with the use of soma body sheets.

One thing the current design fails to do is take a situated mindfulness approach by providing constant feedback to the user. Situated mindfulness entitles having high present-moment awareness throughout the day, not only during the mindfulness ritual [34]. Due to the immersive sensory stimuli environment, the current design of the Gallery of Heartbeats is closely tied to the Sensiks pod – an immovable physical object. The pod cannot be carried with the user. The user has to go to the pod to experience the Gallery of Heartbeats. Therefore, the design is for a ritual mindfulness practice instead. This is also one of the reasons why the Gallery of Heartbeats cannot be considered a true level 4 presence-with or presence-in digital mindfulness artefact [9]. The design qualities of level 4 artefacts presented in [9] establish that the design is integrated with daily life instead of relying on tools or rituals.

Furthermore, the participants reported a desire to change their heart rate instead of simply being with their heartbeat and not judging it or reacting to it. This means a slight conflict with the first design quality of level 4 artefacts – bare undivided attention to the present moment [9]. On the other hand, there were moments where the participants were completely focused on the biofeedback, almost lost in their heartbeats. In those moments, they were present-with-their-heartbeat and present-in-the-sensory-experience.

Assessing the design from the third quality – aesthetics for non-judgemental acceptance – is even more complex. Ideally, a level 4 digital mindfulness design should leave the meaning-making to the user [9]. Instead of the system evaluating the user's affective state, the bio-sensor data is presented to the user in a neutral way that allows the users to reflect on their subjective experiences. To achieve that, the data should be presented in an ambiguous, fluent, and open way. The recordings of the Gallery of Heartbeats are experienced only through the sensory stimuli of heat, lights, sounds, and airflow. This complies with the requirement of data abstraction as it shows none of the recordings as better than another, nor does the presentation vary throughout a single recording as the heart rate is never assessed as good or bad. The real-time biofeedback in the design prototype, however, also takes advantage of numerical and graphical representation of the heart

rate to support deeper insights into the subtle dynamics of the heart. While it still does not assign any values to the heart rate, such non-abstract presentation can certainly trigger judgmentalism and instrumentalism, making users want to change their heart rate.

It is unclear whether designs for bodily awareness can ever also act as presence-with digital mindfulness artefacts. On the one hand, all such designs serve the goal of making the user more aware of their soma. Having goals, however, makes a design instrumental which demolishes its premise as a level 4 artefact. Throughout this study, the Gallery of Heartbeats is sometimes being referred to as a "tool" for increasing bodily awareness and supporting communication, further establishing the notion of it being a means to an end. On the other hand, such designs could create an abstract experience around a somatic feature and almost accidentally result in increased bodily awareness as a fortunate side-product. In those cases, the design could be considered a presence-with artefact because it does not explicitly guide the user in such a direction. The Gallery of Heartbeats falls into this category because although the design itself is created with a specific goal in mind, that goal is not presented to the user as an objective.

All in all, the concept of presence-with and presence-in digital mindfulness is rather complex. Making a true presence-with design artefact is a challenge and the Gallery of Heartbeats in its current form does not succeed in fulfilling all the necessary criteria. However, the Gallery of Heartbeats with its sensory stimuli and biofeedback can be considered a ritual mindfulness design artefact that takes advantage of both somaesthetic appreciation design and digital mindfulness theories.

8.4 The heartbeat as a spectrum

The heartbeat as a data point can be described as a spectrum, carrying meaning from medical to intimate bonding. This study aims to show the heartbeat in a context complimentary to the medical one. On the one end, heartbeat and heart rate carry information on a person's health – it has a medical meaning. Increased heart rate is an indication of stress and can cause strokes or heart disease in the long term [2]. Heart rate variability is used for monitoring health in clinical conditions [83]. Evaluation sessions of the Gallery of Heartbeats also showed how participants' perceptions of their heart aligned with the heartbeat in the medical context. Participants were asking for medically accurate recordings of heartbeats of healthy people to compare their own heart activity to. Seeing the heartbeat first and foremost through a medical lens is natural as externalisation of one's heartbeat is most common in a clinical setting, e.g. being connected to an electrocardiogram (ECG) or during an ultrasound of an unborn baby. Undoubtedly, the heartbeat carries information about an individual's vital signs and health. The Gallery of Heartbeats is less useful for the medical context, giving only basic information about the dynamics of the heart, but evaluation session showed that the design still triggered clinical interest in people engaging with it.

Another lens through which the heartbeat can be viewed is emotional. For example, hearing the heartbeat of their unborn child has an endearing effect on the parents. It strengthens the bond between the parents and the foetus as a new life entering the world. What was before simply a collection of cells suddenly takes on the form of their child, an actual living creature with blood pumping through their tiny underdeveloped organism. The same effect appears with the heartbeats of loved ones. For example, when a person gets a tattoo of a loved one's last ECG pattern. In these cases, the heartbeat carries an emotional significance, expanding from a simple medical signal to a representation of a person or a meaningful situation.

The third lens on the heartbeat is about social value, i.e. sharing. A foetus has no control over who listens to its heartbeat. The parents and medical personnel can freely access it when they desire to do so. After birth and especially when getting older and gaining more boundaries, people have more control over who they enable to observe their heartbeat. During evaluation, participants

pointed out scenarios, such as going to the doctor for a medical check-up or feeling the pulse during sexual intercourse. Adults decide for themselves who gets to listen to their heartbeat, i.e. who they trust with sharing this intimate aspect of themselves. When walking in the street, everyone can look at a person's face – it is a publicly shared feature. The heartbeat, on the other hand, is invisible to the naked eye and has to be shared deliberately. The process of sharing one's heartbeat connects to a sense of ownership and encompasses trust between the sharer and the person being allowed that close.

The intimacy of the heartbeat changes throughout life. Before birth, it is shared with parents and the obstetrician. It is intimate within the family and their trusted doctor. During adult life, a person has the most control over who they share their heartbeat with. It is shared with only a few selected people. At the end of one's life, given that they are in a hospital bed connected to an ECG monitor, a person's heartbeat is broadcasted to everyone within the proximity of the monitor. The intimacy of sharing the heartbeat is the lowest at that point, as the person has little control over who gets to experience their heartbeat. Thus, at various points in life, the heartbeat is also experienced socially, not only by the individual themselves.

The Gallery of Heartbeats lets one share their heartbeat in a controlled way. It is less intimate than being physically close to the person whose heartbeat is observed, so it allows people to keep their boundaries. However, it helps externalise and share an otherwise hidden feature of the user. By doing so, it can also support emotional bonding between people. While recognising each other by our heartbeats is certainly not necessary, if even possible, it is a more intimate way of knowing each other and an alternative to faces and voices.

8.5 The heartbeat as the ultimate truth or something that can be faked

One of the participants of the evaluation session saw heartbeat data as absolute truth – something that is the same for all people and accurately reflects psychological and physiological states. From that perspective, the heartbeat never lies and cannot be changed intentionally. A recent discussion on a similar topic emerged on Twitter where a company pitched a product that would use a pulse sensor to determine when women orgasm [84, 85]. To leave aside the intrusiveness of such technology, it also conveys that the heartbeat carries some ultimate unchangeable truth about a person.

In a sense, the heartbeat itself is certainly objective. It reflects the physiological states, some of which can also be triggered by certain psychological states, e.g. higher heart rate when one feels stressed [2]. However, this also means it is not always possible to map heartbeat patterns to mental states. For example, one can trick the sensor by hyperventilating and, as a result, increasing their heart rate when they are, in fact, feeling calm and relaxed. Therefore, the heartbeat is strongly correlated with physical activity, but certainly not a neutral ultimate truth about how one feels. On the other hand, one could argue that changing one's physiological state inevitably also affects their psychological state. For example, by hyperventilating while calm one is bound to become less calm.

Because of this, the Gallery of Heartbeats avoids assigning any affect states or values to heart rate readings. The meaning-making is left to the user, encouraging them to think about connections between the heartbeat and their physiological and psychological conditions. By doing so, the Gallery of Heartbeats supports introspective reflections. Alternatively, as was also suggested during evaluation sessions, when choosing a title for the recording, the Gallery of Heartbeats could provide a list of affect states (e.g. happy, calm, tense) for the user to select from. This is definitely useful for performing a follow-up statistical analysis on all the recordings. However, such an approach would limit the users and could be counterproductive for letting them contemplate on their somatic feelings. By adopting the first tactic, the Gallery of Heartbeats enables the users to become more somatically aware, albeit in a way that requires them to put more effort into understanding their

somas. That way, the connection between psychological and physiological feelings is left for the user to explore and discover.

An interesting thing to notice is that technology used to measure and present the heart rate is never objective. Sensors measure the heart rate in different ways, for example, by taking an average over time. This was also apparent when writing code for the pulse sensor used in this study (see Appendix C). Different polling rates changed how the heartbeat was perceived, occasionally making the author unsure whether it was her heart or the sensor that was misbehaving. Furthermore, the designer of the technology decides how the readings are presented to the user, e.g. numerically, graphically, or abstractly. Therefore, the technology becomes subjective due to the (unintended) influence by its creators. It measures and presents the heartbeat in specific ways, thus also shaping the output accordingly. When passed through a sensor, the heartbeat gets "flavoured" by the technology, thus becoming subjective. Designers have the privilege and responsibility to decide how their technology presents and represents the heartbeat and to consider how that influences the user.

8.6 Getting to know oneself through the heartbeat

Another trend that emerged from the evaluation sessions was assigning meaning to the heartbeats of others. The Gallery of Heartbeats provides little context around the recordings, showing only the time and what people decided to name them. Despite that, people experiencing these recordings tend to hypothesise who the authors of the recordings were and what they were doing at the time of recording. They fill in the gaps using their imagination, projecting their ideas onto the authors of the recordings. Admittedly, this says more about the people assigning context to the recordings than the actual authors of the recordings. There is not much that can be inferred about another person from a vaguely described heartbeat recording, so these projections mirror the person who engages in such context-creating activity. In a way, the users of the Gallery of Heartbeats become aware of their own hearts by analysing the heartbeats of others and assigning context to them. As a result, they come to know themselves better.

The users of the Gallery of Heartbeats sometimes desired to change their heart rate. In some cases, it was influenced by the participants perceiving their heartbeat to be better or worse or healthier than the heartbeat of others whose recordings they experienced. The design triggers thoughts about what a good heartbeat is and what distinguishes one beating pattern from another. The truth is, heart rate varies greatly between people depending on a variety of factors, such as age, health, and activities. There exists no universally ideal heart rate. Each person has their own range for a healthy heart rate and fluctuations are normal, depending on what activities they are engaging in. Therefore, the design of the Gallery of Heartbeats also avoids showing any heartbeat as better than others.

People wished to see a range of different heartbeats from two distinct perspectives. One was seeing a selection of heartbeats from a single person throughout the day when engaging with different activities, e.g. sleeping, working out, being angry or calm. Another was experiencing a mixture of heartbeat recordings from different people in the same situation, e.g. playing tennis. This shows an understanding of the heartbeat as something that is not constant and varies greatly depending on a person and the situation they are in. However, it also indicates that it is possible to extract information from the heartbeat. Mapping a certain heart rate to a certain activity allows for long-term analysis of one's unconscious bodily reactions. I can act as a tool of learning and observing or controlling and changing.

The motivation for the design was not to control or change anything, but just enable being with the heartbeat in the present moment. The users' desire to change their heart rate does not necessarily mean the design failed to be a presence-with digital mindfulness artefact [9]. The participants did also mention how nice it felt to simply be with their heartbeat and notice its subtle

changes. While the immediate biofeedback certainly encourages exploring how different activities change one's heart rate, the design does not present the users with any goals, such as lowering their heart rate. It simply triggers their curiosity about their heart and focusing on their heartbeat grounds them to the present moment even more. However, experiencing the recordings of others can induce feelings of inferiority and desire for change if they are perceived as better, healthier representations of the heartbeat. From that angle, the design has room for evolvement, so that people do not feel bad about themselves when comparing different heartbeats.

8.7 The Sensiks pod as a space

With the Gallery of Heartbeats, the heartbeat is experienced externally, instead of internally. The Gallery of Heartbeats takes advantage of the Sensiks pod and its sensory technology to create feelings of immersion. The fans, lights, speakers and infrared panels present the heartbeat biofeedback to the user in a multisensory way. The participants even described the sensory technology creating feelings of heartbeats being projected onto them. This differs greatly from how the heartbeat is commonly experienced. Usually, the heartbeat seems to originate from inside the body. It can be felt as a throbbing sensation in limbs and fingers, as a periodic rush of blood in one's skull causing a headache, or pounding in one's chest, for example. In a way, the design of the Gallery of Heartbeats creates dualism between the heart and one's soma. The externalised heartbeat is not seen as a part of the body anymore, but a separate entity. This can reduce present-moment connection with one's body which is the opposite of what this study aims for.

On the other hand, the pod acts as a representation of a heart. From that angle, the user is teleported inside a heart, either their own or someone else's. The sensory environment, for example, the concealment, soft cushions, or the heat pulsations, represent the inner workings of the heart in an abstract way. They either embody cardiovascular activity or the flow of energy. Therefore, the user becomes connected to their heart in a way that is unachievable without such immersive sensory technology – they literally feel like they are inside a heart. It is difficult to get closer to oneself than that. Hence, sensory technology is beneficial for creating feelings of immersion. Notably, the design proposal differs from the prototype used at evaluation sessions. Due to the pulse sensor being influenced by infrared panels, the prototype only provides real-time sensory feedback using audio and visuals. Further experiments are needed to assess the benefits of real-time multisensory feedback on heart rate.

The Sensiks pod acts both as a personal and social space. As a personal space, the pod allows retreating from other people and one's habitual environment. It creates an oasis for individual reflections and a way of being on one's own, away from everything else. There are still people passing by the pod, but they are separated from the user by the curtain concealing the insides of the pod. Additionally, Sensiks pods are typically too expensive to be bought by a single individual. They are commonly obtained and used by a company, e.g. a medical clinic or an office. Therefore, the pod also acts as a social space. The people passing by look into the pod, trying to notice if there is someone in there. Inside the pod lingers the scent of people who were there before the current person experiencing the Gallery of Heartbeats. The archive part of the design portrays people who used it to record their heartbeats previously. All these traces of other people show that the current user is somehow connected to a larger whole, a group of anonymous individuals also using the pod. The factor of anonymity becomes especially apparent in case of the pods at Amsterdam Schiphol Airport lounge, for example. An uncountable number of people pass through the lounge every day and some never return. Yet, by recording their heartbeats, they leave behind an intimate aspect of themselves, creating a living, beating organism of heartbeat traces. Hence, while at any current moment the pod successfully acts as an individual oasis, in the longer term it also becomes a collection of many other people.

8.8 Comfort versus relaxation

A part of this study revolved around increased bodily awareness as a means of relaxation and stress reduction. To support this objective, ways of making the environment more comfortable were looked into (see Appendix A, Appendix B, and Chapter 5). Originally, the Sensiks pod used as a basis for the design was assessed to be rather uncomfortable due to its confined space, exposure to passers-by, and hard seating. Enhancing the pod with curtains and pillows made it more comfortable.

Through the design process, the concepts of comfort and relaxation emerged. To the author, comfort is external, capturing how the surrounding environment feels. If a bench is hard and sitting on it for longer periods makes one's bottom hurt, it makes the person uncomfortable. Relaxation, on the other hand, is internal, tied closely to the mental states. For example, if the mind is racing and focused on a massive influx of thoughts, one has difficulties with relaxing as they are constantly analysing something instead of being in the present moment.

Achieving a state of comfort without being relaxed is possible as one can easily change the external factors, e.g. switch positions or add cushions, to make the environment adjust better to one's physical body. Achieving a state of relaxation without being comfortable, however, is difficult, as discomfort on one's physical body tends to pull focus to the targeted area, create thoughts about pain or stiffness and desire to act upon it, i.e. to change the factor causing discomfort.

The concept of soma tries to avoid the dualism of body and mind, tying one closely to the other [12, 13]. It is apparent that one cannot exist without the physical body and that the body is part of the sensory experiences. Needing physical comfort for mental relaxation indicates a causational relation between comfort and relaxation. This was also apparent when designing for the Gallery of Heartbeats. The author felt more relaxed when engaging with longer design activities when the Sensiks pod had been converted to a more comfortable and, thus, relaxing space.

On the other hand, feelings of discomfort can also serve the purpose of increasing bodily awareness. By pulling attention to the location and cause of discomfort, a person momentarily becomes aware of the body part experiencing discomfort. In this case, the increased bodily awareness does not originate from internal targeting but is caused by an external factor. Therefore, while counterproductive for achieving relaxation, discomfort can be beneficial for increasing somatic awareness and achieving a state of present-moment awareness.

9 Conclusions and future work

The original purpose of this study was to look into the domain of stress and relaxation using soma design. Iteratively reframing the scope of a project is typical of research through design. This is also apparent in this study. What started as a way for the author to develop a better understanding of her own anxiety, turned into an experience revolving around bodily awareness and the heartbeat. Through engaging with various bodily awareness techniques and stress management practices, the author developed a stronger sense of self and rediscovered her own soma from multiple angles. It helped the author become more receiving of her sensory environment and more responsive to the felt experiences around her. Such heightened state was helpful in designing with and for the soma. The heartbeat and cardiovascular activity emerged as a controversial and captivating bodily feature to design for.

Additionally, the aim of this study was to inspect the possible benefit of presenting biofeedback information through external sensory stimuli. The Sensiks pod with its sensory reality technology provides a way for experimenting with combinations of sensory stimuli, such as heat, airflow, and lights. Although the technology was sometimes difficult to work with, especially when it came to mocking the experiences by a single person, it can be used to create immersive environments and experiences. The study has also opened up the rich design space around sensory stimuli and the Sensiks sensory reality pod by proposing various uses for the design and technology.

One of the artefacts resulting from this study is a design critique on the Sensiks pod from the perspective of comfort as a necessary basis for creating feelings of relaxation. The design critique is complemented by the Misuse Magalogue. This fictional combination of a magazine and a catalogue enhances the existing design of the pod by adding pillows to soften the seating and a curtain to conceal the user from passers-by. Additionally, it offers a guide to potential seating positions inside the pod as encouragement to break the habitual and use the pod in another way than originally intended.

This all culminates in the Gallery of Heartbeats – a sensory experience aimed at increasing awareness of the heartbeat from both a personal and social angle. With its appearance and behaviour, the redesigned pod looks like an abstraction of a heart – pulsating and alive, yet concealed and hidden. The Gallery of Heartbeats supports individual reflections by providing the user with real-time multisensory feedback on their heart rate. It takes advantage of explicit numerical, graphical, and auditory feedback to uncover subtle dynamics of the heart rate caused by a variety of factors, such as breathing.

The Gallery of Heartbeats is also a social communication tool. It allows users to record and store their heartbeats to an archive, creating a collection of heartbeats through time. The recordings of self and others can be experienced later via sensory stimuli, triggering feelings of immersion. The Gallery of Heartbeats creates a living, beating collection of heart fragments – a trace of people who have decided to share this intimate feature of themselves with others who wander into the Gallery of Heartbeats.

Feedback from users indicates that the Gallery of Heartbeats succeeds in exposing hidden aspects of one's heart. It sparks the users' interest and increases empathy towards others. The design grounds the users to the present moment, acting as a presence-with digital mindfulness artefact, and makes them more connected to their somas, thus increasing bodily awareness.

However, the design occasionally also makes the users want to change their heart rate. On the one hand, such behaviour goes against the presence-with and presence-in mindfulness principles that the design is based on. On the other hand, this can simply be seen as a sign of curiosity and desire to play around with the sensory stimuli. When consciously exploring what causes changes in

one's heart rate, the users are even more grounded to the present moment and their living body as the centre of sensory appreciation.

The biofeedback enhanced with sensory stimuli, especially sound and visuals, was helpful in creating an immersive environment. However, the secondary stimuli, e.g. heat and airflow, were not assessed as necessary for conveying the heart rate information. Due to technical limitations, the current prototype of the Gallery of Heartbeats did not analyse how heat and airflow can improve the real-time feedback of one's own heart rate. In the prototype, only heartbeat audio combined with numerical and graphical representation of the heartbeat are used.

In conclusion, the study evolved naturally from an exploration into the domain of stress and mindfulness into a design proposal externalising the heartbeat as a step towards bodily awareness and social communication. The resulting experience was assessed as beneficial for increasing somatic awareness and eliciting discussions on the heartbeat as a commonly unnoticed physiological feature with medical, emotional, and social meaning. The rich design space around sensory reality and the heart rate has been opened up and various potential reasons to use the Gallery of Heartbeats have been proposed. Any of those can be explored further in the future to establish what the design works best for.

9.1 Limitations

This study was conducted during the novel coronavirus outbreak. Due to the first-person research through design approach, the pandemic was not critical to the completion of the study. However, there were some complications caused by the governmental guidelines instructing the general public to stay home and avoid unnecessary contact. First, this meant that the researcher reduced the number of times she went to the Sensiks pod located as an office space with a relatively large flow of people. Consequently, this means that fewer design activities were done at the pod and within the context, making it more difficult to design the experience. Additionally, these regulations meant that it was more difficult to find participants for the user tests since people were less keen on interacting with strangers, i.e. the researcher. The user tests were done with less social contact, i.e. only one person was invited to each evaluation session instead of conducting a focus group session. Close contact was avoided as much as possible. The lack of close contact and knowing that other people had used the pod previously, although thoroughly disinfected after each participant, may have affected the participants.

Furthermore, the study faced some limitations caused by the technology. The Sensiks sensory reality technology is relatively difficult for a single individual to use in an advanced way. Their PodPlayer application features a control panel and the API enables controlling the stimuli through code. However, it is not suitable for a single person to use with the goal of mocking an experience as simultaneously controlling multiple stimuli in accordance with the heart rate readings creates a high cognitive workload. To bypass this limitation, static and looped setups were used for experience prototyping instead. The final prototype of the Gallery of Heartbeats was not mocked anymore but did the computations and control in the code side. Taking this approach with every design step would have meant spending unnecessary time and effort on coding instead of designing the experience. The focus of this study, however, was on interaction and experience design and static prototypes helped focus more on that objective.

9.2 Future work

This study did not look at the effects of the sensory stimuli in detail and cannot make any claims about any individual stimuli being better than another. Future studies could model the relations and analyse in detail how different sensory stimuli can create different perceptions of the heart rate.

Alternatively, future designs could explore sensory stimuli other than heat, airflow, light and sound, for example, scents or haptic vibrations.

This study evaluated the design in sessions that the participants attended only once. To be able to conclude anything about the long-term effects of the Gallery of Heartbeats, a longer study is needed. That way, one could analyse how the design increases bodily awareness and supports relaxation after repeated use. Collaboration with psychologists is also suggested to see how the Gallery of Heartbeats could be of use in the socio-psychological domain.

A clear next step is responding to the usability issues of the Gallery of Heartbeats to ensure a more refined experience. In addition, non-stationary designs for communicating heartbeat information from both a personal and a social perspective can be explored, i.e. wearables. A fascinating topic would be to look into how wearable designs could take advantage of sensory stimuli to reach that goal as many current wearable devices use only vibrations. By looking into potential wearable or, at the very least, transportable designs, the Gallery of Heartbeats could truly be turned into a presence-with digital mindfulness artefact.

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Appendix A: Material exploration of the Sensiks pod

This section explores the technological materials and looks at the existing design of the sensory reality pods of the company Sensiks [14]. The aim is to analyse the allowances of the pod. By doing so, one can pinpoint the initial design motivation and observe how the existing design supports or hinders relaxation and focusing on one's soma.

The resulting design critique is mainly conducted based on the experience with the Sensiks demo pod located at XRBase, Amsterdam. This pod is one of the earliest versions and, as a result, some aspects have been improved upon already. If applicable, the author also reflects on encounters with other Sensiks pods in other locations. Overall, the critique can be extrapolated to pods in similar conditions, keeping in mind that the newer models might include some technological advancements.

This study was done in collaboration with the company Sensiks who produces technology for sensory reality. By the term "sensory reality", Sensiks means using sensory stimuli (e.g. scent, wind, sound) to create feelings of being present in a remote environment [14]. The Sensiks sensory reality pods are used for healthcare (e.g. exposure therapy for treating post-traumatic stress disorder), training and experiential learning, and entertainment, for example [14]. The original idea for the Sensiks sensory reality pod came to the founder when he wanted to reproduce the feeling of being at the beach.

1 The Sensiks sensory reality pod

The Sensiks sensory reality pods look like small dressing cabins with a see-through glass door (see Figure 9-1). The pods are aesthetically pleasing, made of plywood and fibreboards. The exterior of the pod is black and has an engraved Sensiks logo near the door. The interior of the pod consists of white panels accentuated with black protective detailing over the heating modules to avoid accidental burns. The most popular Sensiks pod models have a wooden bench piece the user can sit on, although a bigger model that is accessible with a wheelchair also exists.

The pods enable combining audio-visual experiences with scent, temperature, airflow, and light frequencies. To do so, the pods are equipped with one big light panel on the ceiling and two smaller ones in sidewalls, infrared heating panels on the back wall and on both sides of the user (depending on the model, there may be an additional one in the front left[5] side of the pod), four small ventilators in each corner near the ceiling, a scent dispenser in one of the sidewalls, surround-sound speakers (two up top on left and right, two speakers down low on each side), and a digital computer screen that acts as a touch-based control panel built in the wall on the right. Additionally, a virtual reality headset can be connected to the system.

[5] All orientations are presented from the egocentric perspective of the user sitting on the bench inside the pod while facing the glass door.

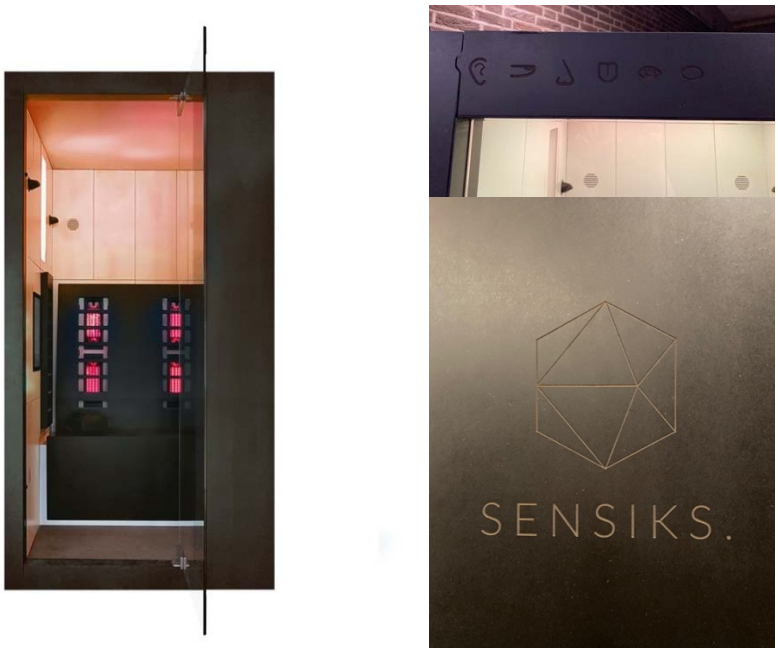

Figure 9-1: Left: The sensory reality pod by Sensiks. Right: The engravings on the exterior of the pod.

2 Location of the pods

Since Sensiks offers their pods as a holistic product, the company itself has little to no control over where their customers position their pods. Some customers prefer to place the pods in a separate room, e.g. Aveleijn's mental healthcare centre in Enschede. Others place it more publicly.

Most of the commercial Sensiks pods are located openly in a way that would capture the attention of passers-by, e.g. at the KLM lounge of Amsterdam Schiphol Airport or the open corridor near the play area of Princess Máxima Center for Pediatric Oncology in Utrecht (see Figure 9-2).The same stands for demo pods, both stationary and temporary, e.g. during events and exhibitions. The open display of the pod triggers curiosity and invites people to try it out, especially when one can see someone else use it beforehand. However, such a public location has some implications if one wishes to use the pod for relaxation.

Figure 9-2: A Sensiks pod located in a corridor near the children's play are at Princess Máxima Center for Pediatric Oncology in Utrecht.

2.1 On display like a doll in a toy store

Although Sensiks provides the clients with the option of equipping their pods with a black or one-way looking glass door, all pods the author came into contact with had a see-through glass door. The see-through glass door of the pod ensures that one can see when the pod is currently being used. The person using the pod is able to see outside, reducing the feelings of claustrophobia that might appear due to the constrained space inside the pod (see Figure 9-3). Yet, the door creates a physical barrier between the interior of the pod and the outside world, somewhat secluding the user from the surroundings.

Figure 9-3: The view from inside the pod at XRBase, Amsterdam. The glass door is closed. The grey doors are an elevator. The wooden door on the left is the entrance to XRBase.

However, when the pod is situated publicly in a place where there are people walking past it, one gets a feeling that can only be described as being like a doll on display of a toy store shelf wrapped in packaging with a see-through plastic window, or an animal at a zoo cage. People passing by the pod are naturally curious and tend to peek in. There is no place to hide from those curious gazes as the glass door takes up most of the front wall.

For example, the demo pod at XRBase, Amsterdam is located in the staircase on the second floor[6] right in front of the elevator and between the bathrooms and the co-working space (see Figure 9-4 and Figure 9-5). This means that people entering and exiting the office will notice what is happening in the pod and the person using the pod has a clear overview of everyone's bathroom habits. The pod located at Princess Máxima Center for Pediatric Oncology in Utrecht is also positioned in an open corridor near the play area for children. This means that people are passing by the pod frequently.

The see-through glass door is less of a problem when using the pod with the virtual reality headset. The user is fully immersed in a virtual world and relatively oblivious to what is happening in the real world. However, when using the pod without the VR headset, it is painfully obvious how

[6] British system: ground floor, first floor, second floor.

on display one is. It seems as if the pod was designed to trigger the curiosity of people passing by, to invite them to try it out themselves, but mostly to be used with the virtual reality headset.

Figure 9-4: A pod located in the staircase at XRBase, Amsterdam. On the left, entry door to XRBase co-working space. In the middle, elevator doors. On the right, hidden behind the pod, are restrooms.

Figure 9-5: A pod located in the staircase at XRBase, Amsterdam. On the left, door to the men's restroom. On the right, stairs.

2.2 External noise

Being located publicly, the pods can be influenced by external noise. For example, the demo pod at XRBase is affected by sounds coming from other companies on lower floors. Occasionally, people go to the corridor for phone calls so as not to disturb their colleagues or have conversations on the stairs when leaving or coming to the office. Sometimes, the offices keep their doors to the corridor open, so everything going on inside the office space will be audible in the corridor.

The pod is not soundproof, although closing the glass door does slightly reduce the external sounds. However, this is not enough to be able to use the pod without being influenced by the

conversations going on outside.Turning on the speakers in the pod helps with blocking the external noise. The high-quality surround sound wraps the user in itself and overpowers the external commotion. This implies that in noisy places the pod was designed to be used with the sound turned on and with an incorporated auditory experience.

3 Internal noise

The inside of the pod also emits some sounds. Due to the smooth flat surfaces, the pod has some echo. This is nearly unnoticeable unless one intentionally pays attention to it and conducts an echo test, e.g. by clapping hands together and observing the reverberation.

The most apparent noise that is audible in the resting state of the pod when no individual sensory technology has been activated is the static noise by the computer – the brain of the pod – and, more specifically, the ventilators designed to cool it. The static ventilator noise emits from the lower right corner, right under the bench where the computer is hidden.

The light panels and infrared heaters emit no noise, apart from some accidental ticking sounds from one of the heating elements when it has not been turned on for a while. The four ventilators in the upper corners of the pod are audible when the fans are turned on. One is able to hear the power level of the ventilators as the motor sound gets louder when the fan speed is increased.

The most intrusive sound comes from the motor of the scent dispenser. The noise originates from the back-left corner under the bench. The sound of the working motor is highly distracting in an otherwise quiet pod. Again, such audible design implies that the inner audible workings of the pod have been imagined to be muffled by surround sound coming from the speakers.

4 Comfort

The positions in which one can use the pod are relatively limited. The most obvious one is sitting on the bench. Standing is possible but depends on the height of the person. In some of the pods with lower ceilings, tall people will not be able to stand upright without bending their head. Due to the restricted space, extended movements are impossible to do. That includes turning around in a full circle while seated. The latter is important to completely enjoy the 360-degree virtual reality experience. Instead, the user has to twist their body to be able to see behind them (see Figure 9-6).

Figure 9-6: The user has to twist her body to be able to see behind her in the virtual environment.

The wooden bench and backrest in the pod are smooth hard surfaces (see Figure 9-7). They are not comfortable to sit on for longer periods of time as one will suffer from soreness in the buttocks and the lower vertebrae. While aesthetically pleasing, the pod is not very cosy, nor pleasant to sit in. The pod was obviously not designed for large-scale movements or for prolonged use.

Figure 9-7: Top-down view of the inside of the pod.

5 Sensory technology

The pod is designed to create a multisensory experience. Audio-visual virtual reality experiences are complimented by airflow, heat, and scent (see Figure 9-8). Light panels are used for ambience.

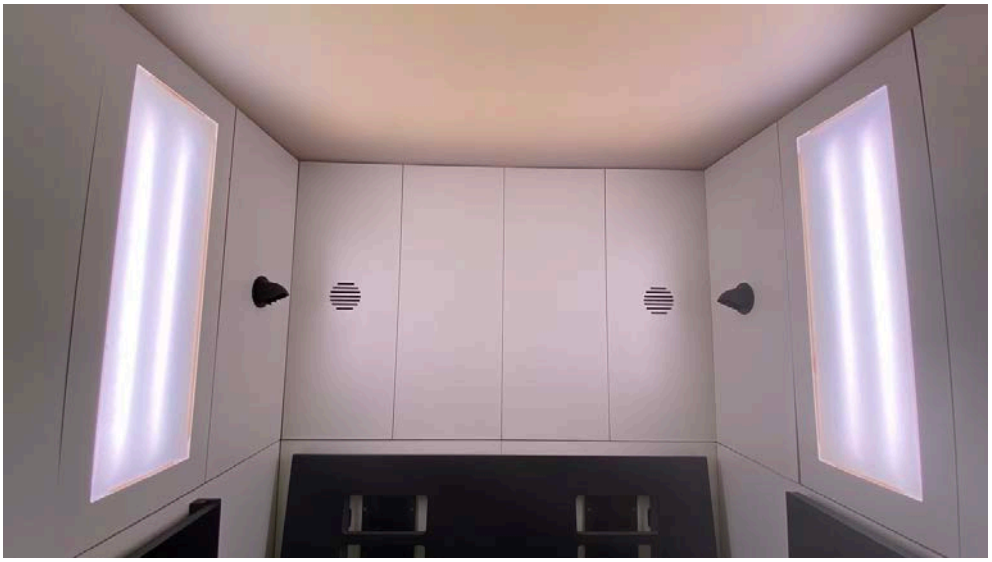

Figure 9-8: Top section of the pod. Big LED light panel in the ceiling, two smaller ones on each side. Speakers in the back wall and ventilators in sidewalls.

In the following section, the sensory technology is looked at on an isolated basis – one set of actuators at a time. Such an approach reveals their individual characteristics and avoids cross-contamination from other actuators.

5.1 Ventilators

There are four ventilators with fans positioned in each upper corner of the pod (see Figure 9-9). The ventilators have 3D-printed rotatable plastic caps that enable airflow 360 degrees in any chosen direction.

Figure 9-9: The four black angular pieces on sidewalls are ventilator caps.

Grilles

The caps have inner grilles that can be moved to an angle to further assist with directing the airflow. They work with the same principle as ventilator outlets in cars. The grilles make a significant difference in the airflow by directing it towards the body (see Figure 9-10). A ventilator without a grille is unfocused, causing air to blow past the user, thus having no effect unless the user intentionally positions themselves in front of the ventilator. Even then the airflow feels more faded than from ventilators with grilles intact.

Figure 9-10: Ventilator caps. Left: with intact grilles. Middle: with broken grilles. Right: with no grilles.

The grilles are an important part of the ventilators. However, they are delicate, difficult to move, and tend to break easily. Some of them are already broken, thus rendering the ventilator nearly useless.

Speed of the fans

The speed of the fans is individually controllable, meaning that while one of the four ventilators is on a maximum power level, another can be turned on at 50%, for example. On maximum power, the airflow can clearly be felt on the body that is located approximately 40 cm away from the ventilator's outlet. It is strong enough to make hair blow in the wind. On a lower power setting, the ventilator creates a gentle brushing sensation on the user's skin.

Sound

The ventilators are loud. One can clearly hear them turning on and off when no other sound source is present. The more powerful the airflow from the ventilator, the more audible it is.

Temperature

The air coming from the ventilators is relatively cold. It should be room temperature since there are no additional cooling elements in the ventilators. However, having the airflow directed to a single spot on the body causes it to feel colder. One even gets chilly when sitting under the ventilators for an extended period of time, especially when the ventilator is directed to the head region.

Scent

The air the ventilators let out does not smell fresh like the air outside the pod. It has a specific musty scent like that of an ancient wooden wardrobe that has not been opened for a while. This is likely due to the air originating from under the bench, passing by the scent containers and getting contaminated.

5.2 Heaters

The infrared heating panels are located on the torso level around the user. They are covered by wooden frames to avoid the user accidentally brushing against the hot heating element and getting burnt (see Figure 9-11).

Stimulated regions on the body

The two heating modules on either side of the user can be felt on the ear, the cheek, the side of the arm, the hip, and the thigh.

The two heating modules on either side behind the back of the user are positioned in a way that they do not hit the back directly but are right next to the body when seated correctly. These ones can be felt on the sides of the neck, the shoulders, the backs of the ears and arms, and the elbows.

The heating module in the front left corner is directed diagonally towards the sitting user. It cannot be felt as well as the ones closer by. It mostly warms up the left side of the face, leaving the right side cold.

Sound

When turned on, the heaters emit a low-pitched static sound that is accompanied by occasional ticking noise, especially from the heater on the left side. The ticking sound is similar to the one wooden benches or heating stones make in a sauna.

Intensity of the infrared panels

The power level of the heaters is individually controllable. Once turned on, the heat can be felt relatively quickly, although there is a slight delay present between turning the heater on and the body perceiving the emitted heat. When turned off, the heat does not linger for long, unless the heater had been kept on for a while and the heat had time to sink into the clothes. Once turned off, the coolness of the surrounding air becomes apparent fast.

The warmth feels nice, comfortable and relaxing as if being held or wrapped in a blanket. The heat triggers memories of sauna and summer. Due to the panel positioning, the face feels somewhat left out, leaving it open from the surrounding heat like a window of freshness. It can be described as having sunk into a warm soft cloud while lying on one's back.

Just like a sauna, sitting with all the heating panels turned on to the maximum for a prolonged period becomes straining. The blood pressure rises and the heartbeat is easier to notice. Cheeks start to blush and the ears get a slight burning sensation. After a while, the heat becomes too intense. Turning the heaters off and feeling the cool air take over is refreshing, although heat lingers on blushing cheeks for a while.

Figure 9-11: Infrared heating panels are covered by wooden frames to avoid the user getting burnt.

5.3 Lights

There are multiple RGBW LED-lights in the pod, hidden behind opaque plexiglass. These LED lights create ambience in the pod environment. The brightness of the LEDs can be controlled individually, making various colour combinations possible.

The big panel in the ceiling consists of multiple small LED pixels creating a customisable grid. The big panel can be animated (see Figure 9-12). It currently has four abstract animations of stars, a sky, a forest, and sunshine. Additionally, there are two smaller panels near the ceiling on both sides

of the user (see Figure 9-13). Both panels consist of two parallel LED-strips. The panels can be controlled independently of each other.

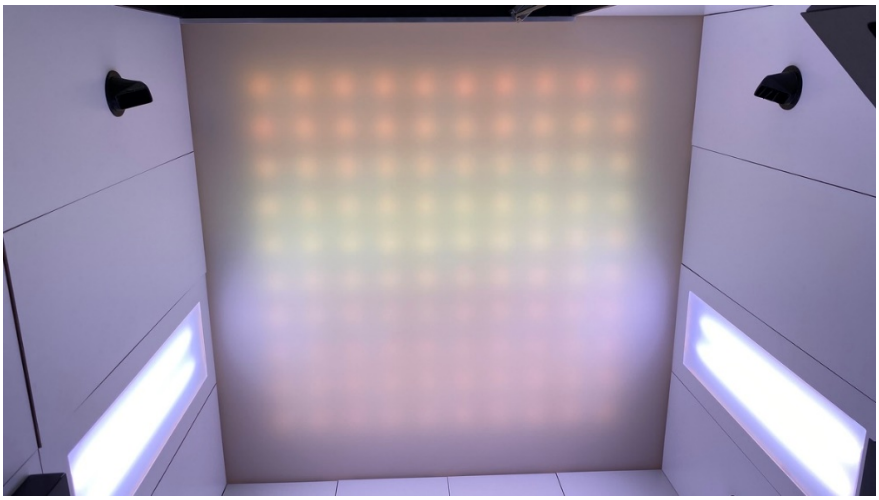

Figure 9-12: The ceiling panel consists of a grid of LEDs and can be animated. The image shows the sun animation pattern.

Figure 9-13: Two LED-panels in sidewalls can be controlled independently of each other.

5.4 Scent

The scent dispenser outlet is located in the sidewall. In the case of the XRBase pod, it is the wall on the right. There are six holes in the wall that are connected to six scent containers. Each scent has its own hole (see Figure 9-14).

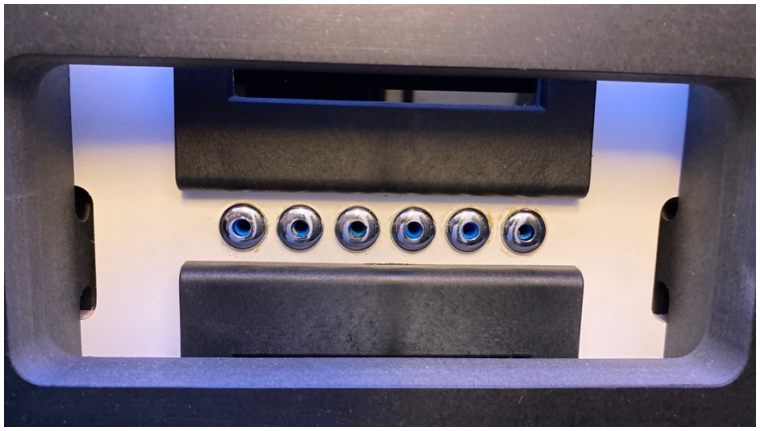

Figure 9-14: The scent dispenser has six holes for six fragrances.

Types

Currently, the scents in the Sensiks pods are bought in from a company who is dedicated to chemically engineering scents. They have a complicated formula and are difficult to replicate.

In the XRBase pod, they have scents called “grass”, “smoke”, “metal”, “misty swamp”, “sea”, and “reptile”. “Smoke” smells like warm wooden benches in a sauna. “Metal” is similar to men’s shampoo. “Reptile” smells fresh like a meadow or grassland. “Grass”, “misty swamp” and “sea” are all sweet scents.

Sensiks is presently working on creating more natural scents using essential oils instead.

Intensity

The scents are extremely overpowering. Just a little is needed for it to be olfactible. In most pre-created experiences that the pod currently has, the scents are intense, even suffocating.

The scents also tend to linger. The pod does not ventilate fast and efficiently enough to purify the air between uses, especially during events when there are multiple people trying out the pod in a row. The scents fade faster when the door is open as the ventilators are not powerful enough to clear the air in the pod on their own.

It seems like there is little to no fresh air coming in when the door is closed, making one believe that the scented air circulates repeatedly inside the pod. This can confuse the user by contaminating experiences, e.g. having smoke scent linger in a nature scene.

Sound

The motor of the scent dispenser is extremely audible and distracting when the pod is completely silent. The noise comes from the back-left corner, right under the bench. The sound starts and ends before the scent fills the pod, so at first it seems to be disconnected from everything and one wonders what it is for.

5.5 Sound

The pod has four speakers: two above the head level in the wall behind the user (see Figure 9-15) and two in each sidewall on the calf level (see Figure 9-16). Such positioning enables using surround sound effects and creating the feeling of the sound originating from a certain direction.

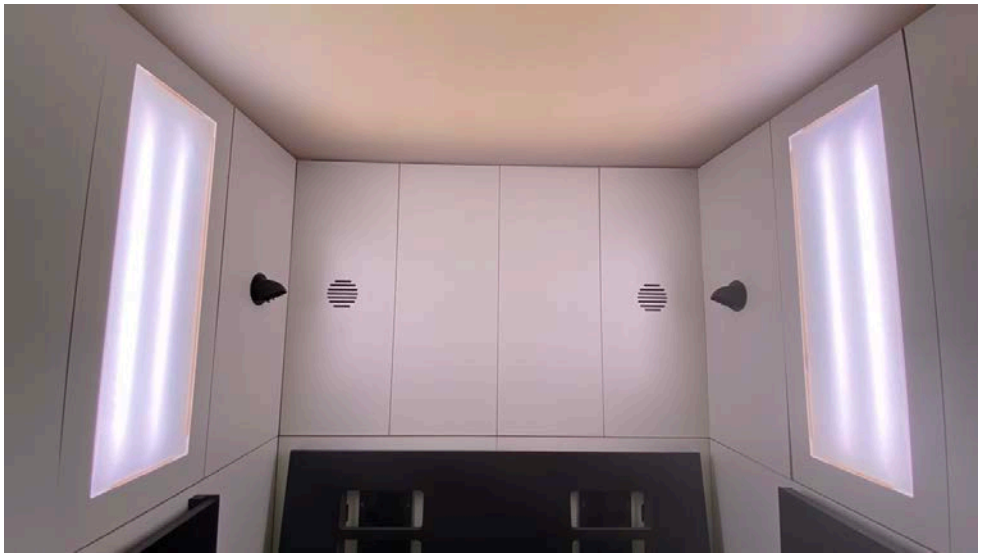

Figure 9-15: Speakers near the top part of the pod.

Figure 9-16: Speakers on the calf-level near the floor.

Volume

The amplifier produces great quality audio that can go to such high volumes that are impossible to be used in the pod – they are simply too loud. The audio of the computer needs to be turned down greatly to be able to enjoy the sounds comfortably and without getting permanent damage to hearing. Due to such great speakers and amplification, recordings played in the pod need to be high quality. Any distortion and unintended noise will be apparent otherwise.

Tangible bass

Low-frequency sounds can also be tangible when positioned right. Sitting on the bench with little buffering between the wood and the body, one might be able to feel the bass stimulate their lower back. Alternatively, the bass is tangible when the skin is positioned immediately in front of a speaker. Naturally, for this effect to appear, low-frequency audio is needed.

The muffling effect

The speakers can be used to make the sounds from the rest of the sensory technology less apparent, e.g. the scent dispenser or ventilator motors. This works in two ways. First, the sound can overpower the motors. Second, the user's attention can be directed to the intentionally created sounds, thus leaving the accidental ones to the background.

5.6 Virtual reality headset

The virtual reality (VR) headset enables one to visually immerse themselves into a virtual environment. It provides a 360-degree view of the virtual surroundings. Handheld controllers are optional, but not needed for the setup that Sensiks has. With Sensiks, one needs to select the desired experience which is then presented in the form of a passive non-participatory video.

Comfort of the gear

The demo pod at XRBase uses Oculus Rift S (see Figure 9-17). The headset itself is slightly uncomfortable as most VR-headsets currently are. The front part is heavy and tends to slide down, unfocusing the image and causing strain on the nose, cheeks, and eyes. To get a perfectly focused image, one might need to support the headset with hands or spend some effort on adjusting the straps beforehand.

Figure 9-17: The demo pod at XRBase features the Oculus Rift S virtual reality headset.

The cord gets in the way

The headset is connected to the computer with a thick and heavy cord. This ensures a flawless connection and high-quality content delivery. On the other hand, it also gets in the way. The cord originates from the right side of the bench and enters the headset near the left ear of the user. This means that the cord will have to hang diagonally in front of the user's body or behind their back. By turning around or moving during an experience one becomes aware of the cord again. Attaching the cord to the ceiling might be a solution to this.

Requires calibration

Some content is omnidirectional, meaning that it does not matter much from which angle one looks at it. Therefore, calibrating the viewpoint is optional. Other content, however, is unidirectional. It has a concrete "front" and "back" or specific directional movement. Such experiences rely strongly on orientation and appropriately configured view.

Viewpoint calibration depends on the concrete headset that is being used. At XRBase, one can reset the view using a single handheld Oculus remote. Although an easy process once familiar with it, the calibration may not be intuitive to everyone, especially less tech-savvy users.

As a worst-case scenario, the user may be completely unable to use the pod. That has previously happened with the Sensiks pod at Princess Máxima Center for Pediatric Oncology. Namely, the headset there displayed a setup screen until calibration was completed. Due to the public location, the handheld controllers needed for calibrating the viewpoint were kept separately from the pod to avoid theft or damage. No guidelines or contact details were present at the pod which made it difficult to find a person responsible for it.

Such a sensitive setup means that for optimal user experience, someone who is capable of recalibrating the VR headset has to be present. However, Sensiks has been looking into a universal option that does not require additional effort from the end-user.

Correlation with the light panels

While wearing the headset, one becomes oblivious to the lighting panels, although they remain activated. Lighting effects are in alignment with the virtual reality experience, mirroring the colours of the virtual world (see Figure 9-18). This implies that the pod is completely usable also without the headset and the experiences can be visually enjoyed in a more abstract way.

Figure 9-18: Light panels correspond to the colour scheme of the virtual reality content and are turned on even when the virtual reality headset is used.

5.7 Touchscreen

In the right wall next to the door is a touchscreen for controlling the pod (see Figure 9-19). By default, the screen shows the Sensiks PodPlayer application with a selection of immersive virtual reality videos enhanced with sensory reality (see Figure 9-20). The PodPlayer interface also enables addressing each sensory actuator individually. Once inside the pod, the user is expected to choose a video, put on the VR-headset and enjoy the experience. During demos, a company representative commonly selects the experience from the screen and closes the door after ensuring it started correctly.

Figure 9-19: The control panel is located in the right wall.

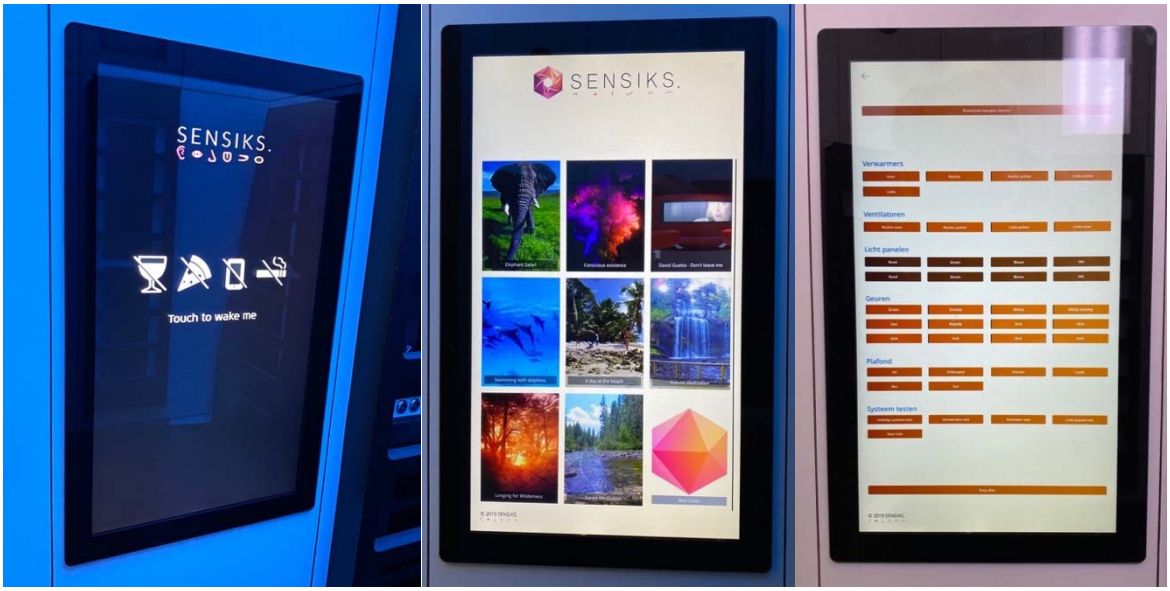

Figure 9-20: PodPlayer software enables controlling the pod hardware. Left: screen saver of the application. Middle: screen for browsing experiences. Right: panel for manually controlling the sensory actuators.

Spoilers for people waiting in line

During the experience, the Sensiks PodPlayer application displays the 360-degree video as a regular video. With the headset on, the user can only see the immersive 360-degree video. However, the regular video shows people standing outside the pod what the user is seeing.

On the one hand, this can comfort the people waiting in line by letting them familiarise themselves with the content of the experience. On the other hand, knowing what will happen loses the surprise effect and can somewhat spoil the experience once they try it inside the pod themselves.

Bend and twist

It is clear that the screen is not intended to be used in any other way than for briefly selecting an experience. The positioning of it makes using it comfortably nearly impossible. For every action on the screen, the user has to bend forward and twist their body to the right. This is not an ergonomic position and, thus, prolonged use of the touchscreen becomes impossible.

Levelling

The screen is lower than the eye level of a sitting user. As a result of such angling, it is easy to hit the wrong keys when typing on the touchscreen. To avoid that, one needs to bend over to be on the same level as the touch keyboard or to aim slightly below the place where the desired key appears.

Irremovable screen

Having a screen built in the wall is obviously good for security. It enables leaving the pod unsupervised without having to worry about someone stealing the input device as might happen with a loose tablet.

Additionally, having the screen inside the pod lowers the possibility of someone stopping or changing the experience as might happen if the screen were outside the pod. It also makes switching between experiences hassle-free as one can remain sitting in the pod.

However, one wonders about the motivation behind positioning the screen in a way that is featured in the current design. There seems to be no clear reason for having the touchscreen on the height and angle it is now.

6 Summary

As can be seen, the Sensiks sensory reality pods have a very interesting design. They are designed for seated short-term use as they are small and not very comfortable. The goal is to attract people passing by the pod, encouraging them to stop and try it out.

Audio-visual virtual reality is the key for hiding the design flaws, such as too audible motors. However, thanks to the ambient lighting, the pod is also perfectly usable without the VR-headset. The sensory technology can be used individually, although the effect feels the greatest when the stimuli are combined.

The design implies a somewhat supervised setup, be it for the security of the technology or simply to help users with calibrating the virtual reality headset.

The positioning of the pod is important as most public spaces are noisy and have a lot of traffic, making the user of the pod feel observed. In the context of relaxation, this is counter-effective for reducing anxiety and stress.

In general, the Sensiks pods do not support achieving a state of relaxation for the author. The user is too visible to passers-by, the seating too uncomfortable, the external noise too apparent, and the loud motors too intrusive. The design could definitely be improved in that aspect by positioning the pods in a more secluded area, cushioning the sitting bench, focusing more on soundproofing the pod or incorporating more silent technology (also see Chapter 5).

Appendix B: Misuse Magalogue

MISUSE MAGALOGUE

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Disclaimer

All opinions presented in this magalogue are independent opinions of Eva Maria Veitmaa and do not represent the opinions and actions of the company Sensiks.

The products in this magalogue do not officially exist in such shapes and forms. They are independent creations of Eva Maria Veitmaa. Sensiks is not connected to the development of these products. The products are not for sale.

This magalogue is part of a Human Computer Interaction and Design MSc thesis done in collaboration with the company Sensiks and KTH Royal Institute of Technology.

April
2020

EDITORIAL
by Eva Maria Veitmaa

What if you could escape the reality? Replace it with anything your heart desires? Relax on a beach, feeling the gentle wind in your hair, the sand grains between your toes, the warm sun on your skin? This is exactly what the sensory reality pod by Sensiks promises - hyperrealistic multisensory experiences for relaxation, entertainment or medical treatment.

But is it always necessary to escape the reality? Traditional relaxation practices, such as meditation and yoga, show how little we notice ourselves and our surroundings. The pressure of a chair against the bottom, the bad posture leading to back pain, the rhythmic heartbeat reminding us that we are still alive. All these things often go unnoticed despite them accompanying us every day, all the time.

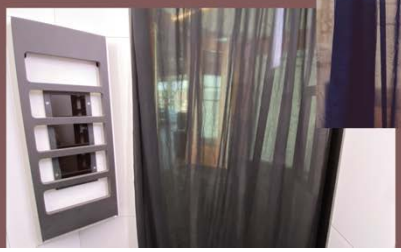
Would it be possible to transform the technology that is designed to mask the reality into something that makes us more in touch with ourselves and our living bodies - the essence of how we sense the world both inside and around us?

In this second edition of the Misuse Magalogue we explore the Sensiks pod and how it could be turned into something more comfortable. We present you with a thorough guide to sitting positions and various product offerings by Sensiks designed to make their sensory reality pods a bit cosier and more relaxing.

CONTENTS

1.

Concealing curtains and disguising drapes



MYSTERIOUS BLACK

Single layer	€ 7.99
Double layer	€ 15.99
Triple layer	€ 19.99

CREAMY WHITE

Single layer	€ 8.99
Double layer	€ 16.99
Triple layer	€ 22.99

Shield yourself from the curious gazes of onlookers and submerge into luxurious fabric. This delicate door cover comes in two colours, matching the black-and-white bamboo panel interiour of the Sensiks pod.

The high-quality drapes are modular and can easily be attached in layers for optimal opacity. These curtains are ideal for creating your own secret haven of relaxation in busy places.

Privacy has never looked better!

Comfort pillows for a softer sitting

2.

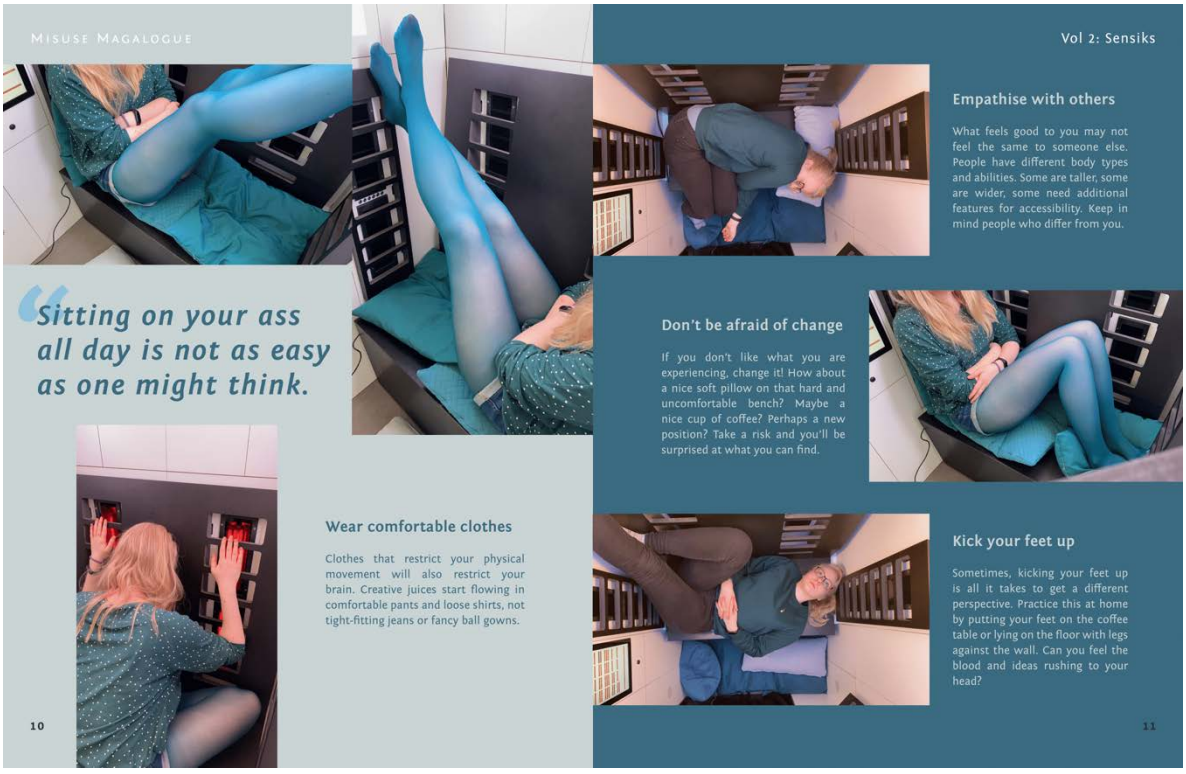
PADDED BELLY
€ 4.99

STURDY FEET
€ 5.99

TEXTURED TUSHIE
€ 9.99

COMPLETE SET
€ 24.99


Misuse Magalogue
COVER STORY:
A DIFFERENT PERSPECTIVE
Vol 2: Sensiks
Professional sitter Eva Maria Veitmaa sheds some light on her occupation and tries out the Sensiks pod.
What is it like being a professional sitter?
People often laugh when I tell them that this is what I do professionally, but the truth is that sitting on your ass all day is not as easy as one might think. A lot of effort goes into figuring out the design flaws of various seats and even more thought has to be put into coming up with ideas on how to make the designs more comfortable.
What differentiates an average seat design from an excellent one?
For me, the best designs are the ones that are padded and surround my body on all sides. They make me feel secure, yet calm. Like being wrapped in a cloud! Comfort is always important. You need to be able to sit without any pains. In the end, it is all very subjective, but the goal of a professional sitter is to try to find a design that satisfies a large group of people with different preferences and physical abilities.
The most memorable seat?
Definitely one at Schiphol Airport. I spent a night there once as a test. It was cold and hard and the armrests made it impossible to find a nice position to fall asleep in. It's often less about the actual seat itself and more about how everything just comes together. The surrounding details are extremely important for a good sitting experience.
What is your verdict on the Sensiks pod?
Well, the Sensiks pod definitely has some room for improvement. It is not very cosy. I would love to see some massage functionality in here, or at least a softer, more comfortable seat. It is an interesting pod with various affordances. I even ended up doing stretching exercises with the cover panels. I love the heating. It reminds me of my sauna back at home.
Can anyone become a professional in this field?
Sure! We all sit daily, don't we? A professional sitter just needs to be more attentive, more connected to her body and surroundings. I recommend getting started with body scan meditations for developing higher body awareness.
On the next page you can find some tips for an aspiring sitter.


Misuse Magalogue
"Sitting on your ass all day is not as easy as one might think.
Wear comfortable clothes
Clothes that restrict your physical movement will also restrict your brain. Creative juices start flowing in comfortable pants and loose shirts, not tight-fitting jeans or fancy ball gowns.
10
Vol 2: Sensiks
Empathise with others
What feels good to you may not feel the same to someone else. People have different body types and abilities. Some are taller, some are wider, some need additional features for accessibility. Keep in mind people who differ from you.
Don't be afraid of change
If you don't like what you are experiencing, change it! How about a nice soft pillow on that hard and uncomfortable bench? Maybe a nice cup of coffee? Perhaps a new position? Take a risk and you'll be surprised at what you can find.
Kick your feet up
Sometimes, kicking your feet up is all it takes to get a different perspective. Practice this at home by putting your feet on the coffee table or lying on the floor with legs against the wall. Can you feel the blood and ideas rushing to your head?
11

THE GROIN PROTECTOR

A tense body with inner thighs pushed together and hands placed in front of the groin ensures the safety of vital reproductive organs, yet indicates ultimate fear.

THE THIGH PROTECTOR

The body is still rigid, but the hands have moved away from the midline and are now on the upper thighs. This posture shows uncomfort, yet slight development of trust.

THE UNLADYLIKE

A loose posture with legs slightly spread and hands resting in the lap shows high levels of trust, comfort, and relaxation. This sitter is enjoying herself and the seat. Notice the added cushions.

THE TRAYLESS WAITRESS

Hands are shaking from being kept elevated for a prolonged period. This is a very uncomfortable pose and should not be kept for extended periods of time.

THE TIGHT HUGGER

This pillow is brand new and hasn't been there before. Clenched hands form a solid barrier keeping the pillow from escaping. It may look harsh but it is necessary for ensuring that the pillow doesn't escape later when left by itself.

THE LOOSE HUGGER

The pillow is given more freedom and a chance to explore its surroundings. It looks curious and eager. The owner's hands are loose enough to show the pillow some trust, yet ready to catch it in case it tries to escape

THE NO HUGGER

The pillow has formed a bond with its new owner, sitting in her lap comfortably. Notice how it has every opportunity to slip away from the lap but remains still to enjoy the warmth of the owner.

3.

Ways of sitting explained

THE LOOSE PRETZEL

A classic meditation position with intertwined legs and palms resting on the thighs. The wall provides additional support for the back, so less effort is needed to keep the body upright.

THE TIGHT PRETZEL

A modification of The Loose Pretzel. The hands are clenched around the ankles to ensure legs do not slip off the elevated bench. The grip also provides support for the back.

THE BENT PRETZEL

The weight of the torso is supported by the arms resting on the thighs. This position is comfortable, but not good for the posture if practiced often.

THE INVERTED PRETZEL

Facing the wall indicates a desire to be alone and undisturbed. This sitter wants to ignore everything that is going on outside and let her mind rest for a moment.

THE "V"

A good position for relaxing after a long day of being on your feet. The elevated legs support blood flow back towards the heart. For an even better effect, lie your torso flat on the seat in the Daddy Longlegs position.

THE "S"

Gravity does its work in this cooped-up, yet loose position. A state of equilibrium might differ between people with some staying upright and others resting their head and knees on the wide black panel of the pod.

THE "O"

The fetal position indicates preparation for rolling backwards off the seat for a quick escape. However, notice the bowed head showing inattentiveness to surroundings. This sitter is focused on herself.

THE "W"

This extended position expands the surface area of the body for optimal heat absorption. Heat flows into the body from the hands and legs which are usually colder than the rest of the body.

THE OPEN CASKET

Surrounded by five sides with firm walls, this position makes one feel either safe and held or claustrofobic. The soft cushions create an effect of sitting in the middle of a cloud.

THE BUS SEAT

An uncomfortable position for getting some shut-eye in tight places. Body is twisted in unnatural angles and the sitter will wake up with back pain and a stiff neck, not feeling rested at all.

THE DADDY LONGLEGS

Keeping legs upright needs intentional effort as gravity pulls them downwards. The ability to engage in this position depends on the width of the bench and the length of the sitter's torso.

THE PRAYER

A complete surrender to the pod and its heating elements. Possibility of accidental burns if the arms and open palms are kept directly in front of the heaters for too long.

THE BICEPS

Hands gripping the panel covers, this biceps exercise relies on bodyweight. For more gains, wear a backpack with books in it.

THE UPPER BACK

This position works muscles in your shoulders, back and arms while providing a gentle stretch to the extended thumbs.

THE STRETCH

Stretching elongates the muscles after a workout and helps with the cumulation of lactic acid. Do stretches to avoid sore muscles and to revitalise your joints.

THE COOLDOWN

Take a moment to rest and congratulate yourself on having found time for yourself. With hands wrapped around the knees, the body holds itself in this position with no additional effort.

4. Functional and elegant

No levels	€ 9.99
Three levels	€ 14.99
Eight levels	€ 24.99

Who said that what is beautiful cannot also be functional? With these stylish cover panels even the most avid multitaskers can be sure that their tasks will continue to be carried out whilst they enjoy a well-deserved break.

These black bamboo panels fit perfectly over the infrared heating elements of the Sensiks pod. They are designed to provide protection from accidental burns, but it is up to you to decide what other purpose they may serve.

We recommend using them for calisthenics exercises. Alternatively, attach a washing line between the two side panels and crank up the heat for a quick and efficient homemade dryer cabinet.

What can you come up with?

Submit your idea to sensiks@misusemagalogue.com before July 31 for a chance to win a set of 8-level cover panels. Winners will be announced in the autumn edition of Misuse Magalogue.

DIY: Custom scents

5.

Have you ever wanted to capture the smell of freshly cut grass or that summer night you simply did not want to end? Is the exceptionally wide scent offering by Sensiks still not enough for you?

Fret not, for here is a quick and easy solution. With this tutorial you will be able to recreate your favourite scents and enjoy them while relaxing in the Sensiks pod.

You will need:

- Your favourite scented product (e.g. shampoo or essential oils)
- Water
- Mixing spoon
- Empty spray bottle

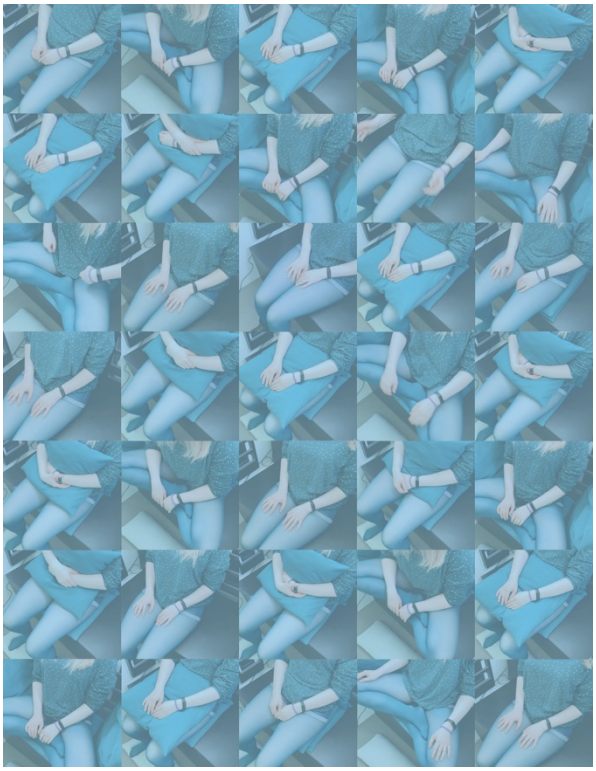
Step 1
Pour the scented product into water.

Step 2
Mix thoroughly.

Step 3
Put the mixture into a spray bottle.

Step 4
Spray away!

** New Sensiks scents are being released monthly!*



Appendix C: Biofeedback

One of the goals of the study was to externalise physiological signals, such as breathing, heart rate, skin conductivity, or body temperature by using the Sensiks pod's sensory technology. Due to availability, only a heart rate sensor was employed.

1 About the heart rate sensor

The exact model of the heart rate sensor provided by Sensiks is unknown, but is akin to Grove ear-clip heart rate sensor [86]. The setup consists of an ear-clip, a receiver module, and connecting cables. The ear-clip is a transmission-type optical pulse sensor meaning that it uses infrared to measure the change in the amount of light transmitted by blood [87]. The sensor is designed as a clip and, thus, requires a thin skin fold to be placed between the two sides of the clip to work.

This heart rate sensor measures intervals between heart beats or interbeat intervals (IBIs) [88]. This data can be converted into heart rate and expressed as beats per minute (bmp). Alternatively, it can be used to capture heart rate variability (HRV) which indicates the changes in time between successive heart beats. High HRV indicates higher tolerance against anxiety and stress.

2 Positioning the sensor on the body

As mentioned above, for proper measurements the sensor needs to be positioned around a thin skin fold. Despite the sensor being designed for being worn on an earlobe, various alternative placements were inspected to potentially discover a better option fitting the context of this study (see Figure 9-21).

Figure 9-21: Some sensor placements in the facial region.

Measurements from the nostrils are accurate, but the sensor obstructs the airways and blocks one side of the nose. Clipping the sensor on either upper or lower lip is painful and uncomfortable and causes the sensor to be covered in saliva. A line of belly fat is too thick for the sensor to be clipped on, unless held in place with fingers, but the thin skin around the navel works well. When putting the sensor around the little finger, not all of it gets covered, but pressure from the sensor makes the blood flow in the finger easier to notice, creating an interesting tangible feeling. Earlobe tends to get sore after a while and the cord might get in the way. Either fingers or ears seem to be the most natural locations for the sensor.

In any case, the sensor is relatively sensitive (see Figure 9-22). It requires careful placement on the body. Any strong movement of the cord interferes with the readings causing them to be inaccurate.

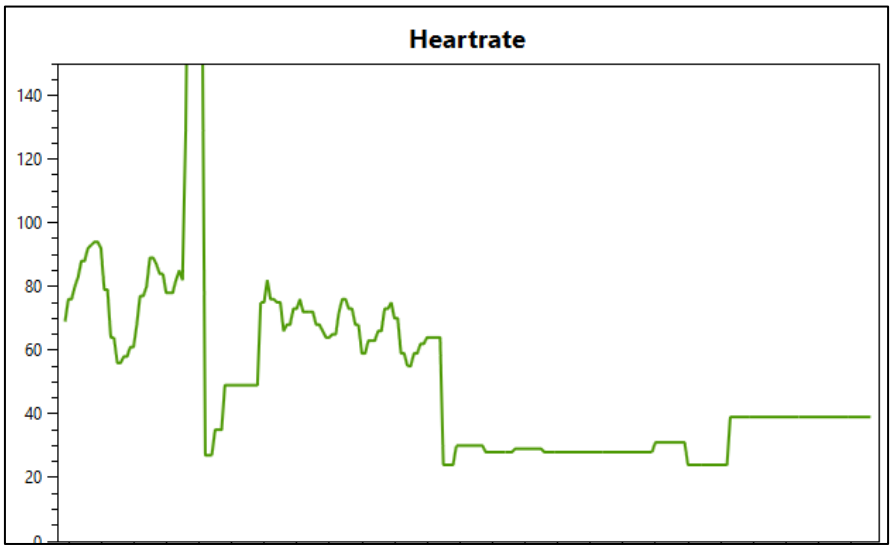


Figure 9-22: The sensor is very sensitive. The graph shows a jump and flatlining caused by movement and incorrect placement of the sensor on body.

3 Visualising the readings

Sensiks provided a basic Windows Presentation Foundation (WPF) application created by Lars Hulsmans that connects to the sensor hardware, polls the pulse sensor for interbeat intervals, converts that data into heart rate and visualises the latter both as a numerical field and a line graph (see Figure 9-23).

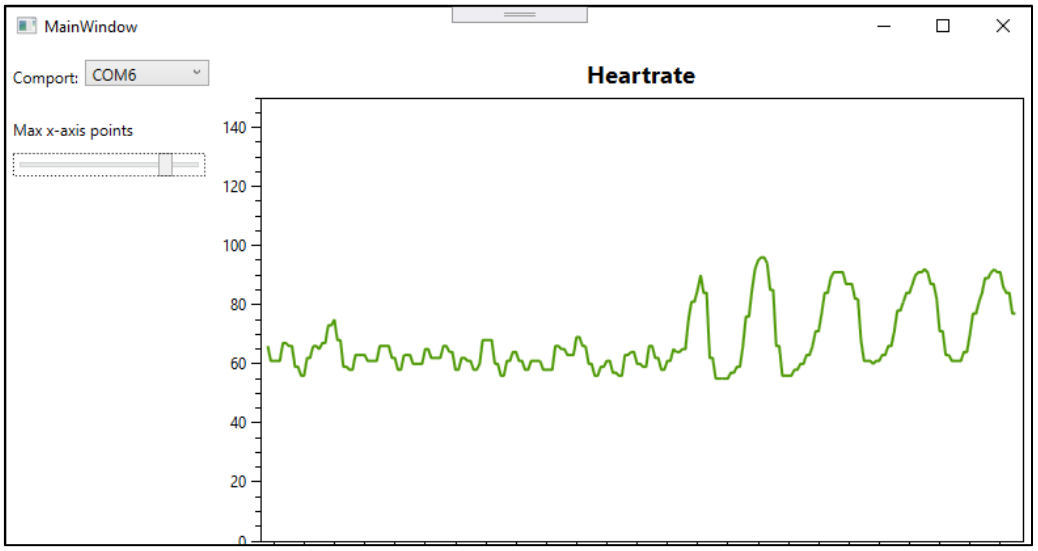


Figure 9-23: Screen capture of the basic data visualisation application. The graph shows changes in heart rate caused by different types of breathing.

Initially, the visualisation rate was set too low (after every 1000 ms), so there was a strong delay between the actual change in pulse and the visualisation on the graph. The graph still captured all changes in heart rate but did it with a time shift. This shift was noticed because of the direct mapping between breathing patterns and heart rate that was first observed when engaging in relaxation practices (see Section 4.5.4).

This delayed representation of heart rate data made it difficult to map bodily actions, such as breathing or movement, to changes in the graph, especially if those actions were short-term. As a result, the feedback became virtually unusable unless engaging in long, controlled breathing.

When the visualisation rate was increased to every 5 ms, the feedback became more direct and the graph was displayed with less of a lag.

4 Cross-checking the sensor readings

Due to the sensor provided by Sensiks being the most accurate one available for use during this study, a problem arose with cross-checking the readings. A way was needed to ensure at least an approximate accuracy of the measurements.

To do so, readings from the Sensiks sensor were converted to heart rate data and compared to readings from a Xiaomi Mi Band 3 activity monitor and a pulse measured manually by positioning two fingers on the neck artery. As both of these control methods enable getting only a single number as an output, they allow for cross validating the approximate range of the pulse sensor measurements but fail to capture the nuanced changes in heart rate variability.

5 Manually controlling the sensory stimuli

To save time and effort before programming the control of sensory technology based on sensor data, a decision was made to mock the interaction instead. Two aspects made this option feasible.

First, the WPF application by Lars Hulsmans that visualizes the sensor data (see Section 3) enables reading immediate information about the heart rate. This information about the increase or decrease in heart rate can be used as input. Second, along with the hardware, Sensiks also delivers the accompanying control interface called PodPlayer which can be used for manually controlling the sensory actuators (see Section 5.7).

Reading the sensor data from one screen and using that as guidance for controlling the sensory actuators via another screen caused an extremely high cognitive workload as two screens had to be interacted with at the same time. As using the heart rate data to mock control of the pod hardware was counter-effective, breathing was used instead. Using breath for input lowered the cognitive workload. Observing inhalations and exhalations did not demand looking at another screen but focusing on the soma instead. During inhalation, an actuator could be turned on and during exhalation, the same actuator could be turned off creating a mapping between the sensory modality and the physiological action.

Due to the unergonomic angle and relatively low sensitivity of the built-in touchscreen, the control slider was often missed when trying to change it with a finger. To resolve the issue of the angle, the pod was connected to via TeamViewer running on an iPhone 11 (see Figure 9-24). However, unlike Android phones, the TeamViewer application on iOS does not support touch-based interactions and using the PodPlayer interface was even more complicated that way.

Since PodPlayer is a full screen application, a setup of two separate screens is required for mocking the biofeedback. A MacBook Air laptop running Windows 10 from an external SSD and connected to the heart rate sensor was used for measuring and visualising the heart rate data. The built-in touchscreen of the Sensiks pod was used to interact with the PodPlayer application since the same computer is already connected to the required hardware including the sensory actuators. In case of a single person, only one or two sensory actuators could be controlled at a time due to each control requiring the use of hands, restricting the testing to a single isolated modality at a time. This was not sufficient for mocking an experience employing more than two actuators.

Figure 9-24: The PodPlayer interface as viewed via TeamViewer on an iPhone. The interface is in Dutch, but it allows manual control of the sensory actuators in the pod.

6 Interference from the infrared panels

Since the sensor uses infrared light to measure the pulse, infrared heat panels cannot be turned on when the sensor is being used. The infrared light from the heat panels interferes with the sensor's own infrared light and causes it to malfunction. Disturbed readings randomly fluctuate between 20 and 160 bpm. The combination of heat panels and heart rate sensor can be used when the sensor is positioned outside the pod, away from the influence of the infrared heat panels.

To make the sensor possible to use also inside the pod while the heat panels are turned on, two methods were investigated (see Figure 9-25). First, the sensor was covered by hand to block out the infrared light from the heat panels. This was not sufficient. Alternatively, a layer of aluminium wrap around the sensor was expected to reflect the external infrared signals. However, aluminium casing was also not enough to achieve undisturbed readings. A combination of hand and aluminium improved the situation slightly but was not deemed effective enough to guarantee accurate results.

Figure 9-25: Blocking out the infrared light from the heat panels using a hand and aluminium wrap was not effective.

7 Static experiences with mocked biofeedback

Since mocking the biofeedback manually turned out to be inefficient and did not enable focusing on the soma, a basic static experience was created instead. This enabled to investigate the mappings between physiological actions, such as breathing and heartbeat, and the pod's sensory stimuli.

Two different audio files were used to present the mocked physiological actions. Breathing audio was recorded by the author of the study using an iPhone 11. Heartbeat audio with a Creative Commons 0 license was downloaded from Freesound [89]. For the latter, the tempo was changed to match a variety of different bpm rhythms. Reaper Digital Audio Workstation was used for audio editing (removing recording noise, changing pitch, equalising) throughout the study.

The pod's actuators were statically controlled using a WPF program[7] written in C#. The program looped the audio clips and turned the actuators on and off correspondingly. For example, heat panels were turned on when inhalation audio was playing and off during exhalation audio. Addressing the actuators in code enabled trying out various combinations, e.g. heat and air at the same time.

During testing, the author adapted her breathing to synchronise with the audio recording and observed how sensory stimuli were perceived. Such a setup was not ideal to create feelings of presence-with, nor did it fully succeed in conveying the connection between the pod and the author's soma. However, some observations could be made (see Table 9-1).

The main conclusion was that there exists no universal setup of sensory stimuli that guarantees success every time the pod is used. On different days, the author preferred different levels and combinations of heat, light and airflow. This indicates a need for customisability and user control.

High levels of heat were mostly perceived as unpleasant since the ventilation in the pod did not succeed in refreshing the air in between the intervals. The air exchange with the outside does not happen quickly enough for this. High fan levels were also distracting. Sometimes it felt like air was being forced into the author's lungs. Another reason was that the fan motors were quite audible on higher speeds.

Table 9-1: Notes from the static biofeedback experience.

Stimuli (status on) inhale...exhale	**Elongated breathing**	**Normal breathing**
No stimuli	Audio provides guidance on how long breaths should be. Allows deviation. Days are different, the 4:7 pattern fits one day, but not another. Forces to follow the breathing rhythm – not presence-with. Don't really make the connection between the pod and my own body. Audio seems to come from someone else. Start picking up the pattern of breathing unintentionally, even when	Matches current breathing more or less. Slightly faster in the recording than in reality. But that is easy to change, just one parameter in the code basically.

[7] https://github.com/3v4m4r14/msc-pod

	deviating from it at the beginning. Is this because I recognise my breathing audio?	
Heat 100…0	Very warm if all panels turned on. Nose feels cold when breathing in and warm when breathing out. Panels warm up the inhaled air making the situation even warmer. Heat raises pulse.	100 is too warm. Panels stay on for a short while bc inhale is short, exhale long. Feels natural apart from the too warm aspect.
Heat 0…100	Pod reflects how nose feels: warm when exhaling, cold when inhaling Inhalation refreshes, exhalation comforts.	Wayyyy to warm. Also bc the panels stay on for long. Inhalation is short, exhalation is long.
Heat 50…0	Less heat is better. Could be even less if all panels are on. Need to open the door for fresh air to get in.	Still too much heat.
Heat 0…20	Would not use more heat than 20%. This already heats up the pod quite well when the door is closed.	For some reason makes less sense than 20...0. Now I want to be wrapped in heat when inhaling, and exhale warmth does little. Heat stays on for too long bc exhale is longer than inhale. So there is too much heat.
Heat 20…0	When actuators are on during inhalation it feels like everything is activated, taking energy into the body. Exhalation = cooldown period, giving energy out, stagnation, letting go, loose, tuning down, turning off.	Creates a gentle pulse. Heat could be even lower. Or maybe I have just warmed up too much bc I have been sitting here for a while.
Heat 50…100	Unbearable. Like being in a sauna. Too hot. Gets very stuffy bc no air exchange with the outside environment. Everything is kept in the pod, just heats up like a greenhouse.	I'm not even going to try.
Fan 100…0	Too strong. Feels like getting blown out of the pod. The wind itself is not the problem, it feels nice and cool on the skin, but the motor sounds make it sound like the pod is about to take off and fly away.	

	Not pleasant bc stuffy air gets blown in the nose, so no option to breathe in fresh air. “Airfeeding” would make sense if the air smelled fresh.	
Fan 0…100	Wind lingers, so some of the moving air gets inhaled even after the fans turn off. Pleasant sensation. Pod becomes a representation/extension of the body. Mirrors the user’s breath – air gets let out when user breathes out. Cooldown at exhalation. Energy is released via breath; skin is cooled down by fan. This feels more relaxing bc cools me down. Makes me nervous for some reason. As if I am attacked during exhalation.	
Fan 0…50	Motor sound less disturbing. Air can be felt less. Better than the maximum.	Mental mismatch. Drags to get started. Full power right before inhalation. Gradual increase, so when exhale starts, fans are on low power and gradually gain speed to reach max by the end of exhalation.
Fan 50…0		This makes a lot of sense. Also see above about the gradual increase. Fans reach their max by the end of inhalation and exhalation matches up with fans winding down. Is good.
Fan 50…100	Feels nice to have a cool breeze on the body all the time.	Nope. See above.
Fan 100…50	100 when inhaling: makes more sense. Why? Body is doing more effort. Motor sound makes it sound like pod is also spending more effort. 1-to-1 mapping. In alignment with audio (louder when inhaling, more quiet, lower pitch when exhaling)	Mm... not better than 50...0. Effect of fans slowing down and becoming quieter is less with this condition. Constant wind feels nice, but unnecessary audio. Preferred when the fan motor sound stopped completely at exhalation.
Heat 0…20 **Fan 100…50**	Perfect match. Cooling when “spending energy”, heating during release. Balanced. Reverse actions. Cooling-heating = tensing, releasing.	

Heat 0…20 **Fan 50…0**	Even better bc the fan audio is not that strong, intense.	
Heat 20…0 **Fan 50…0**	Does not work. Sth is messed up. Makes no sense sensorily.	
Heat 0…20 **Fan 50…100**	Nope. It's the airflow. It cannot be stronger on exhale than it is on inhale.	
Heat 20…0 **Fan 100…50**	This is also not bad. Pod is aligned with what the body is doing – spending more energy on inhalation. Not as good as the reverse, though.	

Appendix D: Recruitment advertisement for the evaluation session

Adapted from [71]:

Subject: Getting feedback on a design for Sensiks sensory reality pod - your help needed!

Attention busy people!

Interested in evaluating a design for bodily awareness and relaxation? Would you like to try out the Sensiks sensory reality pod in a unique and novel way?

I will be conducting a research study between 25 and 29 June at XRBase (https://goo.gl/maps/z2ogwBSCprW7WNxd6) to evaluate a design I have been working on for my master's thesis. Participation will take approximately 1 hour of your time on one day and is rewarded.

To participate in this study, you should be comfortable with:

- Confined spaces
- Darkness
- Flashing lights

The session will be audio and video recorded for analysis. No recordings are shared outside the research team without your explicit consent.

If you are available and would like to be a part of this activity, please fill in this form: https://forms.gle/XfJFPQeRs5udxQvD8.

I will contact you with further details (information sheet, consent form, time slot selection) after having received your response.

Kind regards
Eva Maria Veitmaa
veitmaa@kth.se

Appendix E: Evaluation registration form

Evaluating the Gallery of Heartbeats

Interested in evaluating a design for bodily awareness and relaxation? Would you like to try out the Sensiks sensory reality pod in a unique and novel way?

I will be conducting a research study on June 25 and 26 at XRBase to evaluate a design I have been working on for my master's thesis. Participation will take approximately 1 hour of your time on one day and is rewarded.

To participate in this study, you should be comfortable with:

- Confined spaces
- Darkness
- Flashing lights

If you are available and would like to be a part of this activity, please fill in this form.

I will contact you with further details (information sheet, consent form, time slot selection) after having received your response.

Kind regards
Eva Maria Veitmaa
veitmaa@kth.se
+372 5673 1490

* Required

Email address *

Your email

Your name *

Your answer

Your age (in years) *

Jouw antwoord

Your phone number

Jouw antwoord

I am comfortable with *

Part of the evaluation takes place in the Sensiks pod which is a confined space with changing lights.

- [ ] Confined spaces
- [ ] Darkness
- [ ] Flashing lights

Any comments or questions?

If you qualify for the study, you will be sent additional information and a selection of time slots on June 25 and 26.

Jouw antwoord

Een kopie van je antwoorden wordt gemaild naar het adres dat je hebt opgegeven.

Verzenden

Verzend nooit wachtwoorden via Google Formulieren.

Appendix F: Information sheet for participants

Purpose: This study will help us investigate using sensory technology for increasing bodily awareness in the context of relaxation. The study will help us evaluate our design; it is not intended to test your individual performance in any way.

Procedure: If you agree to participate, you will attend an evaluation session lead by the contact researcher. The evaluation session consists of testing the design prototype by engaging with the Sensiks sensory reality pod, and an oral in-person interview. We will video and audio record the session. There will be no breaks.

Voluntary Participation: Your decision to be in this study is voluntary. You can stop at any time without giving a reason. You are not required to answer questions during the study. Refusal to take part in or withdrawing from this study will involve no penalty.

Risks and Discomforts: The design prototype features a dark confined space and bright lights that may flash. Notify the investigator before the session if you have claustrophobia or epilepsy. Other than that, the participation does not present any foreseeable risks. This study does not involve any medical intervention or medication.

Potential Benefits: You will not receive any financial compensation. Along with contributing to novel research, you will be able to reflect about experiences of bodily awareness and relaxation. Additionally, you will receive a gift card.

Duration: The workshop will take a total of 1 hour without breaks.

Data protection: Your participation in this study is confidential. We will assign you a unique participant ID that will be associated with all of the data we collect. The contact researcher Eva Maria Veitmaa will maintain a separate list that links your participant ID to your name and other personal information and will not be accessible to other researchers. We will store and secure the data in a safe location at the contact researcher's private password-protected iCloud and the password-protected Google Drive of the University of Twente. The research team members, listed below, may review all data records related to this research study, but without personal identifiers. The data will only be used for research purposes. All publications and presentations resulting from this research will present data with no personal identifiers, unless you explicitly request to be mentioned by name.

Right to ask questions: Please contact veitmaa@kth.se with questions, complaints, or concerns about this research.

Research team:

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Appendix G: Consent form for participants

I give consent to participate in the study: '**Using external sensory stimuli to increase bodily awareness in the context of relaxation"** being carried out by KTH Royal Institute of Technologies, in collaboration with Sensiks and the University of Twente. Please tick each box.

- ☐ I have read and understood the information sheet about taking part.
- ☐ A team member has answered any questions that I had/I have no further questions.
- ☐ I understand that this session is video and audio recorded.
- ☐ I understand that information recorded in the workshop will be made accessible to the research team.
- ☐ I understand that the data collected for this study will be stored in a secure location in the contact researcher's personal iCloud and the Google Drive of the University of Twente.
- ☐ I understand that the data collected about me will be used only for research purposes.
- ☐ I understand that I will not be mentioned by name on any documents or in any presentations about the research, unless I request so.
- ☐ I understand that I can withdraw from the study at any time without needing to give a reason.
- ☐ Withdrawing from the study will not affect any services that I am currently receiving now or might receive in the future.
- ☐ I have received an incentive for my participation in session.

Signature of participant _____

Name (in capitals) _____ Date ___ / ___ / ____

Signature of team member_____

Name (in capitals) _____ Date ___ / ___ / ____

Information about the participant

Name of the participant _____

Age _____ Gender _____ Nationality _____

What is your email or phone number? _____

Is there anything you would like to add? _____

Appendix H: Evaluation session protocol

Adapted from [71]:

Before the participant arrives:

- Turn on the Sensiks pod
- Disinfect the surfaces and your hands
- Prepare the camera stand inside the pod
- Prepare the pre-test interview room
- Put a chair near the pod for the post-test interview that takes place inside the pod
- Make sure you have paper and pens readily available
- Prepare the consent form and the soma body sheet (one per participant)
- Make sure you have incentives ready

After the participant arrives:

- Direct them to the bathroom or hand sanitiser
- Explain who you are and the purpose of the study
- Explain the procedure and notify the participant of the video and audio recording
- Answer any questions
- Explain the consent form and ask the participant to sign it
- Ask them to mute or turn off their mobile phone to reduce distractions
- Stress that you are testing the design, not the participant, and that honesty is expected and appreciated

Facilitator says:

"We are designing an experience with the goal of increasing bodily awareness. Today, you are here to help us evaluate a design prototype. I want to assure you that we are testing the design, not you, and your honest feedback is very important to us. Since the questions are mainly about YOUR individual experience and opinions, there are NO wrong answers.

I would first like to ask you some questions about comfort, relaxation, and bodily awareness.

<Ask the pre-test questions. Let them fill in the "before" part of the soma body sheet.>

Now, I will take you to the Sensiks sensory reality pod where you can freely explore the design prototype. Take as much time as you need. I will be waiting for you outside. Call for me when you have finished your exploration.

<Guide the participant to the pod and wait a bit further from it. Do not observe the participant directly. Let the participant explore the design freely and independently, both inside and outside the pod. Wait for an indication that the participant is done with the exploration.>

I will now come to you and we can discuss your experience.

<Move a chair closer to the pod, open the pod door, and move the curtain aside. Let the participant stay inside the pod or join you sitting outside the pod.>

<Ask the post-test questions. Let them fill in the "after" part of the soma body sheet.>"

Finishing up:

- Thank the participant for their time, give them a gift card, and escort them away from the pod
- Disinfect the surfaces
- Organise your notes and the soma body sheet

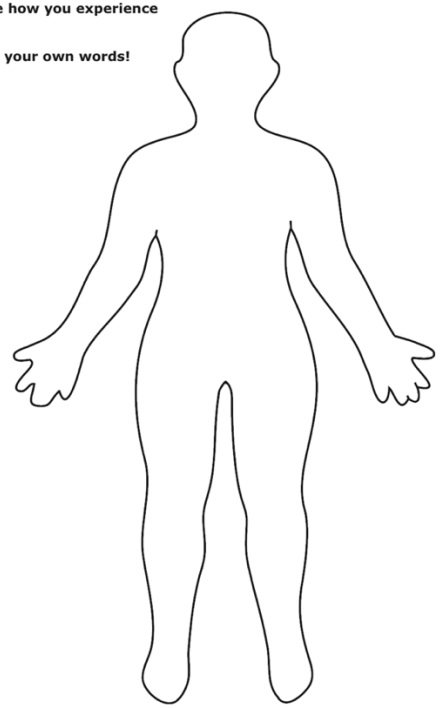
Appendix I: Soma body sheet

EXPERIENCED BODY NAME: DATE:

BEFORE

Please illustrate how you experience your body.

Feel free to add your own words!



WARM

SYMMETRIC

PULSATING

HEAVY

SMALL

JITTERY

BIG

SOFT

ASYMMETRIC

UNBALANCED

COLD

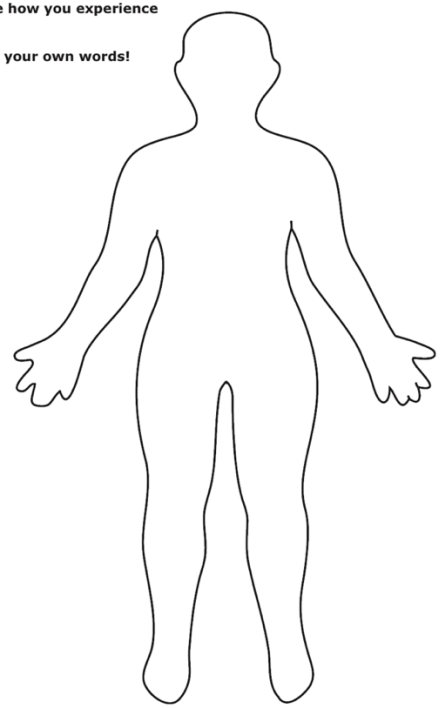
LIGHT

TIGHT

AFTER

Please illustrate how you experience your body.

Feel free to add your own words!



WARM

SYMMETRIC

PULSATING

HEAVY

SMALL

JITTERY

BIG

SOFT

ASYMMETRIC

UNBALANCED

COLD

LIGHT

TIGHT

Appendix J: A selection of interview questions for the evaluation session

Sensiks pod:

Do you have any previous experience with the Sensiks pod?

Relaxation:

When do you feel the need for relaxation?

Why do you feel the need for relaxation?

How do you usually relax?

Bodily experiences:

Have you tried any bodily awareness practices (e.g. yoga)? Relaxation techniques (e.g. meditation)? What was your experience like?

What physical sensations / bodily feelings are you experiencing right now? *(filling in the soma body sheet)*

When was the last time you noticed your heartbeat? Where on your body did you notice it? In what situation?

When was the last time you noticed the heartbeat of someone else? In what situation?

<exploring the pod>

General impressions:

What is your impression of the Gallery of Heartbeats?

Which features did you explore/discover?

How would you describe your heartbeat now?

Sensory stimuli:

Which sensory stimulus did you notice?

Which sensory stimulus would you add/remove?

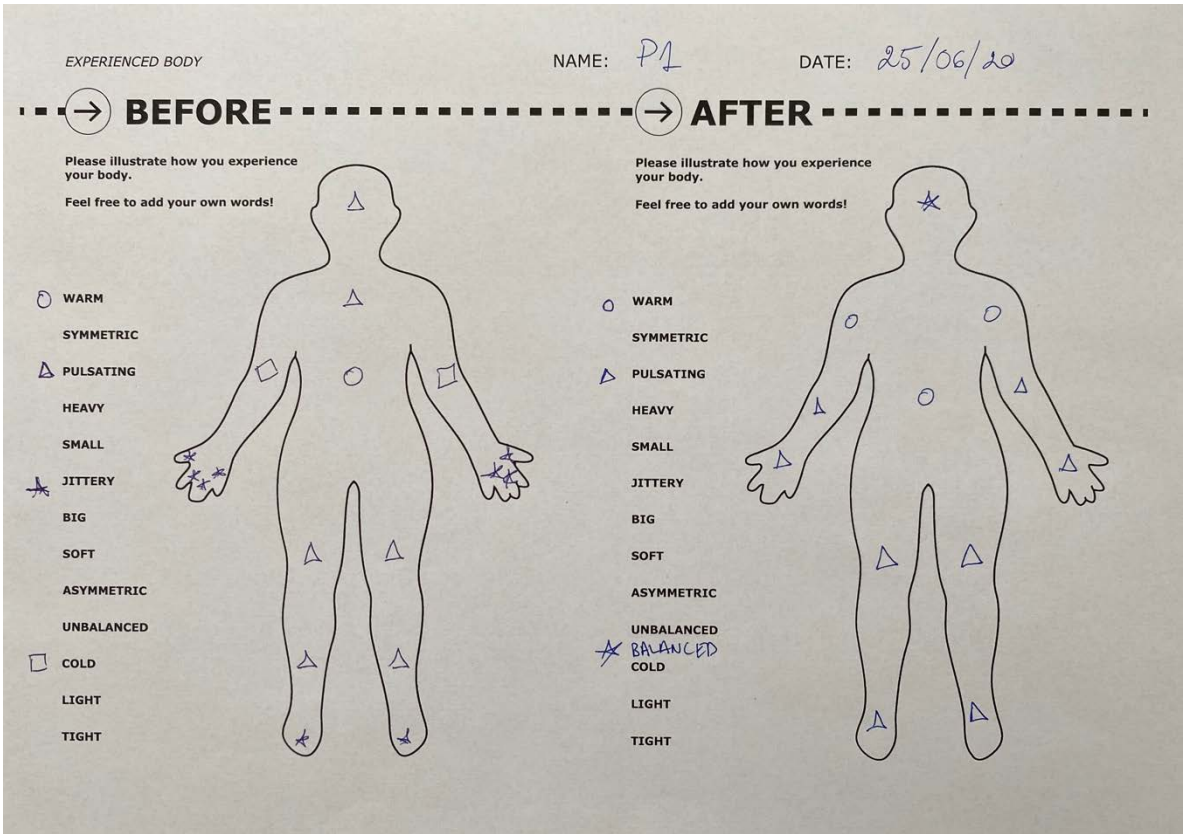
Usage scenarios:

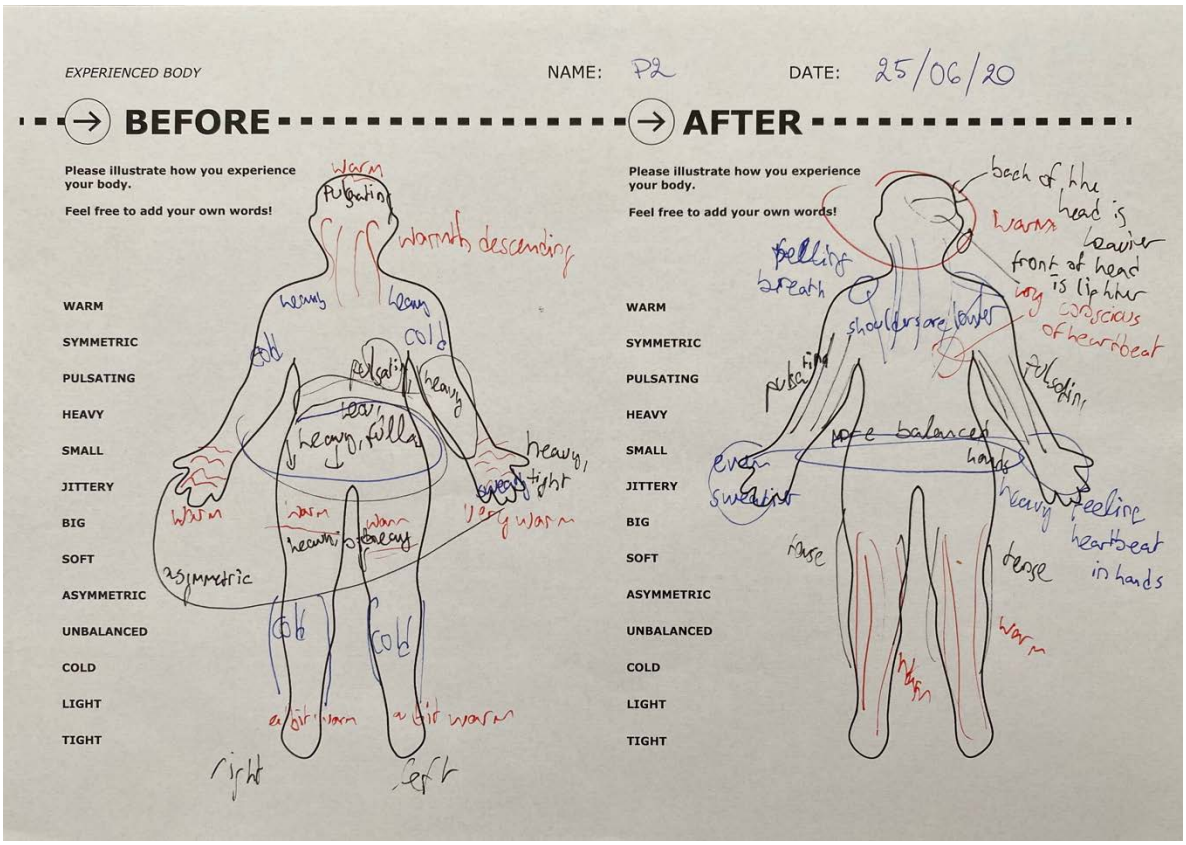
When / how often would you use the Gallery of Heartbeats?

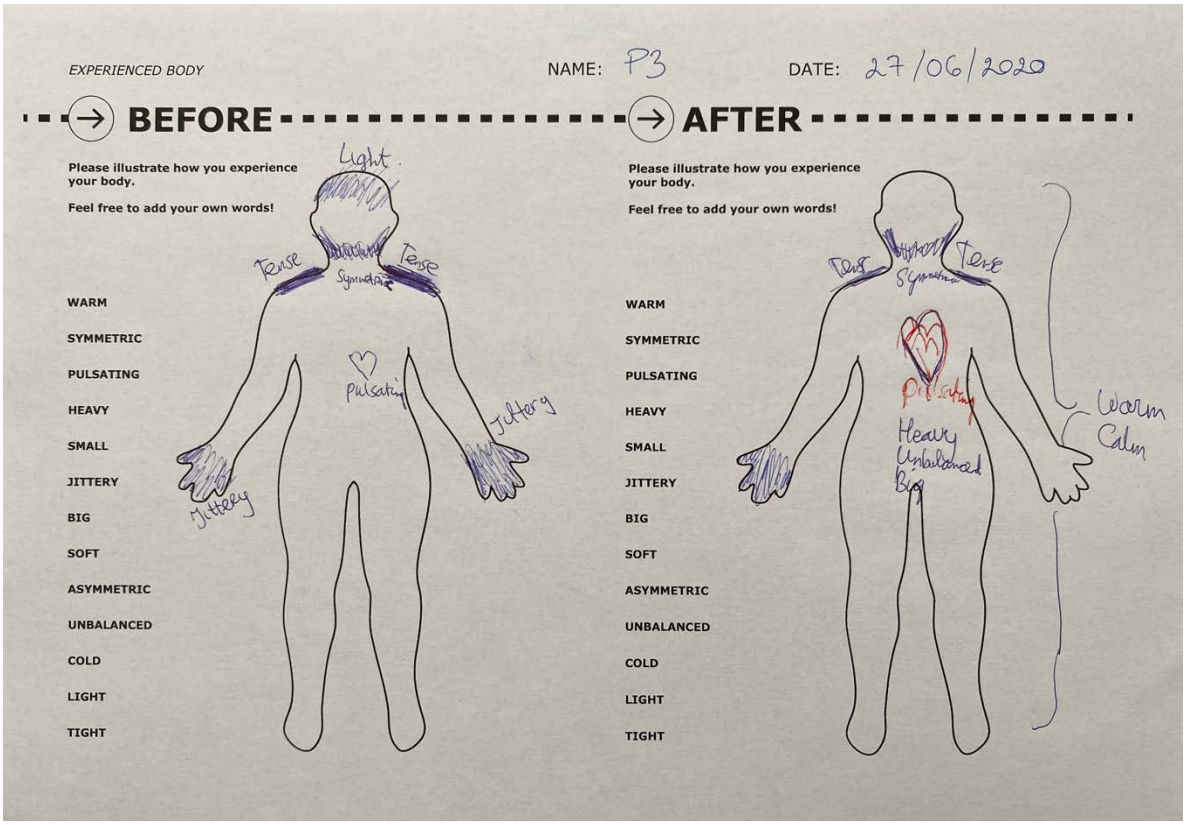
For what purpose would you use the Gallery of Heartbeats?

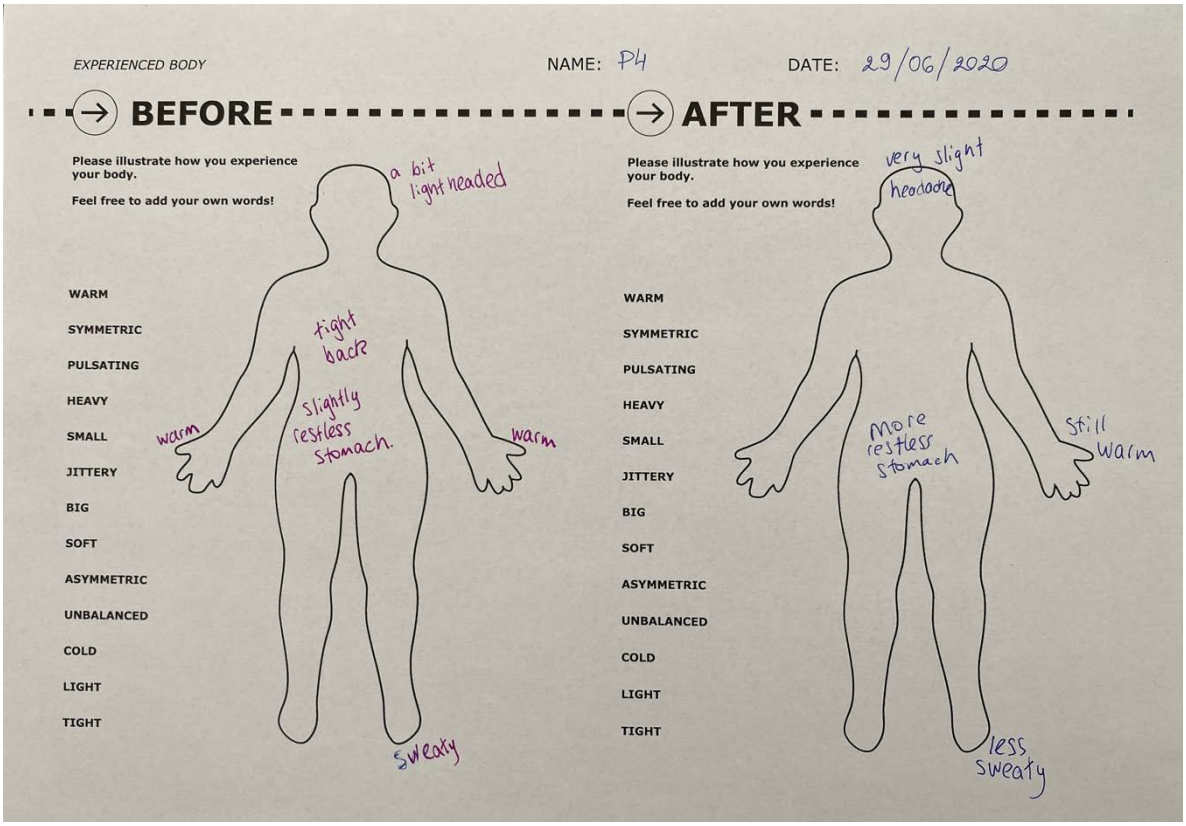
Whose heartbeat would you like to hear in the Gallery of Heartbeats?

Appendix K: Participants' soma body sheets






EXPERIENCED BODY
NAME: P3
DATE: 27/06/2020
BEFORE
AFTER
Please illustrate how you experience your body.
Feel free to add your own words!
WARM
SYMMETRIC
PULSATING
HEAVY
SMALL
JITTERY
BIG
SOFT
ASYMMETRIC
UNBALANCED
COLD
LIGHT
TIGHT
Light.
Tense
Tense
Pulsating
Jittery
Jittery
Pulsating
Heavy
Unbalanced
Big
Warm
Calm


EXPERIENCED BODY
NAME: P4
DATE: 29/06/2020
BEFORE
AFTER
Please illustrate how you experience your body.
Feel free to add your own words!
WARM
SYMMETRIC
PULSATING
HEAVY
SMALL
JITTERY
BIG
SOFT
ASYMMETRIC
UNBALANCED
COLD
LIGHT
TIGHT
a bit light headed
tight back
Slightly restless stomach.
warm
warm
sweaty
very slight headache
more restless stomach
still warm
less sweaty

Appendix L: Usability issues of the Gallery of Heartbeats

1 Pod hardware

All participants had difficulties with the touchscreen of the Sensiks pod. There were areas on the screen which were unresponsive to touch (see also Section 5.7, page 91). This mostly happened with the top part of the screen. Oliver captured how he felt as:

"I feel like my grandma on an iPad for the first time."

Peter also struggled with entering information using the on-screen keyboard.

Peter pointed out that while the pod itself looked like a photo booth, the red light inside the pod reminded him of the Red-Light District of Amsterdam.

Peter also pointed out the makeshift armchair inside the pod. The pillows provided more cushioning than the regular hardwood seat but were still not a proper chair:

"It's like sitting on something that's not supposed to be a chair."

He recommended an actual armchair or a thin massage cushion on the backrest of the seat.

2 Gallery of Heartbeats software

The user test revealed various flaws with the designed software and interface. Some of these were previously known to the author. Those remained in the design prototype used during evaluation sessions due to the limitations of the chosen framework. Apart from resolving one issue after the pilot test, no additional bug fixes were done during the evaluation period to ensure the same conditions for all participants.

2.1 Labels on the screensaver are perceived as buttons

The idle view screensaver of the Gallery of Heartbeats features the title of the experience and the slogan "Record it. Compare it. Feel it. Share it.". The latter was perceived as actionable buttons by all but one participant. They tried to tap on the words expecting to be redirected to a corresponding view and got frustrated when it did not happen (see Figure 9-26).

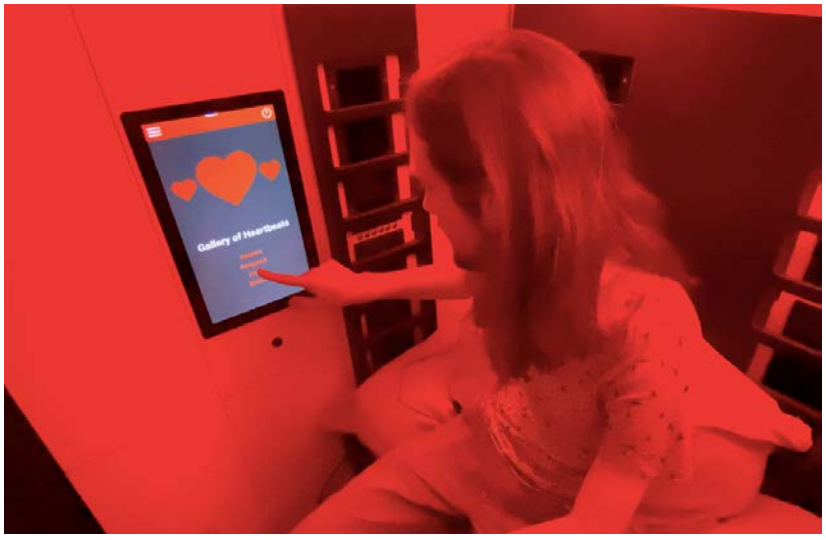


Figure 9-26: Participants tried to click on labels, expecting navigation.

Alternatively, three participants tried to start the program and navigate away from the screensaver by tapping elsewhere, either on the title or the hearts above it.

All participants figured out that the hamburger menu will let them navigate away from the idle view. However, that was not intuitive for them. Therefore, the idle view design needs improvement to make labels look less clickable or to make them function as responsive buttons.

2.2 Tapping on the overlay to close the menu

Instead of tapping on the cross icon to close the menu, two participants tried to close the menu by tapping on the overlay part of the view next to the menu panel. This is a common design pattern that needs to be implemented in the Gallery of Heartbeats as well to confirm to common interface and interaction design principles.

2.3 The disappearing graph

For two participants, the graph in recording view disappeared randomly when navigating between views (see Figure 9-27). The numerical reading of the heart rate was still visible, enabling the participants to continue using the application. However, the graph gives a much better overview of the dynamics of the heartbeat in time.

None of the participants pointed out the lack of the graph when it happened. The exact reason for the graph to disappear is yet unknown.

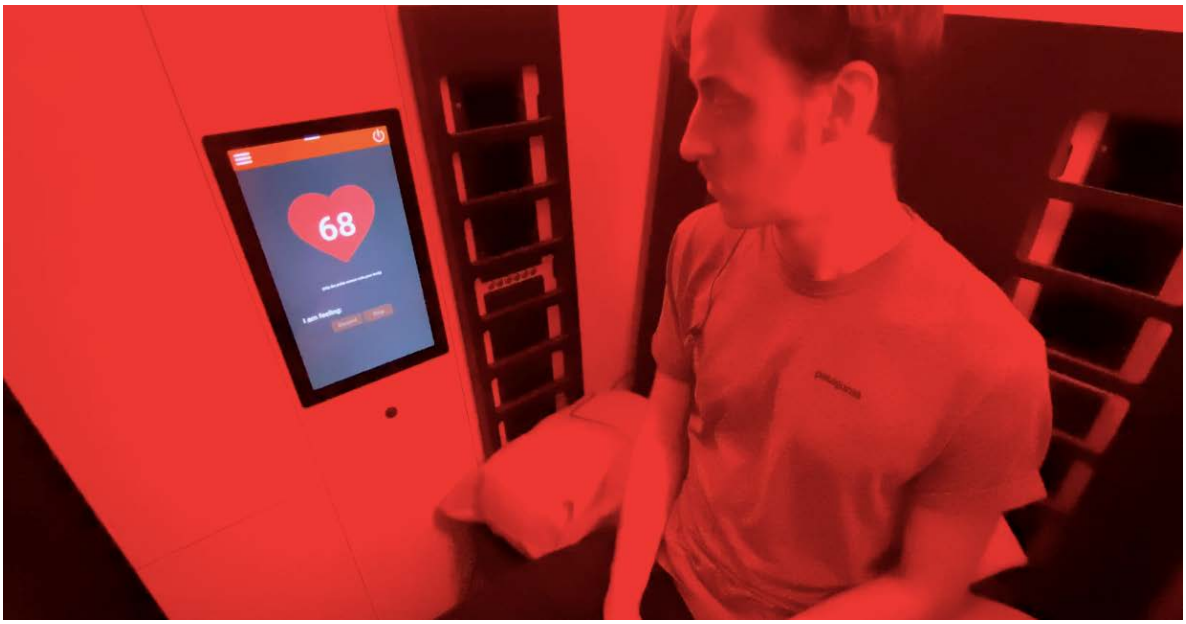


Figure 9-27: The graph has disappeared from the recording view, leaving the participant with numerical feedback only.

2.4 Adding a new recording

Three out of five participants tried to start the recording without having entered a title after the prompt “I am feeling:”. They tried to press both disabled “record” or “stop” buttons and were frustrated when nothing happened.

This indicates two things. First, the text box is not visible or understandable enough. Second, since both buttons are disabled, they look the same which may cause the user to perceive them both as enabled buttons instead.

It is also unclear for how long the recording has been going on. Mary pointed out how she did not know when exactly the recording started:

"I thought I was saving it already, but it only recorded a few seconds."

Peter also expected new recordings to be added to the top of the gallery list, not at the bottom. He could not find his own recording in the gallery as he did not scroll far enough.

2.5 Confusing settings

The settings view features a mode titled "designer's special". With no further elaboration, it was unclear to participants what this meant. They did not make a connection between the mode and certain pre-set sensory modalities.

Mike also pointed out the labels, such as "heat level 1" and "heat level 2", as something abstract the meaning of which he did not comprehend.

2.6 Not discovering everything

Some participants struggled to explore the application to its fullest. Four out of the five participants did not change any settings when exploring the pod independently. When encouraged to change the settings, Peter expected it to have an effect on the recording view, not on the gallery playback view.

Two participants did not make it to the settings view on their own. Oliver stated that he had thought the settings and about views are purely administrative or regulatory:

"I wasn't really interested in messing around with the settings. [...] I don't generally go to the setting that quickly and the about [section] I would never go to."

He explained that it might have been a combination of previous experience with those terms and the boring, uninviting icons (a gear and an information bubble).

Peter only explored the gallery first and did not want to go to the record view because he was not sure what it would record.

Since the Gallery of Heartbeats is created for using sensory stimuli to present heartbeats in a novel, immersive, and customisable way, participants not discovering the settings or failing to make the connection between the settings and the playback is a colossal shortcoming.

"I realised I basically did not do anything the first time" is an alarming quote by Oliver.

3 Pulse sensor

The pulse sensor was accompanied by very vague guidelines about how to use it. The participants occasionally struggled with the sensor due to the lack of concrete instructions and the unknown inner workings of the sensor (see Figure 9-28).

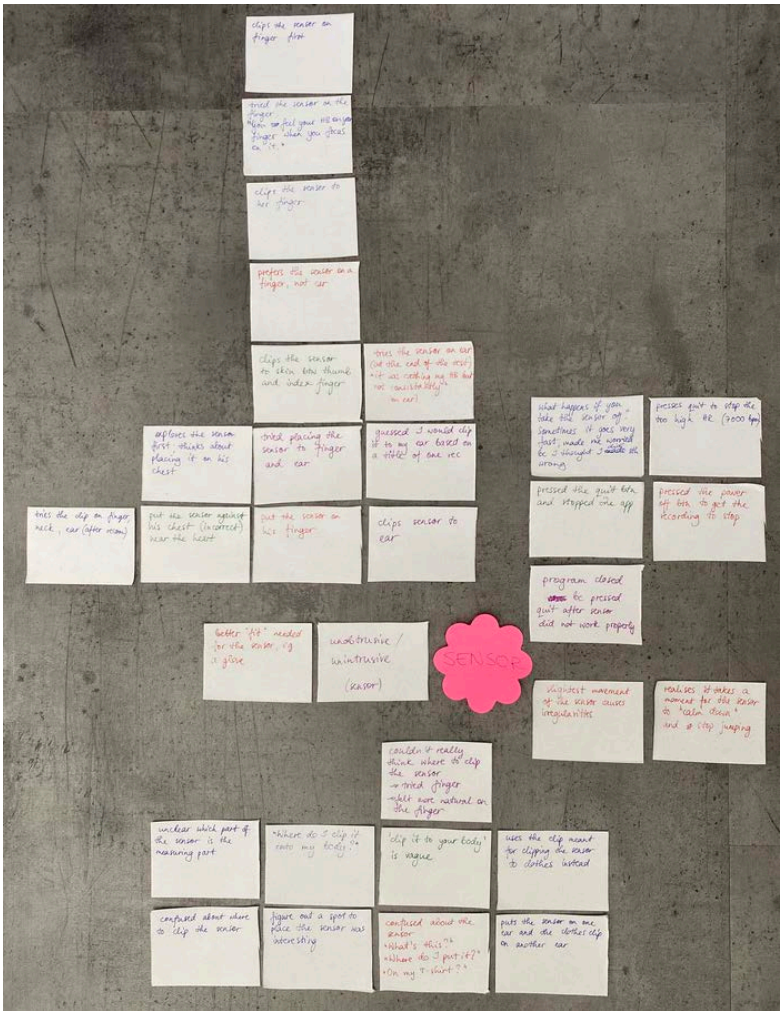


Figure 9-28: The affinity diagram for the sensor.

Participants pointed out the unobtrusiveness of the sensor as a good thing but recommended to have it in another form that better affords being positioned on the body, e.g. a glove (from Peter).

Peter also noted the sensitivity of the sensor and how slightest movement of the sensor causes irregularities. He realised it takes a moment for the sensor to "calm down" and the readings to stabilise.

3.1 Where to put the sensor?

The application guides the user to clip the sensor on their body. No exact locations on the body are provided to encourage bodily exploration and improvisation. Such freedom seemed to be confusing for the partcipants.

Mary: "*Where do I clip it onto my body?*"

The sensor is designed to be used on the earlobe. However, the most popular location for these participants were fingers instead. All participants put the sensor on a finger before trying it on their ear. Mary explained why she chose the finger:

"*You feel your heartbeat on your finger when you focus on it.*"

James said that a recording title ("[I feel like] there is sth clipped to my ear", recording by the author) inspired him to try the sensor on his ear. Peter claimed that the sensor worked worse on the ear:

"It was catching my heartbeat but not consistently."

Mike and Oliver also tried to use the pulse sensor by positioning it against their chest near the heart like a stethoscope.

The sensor setup consists of three main parts: a sensor, a cord, and a clip for securing the sensor on the clothes. For Oliver, it was unclear which is the part that actually does the measurements. He tried using the clothes clip first and was unsure whether it was actually measuring anything.

3.2 Quitting the application when sensor readings get too high

When the pulse sensor is removed from the body, it will start producing near-random inputs. Sometimes, the input remains around 40 bpm. Other times, it can jump to 30,000 bmp.

Since the readings from the pulse sensor were fed back to the participant as an audio file of a heartbeat, the speed of said audio file also changes in correspondence to the sensor readings. Four out of the five participants experienced a high-tempo audio feedback from the loose sensor. To stop the rapid audio, they pressed the power off button causing the application to quit (see Figure 9-29). In cases like these, the researcher restarted the application for them.

This indicates the necessity for recognising when the heartbeat sensor is off the body and shutting the feedback down for that time. An option is to enable fully manual control, letting the users decide when the sensor is measuring their heart rate. Alternatively, this could be achieved automatically.

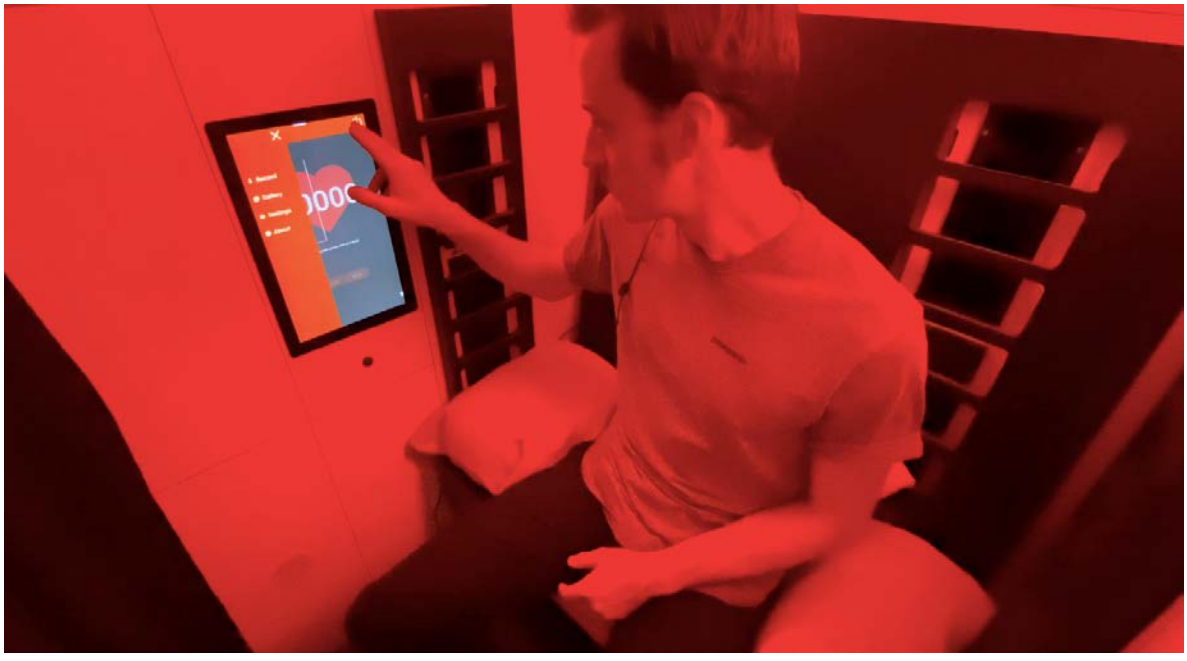


Figure 9-29: Due to incorrect sensor placement, the participant is presented with a heart rate of 30000 bpm. To stop the rapid audio feedback, the participant presses the quit button.