SensAble: a device and app for reducing anxiety in university students

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Abstract

Many young adults experience anxiety in some form or another, and it is particularly common among university students. The isolation and lockdown caused by the COVID-19 pandemic might have increased furthermore feelings of anxiety among this group. As part of my thesis, I aimed to develop a prototype of a wearable device that is hypothetically connected to an app for young adults (aged 18 to 29 years) in university that could potentially help reduce anxiety. Through literature review, contextual review, and primary research methods of user testing, I created a prototype, SensAble, that incorporates various sensory elements such as weight, light, music, and haptic vibration for the user to use at home to create a calming experience. In this document, I describe and reflect on the process of making, testing, and finalizing SensAble.

Keywords

Anxiety, young adults, university students, mobile app, multisensory integration, wearable haptic technology, weighted blanket, music therapy, chromotherapy.

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Chapter 1 - Introduction

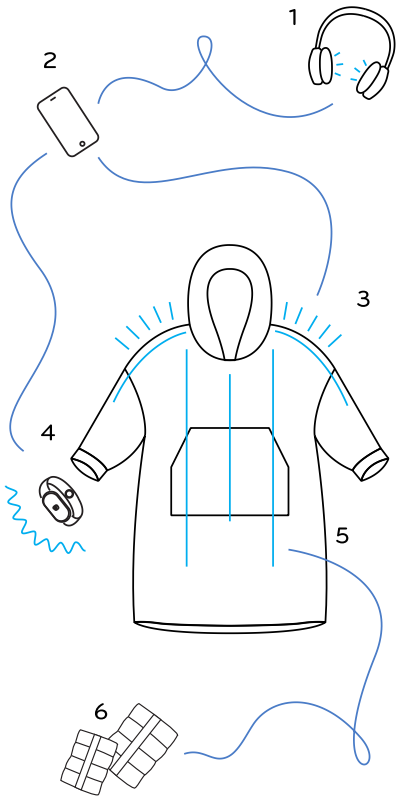
Anxiety is the natural body's reaction to worry, fear, and the unknown, as well as stress from social situations, school, and work (“Anxiety Stats in the U.S.,” 2020). Many young people experience anxiety in some form or another, such as before a test, meeting new people, or being in a new environment. Anxiety is particularly common among university students as this time is a pivotal period in their life. Anxiety may also have increased due to the isolation and lockdown caused by the COVID-19 pandemic (“Anxiety Stats in the U.S.,” 2020; Liyanage et al., 2021). In this paper, when referring to anxiety, it talks about anxiety as the occasional form of anxiety, unless specified differently, as opposed to general anxiety disorder (GAD) or any other medically diagnosed condition. GAD is distinguished by a continuous feeling of anxiety that might disrupt our day-to-to activities, which can be experienced for months or even years. It is not the same as occasionally worrying or feeling anxious as a result of challenging life situations (U.S. Department of Health and Human Services, n.d.).

Using technology to decrease anxiety is one way to help young adults in university during times of distress. Wearable technology is becoming more popular in daily life and has a variety of uses, such as tracking physical activity, monitoring heart rate, and giving insight into emotional states (Firth et al., 2018; Pedrelli et al., 2015). Over the last few years, many electronic applications have been developed for people suffering from anxiety (Drissi et al., 2020). More young adults are using mobile devices globally, which makes apps more accessible anytime and anywhere for people who need support. Especially during the COVID-19 pandemic, apps were shown to be a useful tool to assist in managing anxiety, as people could not easily seek therapy face-to-face (Alqahtani et al., 2021; Drissi et al., 2020; Garrido et al., 2019). The use of weighted blankets is a non-intrusive, self-directed sensory modulating intervention technique. There is compelling evidence to suggest that deep pressure stimulation (DPS), as provided by a weighted blanket, may have a calming effect (Chen et al., 2013; Eron et al., 2020). Chromotherapy is the use of color in a variety of settings to improve well-being and healing and can be a source of stress relief for many (Azeemi & Raza, 2005; Goldstein, 1942; Saklecha et al.,

2022). By including specific colors in an app and colored LED light strips attached to the weighted blanket projecting particular light in a room, it can help alleviate anxiety when people interact with the device. To date, there is no device discussed in the literature that combines the above technologies and materials (i.e., weighted blanket, music, chromotherapy, haptic vibrations) which can be personalized.

My goal was to develop a prototype of a wearable device that is connected to an app for young adults (aged 18 to 29 years) in university with occasional forms of anxiety who find it difficult to deal with 'in the moment' struggles. The rationale for this age group is that undergraduate and graduate students are aged most commonly between 18 and 29 years (*UBC Demographics - Age*, n.d.; *Young Adult Development Project*. (n.d.)). I researched what effective sensations are in a wearable device, elements of apps, and colored lights that work for anxiety sufferers. Based on that, I created a prototype of an app, colored LED lights, a wearable device with specific attention to haptic vibration, a wearable weighted blanket, music therapy, and chromotherapy. The weighted blanket is similar to an oversized hoodie but comes down to the feet on the front (where most of the weight is), and in the back, it stops around the mid back as the weights on the back are not necessarily felt and therefore not needed when the person is sitting or laying down. The LED lights start at the shoulders on each side and go to the mid-lower arm, with an on and off button as well as three different color options, by the back of the neck. The haptic device has the shape of a bracelet and is located on the wrist, and includes a button to select different vibration options (Figure 1). The wearable and app would support young university students in moments of stress and help them to better understand how they feel while learning some simple coping mechanisms and experiencing calming sensations from the wearable and light. The earlier these students learn to recognize moments of anxiety by developing the skills to help themselves in moments of need, the better the chance they will have of avoiding serious incidents and burnout. I have chosen the name SensAble for my project. It is a combination of the words 'sense' and 'wearable', and the capital 'A' refers to anxiety. 'Sense' refers to the three senses the project provides: touch, sight, and hearing.

SensAble does not aim to replace any professional medical treatment such as therapy or medication, but rather for it to be used as an additional tool with the idea to help relieve in the moment feelings of anxiety.



1. Self-selection of music
2. Mobile app
3. Chromotherapy
4. Haptic device
5. Weighted blanket
6. Weighted pouches

Figure 1 - Illustration diagram of prototypes, SensAble – (Merel Ververs-Spiegel)

1.2 Research Summary

The research questions I address throughout my research are:

- How can a mobile app connected to a wearable device be used to support young adults (18-29 years) in university with moments of anxiety?
- How can Research through Design combine the above app and device into a hybrid user-friendly product that can be used as a self-help tool at home?

My hypothesis, based on the literature review, contextual review, and user testing, is that a weighted wearable blanket with a built-in haptic motor and LED light strips connected to an app offering relaxing music self-selected by the user, may reduce moments of anxiety in university students aged 18 to 29 years at home.

1.3 Limitations to research

My research will not be able to establish whether the prototype that will be developed will actually reduce anxiety (from a clinical standpoint).

The reasons why I cannot do such a study are:

1. This would require a very specific study, ideally a randomized control trial.
2. Such a study would span over a much longer period than I would have for this thesis project.
3. This would require substantial funding and trained (clinical) researchers.

Based on the findings of the literature research and user testing, we could assume that it could work, by proxy, though this would need additional in-depth studies.

However, the value of this research is to create a prototype that focuses on the human senses and how users interact with it. The design and usability of a product are equally as important as the issue that is being targeted.

1.4 Chapters Overview

In Chapter 2, I provide the literature background on anxiety, wearable haptic technology, self-selected music, mobile apps for anxiety, weighted blankets, and chromotherapy, which are the necessary elements to incorporate into the wearable device. In Chapter 3, I describe the

contextual review of existing products and systems that have been developed to ease anxiety. In Chapter 4, I explain methods and methodologies, which include Research through Design, expert interview, and user testing. In Chapter 5, I describe the different prototypes of this study, what I learned through each iteration and the user testing feedback, and what components need improvements. In Chapter 6, I describe the next steps for this research and prototypes, scopes and limitation, and final thoughts on my project.

Chapter 2 – Literature Review

In this Chapter, I provide the literature background for the necessary elements to be put into the wearable device based on my research. This literature review will discuss anxiety, wearable haptic technology, self-selection of music, mobile apps for anxiety, weighted blankets, and chromotherapy.

2.1 Anxiety

Anxiety is a common mental health issue. According to the World Health Organization statistics of 2017, around 264 million adults suffer from anxiety around the world ("Anxiety Stats in the U.S.," 2020). Anxiety is the body's reaction to worry, fear, and the unknown, as well as stress from social situations, school, and work. Anxiety can affect people in many different ways, depending on the type of anxiety ("Anxiety Stats in the U.S.," 2020). Mental health issues are not only common among college students, but they also often last for years (Zivin et al., 2009). However, many people have experienced anxiety in some form or another, such as before a test, meeting new people, being in a new environment, speaking in front of a crowd, or going back into the office after the pandemic. Some may experience anxiety more frequently or more intensely than others, which could result in a diagnosis of an anxiety disorder.

The US population aged 18 to 29 years experiencing anxiety was 22.3% ("Anxiety Stats in the U.S.," 2020). Through data collected in a web-based survey on 763 undergraduate and graduate students at a large, Midwestern, public university in the US in the fall 2005, it was found that 60% of those who reported a mental health issue at the beginning of their study continued to report it two years later (Zivin et al., 2009). In addition, anxiety is most common among university students as it is a pivotal period in their life and may have increased due to the isolation and lockdown caused by the COVID-19 pandemic (Liyanage et al., 2021). Attending university can be stressful because of academic pressure, moving away from home and a student's support system, and having new responsibilities. Depending on the diagnosis,

between 37% and 84% of students with positive depression or anxiety evaluations did not receive any treatment. Lack of perceived need, ignorance of available services or insurance coverage, doubts about the effectiveness of therapy, low socioeconomic status, and other factors all contributed to people not getting treatments (Eisenberg et al., 2007). Many young university students prefer to seek the anonymity of online mental health resources because of the potential stigma associated with mental illness, the fear of it being on record, or being embarrassed (Eisenberg et al., 2007). Employing the use of technology such as mobile apps and web-based platforms to decrease occasional forms of anxiety is one of many ways to help university students in a time of distress (Firth et al., 2018; Pedrelli et al., 2015).

A widely used tool for assessing trait and state anxiety is the State-Trait Anxiety Inventory (STAI) (Spielberger, 2010). The questionnaire can be used to diagnose anxiety and separate it from depressive disorders in clinical settings. The questionnaire differentiates between the state of anxiety (which is transitory and based on a person's interpretation of a situation at a certain moment) and trait anxiety (which is more a personality characteristic) (Vitasari et al., 2011). For example, items related to the state of a person include terms such as "I am tense; I am worried" and "I feel calm; I feel secure." Anxiety traits include items such as "I worry too much over something that really doesn't matter" and "I am content; I am a steady person" (*The State-Trait Anxiety Inventory (STAI)*, n.d.). The STAI is used in many studies designed to evaluate anxiety, medical disorders, and treatment of anxiety (Vitasari et al., 2011). The reason I am including the STAI in my literature review is to understand the results of the studies and how they were conducted. As mentioned in my limitations, I am not testing whether my project reduces anxiety as I am basing these facts on the studies, including those using STAI in their methodology.

2.2 Wearable haptic technology

Wearable technology is an electronic device that can be worn on a person, such as a smartwatch, smart ring, fabric, smart glasses, or activity tracker (*Wearable Technology - an*

Overview | ScienceDirect Topics, n.d.). Wearable technology is becoming more popular in daily life and has a variety of uses, such as tracking physical activity, monitoring heart rate, and giving insight into emotional states. An example of wearable technology is haptic technology, a small motor that vibrates. This is a tactile sensory technology that delivers vibrations or the application of force. A slow heartbeat like vibration has proven to be effective in decreasing anxiety (Haynes et al., 2022). Combining the two technologies, a weighted blanket and a haptic device can reduce anxiety. For example, when someone experiences stress, the heart rate increases, and as our bodies and brains naturally respond to rhythm, it may increase anxiety. Therefore, Azevedo et al. argue that by delivering a slow heartbeat-like vibration on the inner part of the wrist can help calm a user (Azevedo et al., 2017).

Studies such as one conducted by Azevedo et al. on 52 volunteers with an average age of 26 years in London, England, who tested a Doppel device (a wristband device that delivers vibration mimicking a heartbeat) showed a connection between anxiety and how our bodies interpret signals like a heart rate. If a person notices that their heart rate is high, this can exacerbate anxiety and make that person feel more anxious. However, if a signal is delivered at a slower rate than the person's heart rate through a haptic device, this could change how the person perceives their circumstance, and help them feel more at ease (Costa et al., 2017). An important feature in this technology is the possibility for the user to have control over the vibration intensity and speed of the haptic stimulation in relation to the user's own heart rate (Costa et al., 2017; Azevedo et al., 2017).

From these studies, it is clear that wearable haptic technology can be applied to calm the user through reducing the heart rate by mimicking a slow heartbeat-like vibration on the inner part of the wrist. Therefore, I will also be focusing on creating a wearable haptic device that can be worn on the wrist and has the option for the users to control the intensity and speed of the vibration through an app.

2.3 Self-selected music

Music is universal and is widely used globally in restaurants, malls, advertisements, waiting rooms, spas, bars, and other public spaces to create a certain ambiance. Listening to music can be a tool for young adults to reduce their anxiety and promote relaxation (Burns et al., 2002). Youth culture is heavily influenced by music, which most young people listen to for a number of reasons (Labbé et al., 2007). Music is a readily available, easy-to-use, and non-invasive medium to manage stress (Thoma et al., 2013).

In a study from 2021, Alqahtani et al. mentioned that the participants particularly regarded the concept of relaxing audio, such as music and natural sounds, as a valuable element for relaxing. The article quoted one of the participants stating: “The first thing I want is sound or music just to help me calm down.”(Alqahtani et al., 2021).

As mentioned previously in the wearable haptic device section, our bodies and brains naturally respond to rhythm. The physiological significance of a quicker or slower heart rate for one's physical and mental health is well-documented (Azevedo et al., 2017). When listening to a song, the tempo can affect our heart rate and has repeatedly been proven to be crucial for evoking emotions. For instance, listening to music at a slower speed reduces anxiety and produces calmer or more positive emotional states (Azevedo et al., 2017). In the same paper, Azevedo et al. provide an example: “choir singers not only harmonize their voices, they can also synchronize their heartbeats.”

In a study conducted in 2007 on 56 university students in the USA, they observed the students’ reactions and responses to what kind of music the students considered relaxing among classical, heavy metal, self-selected, as well as silence. It showed that there was a decrease in heart rate and improved perceptions of their mental health and emotional state (measured with STAI) when the user was able to self-select the music. The study determined that giving the students the option to choose their own music provides them with some degree of control

over the experiment (Labbé et al., 2007). According to a health psychology study from 2007, perceived control is a key element in lowering the stress response (Brannon & Feist, 2007). In a similar study from 2002 with 60 undergraduate students, the group listening to classical music, or self-selected music that they considered relaxing, showed that they were more relaxed after listening to music rather than silence or listening to heavy metal music (Burns et al., 2002).

Listening to music can be a tool for young adults in university to reduce their anxiety and promote relaxation, as it is a non-invasive medium to manage stress. Studies above show that the importance of self-selected music, as opposed to music that is prescribed, may be more successful at reducing stress because it gives the listener some control over their environment by allowing them to select music that they find to be calming.

2.4 Mobile apps for anxiety

There has been a massive increase in the number of people using mobile devices globally (Alqahtani et al., 2021; Garrido et al., 2019). Apps are used for many different mental health issues, such as anxiety, depression, insomnia, post-traumatic stress disorder (PTSD), and more, which makes them accessible anytime and anywhere people need support (Drissi et al., 2020). Over the last few years, many mobile electronic applications have been developed for people suffering from anxiety, such as Happify, Self-Help Anxiety Management, and Headspace (Alqahtani et al., 2021; Garrido et al., 2019). Therefore, it is much easier now for people who have access to these devices to get support for anxiety. The development of apps can now reach a huge audience nearly anywhere in the world. Most of the apps that are available are either free or at a relatively low cost, and are anonymous, making them accessible to nearly anyone who needs support (Drissi et al., 2020). Especially during the COVID-19 pandemic, apps, and online web-based platforms were shown to be useful tools to assist in managing anxiety, as people could not easily seek therapy face-to-face, the costs were high, and there was a lack of accessible mental health care professionals (Drissi et al., 2020; Garrido et al., 2019). In general,

students did not seek professional help due to the lack of knowledge about services, stigma, and lack of time (Eisenberg et al., 2007).

Two focus group studies have been conducted on mental health apps with young adults, one by Alqahtani et al. and a second by Garrido et al. The first study by Alqahtani et al. asked 32 participants aged 18 to 34 years in Canada about their experiences and desires using two different mental health apps, Happify and Self-Help Anxiety Management (Alqahtani et al., 2021). Over half of the participants (56%) wanted the ability to personalize the apps' function and style. Design characteristics of the app included engagement (people are interested in using the app), accessibility (easy to access), functionality (serves well the purpose for which it was meant), autonomy (using it when a person wants to use it), ease of use, and for young people to have control (Alqahtani et al., 2021). The participants expressed the desire to design their own unique in-app functions and modify the music, background, color, and reminders (Alqahtani et al., 2021).

The second focus group study from 2019 on 23 young people aged 13-25 years in Western Sydney, Australia, was led by Garrido et al. on six different apps for anxiety, Mood Mission, Music eScape, Pacifica, Mindshift, Headspace, and What's Up (Garrido et al., 2019). It provided similar results to Alqahtani et al. study on the importance of autonomy and personalization. Those apps that did not offer those features were regarded as less effective (Garrido et al., 2019). Rather than receiving face-to-face support, young people preferred to seek the anonymity of online mental health resources because of the potential stigma associated with mental illness, the fear of it being on record, or being embarrassed (Garrido et al., 2019).

A study conducted on 16 participants aged 25-38 years in the UK using a mindfulness app showed that mindfulness can reduce anxiety if it is used consistently for a period of time. However, some of the attributes mentioned previously, such as engagement, as well as perseverance, may make it difficult for people to benefit from such apps because they want quick and easy results (Laurie & Blandford, 2016). In the same study, it was found that

environment and location were found to be important factors for successful app usage. Especially in places with limited distraction, such as at home and a safe, quiet, and comfortable environment, the usage of the app was more beneficial (Laurie & Blandford, 2016).

Studies above have shown that personalization and ease of use are important features for an app, and more specifically for anxiety apps. However, many mindfulness apps have already been created, and the effectiveness of the apps are determined by a longer duration of their use. Therefore, the app for my thesis will focus on the personalization of physical sensations for in-the-moment reduction of anxiety in a preferred environment.

2.5 Weighted Blanket

There is compelling evidence to suggest that deep pressure stimulation (DPS) or deep touch pressure (DTP), a type of tactile sensory stimulation such as holding, hugging, and squeezing, may have a calming effect (Chen et al., 2013). DPS seems to result in a reduction in the autonomous nerve system's sympathetic stimulation (the system that prepares the body for strenuous physical activity) and an increase of the parasympathetic stimulation, which controls the body's response during times of rest (Eron et al., 2020; Chen et al., 2013). Weighted blankets are a non-intrusive, self-directed sensory modulating intervention tool. The recommended weight load for users is approximately 10% of their body weight[1], according to earlier studies on weighted vests and blankets (Chen et al., 2013; Eron et al., 2020; Mullen et al., 2008).

A study conducted in 2008 in the USA on 32 adults aged 18-64 years by Mullen et al. showed results of the effectiveness and the safe use of a weighted blanket for people with anxiety, which was backed up by the vital sign metrics and STAI. Sixty-three percent of the participants

[1] The recommended formula is: Weight of weighted blanket (in kg) = subject's body weight (in kg) x 10% - 0.5 kg (Chen et al., 2013; Eron et al., 2020; Mullen et al., 2008).

reported lower anxiety after using a weighted blanket, and 78% reported that it was an effective calming tool as they felt more relaxed (Mullen et al., 2008). In a related study from 2021 on 66 adults in an inpatient mental health hospital in the USA, it was established that after the patients who were experiencing anxiety used the weighted blanket, their heart rate and anxiety levels were noticeably lower. The comparison group, who did not utilize a lap pad or weighted blanket, did not experience a significant statistical decrease in anxiety or heart rate (Becklund et al., 2021).

Weighted blankets are effective tools that are non-intrusive and safe to use to help reduce anxiety. Designing a wearable weighted blanket with the option of adjusting the weight through adding or taking off weighted pouches, will enable the users to personalize the weight (total weight and location on the body) for optimum comfort.

2.6 Chromotherapy

Chromotherapy is the use of color in a variety of settings to improve well-being and healing (Azeemi & Raza, 2005). Chromotherapy is a traditional alternative medicine procedure that uses electromagnetic radiation energy from the visible spectrum (i.e., colored light) to affect changes in the human body. Various hues may elicit particular feelings and may have the ability to be a source of stress relief for many (Goldstein, 1942). Since color can be perceived both physically and emotionally, it has the capacity to cause psychological reactions (Saklecha et al., 2022).

A study from 1975 conducted on 40 undergraduate students in the USA on the effects of four primary colors showed that blue and green were more calming colors compared to yellow and red. By using the STAI, it concluded that the groups with blue and green had a lower A-state score. The participants stated that blue and green were scored as ‘most pleasant’. Green was perceived as agreeable, quieting, and calming. Green was also associated with relatively low

anxiety. The current study not only supports previous earlier research but also raises the possibility that different colors have distinct effects on anxiety levels (Jacobs & Suess, 1975).

Another study from 2022 in India was conducted on 90 patients aged 18-60 years with anxiety, and results concluded that the color blue reduced the patients' heart rate and stress, had a soothing impact, and made the participants calm and relaxed. Pink helped calm, relax, and tranquilized the patients. Additionally, it showed a reduction in anxiety when exposed to the colors blue and pink (Saklecha et al., 2022). Cool hues act as a relaxant and sedative, lowers blood pressure (BP), and eases tension in anxious persons (Azeemi & Raza, 2005; Saklecha et al., 2022).

The current studies showed that chromotherapy is an important technique for helping anxious people experience less anxiety. Chromotherapy works to calm down patients, allowing for a comfortable and quiet healing environment (Jacobs & Suess, 1975; Saklecha et al., 2022). Based on these findings, creating LED light strips that have different color options that are attachable to the weighted blanket as a form of chromotherapy may have promising effects in alleviating anxiety.

2.7 Summary of literature review

Based on my findings in each topic of the literature review, I will be able to create and design a weighted blanket, a haptic device, LED light strips, and a mobile app that will ideally help decrease users' anxiety. Each section will additionally help me understand what elements are important to focus on and, specifically, why and how they can ease anxiety. The studies that have been conducted have helped to show me how I should conduct my user testing and how to analyze what data I need to collect.

Chapter 3 – Contextual Review

In Chapter 3, I discuss existing products that have been developed to ease anxiety. I describe the features as well as the pros and cons, and how they are similar or different than what I am researching and designing for my thesis.

3.1 Haptic device - TouchPoints®

TouchPoints are wearable devices that help users to reduce stress, regain focus and improve their sleep by releasing a gentle vibration (Figure 2). The two devices have to be worn on the right and left side of the body and can be worn in many different places such as on the wrists, attached to the socks, on a belt, in pockets, on palms, or in bands (AdornThemes, n.d.). TouchPoints use BLAST (Bi-lateral Alternating Stimulation Tactile) technology, which has been scientifically shown to change the body's stress response. To change your brain's normal "fight or flight" response to your calm and in-control response, BLAST uses light, rotating vibrations on each side of the body (Serin, n.d.). TouchPoints slowly retrain your body, forming new behavioral responses that reduce the negative effects of stress. Using TouchPoints to reduce stress without the use of medicines or negative side effects is non-intrusive and safe for both adults and children (AdornThemes, n.d.).

Figure 2 – TouchPoints wearable device (AdornThemes, n.d.) – used with permission

TouchPoints can be worn throughout the day and on numerous different parts of the body, making them accessible to use whenever the user needs. The website also offers wristbands to insert the devices in a more comfortable wear, as well as clothing clips to attach to the devices to the belt, a bag, or socks, which is ideal for users to wear discretely (AdornThemes, n.d.)

TouchPoints do not connect to a mobile app that can easily personalize the response. However, the user can change the settings by pressing the button on the main device. It is unclear as to what setting the user is changing, whether it is the frequency or the intensity of the vibrations. It is also unclear on the device itself which buttons do what unless the user looks at the guide (AdornThemes, n.d.).

I believe that incorporating a mobile app that is connected to the wearable device will enhance the users' experience and will be an easier way for them to personalize the sensation that brings them the most comfort and lessens their anxiety. Incorporating one wearable haptic device rather than two will allow the user to have a free hand to interact and change the frequency and strength of the vibration on the app, as well as use the light and music features. Additionally, studies have suggested that the wearable device should be worn on the non-dominant hand, as they have tested it on numerous participants (Azevedo et al., 2017).

3.2 Weighted blanket - Hush

Hush is a weighted blanket that helps reduce stress, anxiety, and insomnia (Figure 3). It is meant to be used in bed while the user is sleeping. Hush is available in different sizes and in different weights as the blanket should ideally be 10% of one's body weight. Weighted blankets mimic deep touch pressure (DTP) that helps reduce cortisol levels, which is the fight or flight hormone, leading the user to feel calmer. Hush weighted blanket comes in two different weights; 15LB and 20LB, giving the user the option for optimal comfort and result (*Hush - Why This Weighted Blanket Makes Canadians Sleep Better*, n.d.).

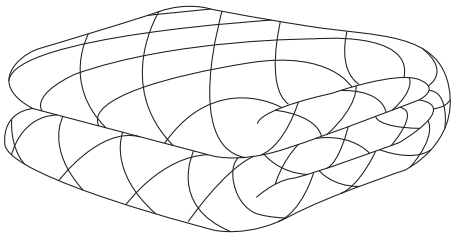


Figure 3 – Sketch adapted from Hush Weighted blanket (Hush - Why This Weighted Blanket Makes Canadians Sleep Better, n.d.)

Hush is mainly used as a blanket to sleep under during the night, making it ideal for one or more people to use (*Hush - Why This Weighted Blanket Makes Canadians Sleep Better*, n.d.). However, even though the weight is distributed across the blanket, some people might prefer a lighter or heavier weight. Adding a feature such as buttons, snap buttons, or Velcro, would enable users to adjust the desired weight and the placement of the weight.

Instead of a weighted blanket, I am choosing to design a weighted wearable blanket that is similar to an 'oversized hoodie' to which I add weights. Additionally, there will be a haptic device and LED lights strips that will be attachable to the weighted blanket so the user can experience multiple useful sensations (slow heartbeat-like vibrations, chromotherapy, and DTP), which have been proven to reduce anxiety (Chen et al., 2013; Azevedo et al., 2017; Jacob & Suess, 1975; Azeemi & Raza, 2005).

3.3 Chromotherapy - BlissBulb

BlissLights offers a blue light bulb called BlissBulb that helps the user to relax, feel a calming effect, and to reduce anxiety (Figure 4). The bulb projects a blue light with bright laser lights. It also comes in green, which is also a helpful color to ease anxiety. The company has recently developed an app together with a special device (not just the bulb) that can be used to control different light *settings (Decorative Laser Lights | Red & Green Lightbulbs, n.d.).*

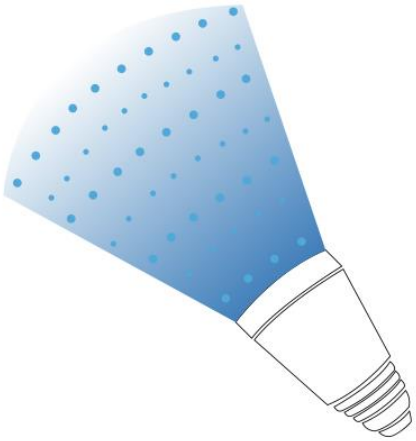


Figure 4 – Sketch adapted from BlissBulb blue light bulb (Decorative Laser Lights | Red & Green Lightbulbs, n.d.)

The founder, Randy Johnson, wanted to reduce his daughter's fear of the dark. Using his experience with laser lights for parties, he created a projector that put different color lights and stars in her bedroom. He eventually developed BlissBulb with an array of different colors.

The BlissBulb is a useful product as it fits standard bulb sockets, making it more appealing to consumers as they are not required to purchase an additional lamp to be able to use it. However, people who want to use BlissBulb may not have access to a standard bulb socket or, in certain contexts, may not even have access to electricity, making it harder for them to use it while they are experiencing anxiety (*Decorative Laser Lights | Red & Green Lightbulbs*, n.d.).

My solution is to have an LED light strip on each arm that can be hypothetically controlled by the app to turn it on and off and change the colors. The light colors, blue, green, and purple, depending upon a person's preference, can provide a calming color in a dark room. This calming light, used in conjunction with the other elements of my project, can hopefully reduce users' anxiety.

3.4 Mobile app – Calm

The Calm app offers users ways to manage stress, anxiety, and sleep through guided meditation, mindfulness, and music (Figure 5). Calm is a popular mindfulness app that is also accessible on a computer online. It also offers features for mood tracking, guided exercises, and meditative audio. Most of the features the app offers are limited in the free version. To access all the features, including nature sounds and sleep stories, there is a paid subscription that is rather expensive ($14.99/ month, $69.99/ year) (*Experience Calm*, n.d.).

Figure 5 – Calm mobile app (Experience Calm, n.d.) – used with permission

Mindfulness is a strong tool to reduce anxiety for people who are committed to it and are regular users of an app. However, it takes time to develop the skills and training to benefit from mindfulness and meditation. Unfortunately, many people do not benefit in the long term

because they want quick results, and therefore stop using mindfulness apps after a short period of time (Laurie & Blandford, 2016).

The Calm app offers a wide range of predefined music that is primarily meditative or natural sounds, but not from well-noted artists or from music that is commonly on people's phones. However, most of the music, meditation, and nature sounds are only accessible through a paid subscription (*Experience Calm*, n.d.). Furthermore, since the music option is already on the phone where my proposed app will be, there is no further cost as users will be able to link their music account (e.g. Apple Music, Spotify) to my proposed app in a future version of the project.

The incorporation of an app into my project will help users interact with the physical and auditory sensations of my product (e.g. touch-sound-sight) to help them ease their anxiety as well as to be able to listen to music that the user themselves find relaxing. I will be creating an app that does not focus on mindfulness but rather focuses on physical sensations that can be controlled through the app.

3.5 Summary of contextual review

In this table (Figure 6), I analyze the key features and functionalities of the existing products compared to SensAble. This has enabled me to understand the gaps in the products and how to create a product that is different from what is already on the market.

✓=Yes X=No =N/A		TouchPoints	Hush	BlissBulb	Calm	SensAble
Haptic Device	Number of devices	2				1
	Mutliple settings	✓				✓
	Multiple locations	✓				✓
	Connected to an app	X				✓
Weighted Blanket	Adjustable weight		X			✓
	Different sizes of product		✓			X
	Blanket / wearable		Blanket			Wearable
Chromotherapy	Light source			Bulb		LEDs
	Powered by			Electricity		Battery
	Connected to an app			X		✓
	Different color options (in one device)			X		✓
Mobile App	Mindfulness/mood tracking				✓	X
	Free or paid				Free & Paid	Free
	Provide audio in app				✓	✓
	Connected to other devices				X	✓

Figure 6 - Table of key features of each existing product and SensAble – (Merel Ververs-Spiegel)

Each of these products has already been created; however, there is no product that combines all of these technologies above. Therefore, SensAble differentiates from these existing products as it has combined a haptic device, weighted blanket, self-selected music, chromotherapy, and an app into one product. By combining these technologies, it could increase the potential of helping and calming a user, as these products have shown to be successful when used individually.

Chapter 4 – Methods and Methodologies

In my research, I am exploring how to combine tangible and electronic devices into a product that can be used as a self-help tool for anxiety reduction. This could be used in the comfort of the user's own home. In the process of my research, I use as methods expert interviews and user testing, and as the methodology Research through Design, I will describe each of them here below.

4.1 Research through Design

Research through Design (RtD) is a way of materializing knowledge and insights based on hands-on design work. It can be used to explore how to deal with materials, technologies, and situations that are new and it is interdisciplinary (Baytas, 2021). Figure 7 illustrates how I aim to use Research through Design in the process of developing the final product for my thesis.

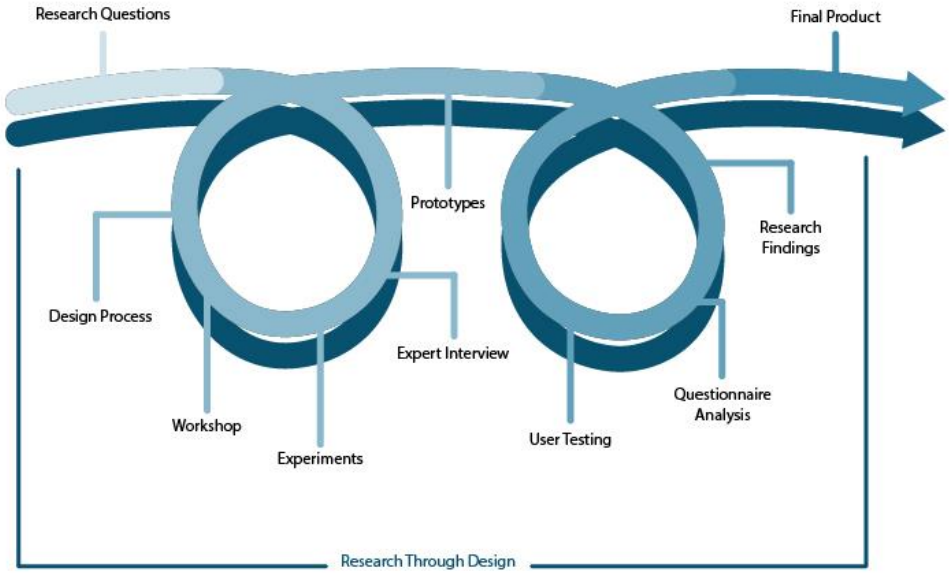


Figure 7 – Research through Design process – (Merel Ververs-Spiegel)

Starting by looking at my research questions and understanding what I wanted to create, I explored what products already existed in the contextual review to learn the gaps in the existing products. I was then able to start with the design process, attend a workshop, experiment with various materials and technologies, and conduct an expert interview. Then, I created several iterations of prototypes that I then user tested. Next, I analyzed the results of the questionnaire and combined the research findings.

The final product I created is a result of these various design processes in which I created sketches and 3D models of the various inputs. I created various prototypes before I came to a final product. This design process is supported by research and learning activities that created the foundation for the final product.

4.2 Expert Interviews

In the next step of my research, I conducted an expert interview with a licensed clinical social worker who provides psychotherapy, Ivy Seraphin. I asked her about her specific expertise (and not about their personal opinions), experience, and knowledge in relation to anxiety, as well as potential devices and coping skills that could help reduce anxiety. The questions I asked were:

- During your career, what are other effective sensory tools that your patients have used to help their anxiety?
- What do professionals in your field recommend using as tools in the reduction of anxiety?
- Does your organization have an official stance on weighted blankets?

What I learned from this interview was that it backed some of the literature research I did, such as DPS of the weighted blankets, as well as solidified my interest in focusing on the human senses for my product. Seraphin's professional stance on weighted blankets was that many professionals in her field recommend using a weighted blanket as a tool for the reduction of anxiety. During her career, Seraphin found that grounding is an effective sensory tool that

patients use. The grounding exercise is using our five senses by observing, for example, 5 things you see, 4 things you hear, 3 things you can touch, 2 things you smell, and 1 thing you can taste. The order of the numbers and senses can change depending on what people find more soothing and the environment they are in.

4.3 User Testing Session

The methods of user testing tested the user experience of the device among young adult volunteers (graduate students of OCAD) and did not test the efficacy of the device in the reduction of anxiety. To test the usability of the device and technology, human participants were needed, but they were not selected based on the presence or absence of anxiety. The user testing looked at the user-friendliness, design, and sensations while using the device and technology for a general young adult student population in order to understand what changes needed to be made to improve the interaction and overall design. After receiving approval from the REB, I advertised my poster (Appendix A) to call for participants and proceed with the user testing (Figure 8).

Individual in-person sessions were conducted in February 2023. For the testing sessions, in total nine participants agreed to participate. I gave a brief description of what the project was, explained each component of the prototypes, and went over the consent form (Appendix B). Each participant was asked to fill in the first question of the questionnaire (Appendix C) on how they felt. Subsequently, the participants were given the following:

- A wearable weighted blanket
- A haptic device (three different vibration options were offered)
- Additional pouches with weight (7 x 100 g and 12 x 200 g) were offered as an option to adjust the weight of the wearable weighted blanket
- A mobile device with an app that would hypothetically be connected to the devices

- An LED light strip with the option of a darkened room (three colors were offered: blue, green, and purple)
- Music was offered as an option (self-suggested and/or prescribed)

The participants were given 15-20 min to explore and interact with the devices. Each session complied with OCAD U's Safety Protocols and COVID-19 Protocols. If the participant preferred not to be directly in touch with the blanket on his/her clothes, a disposable lab coat was offered.

After testing, a questionnaire was provided to fill in and subsequently returned to me (Appendix C). Each questionnaire was given a number that the participant needed to remember in case they wanted to withdraw their data from the analysis. That number was not related to any personal identifier. This testing was followed by quantitative and qualitative analysis. The questionnaire reported on the participant's user experience (the questionnaire contained a mix of open and closed questions).

Figure 8 – Participant during user testing – used with permission – (Merel Ververs-Spiegel)

Chapter 5 – Projects and Prototypes

In this Chapter, I describe the prototypes I have created to date. I designed three different prototypes for the haptic device and was able to improve the overall design by learning from each prototype. Another prototype I created was of a colored light lens which then led me to create a prototype of LED light strips. Additionally, I made a prototype of a weighted blanket and weighted pouches, and an app. With each prototype and the user testing feedback, I learned what I needed to consider improving and evolving in my next designs (Figure 9).

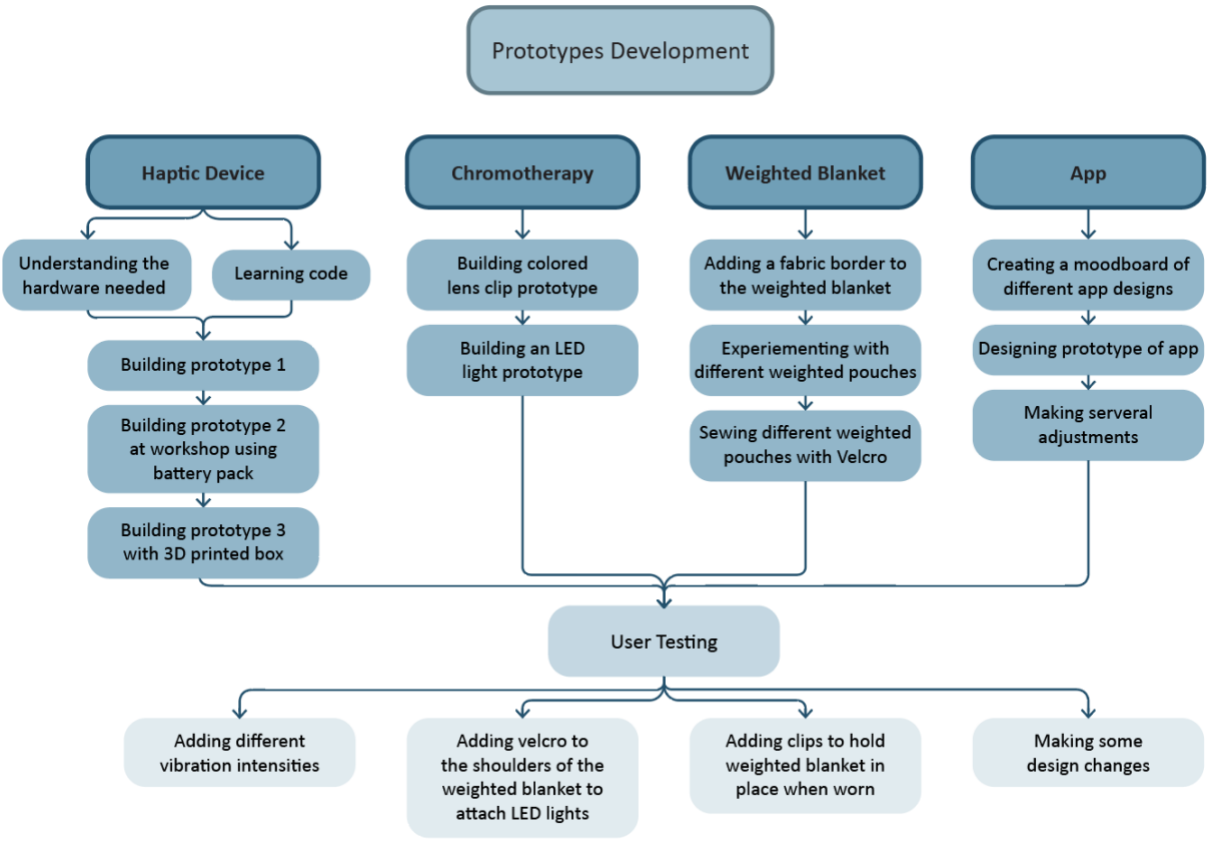


Figure 9 – Top level map of prototypes development – (Merel Ververs-Spiegel)

5.1 Haptic prototype

My goal in creating these prototypes was to understand the technology, how to improve each prototype, and learn which materials are more effective for my final products. Including what different modes of vibration would be felt through different materials and how to make the smallest and most comfortable device for a user to wear.

5.1.1 Haptic device Prototype 1

The first prototype that I worked on is the haptic motor device, which will hypothetically be connected to a mobile app where users would be able to control the frequency and intensity of the vibrations delivered in the haptic motor.

I started off by assembling a haptic motor and an Arduino Uno (Figure 10). I then coded the vibration frequency to mimic a heartbeat. According to my literature research (Costa et al., 2017; Azevedo et al., 2017), the goal is to have a slow heartbeat-like vibration that is slower than the regular resting heart rate. On average, a resting heart rate for adults (18 + years) is 60 – 100 beats per minute (*Pulse & Heart Rate*, n.d.). Our bodies and brains naturally respond to rhythm, so by releasing a slow heartbeat-like vibration when a person has a fast heart rate due to experiencing a moment of anxiety, it will enable the device to somewhat trick the users' bodies and brains into reducing their heartbeat as they will naturally sync with the rhythm and come to a calming state (Azevedo et al., 2017). I proceeded to code different speeds and calculate how many beats per minute were delivered by the haptic motor, and test it out on myself to see which one felt the most calming. After testing a few different speeds, my ideal number was 45 beats per minute. As I was only testing it on myself, the next step of the haptic device design would be to include different speed options during the testing phase and gather data through the questionnaire that I will provide the participants to understand which was the average ideal speed of the vibration.

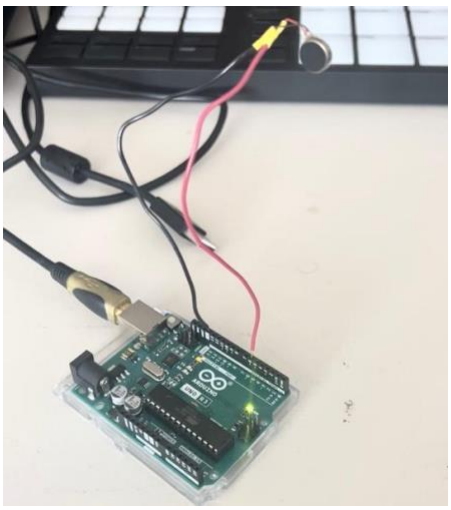


Figure 10 – Haptic device prototype 1 – (Merel Ververs-Spiegel)

The reason for wanting to know the preferred average speed is that in the app, I will be able to suggest a speed to the users. However, I intend to keep the option to reduce or increase the speed as not everyone prefers the same speed of heartbeats per minute to help them ease their anxiety.

Next, I sewed a piece of fabric cloth together that wraps around the wrist (27cm x 6.5cm) with 4 Velcro strips to easily adjust the size, as well as a small pocket (5.5cm x 3cm) where the haptic motor would be placed in (Figure 11).

Figure 11 – Haptic device prototype 1 – (Merel Ververs-Spiegel)

With my first prototype, I learned through coding the Arduino, I was able to successfully mimic a heartbeat-like vibration using a haptic motor. I also learned that the thickness of the fabric is important to consider to be able to feel the vibrations because the different thickness of fabrics means different feelings of intensity.

5.1.2 Haptic device Prototype 2

I made a second haptic device prototype during a workshop on Bodies in Wearables[2] at OCADU. My goal during the workshop was to use a smaller Arduino and to use another source of battery than the computer so I could walk around the room while using the haptic device, and to make the wearable smaller.

While going over my ideas and goal for the end of the workshop, I realized I was unable to use the ESP32-Wroom-32 as I did not have the additional hardware to make it function. I had to reevaluate what I was able to accomplish during that time and my solution was to use an Adafruit Circuit Playground Express. However, the Adafruit Circuit Playground Express does not function with a haptic motor without a haptic driver to act as a converter. After acquiring an Adafruit Circuit Playground Express with a soldered haptic driver and haptic motor, I was able to then attach a battery pack and disconnect it from my computer. Using the buttons on the Adafruit Circuit Playground Express, I was able to turn on and off the vibrations. My last step was to design a system to be able to wear it around the wrist. I hot glued fabric to create two pockets, one for the battery pack and another for the Adafruit Circuit Playground Express, haptic driver, and haptic motor, and attached them to a Velcro strip to make the size adjustable (Figure 12).

[2] http://socialbodylab.com/biw-resources/

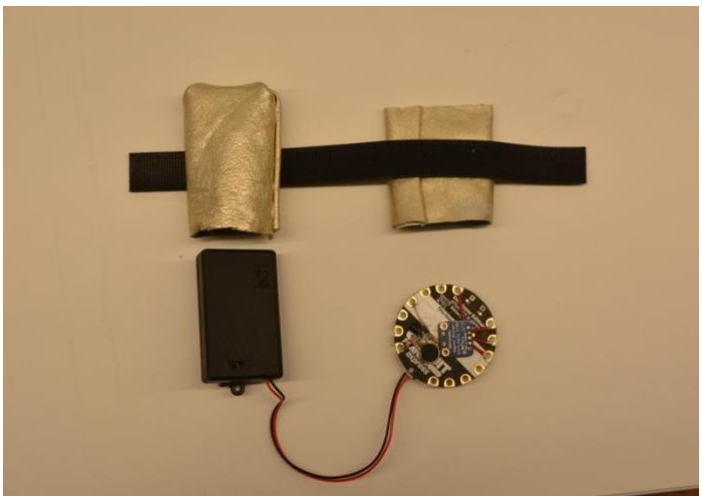


Figure 12 – Haptic device prototype 2 – (Merel Ververs-Spiegel)

I came to the conclusion that I will not be working with an Adafruit Circuit Playground Express when building a haptic device because I am more comfortable working with an Adafruit Gemma 8Mhz. However, I learned how to incorporate a button and a battery back to make the haptic device wireless and easy to turn on and off. I also learned that Velcro is a useful material that I will also be used in future prototypes of the haptic device.

5.1.3 Haptic Device Prototype 3

For the third prototype, my goal was to create a fully functional haptic device with a button, a 3D case and that could be worn on the wrist with Velcro. I used an Adafruit Gemma 8Mhz as it was small and had all the components, I needed to create a haptic device. However, when I started to code, I quickly learned that there are additional libraries and some differences in the code language. Once I understood the code, I was able to play around with different intensities and patterns to create a slow heartbeat-like vibration.

I first mapped out and drew the circuit diagram to ensure the connections between each part were correct and easy to follow. I soldered the button, Adafruit Gemma 8Mhz. transistor,

capacitor, haptic motor, and a lithium battery together to a blank printed circuit board (PCB). After putting them all together, I was able to measure the height, length, and width to design a 3D printed box and place the final device I made in the box (Appendix D, Figure 23). Through designing the box, I learned that not only did I have to measure the device, but I had to include the measurements of the space inside and leave enough room for the device, the thickness of the box, a hole for where the button would emerge from, and an entrance and exit for the Velcro to go through.

As the haptic motor wires are quite fragile, while experimenting with different patterns, three of my haptic motors broke. This led me to find a solution to fix that problem by hot gluing the haptic motor to the inside of the 3D printed box (Figure 13).

Figure 13 – Prototype 3 of haptic device – (Merel Ververs-Spiegel)

When using a button with delays (delays are used in the code to give an action of the haptic motor to stop for a period of time). I quickly came to realize that when I pushed the button, the haptic device would not turn off and I had to press it multiple times until it did turn off. During the delay, the action that we give tells the haptic to turn “off”, so when I pushed the button, nothing would happen. I started learning more about an action called ‘millis’, which is similar to

a counter. It counts in milliseconds when the haptic should stop vibrating without turning it off completely, allowing for the button to be pressed and the actions to follow.
The final prototype has three different vibration modes, with different speeds and slight variations in the slow heartbeat-like rhythm. Additionally, to the three modes, there is an off mode when the button is pressed the fourth time. For my next iteration, I will redesign the 3D box and add more space within it to be able to fit all the electronic components securely.

5.2 Colored Lens Prototype

I worked on creating a prototype of a colored lens clip to place on the flashlight on the back of the phone to project a colored light in a dark room.

I took apart a scented car vent clip and removed the scented liquid. Using a purple, green, and blue transparent plastic binder, I cut out four circles and glued them to the car vent clip (Figure 14). On one side of the clip, I glued a green, purple, and blue circle to see how the light would go through each small colored circle, but concluded that the circles were too small and did not light up the dark room fully but only lit a circle on the ceiling. The one thing I found interesting is that I was able to rotate the clip and select the color I wanted to be projected. I then took the other side of the car vent clip and placed a bigger circle. I chose the color blue for this prototype, and as the opening was much larger, the blue light was projected into the entire room.

Figure 14 – Colored light lens clip prototype – (Merel Ververs-Spiegel)

My conclusion is that the circle that the light passes through in the side of the clip with the three different colors, has to be larger than the flashlight circumference. However, an option is to use a similar structure as the first clip with different colors but just at a bigger scale so that the users are able to choose between three colored lights to help them with their anxiety. In my future prototype, I will have to consider if the colored lens would be the best option because the flashlight would not be bright enough unless it is used in a relatively dark room. A potential solution to explore further would be to incorporate LED lights into the weighted blanket.

5.3 LED Lights Strips Prototype

Through experimenting with the colored light clip lens and discussing different options with peers, I decided that instead of a light clip for the phone, I will be putting a LED strip on the sleeves bilateral of the weighted blanket, starting from the shoulder to the mid-lower arm.

The reason I wanted to make this change is that people may have different phones, so the light clip might not work for each phone or will not be able to cover the flashlight section of the phone fully. Another reason is that the clip is located on the back of the phone, and when

interacting with the phone, the flashlight points downwards to the ground rather than the room.

The LED lights will be easier for people to use as the brightness can be adjusted, which is not the case if people use the colored lens clip as the flashlight on the phone is insufficiently strong, and this will be more effective for chromotherapy. People can adjust the light and interact with the app on the phone without having to turn off the flashlight or worry about where the light will be projected.

The LED strips I choose are NeoPixel Clip 60 and are safe to include as a light source on the weighted blanket. The LED lights carry minimal risks as they are placed from the shoulder to the mid-lower arm so that people are not directly looking into the light. However, a warning before use could be added that people should not look directly into the light and only turn them on when the blanket is being worn. This change will make the weighted wearable blanket an improved tool for reducing anxiety and the phone as a control for the vibrations, music, and lights.

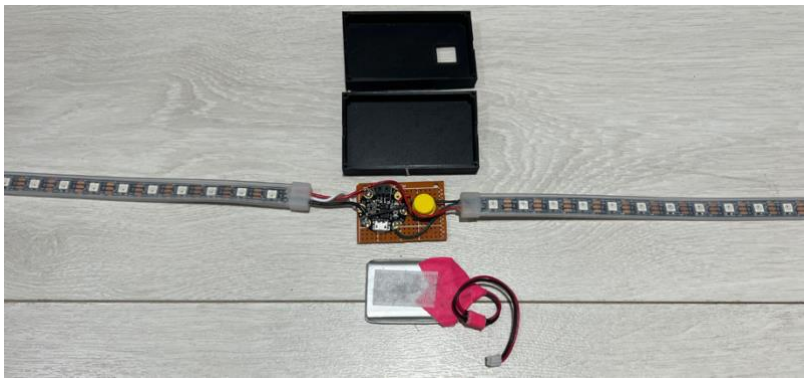


Figure 15 – Prototype of LED light strips – (Merel Ververs-Spiegel)

Similar to the haptic device prototype 3, I used an Adafruit Gemma 8Mhz to create an LED light strip prototype. I soldered two LED light strips, a button, and a lithium battery to a blank PCB

(Figure 15). On the first button press, the LEDs turn to blue, the second press, turns the LEDs green, the third press, turns purple, and on the fourth press the LEDs turn off (Figure 16). I measured the height, length, and width of the PCB, lithium battery, button, and Adafruit Gemma 8Mhz all together to create a 3D printed box (Appendix D, Figure 24) almost identical to the haptic device prototype 3 box.

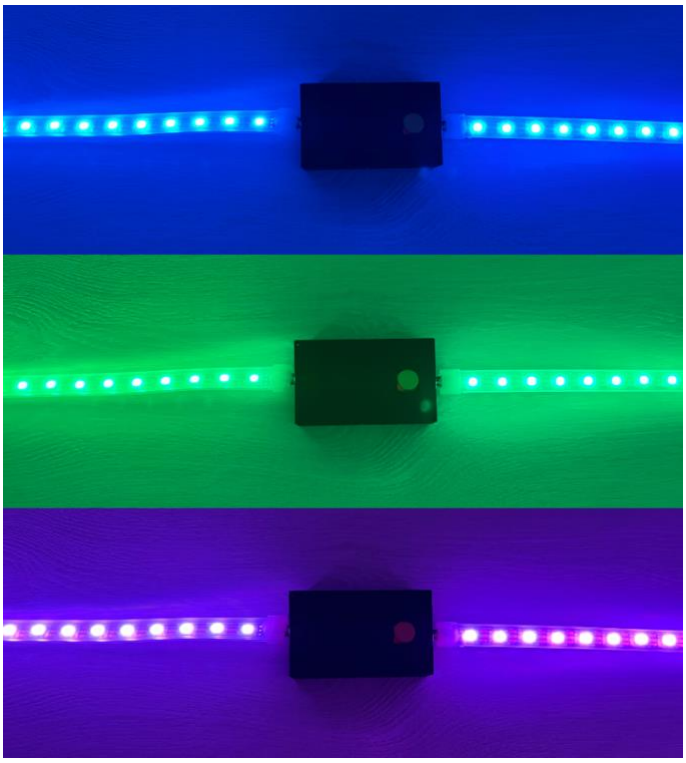


Figure 16 – Prototype of the different LED light strip colors – (Merel Ververs-Spiegel)

To ensure that the LED light strips were secured to the shoulders of the wearable weighted blanket, I glued some patches of Velcro to the bottom of the LED strips. The reason for not permanently attaching the LEDs is so that the users can remove the lights and be able to wash the weighted blanket.

5.4 Weighted Blanket

Instead of building/sewing an entire wearable weighted blanket, I bought one and made several adjustments and additions. The blanket is a slight beige and yellow color with a soft fabric. I sewed a 4 cm dark grey/ brown cotton border to the bottom and sides of the blanket so that it would not get dirty by dragging on the floor (Figure 17).

Figure 17 – Weighted blanket prototype and pouches – (Merel Ververs-Spiegel)

As I learned in the literature review, the ideal weight depends on the weight of the person wearing the weighted blanket. Keeping that in mind, I thought of a way for people to be able to personalize the weight to their preferred weight. I sewed two different kinds of pouches, filling them up with small glass beads, 7 pouches weighing 100 g that were sectioned into four 25g

compartments, and 12 pouches weighing 200g sectioned into four 50g compartments. The reason I separated the weight into 4 compartments is because in my first pouch prototype, I noticed that all the small glass beads would gather at the bottom of the pouch which did not equally distribute the weight. On each pouch, I sewed a strip of Velcro that went across the four compartments. In order to attach them to the weighted blanket, using the softer side of the Velcro (to ensure that any other fabric of clothing would not get caught to the blanket), I hand-sewed three long Velcro strips to the front of the weighted blanket. Two starting from the collarbones to the knees and the third from the chest to the lower abdomen.

Additionally, I hand-sewed Velcro strips from the neck to the mid-lower arm length on the top part of both arms. This allows the user to attach or remove the LED light strips.

5.5 App Prototype

I designed a prototype of an app that would hypothetically be connected to the haptic device and the LEDs. The app would allow the users to turn the haptic device, LEDs, and music on and off, control the intensity and speed of the vibration, the brightness, and different colors for the light, and connect to different music streaming services. The app also includes a guide and information about each component on how to use the wearable weighted blanket (Figure 18).

To create the app prototype, I used a program called Adobe XD which I had not used before. It was easy to learn and navigate through as it has very similar features to Figma, a program I had used in the past. Prior to starting, I created a picture mood board of different elements of apps that could inspire me, such as different types of buttons, colors, illustrations, and layouts.

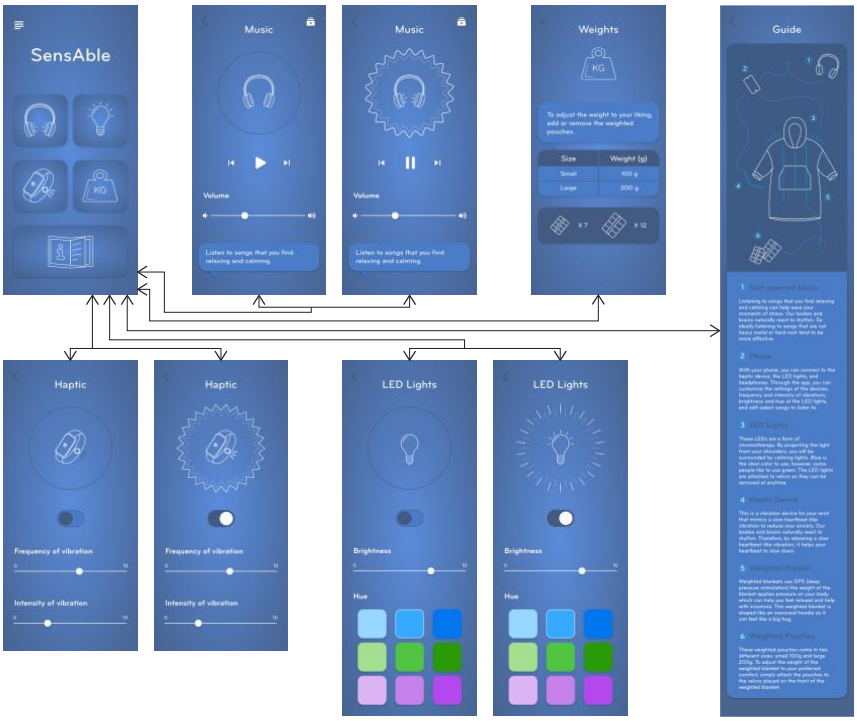


Figure 18 – Wireframe of app prototype before user testing – (Merel Ververs-Spiegel)

In the literature review, I learned that blue is a calming color. Therefore, I implemented blue in the design of the app. My background in graphic design helped me create a cohesive visual language within the app, such as the illustrations, the font, and the layouts. Furthermore, my background helped me design the wireframe of the app.

5.6 Findings from user testing

Overall, the feedback from the participants indicated that they had a positive interaction with the prototypes. They noted that they liked the personalization aspect and the multiple sensations that were felt. The number of options to customize was found to be sufficient and not too overwhelming. The participants expressed that the LED lights and the music feature added to the experience. The weighted blanket was described as easy to put on, comfortable and calming, and the weight adjustment feature was well-regarded. The app prototype was

easy to navigate through, and the participants liked the overall design and illustrations. I received some useful feedback that helped me understand what improvements I needed to make for each prototype.

What I learned from my app prototype through my own interaction and the feedback of the user testing, was that the homepage should not include a section on the weights but rather include that section in the guide. The reason for this is that the three sections (haptic, light, and music) are personalizable within the app, and it created confusion as to whether there was an interaction in the app with the weights. For the haptic motor prototype, most participants commented that they preferred a lighter intensity than what was given. The slower frequencies of the heartbeat like vibration were well-liked. The front weight of the weighted blanket was pulling the back side, so to keep the weight from pulling in the front, a solution would be adding clips or buttons to each side to keep the weighted blanket in place. However, this was only an issue due to it being tested while sitting in an office chair and not how it is intended to be used on a sofa, bed, or armchair.

One of the findings from my user testing that I found interesting was that even though I only conducted a user testing on 9 people, most participants preferred using the purple LED lights despite the literature review indicating blue light was preferred for its calming effect.

5.7 Prototype iterations from user testing feedback

In this section, I explain the changes I made to the prototypes using the feedback from user testing.

As the weight of the weighted blanket was pulling in the front, my solution was to add clips on each side to clamp the fabric together and hold the blanket in place. I sewed fabric over two clips using the same material I used for the border of the weighted blanket. Adding Velcro to the shoulders and under the hoodie, allowed the box of the LED lights to be securely attached

or easily detached if one preferred not to use the lights. This addition also allowed attaching extra pouches, i.e. weight, to be added to the shoulders and arms. To ensure that people were able to still have different intensities of the vibrations, I added two extra intensity options, both slower intensities than in the third prototype used in the user testing. In the app, I removed some of the on and off buttons and kept the illustration of each device as the power button. I changed the layout of the home screen by moving the 'weights' section to the guide screen. For the designs, I used a lighter pallet of blues and removed the scrollable feature except for the guide page as I learned that apps do not usually have pages that scroll (except for e.g. news feed and social media apps).

Figure 19 - Prototype of weighted blanket, pouches, haptic device, and LEDs-(Merel Ververs-Spiegel)

Figure 20 – Mannequin wearing SensAble - (Merel Ververs-Spiegel)

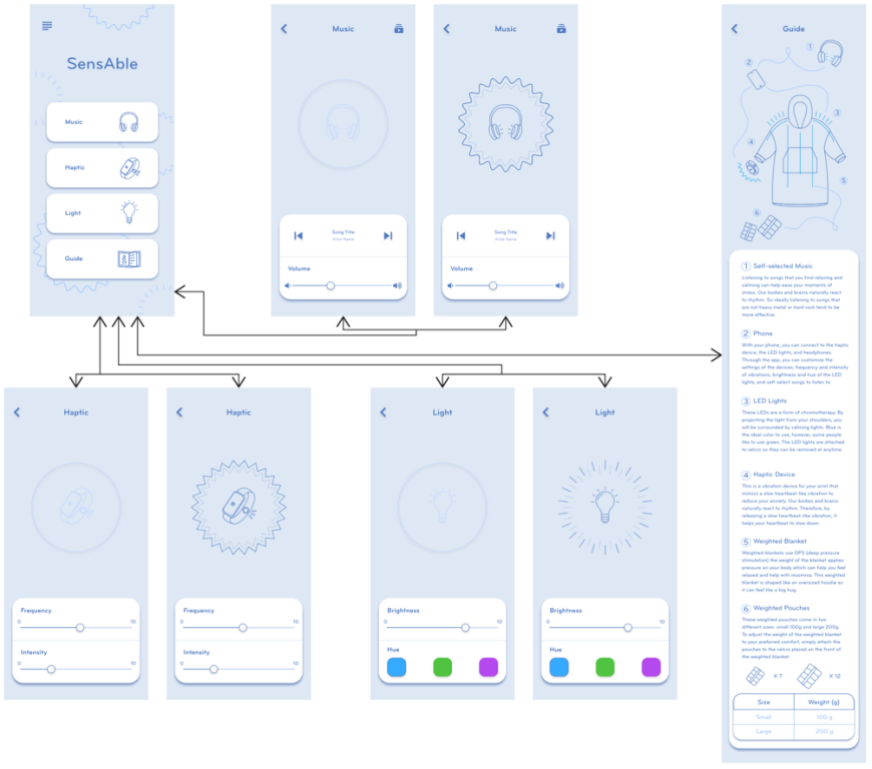


Figure 21 - Wireframe of app after user testing – (Merel Ververs-Spiegel)

Chapter 6 – Conclusion

6.1 Future Works

The time for this thesis project was limited, but I could foresee further iterations and future work for this project.

There are several ways I would like to improve the haptic device and the LED light strips. I would continue exploring more materials for the strap of the haptic device, the boxes that contain the hardware, and how to make the boxes smaller and more compact. Additionally, I would like to conduct another user testing to test the intensity of the vibration through other materials surrounding the haptic motor.

The app in this project is not connected to the devices. Therefore, researching, learning, and writing the software to be able to connect to the app would be very beneficial as it would be a way to control and personalize the experience even further. Similarly, I would like to add the possibility of connecting different music streaming services to allow users to select their own music within the app.

Another element that I would like to explore is different materials for the weighted blanket. Through experimenting with different fabrics, I could potentially create a weighted blanket without any stiff feeling Velcro and instead have a fabric on the outside layer where weighted pouches can be attached or removed but maintain a soft feel.

6.2 Scopes and limitation

With this iteration of the prototype, I have not been able to establish whether my device reduces anxiety. This will require collaboration with trained researchers in fields studying clinical anxiety in the mental health field. However, participants noted that they had a positive

experience after interacting with the prototypes and that they felt more relaxed. A second limitation was that I was only able to conduct a user testing on a small number of graduate students and not a mix of graduate and undergraduate university students. Third, the user testing was in a room at the graduate school campus rather than in a participant's home or more private space and was only tested for a limited amount of time.

6.3 Final thoughts

By Research through Design, I was able to combine an app and a wearable device into a user-friendly hybrid product that can be used at home and has the potential for anxiety reduction among young adults in university. I was able to successfully design and build prototypes using multisensory components with different materials and technology. The literature review directed me on what senses to include and combine, and what to build. The results of the user testing confirmed the research findings from the literature review. SensAble was well received during user testing.

The mobile app connected to a wearable device enables users to access and personalize chromotherapy, deep pressure stimulation, self-select music, and haptic vibration as tools that are known to reduce moments of anxiety. The effectiveness of SensAble on anxiety would need further research.

SensAble differentiates from existing products, that were analyzed and discussed in the contextual review, as it combines a haptic device, weighted blanket, self-selected music, chromotherapy, and an app, into one product that is personalizable. By combining these technologies and products, it could potentially increase the effectiveness of helping calm a user, as these products have shown to be successful when used individually.

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Appendices

The appendix contains the poster for the call of participants for the study, the consent form that was given to participants after it was explained and gone over with the student investigator to be signed, the questionnaire that was given to participants during the user testing session, which they were asked to fill out after they interacted with the project. It also contains 3D designs of the haptic device prototype 3 and LED light box prototype.

Appendix A: Poster – Call for participants

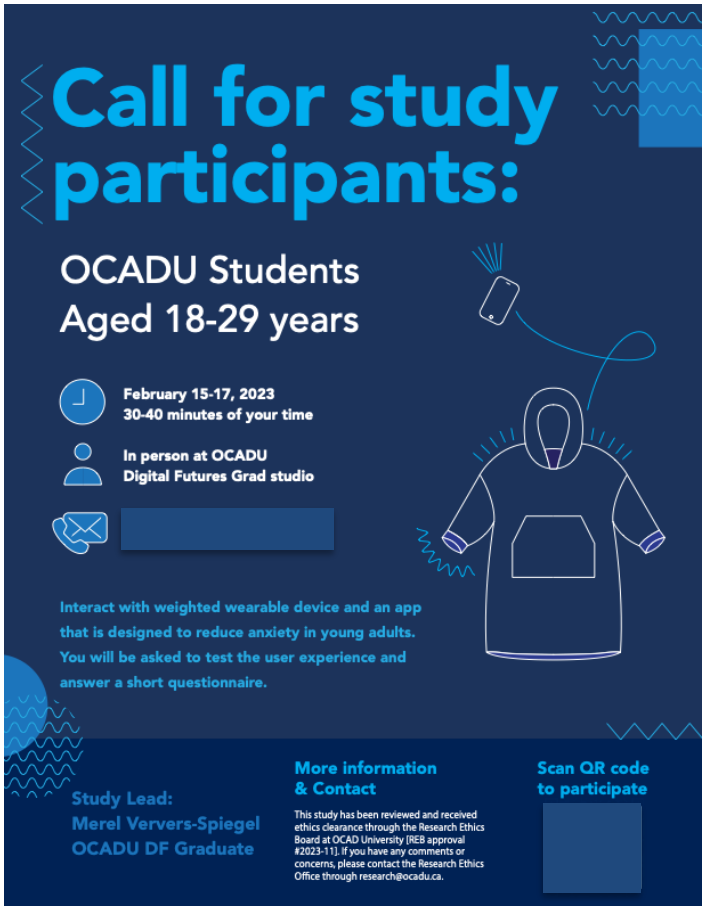


Figure 22 – User testing poster, Call for Participants – (Merel Ververs-Spiegel)

Appendix B: Consent Form

Interview Consent Form

Date: November 2022
Project Title: **A wearable weighted device and app for anxiety reduction among young adults and students**

Student Investigator:
Merel Ververs-Spiegel
Graduate Student,
DIGITAL FUTURES
OCAD University

PURPOSE

You are invited to participate in a brief study that looks at the user experience of a Wearable Device connected to an app as part of a graduate thesis at OCAD University. This device aims to reduce anxiety among young adults when used. There will be a testing of the device followed by a questionnaire. The purpose of the testing and questionnaire is to evaluate the device and to describe the user experience. Approximately 10 people will be asked to undergo a test session for this study. This study is not funded by any entity.

WHAT TO EXPECT

For the testing session you will be asked to sit down on a couch in a room at OCAD Digital Future studio and apply a wearable weighted blanket device for approx. 15-20 minutes. During this time you will be able to interact with various components of the device (including an iPhone, an app, a small vibrating device, LED lights strip, a headphone, pochettes of variable weights). For the Questionnaire on paper you will be asked 30-40 mostly closed and some open-ended questions and it will take approx. 15 minutes to fill out. Data collected is intended for both the internal use of the student researcher and the Questionnaire results may be publicly disseminated as part of the thesis project but this will all be anonymous.

POTENTIAL BENEFITS

Possible benefits of participation include the opportunity to be exposed to a device that aims to reduce anxiety. The participant might find the experience enjoyable and relaxing. Through its testing the participant might become inspired to use all or parts of the elements of the device in future settings.

POTENTIAL RISKS

There also may be risks associated with participation. A weighted blanket might cause a sensory overload because it involves some weight applied on the body. The vibrations of the small haptic device might be anxiety provoking. However, we anticipate this risk will be minimal. Weighted blankets have been shown to be safe for participants. Vibrations are currently used on a wide scale in an Apple Watch, FitBit, etc. The Guide to Supporting Students in Distress at OCAD University (March 2015) will be provided upon request. During the user testing, participants will be advised not to look directly into the LED lights (the placement of the LED lights on the shoulder to mid-upper arm also limits direct eye exposure). Prior to each session all involved materials will be sanitized with an alcohol swab (headphone, iPhone, LED strip) and a disposable lab coat and face mask will be offered to reduce contact between the blanket and the participant's clothes. Hand sanitizer will also be available.

CONFIDENTIALITY

Your name, and/or identifying information, will not be included or associated with the data collected in the study, and you can expect not to be identified in written outcomes. Each participant will be assigned a number on the questionnaire which will not be associated with your name in the consent form. You can ask the Student Investigator to destroy your questionnaire until 3 weeks after the in-person session. For this you just have to provide your participant number as there are no other identifiers.
The consent form and the paper copies of the questionnaires will be transformed into digital (Excel) records. The paper copies will be shredded. They will be retained by the student investigator on a secured drive (USB key). After 3 years the project data will be erased and the drives (including the USB key) re-formatted.

INCENTIVES FOR PARTICIPATION

You will not be paid to participate in this study. You may, however, request a copy of your own questionnaire for your personal use.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or participate in any component of the study.

Further, you may decide to withdraw from this study at any time, or request withdrawal of your data prior to submission and you may do so without any penalty. Your choice of whether or not to participate will not influence your future relations with OCAD University or the investigator involved in the research. To withdraw your data from the study prior to analysis, let the Student Investigator know within 3 weeks after the in-person session. You only need to provide your participant number to the investigator in order to destroy your questionnaire (as there are no identifiers related to your questionnaire).

PUBLICATION OF RESULTS

Data collected through these interviews will inform the graduate thesis of the Student Investigator which will be published on OCAD's website. Results of this study might be published in a journal at a later date.

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please ask. If you have questions later about the research, you may contact the Student Investigator, Merel Ververs-Spiegel, using the contact information provided on this form. This study has been reviewed and received ethics clearance through the Research Ethics Board at OCAD University [insert REB approval 2023-11].

If you have questions regarding your rights as a participant in this study please contact:
Research Ethics Board c/o Office of the Vice President, Research and Innovation
OCAD University
100 McCaul Street
Toronto, M5T 1W1
416 977 6000 x4368
research@ocadu.ca

AGREEMENT

I agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name:

Signature: Date:

Thank you for your assistance in this project. Please keep a copy of this form for your records.

Signature of Participant Date

Appendix C: Questionnaire

This questionnaire was given to each participant to fill out after the interaction with the prototypes, with the exception of question number 1 which was asked to be completed prior to the user testing.

PARTICIPANT NUMBER: ……..

Please fill in this form, but you are not obliged to answer every question.

What sex/gender do you associate with: F M Other Rather not say

Year of study (if applicable) :…….....

<u>Before</u> Interaction with the Device

1. **How do you feel?**

   ……

<u>After</u> Interaction with the Device

2. **How do you**

   feel?……

Weighted blanket

3. **Was the blanket easy to put on?**

   Yes No

4. **If No, why not:**

……

……

5. **What adjustments are needed to make it easier to put on?**

……

……

6. **What did you think of the weight of the blanket?**

Too light Ok Too heavy

7. **Did you change the total weight of the blanket?**

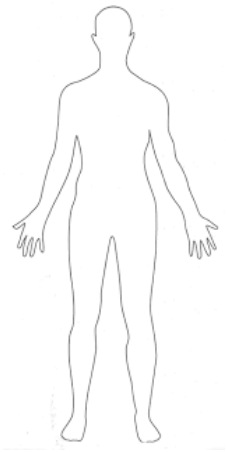
Yes No

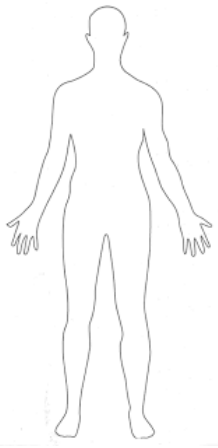
8. **If Yes, in what way did you change the weight**

I added …….. (please mark the number) pochettes

I took off …….. (please mark the number) pochettes

9. **Where do you prefer the weights of the blanket? (please indicate where)**



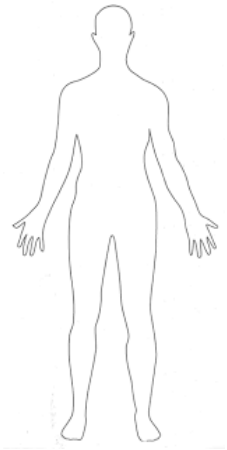


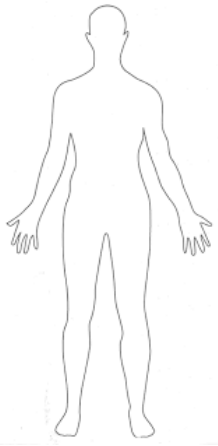
Front **Back**

10. **Was there a place you didn't like the weight of the blanket being felt?**

No Yes

11. **If yes, please indicate where:**





Front **Back**

12. **What do you think of the option that you can adjust the weight of your blanket?**

……

……

13. **What effect did the weighted blanket have on you?**

    a. Overwhelmed

    b. Restless

    c. Calming

    d. Neutral

    e. Other: ……..

14. **Did you put the hoodie on?**

    Yes No

15. **If Yes, what effect did it have on you?**

    ….....……..…..

    ....

Haptic Motor/vibrations

16. **What did you experience during the use of the vibration option on your wrist (please note for each option)**

1	**2**	**3**
a. Overwhelming	a. Overwhelming	a. Overwhelming
b. Annoying	b. Annoying	b. Annoying
c. Nervous	c. Nervous	c. Nervous
d. Calming	d. Calming	d. Calming

e. Pleasant f. Indifferent g. Other:……. h. Did not try this	e. Pleasant f. Indifferent g. Other:... h. Did not try this	e. Pleasant f. Indifferent g. Other:... h. Did not try this

17. **If you used the vibration mode, which <u>frequency</u> did you prefer?**

a. 1

b. 2

c. 3

d. All

e. None

f. Indifferent

g. I did not change the vibration frequency

18. **If you answered a,b,c or d in the previous question what effect did the preferred vibration have on you?**

……

19. **What do you think of the <u>intensity</u> (strength) of the vibration?**

a. Prefer lighter

b. Good

c. Prefer stronger

d. Other:…….

20. **Did you try the vibrations on other parts of the body (e.g., other parts of the arm, hand, neck, torso)**

Yes No

21. **If yes, where did you prefer the vibrations to be felt and why?**

……

……

Music

22. **Did you listen to music while using the wearable?**

Yes No

23. **If yes, what genre of music did you prefer to listen to?**

……

24. **Should the music be suggested or self-selected?**

Suggested Self-selected

25. **Did listening to music add to the experience of the wearable?**

Yes No

26. **If yes, in what way?**

……

……

……

Screen Color

27. **What screen color would you have preferred to be included as an option?**

……

LED lights

28. **Did you use the <u>LED lights</u>?**

Yes No

29. **If yes, which color did you prefer?**

Blue Green Purple None All

30. **How was it to attach the LEDs to the weighted blanket?**

a. Easy

b. Difficult

c. It fell off

d. Other: ……..

31. **Should the LED lights be improved?**

Yes No

32. **If yes, in what way (e.g., stronger colors, different colors, different placement)**

……..

……..

33. **Did the LED lights add to the experience of the wearable?**

Yes No

34. **If yes, in what way?**

……

……

……

General

35. **What was your favorite interaction with the project? (you can mark more than one option)**

a. The app

b. Wearing the weighted blanket

c. Feeling the vibrations on the wrist

d. Being able to listen to music

e. Using the LED lights

f. Experiencing multiple sensations at the same time

g. Other:

……..

..

36. **How easy was it to navigate <u>within</u> the app?**

a. Easy

b. Confusing

c. Difficult

d. Other: ……..

37. **Please explain your answer**

.……..

……..

……..

38. **Were you satisfied with the possibilities of personalization?**

Yes No

39. **Please explain your answer:**

……

……

……..

40. **Could you imagine yourself using this wearable at home?**

Yes No

41. **Please explain your answer:**

……

……

……..

42. **What is something you wish was designed differently?**

……

……

43**. Is there anything else you like to mention about this experience?**

……

……

……

……

After interaction

- **Are you interested in getting a copy of the Guide to supporting students in distress?**

Yes No

(If yes, the student investigator will provide a copy.)

This study has been reviewed and received ethics clearance through the Research Ethics Board at OCAD University [REB approval # 2023-11]. If you have any comments or concerns, please contact the Research Ethics Office through research@ocadu.ca.

Appendix D: 3D designs of Prototypes

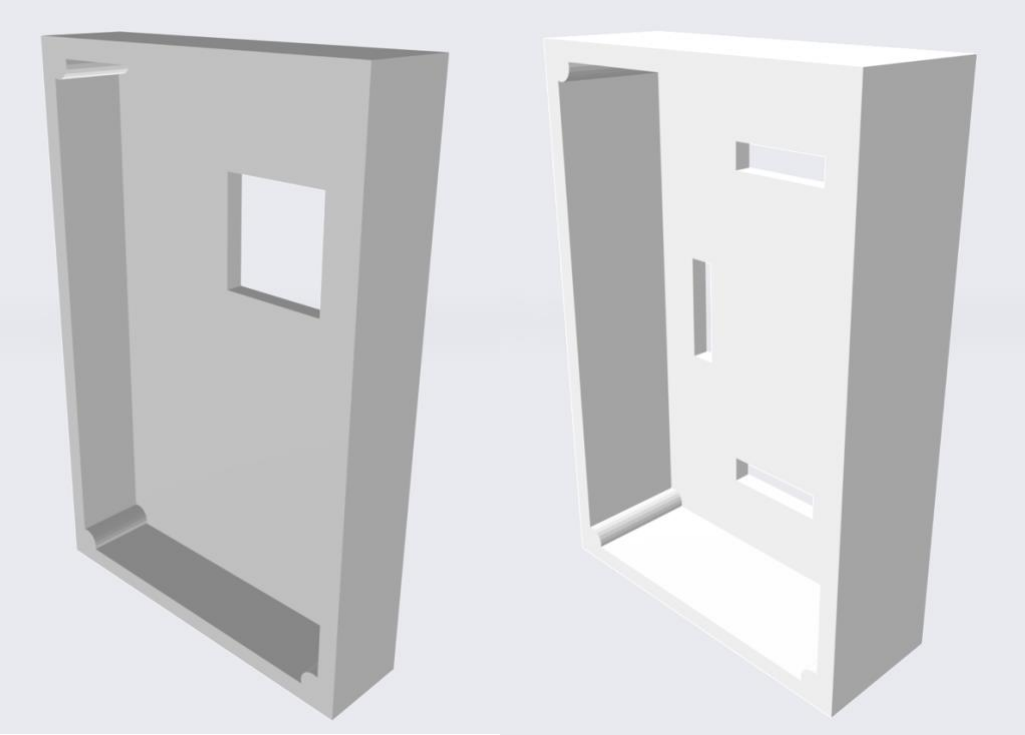


Figure 23 – 3D design of haptic device prototype 3 – (Merel Ververs-Spiegel)

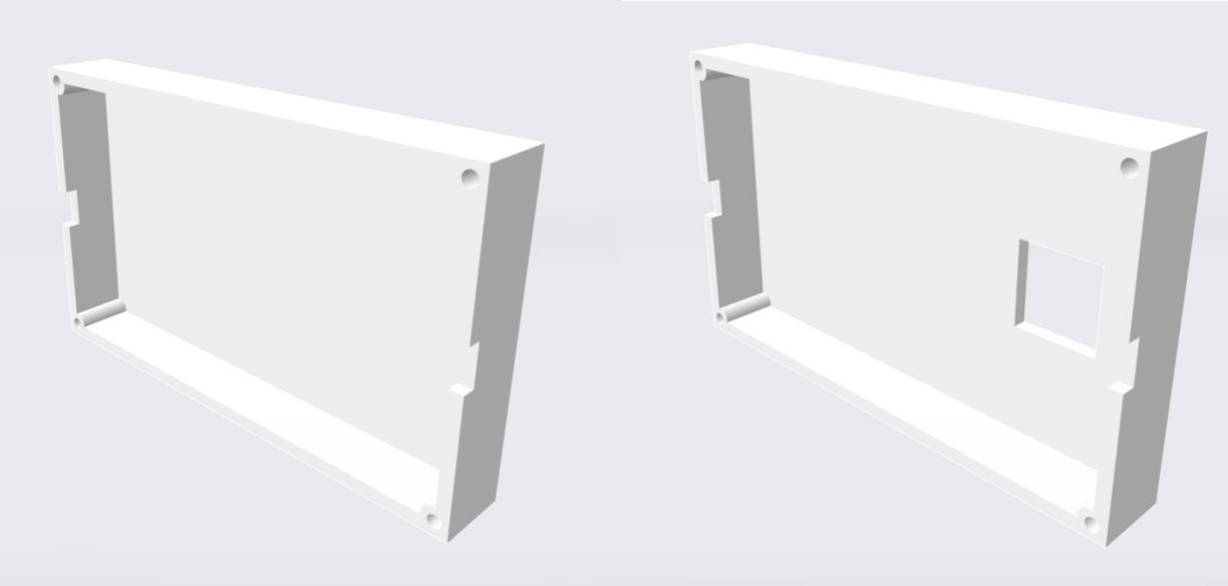


Figure 24 – 3D design of LED light box – (Merel Ververs-Spiegel)