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SCAARF
A Subtle Conditioning Approach
for Anxiety Relief Facilitation

MASTER DISSERTATION

Laís dos Santos Lopes
MASTER IN INTERACTIVE MEDIA DESIGN



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ORIENTATION
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Abstract

Anxiety disorders represent a significant public health problem, affecting more than 280 million people worldwide.

Although mobile and wearable interfaces have long been developed to improve mental health issues, most of the current approaches still operate in the so-called “reflective mind”. However, learning about self-regulation techniques and coping strategies for dealing with and learning about stress can be counterproductive when it comes to anxiety disorders, since reflecting on your own health data can enhance stress and anxiety symptoms.

This work introduces an alternative method to mitigating anxiety symptoms through the use of a smart wearable interface, SCAARF, which implements a subconscious, less invasive approach in the design of assistive technologies for mental health, that takes advantage of a multimodal intervention (haptic and auditory) to help users cope with anxious states.

Qualitative results suggest that the SCAARF mobile app is effective in helping users relax and cope with anxious states of mind, and that the scarf form-factor is perceived as comfortable, familiar (and thus non-intrusive). Moreover, user feedback shows the SCAARF wearable supports a calm state of mind, as it reminds users to relax.

Keywords

Mental Health, Anxiety Disorders, Subconscious, Assistive Technologies, Wearables, Embodied Interaction.

Resumo

Os transtornos de ansiedade representam um problema significativo de saúde pública, que afeta mais de 280 milhões de pessoas em todo o mundo. Apesar do crescente desenvolvimento de interfaces móveis e *wearables* que visam melhorar a saúde mental, a maioria das abordagens utilizadas actualmente focam-se na “mente reflexiva”. No entanto, a aprendizagem de técnicas de autorregulação e de estratégias de *coping* para lidar com o stress podem ser contraproduativas, especialmente em casos de transtornos de ansiedade, visto que refletir sobre dados relativos à própria saúde pode induzir ainda mais stress e ansiedade.

Nesta dissertação é apresentado um método alternativo para mitigar os sintomas de ansiedade, através do uso de um *wearable* inteligente, SCAARF, onde é implementada uma abordagem subconsciente e menos invasiva ao design de tecnologias assistivas para a saúde mental, e que utiliza uma intervenção multimodal (háptica e auditiva) para ajudar indivíduos a lidar com estados de ansiedade.

Resultados qualitativos sugerem que, com a aplicação móvel SCAARF, é possível induzir um estado de relaxamento nos utilizadores, o que os ajuda a superar os sintomas iniciais de ansiedade.

A escolha do formato (i.e., lenço, cachecol) é percebida pelos utilizadores como confortável e familiar (o que o torna não-intrusivo), e, segundo feedback recebido, incentiva um estado de tranquilidade, pois relembra os utilizadores a importância de parar e relaxar.

Palavras-Chave

Saúde Mental, Transtorno de Ansiedade, Subconsciente, Tecnologias Assistivas, Wearables, Interação Personificada.

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*To my grandmothers,
Idalina and Maria Olívia*

1 Introduction

1.1 Motivation

According to World Health Organization' estimates, by 2015, 264 million people were struggling with some form of anxiety disorder, 14% of which were European. A similar research, made by the Institute for Health Metrics and Evaluation¹, showed that, by 2017, this number was even higher, with an estimated 284 million individuals having experienced anxiety disorders. This 7,5% increase in only two years shows the critical pace at which mental health is deteriorating worldwide.

Meanwhile, mHealth is growing, with new technologies that allow people constant access to their health information, and several mobile applications being designed that claim to help people cope with stress, anxiety and panic attacks. However, not all of them do, in fact, contribute to healthier behaviors and mental states, as they require an overwhelming amount of attention demand and overloads people's senses (Adams *et al.*, 2015), which can cause additional stress and anxiety on people who suffer from mental health issues.

Although sensing and monitoring patients with anxiety using wearable devices can help assess, predict and even deliver interventions to promote a long-term reduction of stress, most current devices available for this purpose are still invasive and draw unnecessary attention to whoever is wearing them.

¹ healthdata.org

Moreover, delivering just-in-time interventions informed by wearable biosensing can also be counterproductive in the moment, as the realization that a panic episode will probably occur in the near future can further intensify anxiety symptoms and even trigger a panic attack sooner than expected.

In this dissertation a novel research direction for wearables as subtle haptic interfaces is presented, which aims to embody a sense of calmness. Such approach for an assistive technology for mental health aims to help people fight anxiety symptoms through the combined use of a mobile and wearable interface that do not require sensors and can be worn anytime, anywhere.

1.1.1 Research Questions and Methodology

This work aims to assess whether anxiety symptoms can be mitigated through technology embedded garments using a subtle approach. To do so, a qualitative research methodology was employed, in order to gain user feedback (which helped inform and refine the system's final design), using an iterative design approach.

As the focus of this research is in the mental health domain, it was also important that participants had already experienced some form of anxiety to ensure we gathered accurate data.

Since other types of anxiety disorders can be too specific, or associated with other conditions (e.g., depression and substance abuse), this dissertation focuses on mitigating anxiety symptoms in individuals who display higher levels of trait anxiety, since they usually perceive stressful situations to be more dangerous and threatening than they actually are, and are more likely to develop General Anxiety Disorder (GAD, which is the clinical presentation of trait anxiety).

To truly understand the benefits of using wearables in the mental health domain, some questions have emerged that helped us identify not only gaps in this design space, but also some possible future developments in the area, concerning anxiety disorders:

RQ1: What projects, in the last 10 years, have used wearable technology for monitoring, treating, or improving mental health? How many focuses on anxiety disorders specifically?

RQ2: Which of those projects use wearable technology or smart textiles, and how?

RQ3: How many of them focus on a subliminal/subconscious approach?

These initial questions also raised other issues, since most of the current approaches still operate in the so-called “reflective mind”, which can hamper results, since reflecting on your own health data can induce even more stress and anxiety.:

RQ4: Can System 1 (Kahneman, 2012) be enough to help fight anxiety symptoms?

RQ5: Can technology embedded garments be designed in such a way they are effective at subtly mitigating anxiety symptoms?

1.2 Contribution

Our results are preliminary, and based on qualitative analysis, observation and interviews performed throughout the various iterations of the wearable, from its initial concept to its current form. They suggest two main design implications:

- Subtle, non-intrusive approaches for mitigating anxiety symptoms are much harder to conceive than the approaches based on the reflective mind – to achieve solid results, the exposure period must be extensive (i.e. more than just a few weeks);
- Combining a classical conditioning approach (via a mobile app) with our smart scarf provides a solution that can be worn anytime anywhere to fight anxiety symptoms. The subtlety inherent to such solution reduces stigma and brings convenience to users. This haptic-based approach, through a scarf form factor, is less invasive and more portable than many other existing solutions², which is of extreme importance for anxiety and mental health cases, since symptoms can arise at any moment in time and at any place (public or private).

Nevertheless, this work also raises many privacy and ethical concerns which should be discussed by the HCI community: how can designers balance the opaqueness of subconscious approaches with the necessary ethical transparency? And how can mental health technologies be conceived in such a way they do not instigate societal stigma in users?

² Most of the current haptic-based wearables are developed to help improve general wellbeing, and focus primarily on haptics as a way of delivering information (See section 2.1.1).

1.3 Document Overview

The next chapter describes relevant background and related work that contributed to establish the direction of this dissertation. Section 2.1 discusses the importance of touch in the development of haptic interfaces for mental health, as well as existing research done in the field, and 2.2 characterizes anxiety disorders and its current treatment method. Section 2.3 expands on existing wearable interfaces developed for dealing with mental health problems, and why the design of subtle assistive technologies is important in anxiety disorder cases.

Chapter 3 presents the SCAARF system. Section 3.1 describes the iterative design approach of the wearable prototype, which provided valuable insights to the development of the final form-factor. Section 3.2 illustrates how the conditioning approach is used in this work and presents the final system implementation.

The evaluation of SCAARF is described in detail in Chapter 4, and the preliminary test results are presented, and limitations are discussed, in Section 4.1.

Finally, we draw some conclusions about our approach and outline future developments in the design of subtle wearable interfaces for mental health.

2 Background and Related Work

2.1 The Importance of Touch

It is strange that the tactile sense, which is so infinitely less precious to men than sight, becomes at critical moments our main, if not only, handle to reality.

Vladimir Nabokov

Touch is the paramount sense, and the first sensory system developed in animal species (Field, 2001). From an early age, touch is an important part of the development of immunological system in both animals and humans, and research suggests this type of stimulation help lower cortisol levels, which in turn can improve quality of life and mental health.

In 1958, Harlow and Zimmermann's work showed how the tactile sense can also impact affection, as their experiment made visible that infant monkeys – separated from their mothers after birth – were drawn to, spent more time with, and sought comfort in softer materials like cloths, opposed to cold, hard materials like wire, especially when exposed to threatening situations (Figure 1).



Figure 1. An infant rhesus monkey holds a terry cloth surrogate mother for security when exposed to a strange situation (Photos by Al Fenn from Harlow's experiment).

Such contact comfort is a crucial part of the monkey's brain development, specifically the development of affectional responses, which shares close similarity to the development of perception and emotion on human babies.

As the largest, most sensitive sense organ humans have, the skin, when touched, sends information to the brain, specifically the somatosensory cortex, that allow us to accurately perceive, process, and respond to information we interpret as texture, pressure, temperature, and vibration.

This haptic perception is what puts us in direct contact with our surroundings and can even shape our interpersonal relationships (Eid and Osman, 2016) and unconsciously influence our decision-making process (Ackerman, Nocera and Bargh, 2010).

The way we experience such sensations can impact not only how we perceive other people and our surroundings, but also affect the quality of our sleep, due to the distinct tactile properties of fabrics. A study done by Mori, Sugita and Kioka (2005) measured participant's biological reactions to two different types of fabrics, and found that pajamas with a blend of 70% cotton and 30% RAFUMA hemp were not only perceived as more comfortable (when compared to a 85% cotton and 15% nylon blend), but also had an impact on the alpha brain waves – associated with a relaxed state of mind and decrease in heart rate and blood pressure –, which makes technology embedded garments promising for the treatment of anxiety symptoms.

2.1.1 Existing Haptic Interfaces

Research has proven touch to be a powerful and universal means of communicating emotion (Hertenstein *et al.*, 2009; Wang and Quek, 2010). Yet, the majority of interfaces developed in this area still focus on haptics as

a channel to deliver information – in an unobtrusive manner – to a single or more users, or to mediate social interactions (van Erp and Toet, 2015).

Even though research has been done on how combining vibrotactile and vibroacoustic modalities can help improve individual's mental wellbeing, the majority of current systems still disregard the possibilities of using haptic interfaces in a more subtle, unconscious approach to help mitigate anxiety symptoms, capitalizing on the principles of embodied interaction (Dourish, 2001; Antle, 2009; Hartson and Pyla, 2012).

While studies have shown that haptic interfaces can improve mental health by simulating human touch (Bonanni *et al.*, 2006; Kelling, Pitaro and Rantala, 2016) and increasing awareness, thus helping user's regulate their emotions (Alonso, Keyson and Hummels, 2008; Miri *et al.*, 2017; Seol *et al.*, 2017), we argue that the intrinsic properties of fabrics offer an exciting promise in the development of new wearable interfaces that capitalize on haptics in a subconscious level.

Although there has been research done in HCI about textile-based displays, their main focus is still on the level of accuracy with which information can be delivered through different surface textures (Harrison and Hudson, 2009), and less on how users perceive and emotionally process such sensory inputs (Hernandez, 2018; Morrison, Manresa-Yee and Knoche, 2017), which can be instrumental in the development of new wearable assistive technologies for mental health, specifically in anxiety cases.

2.2 Anxiety Disorders

Man is not worried by real problems so much as by his imagined anxieties about real problems.

Epictetus

Anxiety disorders represent a significant public health issue and are one of the most prevalent mental health conditions, affecting an estimated 284 million individuals worldwide.

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), anxiety disorders are characterized by excessive fear and worry about otherwise non-threatening situations, and encompass a number of disorders that range from general anxiety disorder to agoraphobia.

Although these conditions are usually non-fatal, individuals who suffer from anxiety disorders can experience symptoms like shortness of breath, chest pain, muscle tension, fatigue, confusion, irritability and nausea, which can not only lead to debilitating feelings – such as fear of dying – but also increase the likelihood of situational avoidance and behavior change.

This happens because, according to Clark and Beck (2011), anxiety arises when an individual lacks the ability to accurately perceive and assess a dangerous situation, which lowers their judgement in their ability to cope with such event.

However, there is still a common misconception about the notion of anxiety and fear, which can further contribute to stigma around mental health conditions, since fear is a natural human response to dangerous situations. Thus, according to LeDoux's (2016) premise, the term fear should be used to describe an individual's response towards imminent danger, while anxiety should be used when the threat is anticipated, and the individual is apprehensive about a perceived danger.

Consequently, it is also necessary to make a distinction about two types of anxiety: state and trait.

2.2.1 State and Trait Anxiety

On one hand, state anxiety is a common reaction to a specific stressful situation (e.g. public speaking). Because it is temporary – as its symptoms disappear when the threat goes away –, it conforms to LeDoux’s definition of fear. On the other hand, trait anxiety typically emerges in response to threat anticipation, and is felt more intensely and during longer periods of time.

Individuals with trait anxiety usually perceive stressful situations to be more dangerous and threatening than they actually are, and are more likely to develop General Anxiety Disorder (GAD), which is the clinical presentation of trait anxiety.

Because other types of anxiety disorders can be too specific, or associated with other conditions (e.g., depression and substance abuse), this dissertation focuses on mitigating anxiety symptoms in individuals who display higher levels of trait anxiety.

2.2.2 The Anxious Brain

When faced with a threatening situation, the human brain processes and responds to primary reinforcers (e.g., taste and touch) and external stimuli, which increases blood pressure, heart rate and other physiological symptoms (Figure 2).

While visual and auditory stimuli first pass through and are filtered by the thalamus, olfactory and tactile stimuli are processed directly by the amygdala, which gives emotional significance to such signals and is responsible for eliciting anxious feelings (Rolls, 2015).

The difference between a healthy brain’s response to immediate danger and the anxious brain, when faced with a perceived potential threat, is that the

latter processes olfactory and tactile stimuli not by the amygdala, but by the bed nucleus of the stria terminalis (BNST), which increases negative emotional responses such as avoidance behaviors (LeDoux and Pine, 2016; Grupe and Nitschke, 2013).

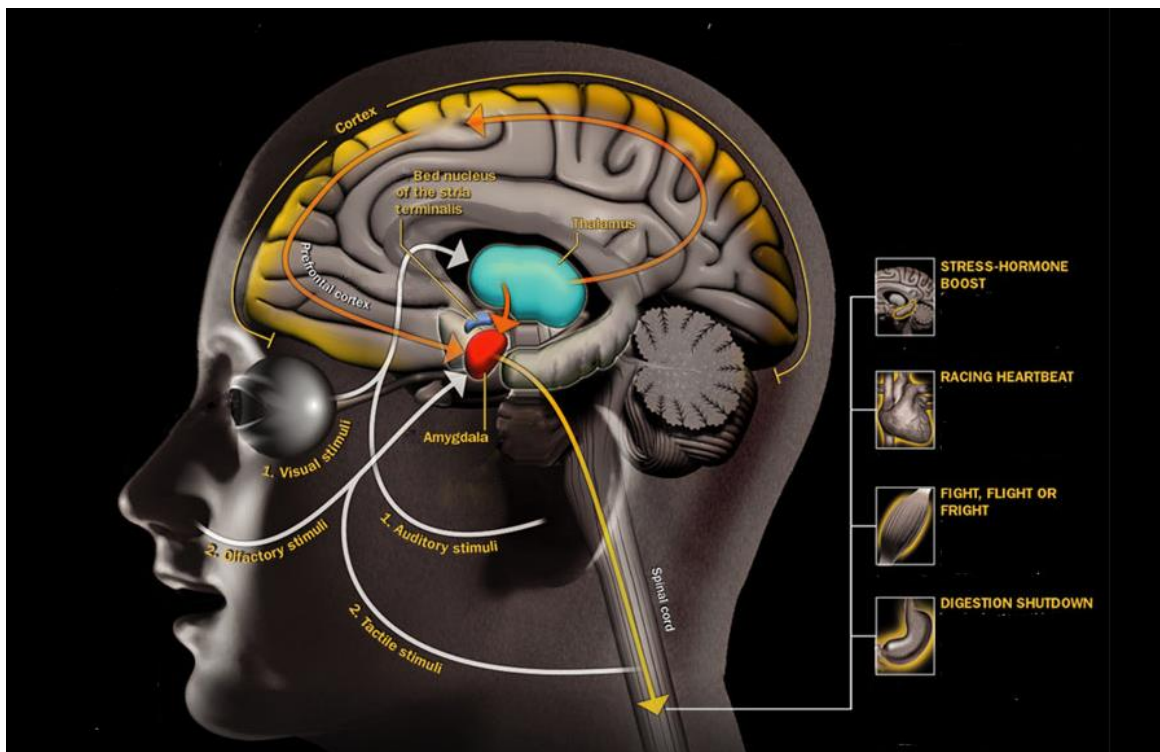


Figure 2. Simplified version of Joe Lertola's TIME Diagram (2002), of the anxious brain.

To address this problem, this dissertation exploits on the aforementioned unconscious processes to design a novel assistive technology that is based upon a conditioning approach and uses both auditory and tactile stimuli to help mitigate anxiety symptoms.

2.2.3 Current Treatments

Cognitive-behavioral therapy (CBT) and drug-based approaches have been the prevailing practices to help improve mental health, especially in anxiety disorders cases.

Although medication is intended to be used as a supplement or complement of psychotherapy, cases have been reported where patients abandon counseling after being prescribed drugs (i.e., antidepressants, GABA reuptake inhibitors, benzodiazepines, etc.), as they promote relaxation and aid in mood regulation. However, the long-term use of some medications can lead to dependence and even increase the risk of not only patients having a relapse, but also developing suicidal thoughts, thrombosis, diabetes, strokes, etc.

Since CBT, much like classical conditioning, is built on the notion that all behavior is learned – where patients are taught that the way they feel is directly connected to the way they think (Clark and Beck, 2011) – and seeing research has shown a person’s behavior also revolves around information they do not process consciously (Jaśkowski and Verleger, 2007), we aim to subtly help shift a person’s negative thoughts by replacing an existing negative conditioned stimulus with a positive one.

Even though it is not our purpose to replace any form of psychological or drug-based treatments, this divergence from the dominant reflective-based approaches is exciting in the mental health domain, as it can enable users to perform manageable tasks seemingly unrelated to their mental state.

Additionally, and in the same way placebos have been effective in helping individuals suffering from anxiety disorders (Sugarman *et al.*, 2014; Faria *et al.*, 2017), our expectation is that the SCAARF wearable can act as an empowering technology, that can eventually become ubiquitous, and help individuals cope with stressful situations in their day to day lives.

2.3 Wearable Technologies

Our bodies are our primary interface for the world. Interactive systems that live on the body can be intimate, upfront, and sometimes quite literally in your face. They sit close to your skin, inhabit your clothing, and sometimes even start to feel like part of you.

Kate Hartman

Wearable technology has been around for decades, but has seen an increasing development in the past 20 years. From Edward Thorp's roulette predicting shoe and Steve Mann's Digital Eye Glass, wearables have taken on new directions and form-factors. Today, wearables for healthcare, fitness and entertainment are at an all-time high, making it an industry valued at an estimated 27 billion USD by 2022, according to CCS Insight³.

However, most wearable technologies still operate in the so-called reflective mind (Kahneman, 2012; Adams *et al.*, 2015), which does not bring positive results to mental health conditions such as anxiety disorders, since reflecting on your own health data can enhance stress and anxiety symptoms. Although research has been done on the importance of effortlessly (i.e., below the threshold of conscious perception) inducing calming states (Amores and Maes, 2017; Ghandeharioun and Picard, 2017), their primary focus is to reduce day-to-day stress, and not help mitigate anxious states of individuals who suffer from anxiety disorders.

2.3.1 Wearable Interfaces for Mental Health

When talking about mental health, the form-factor plays an important role in the success or failure of wearable devices. Several wearable interfaces have been developed that capitalize on the unobtrusiveness, familiarity, and

³ ccsinsight.com

social acceptance of designing garments embedded with technology (Bonanni *et al.*, 2006; Radziewsky, Krüger and Löchtefeld, 2015; Williams *et al.*, 2015).

Lightwear, for example, takes advantage of this approach and presents a garment-based alternative to light boxes, the predominant yet outdated method of treatment for Seasonal Affective Disorder (SAD), which no longer constrains users to a sitting position nor requires them to learn new skills in order to operate and interact with such objects (Profita, Roseway and Czerwinski, 2015).

SWARM is another example of how everyday items can be embedded with technology and the importance of such an approach in the design of assistive technology, as people with disabilities already experience a fair share of stigma and discrimination in their everyday lives (Williams *et al.*, 2015).



Figure 3. Left to right: Fiona Carswell's The Smoking Jacket, Lee's Hatching Scarf (2013), Bacci's Veasyble, and Teresa Almeida's Space Dress.

Although other wearables (Figure 3) aim to help users cope with stressful situations, they take on a less subtle approach and act almost as a social statement, instead of blending in, which – in the mental health domain – can draw unwanted attention to individuals who already feel self-conscious.

2.3.2 Literature Review

To complement the initial research, a systematic literature review was performed (N=1108), that allowed to identify gaps in the existing scientific wearable approaches in mental health domain and to better understand future new developments in this research area, concerning anxiety disorders, specifically.

Search process

The following scientific repositories and databases were searched for conference papers and journal papers published during the last 10 years: ACM Digital Library (The ACM Guide to Computing Literature) and IEEE Xplore. This was done by combining the following search terms: (wearable OR wearables) AND (mental health OR mental wellbeing OR mental disorder).

The output of records were then examined by reading the title of the article as well as the author's keywords. When it was unclear if the record matched the inclusion criteria, the abstract was also read. The search process and subsequent examination lasted from 18th of March to 5th of May (2019).

Inclusion criteria

Records needed to be absolutely related to the development of wearable systems focused on the assessment, intervention or treatment of mental health conditions. To obtain a more manageable sample, only records from the past 10 years were considered eligible (2009–2019).

Studies found

From 1108 reviewed papers, 241 duplicates were removed, and 73 were found that used wearables to either monitor, treat or improve mental health (Figure 4). From the 73 identified, only 9 were focused specifically on assessing and delivering interventions for individuals who suffer from

anxiety disorders. Among those, three are aimed at helping individuals with Panic Disorder (Cruz *et al.*, 2015; Sapounaki *et al.*, 2017; Lee, Lee and Cho, 2018), one with Generalized Anxiety Disorder (Costarides *et al.*, 2017), and one with Social Anxiety Disorder (Miranda, Calderón and Favela, 2014), while the remainder focus on the assessment and intervention of anxiety disorders as a whole (Simm *et al.*, 2016; Gu *et al.*, 2017; McGinnis *et al.*, 2017; Antle *et al.*, 2019).

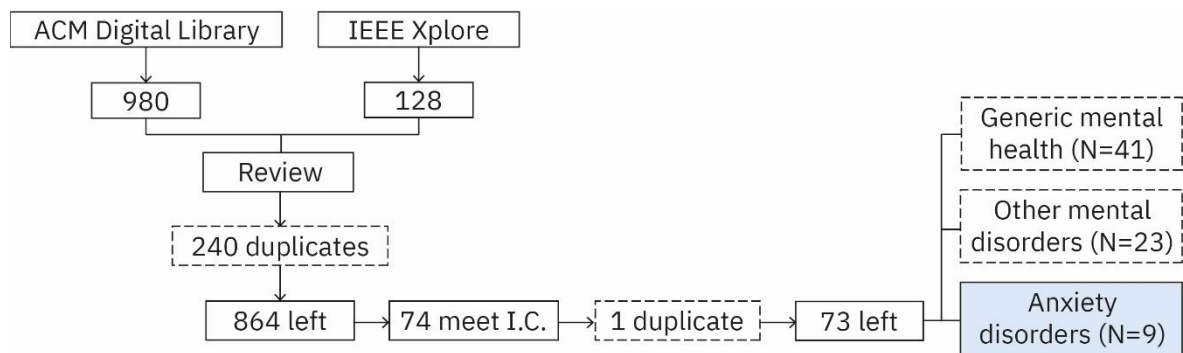


Figure 4. A descriptive flowchart of the search process.

Results

While work has been done that uses a combination of mobile applications and wearable devices to deliver interventions based on cognitive behavioral therapy principles, there is still a lack of truly non-intrusive, wearable assistive technologies being used to help treat anxiety disorders.

Moonglow, for example, uses cognitive behavioral therapy principles to mitigate panic-related symptoms. It does so by sensing physiological changes through a wrist-worn device and actively asking users to select an emotion when their heart rate increases. If the feeling reported is sad, the mobile app asks users to do a breathing exercise as an intervention, and to write a digital diary entry about how they are feeling (Lee, Lee and Cho, 2018).

Although such approach is effective in improving an individual's thought patterns, the way it is implemented falls at risk of increasing anxious states, since the wearable also warns them about physiological changes. This is also what happens with PanicPal, where a Zephyr⁴ BioPatch™ wearable chest-worn device gathers data to predict panic episodes up to one hour before they occur. By doing so, they aim to provide users with a respiration-based intervention, which is delivered as a notification in a graphical user interface to individuals who exhibit panic-related symptoms.

According to Cruz *et al.* (2015), this enables users to better manage and act on escalating stress-inducing symptoms. However, while the development of wearables that are able to successfully predict a panic attack (Sapounaki *et al.*, 2017) can be considered a breakthrough, not being able to intervene at the right time and with the right tools can make this prognostic ineffective.

Although delivering this call to action just-in-time can promote a long-term reduction of stress, it can also be counterproductive in the moment, as the realization that a panic episode will probably occur in the near future can further intensify anxiety symptoms and even trigger a panic attack sooner than expected.

Simm *et al.*, on the other hand, developed a fully customizable wearable assistive technology to help individuals with autism self-manage their anxiety. This is of great importance, since the way every person experiences anxiety is unique, and why their work followed a participative design approach.

Even though their bracelets use haptic distractions to promote more meaningful tactile interactions, they still require individuals to actively trigger the system and reflect upon their health information. Again,

⁴ zephyranywhere.com

notwithstanding the validity of such approach for the long-term reduction of stress (as it can help users break negative thought patterns), our research interest lies in achieving the same goal below the threshold of conscious perception.

Nevertheless, capitalizing on haptics and the tactile properties of wearable devices seem a more interesting direction for helping mitigate anxiety symptoms when compared to the existing approaches, that require the use of sometimes uncomfortable devices (e.g., EEG headsets, chest-worn devices) to simply monitor psychophysical signals of individuals who may already feel self-conscious about their condition.

Although the work of Miranda, Calderón and Favela (2014) shows it is possible to detect anxiety using wearable devices, they use Google Glasses and a Zephyr HxM Bluetooth Band to monitor the heart and spontaneous blink rates of individuals who suffer from social anxiety disorder, which not only can draw additional unwanted attention to users, but also fall at risk of increasing feelings of awkwardness and negative self-talk.

McGinnis *et al.* (2017) have also tested a new way of predicting anxiety, where a belt-worn inertial measurement unit monitors children's response to threatening situations and is capable of predicting the development of anxiety in the future. Even though their approach is less intrusive, it still focuses on collecting data and monitoring individuals, and overlooks the potential of wearables as assistive technologies for helping mitigate anxiety symptoms.

The same is what happens with the work of Gu *et al.* (2017), where the innovation is found on the system development, which calculates and analyzes behavioral signals to assess anxious states.

Finally, the alternative found to prevent anxiety (Costarides *et al.*, 2017) and help individual's self-regulate their emotions (Antle *et al.*, 2019) relies on a gamified approach, and uses wearables mainly for sensing purposes to collect physiological data (e.g., heart rate variability, galvanic skin response).

The results of this literature review show that most wearable devices, developed to assess and help treat anxiety disorders, are either intrusive, as they require individuals to use uncomfortable devices such as head-mounted displays and chest-worn devices (Miranda, Calderón and Favela, 2014; Cruz *et al.*, 2015; Antle *et al.*, 2019), or, when this is not the case, are still used mainly for sensing and monitoring purposes (Simm *et al.*, 2016; Costarides *et al.*, 2017; Gu *et al.*, 2017; McGinnis *et al.*, 2017).

Moreover, the majority of those wearables need mobile applications, which are used mainly to merely record data and deliver interventions through a graphical user interface that help users deal with stress and self-manage their anxiety.

With the development of smart textiles that allow for ever smaller actuators, it would be expected that there would already be wearable interfaces operating at the subconscious level, capable of improving mental well-being without the need for constant self-monitoring or overloading users with access to unnecessary health-related information. This is where our work comes in.

3 SCAARF: A Subtle Conditioning Approach for Anxiety Relief Facilitation

3.1 Design Process and Design Alternatives

Technology is seductive when what it offers meets our human vulnerabilities.

Sherry Turkle

As previously stated, the development of new interfaces to improve mental health is of extreme importance.

Since wearable technology, specifically smart textiles, are effective at conveying information in an unobtrusive way (Jacobs and Worbin, 2005; Harrison and Hudson, 2009), this work explored different techniques to design smart garments that capitalized on a subliminal approach to help mitigate anxiety symptoms.

Even though the wearable part of this system could be implemented using a variety of form-factors, a smart scarf not only enabled us to develop the prototype within the timeframe of this dissertation, but also made the evaluation of the system simpler, as it did not require people to change their routines or interfered with their personal style in order to test the wearable.

3.1.1 First Iteration

As already shown by the Textile and Fashion industries, textile properties can evoke feelings of luxury and elicit the idea of durability (Solomon *et al.*, 2006), suggesting that it is possible to use visual cues associated to the sense of touch to appeal to people's emotion on a visceral level (Norman, 2004; Hernandez, 2018).

Also, tactile displays and dynamic textile patterns are proven to trigger positive emotional responses, which help individuals suffering from anxiety disorders and other mental health issues regulate their emotions (Stylios and Chen, 2016), while requiring individuals a lesser attention demand than that of visual or auditory stimuli (King and Janiszewski, 2011).

Following a mHealth and psycho-physical wellbeing workshop, where a preliminary work was presented on this topic (Lopes and Campos, 2018), and to gain a better understanding of how smart dynamic textiles could be incorporated into people's routines, 5 participants (4 females and 1 male, with a mean age of 24.8, SD=2.6), who had already experienced anxiety symptoms, were asked to photograph things that made them feel calm and relaxed in their day to day life during a 4 day period (Figure 5).

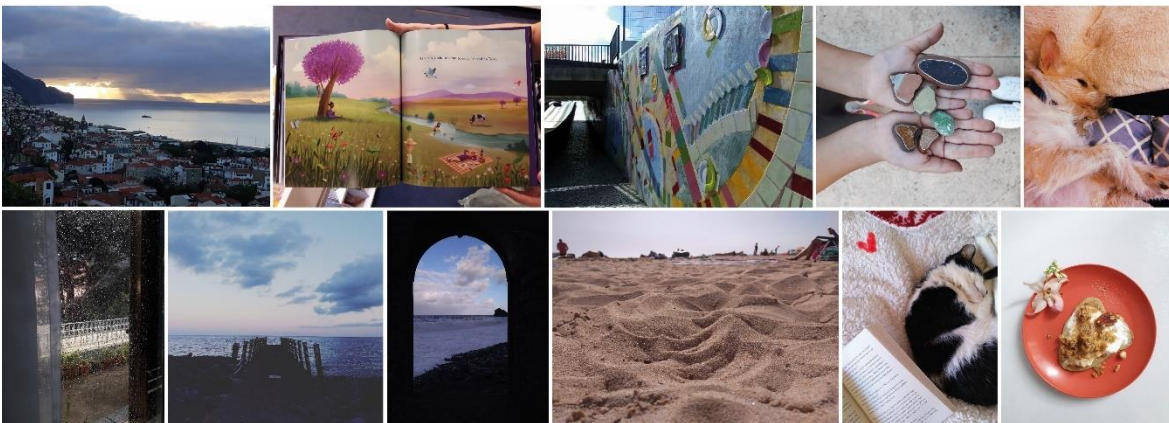


Figure 5. A sample of the photographs taken by participants.

From this, along with the follow up semi-structured interviews, emerged some useful patterns which, in line with the literature, informed the design of the wearable prototype going forward.

Colors

When asked to describe why the images represented a relaxed state of mind, participants often acknowledged the colors had a calming effect. P1, for example, said “this image is so calming (...) I don't know if it's the purple,

that purple there (...) gives me this instant serenity” and P2 talked about “the pastel colors of the photo” that “convey this sense of calm”.

Although none of the participants mentioned blue specifically, it becomes clear when looking at the photos, that it is a recurring color that individuals associate with “being near the sea, listening to the sound of the waves” (P2) and the “morning, before the day gets hectic” (P3).

With this in mind, the first iteration of the prototype (Figure 6) expanded on the work done by Stylios and Chen (2016), where highly personalized smart fabrics have been shown to have calming effects on people, through the display of weaker, repeating patterns.

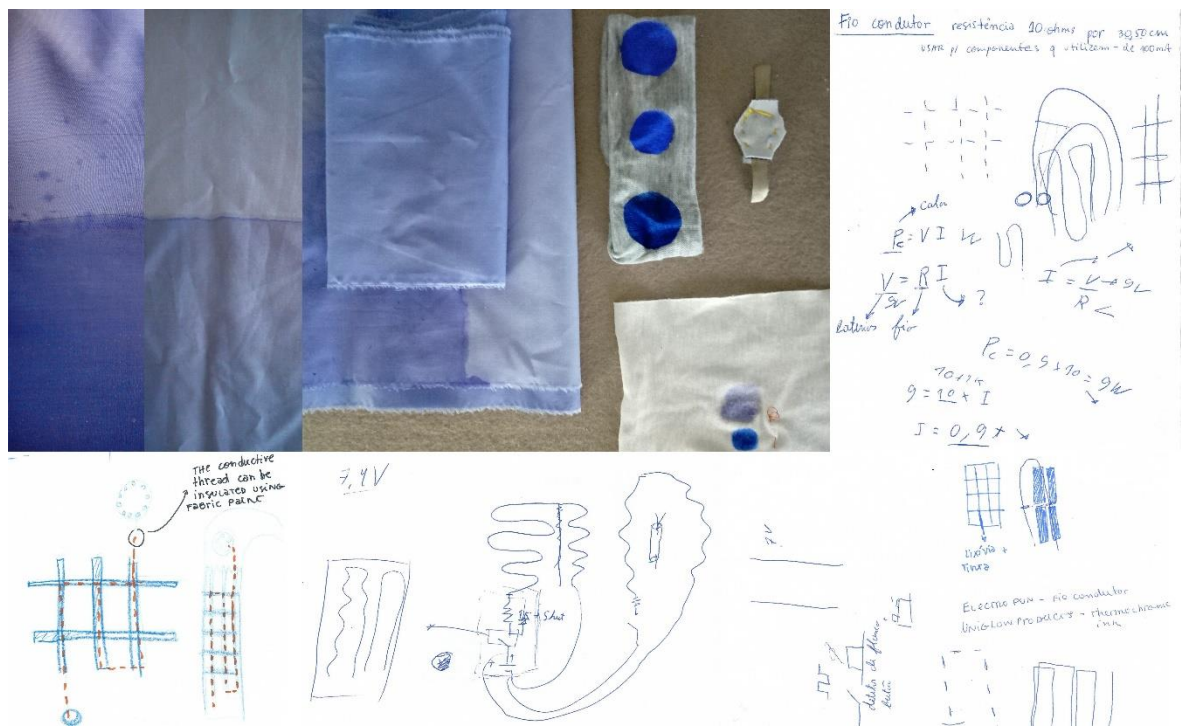


Figure 6. Development of the first wearable prototype.

To do so, we used thermochromic ink⁵, a 3.7v Li-Po battery, a piece of woven conductive fabric and conductive thread from Adafruit. The soft sandwich

⁵ Thermochromic pigments change color in response to temperature fluctuations. The thermochromic ink used for this project is sapphire blue at room temperature and becomes transparent at 31°C.

switch, when pressed, heats the conductive thread that activates the thermochromic ink, revealing a pattern in the fabric.

Although this approach can be customizable and a discreet way of delivering information to a specific user, making it of great value in the mental health domain (especially in cases where individuals may fear being the focus of attention), it was unfeasible to evaluate it in the scope of this dissertation, as it would simply take too much time to properly conclude anything solid. Nevertheless, it is still part of our future work, post-MSc.

3.1.2 Second Iteration

At the same time, seeing that the use of textures and sound had also emerged during interviews, and to test which approach would work on a more subliminal level, a second version of the scarf was developed, that capitalized on the tactile properties of fabrics.

According to Hernandez, tactile stimuli can make users more engaged with technology, which translates to a more meaningful interactive experience.

To take advantage of that, and inspired by the works of Loy (2015), Du *et al.* (2018) and Hernandez (2018), we tested how different fabrics reacted to heat (see Appendix A) in order to create a scarf that resembled bubble wrap (Figure 7).

The idea was to conduct an A/B test to compare both version of the prototype. To do so, the second iteration of the scarf was developed alongside a mobile application (see section 3.2.2), that would prime users to associate an audio clip with a relaxed state of mind.

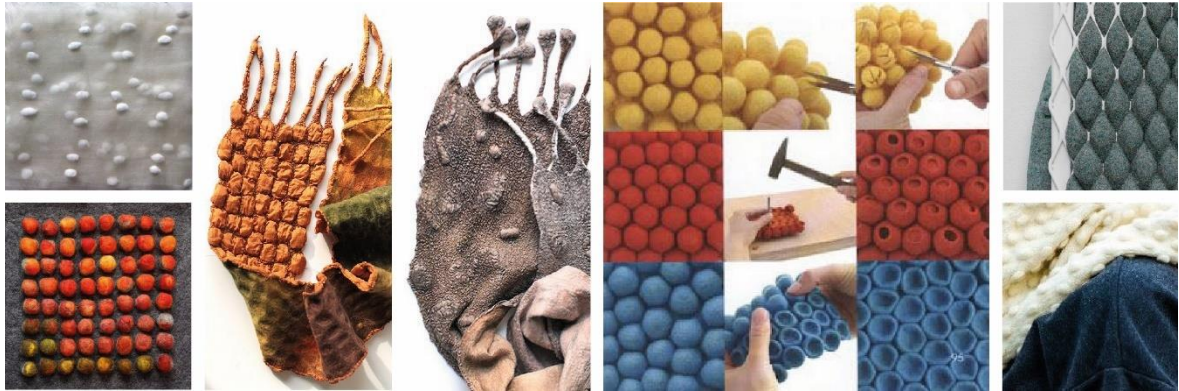


Figure 7. Moodboard for the second iteration of the scarf.

The scarf was designed with a series of sandwich switches (Figure 8), that – when pressed – closed the circuit, and played the same audio clip as the mobile app.

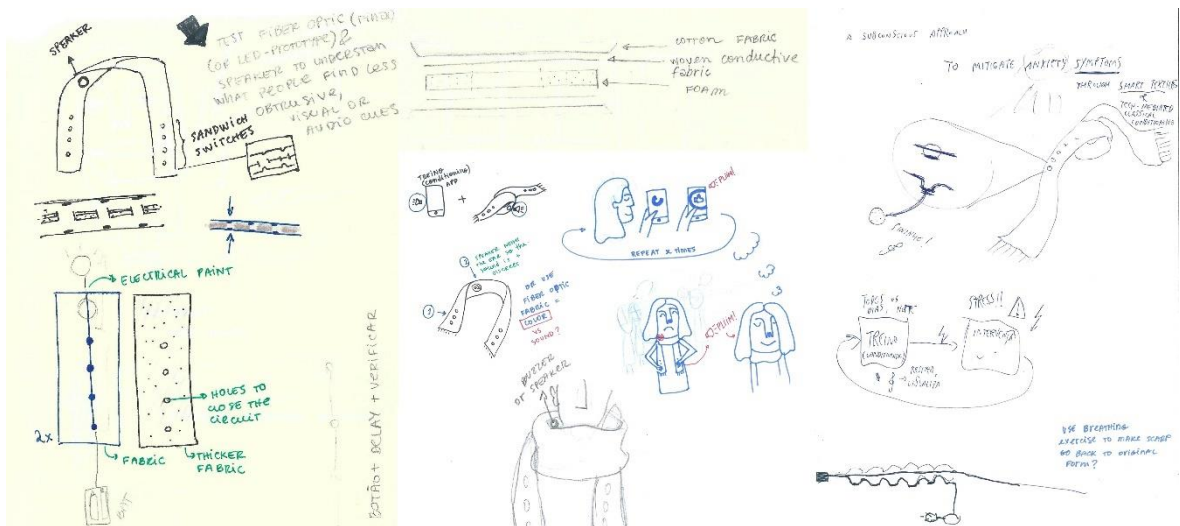


Figure 8. Development of the second iteration of the wearable prototype.

Since the creation process of the scarf was too time consuming, and would require a great level of programming skills, a different form-factor was chosen to test this conditioning approach.

3.1.3 Third Iteration

On that account, a third version of the smart scarf was developed using conductive ink and a touch board by Bare Conductive.

The decision to use Bare Conductive's⁶ touch board (Figure 9) instead of LilyPad Arduino or Adafruit's FLORA ensured the development of the wearable prototype was feasible within the time frame of this dissertation, since it required less programming.

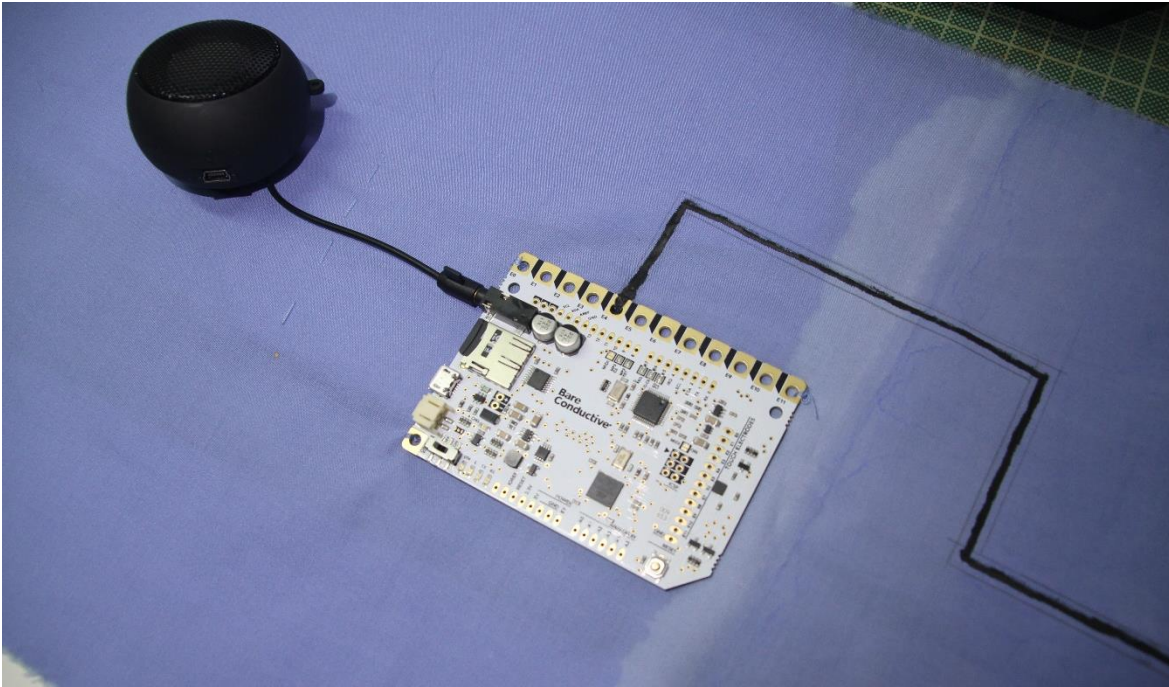


Figure 9. Development of the third iteration of the wearable prototype, with Bare Conductive's touch board, portable speaker and conductive ink.

The touch board starter kit came with a mini portable speaker (5x3,5 cm), which was placed to rest upon the shoulder when users wore the scarf (Figure 10). This ensured the weight of the speaker would not pull down the fabric and, because of its proximity to the ear, that the volume of the audio clip could be lower, so not to draw other people's attention to the individual using the scarf.

⁶ bareconductive.com



Figure 10. Third iteration of the wearable prototype.

The paired combination of a conditioning phase, via a mobile app – where users are primed to associate an audio clip with a relaxed state of mind – and an intervention phase, delivered by the wearable, goes against the dominant narrative of reflective-based approaches, and uses positive reinforcement to subtly mitigate anxiety symptoms.

Limitations

Although this version of the scarf was functional and considered a novel approach to the design of wearable assistive technologies by both the HCI community (Lopes and Campos, 2019) and psychologists (during informal interviews), which supports our hypothesis as a promising direction for the development of assistive technologies for mental health, some improvements were still needed to take full advantage of the tactile properties of such form-factor.

The stiffness of the fabric chosen for this iteration diminished the feeling of comfort the scarf should provide, and the size of the mini speaker made it very noticeable and too heavy to be easily placed in the scarf. Not only that, but the ink lost its conductivity after usage (especially if the prototype was folded), which would be a drawback during evaluation.

Taking that into account, a fourth and final version of the smart scarf was developed, explained in detail in the next section.

3.2 Final System

Being aware of your breath forces you into the present moment - the key to all inner transformation. Whenever you are conscious of the breath, you are absolutely present. You may also notice that you cannot think and be aware of your breathing. Conscious breathing stops your mind.

Eckhart Tolle

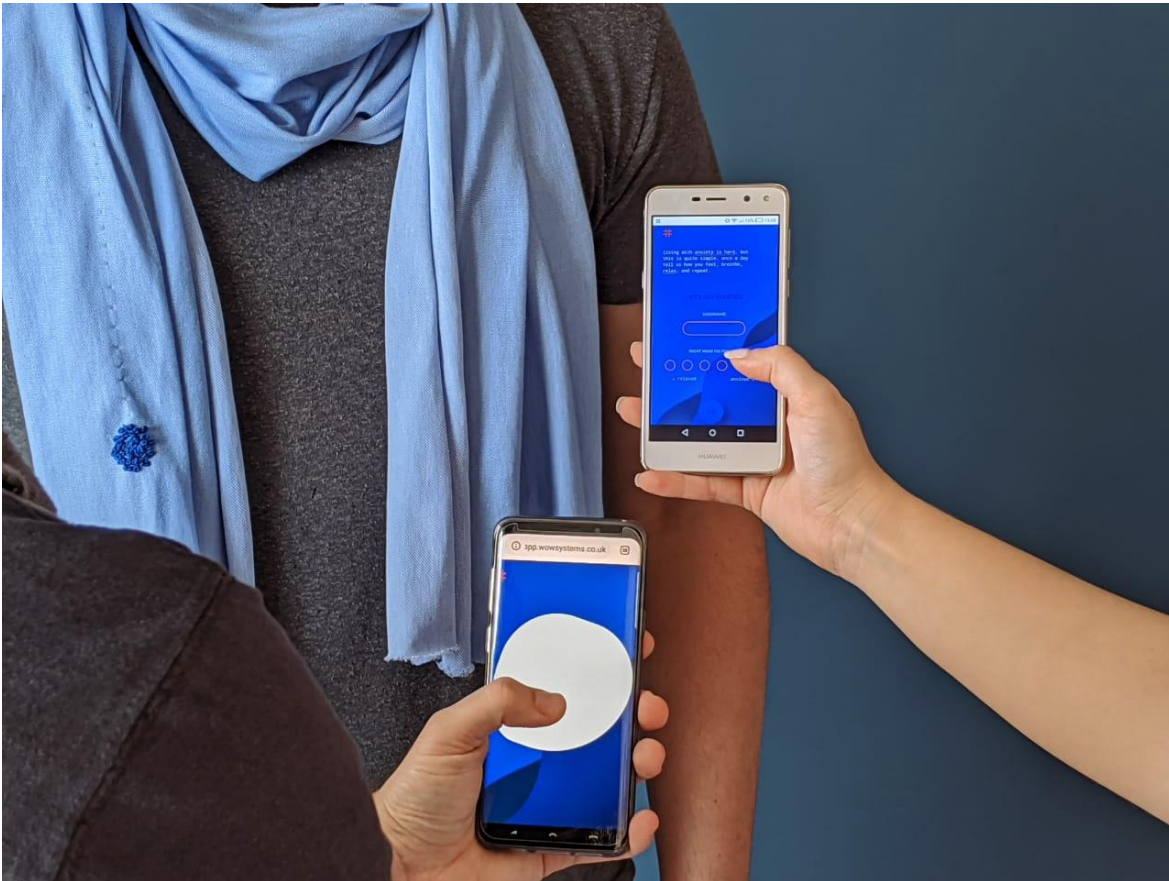


Figure 11. Final version of SCAARF's mobile and wearable prototypes.

3.2.1 How it Works

Since both CBT and classical conditioning are built on the notion that all behavior is learned, we exploit this concept by replacing a pre-existent negative conditioned stimulus (that can, for example, lead to avoidance behaviors) with a positive one, in the form of an audio clip.

With this priming, multimodal approach we aim to subtly induce positive behavior change in individuals who suffer from anxiety by conditioning them to associate the wearable prototype with a relaxed state of mind, as a result of previous exposure to the mobile breathing exercise.

Before conditioning (Figure 12), any breathing exercise – in this case delivered by the mobile application – will naturally elicit a positive, relaxed state in users, while the audio clip (which is, at this stage, a neutral stimulus) should elicit no response whatsoever.

However, by combining both stimuli during a conditioning phase, the audio clip should later (during the wearable intervention phase) be perceived as relaxing, since the user's response is now conditioned, due to the previous exposure to the mobile deep-breathing exercise.

Although it is not our purpose to replace psychological or drug-based treatments, our approach focuses on discovering new, more effective digital interventions for anxiety disorders, based on the subconscious processes of the human mind.

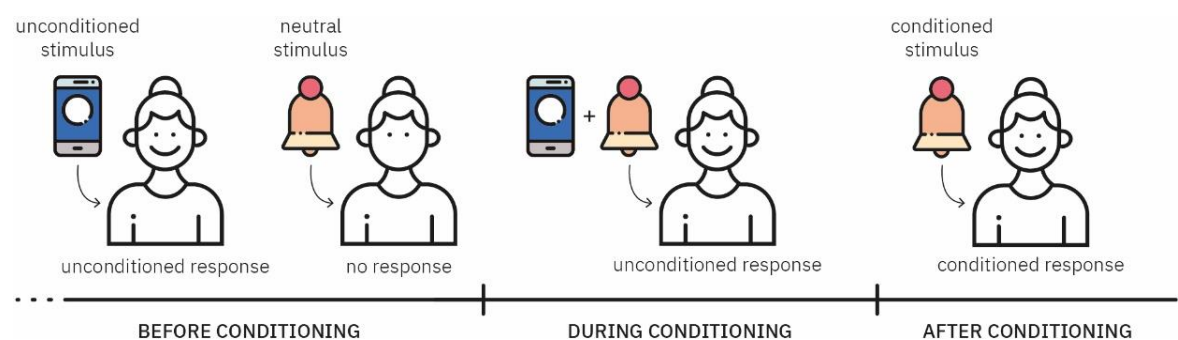


Figure 12. The SCAARF system before, during and after conditioning. It works by priming users to associate a previously neutral stimulus with a positive, unconditioned one.

The concept that technology can work below the threshold of conscious perception is not new (Weiser, 1999), and Polanyi's (1966) notion of tacit knowledge supports our approach that it is possible to establish a

meaningful relation between two distinct interfaces that result in an implicit behavioral response.

Thus, the two separate interfaces (the mobile app and the wearable) share the same affordances and, when combined, help individuals cope with stressful situations by using a subconscious, less-invasive approach, where the physical manipulation of a wearable device is unconsciously associated with a relaxed state of mind as a result of the a previous conditioning phase.

This is particularly attractive for mental health issues, as the reflective mind – as defined by Kahneman (2012) – does not bring solid results for anxiety, since reflecting on your own anxiety data can induce even more stress.

3.2.2 The Wearable



Figure 13. Different people using the SCAARF wearable prototype.

The final version of the smart wearable prototype was developed using Adafruit’s stainless medium conductive thread (coated with embroidery thread) and a touch board by Bare Conductive. The board is connected to a 3.7V Li-Po battery and has a headphone socket, which allows the audio clip to be triggered in the scarf when the user touches its fabric (i.e., where the conductive thread is sewn) in a repetitive way (Figure 14).

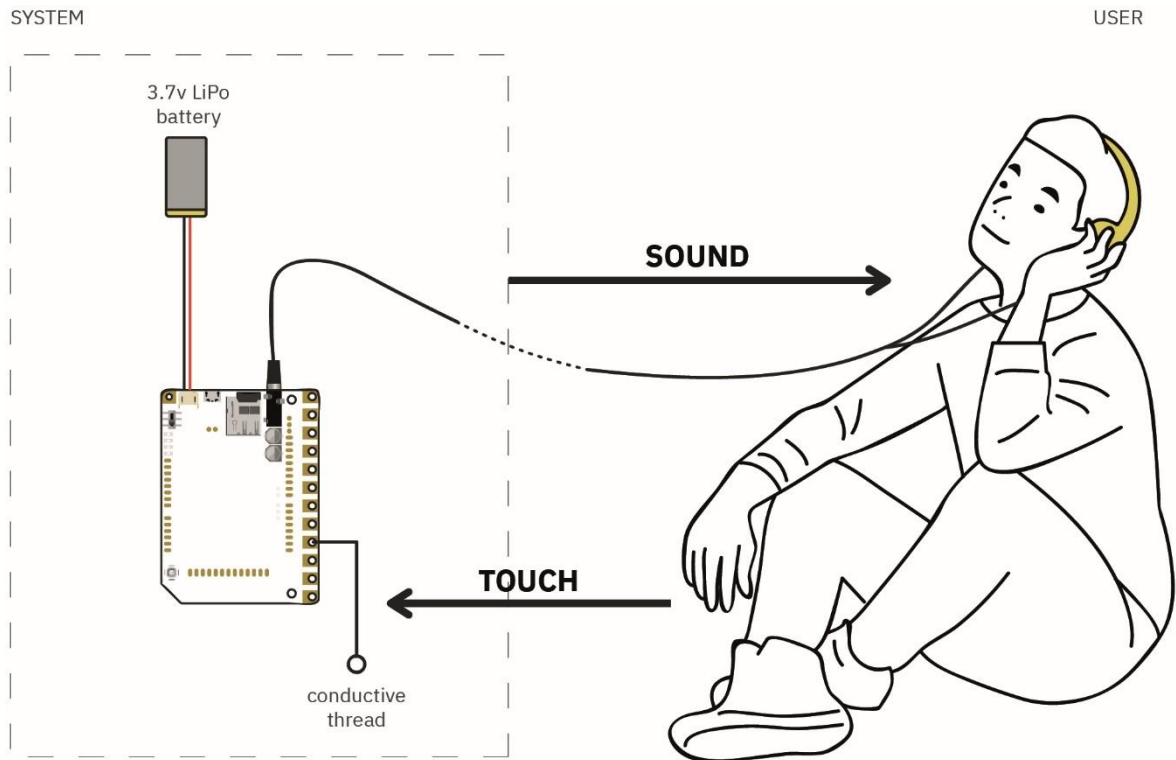


Figure 14. System architecture.

The use of headphones as an alternative to the mini speaker not only solved the weight issue, but also made the intervention more private, since now only the user can hear the positive audio reinforcement.

The replacement of the previous fabric with a softer, more flexible one, and the use of embroidered conductive thread (Figure 15), as opposed to the conductive ink, also ensured a more meaningful tactile interaction with the wearable prototype.

As smart textile technologies evolve further, one can expect smaller and softer actuators to become mainstream, allowing the SCAARF wearable to become even less intrusive.

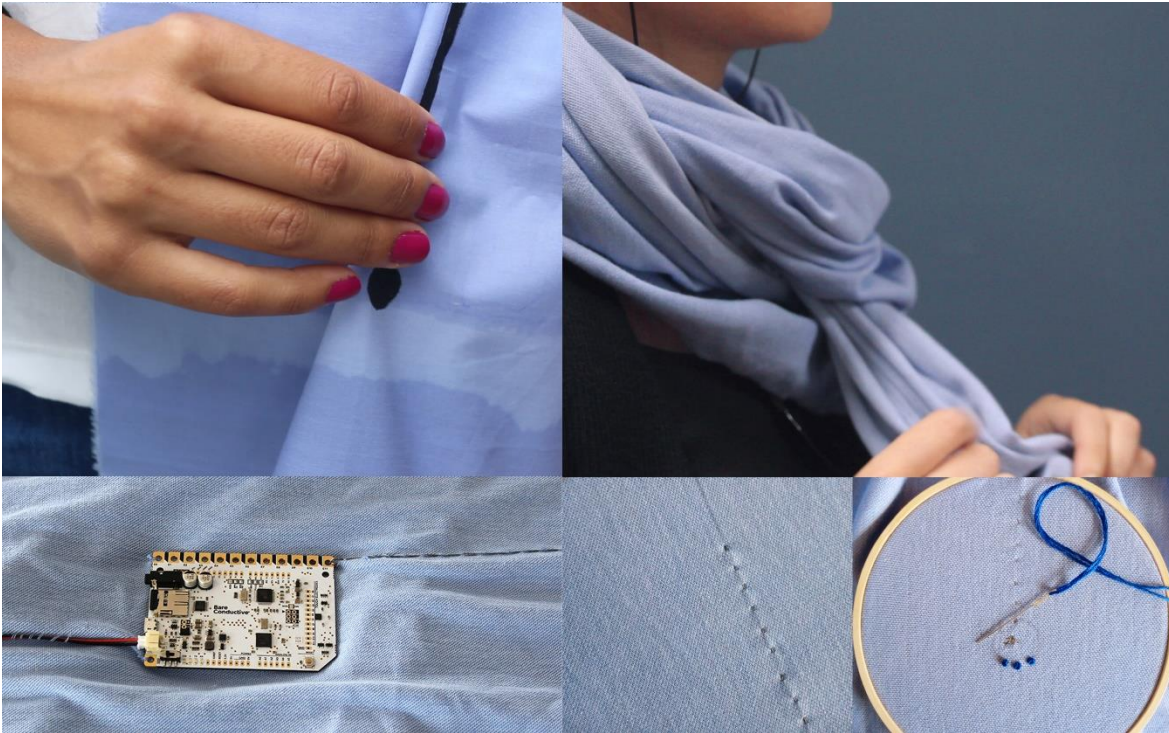


Figure 15. Differences between the second (top left) and last versions of the wearable prototype.

3.2.3 Mobile App

To test the feasibility of our research hypothesis, a mobile application was developed to provide a deep-breathing exercise, used to prime users during the conditioning phase of the experiment.

The SCAARF mobile application (Figure 16) was designed as a responsive website, for testing purposes, so it would be able to run on the two main operating systems currently available for smartphones (iOS and Android, see Appendix B). This helped ensure users could test the platform without restrictions.



Figure 16. SCAARF's mobile app screens.

The SCAARF app aims to replace a negative conditioned stimulus with a positive one, in the form of an audio clip. The same clip, played at the end of a 50-second deep breathing exercise, is then triggered in a smart scarf when the user touches its fabric in a repetitive way, i.e. when anxiety symptoms occur.

A breathing exercise was selected to prime users, since it is currently one of the conventional methods for dealing with anxiety available at Google Play and the App Store. For 50 seconds, users sync their breathing with the circle animation, which oscillates to mimic an inhale (4 seconds) and exhale (6 seconds) movement.

The effectiveness of such approach has also been the focus of extensive research, that shows breathing can positively influence individual's affective states (Brown and Gerbarg, 2005; Philippot, Chapelle and Blairy, 2010; Ghandeharioun and Picard, 2017), and even improve cardiovascular health (Mourya *et al.*, 2009; Ankad *et al.*, 2011).

The app is also used to record participant's mental states in a SQL database (Appendix C), during the conditioning phase, in which users are assigned a personal identification code and surveyed about their mental well-being,

prior to the breathing exercise and after being exposed to the positive audio reinforcement signal (Figure 17).

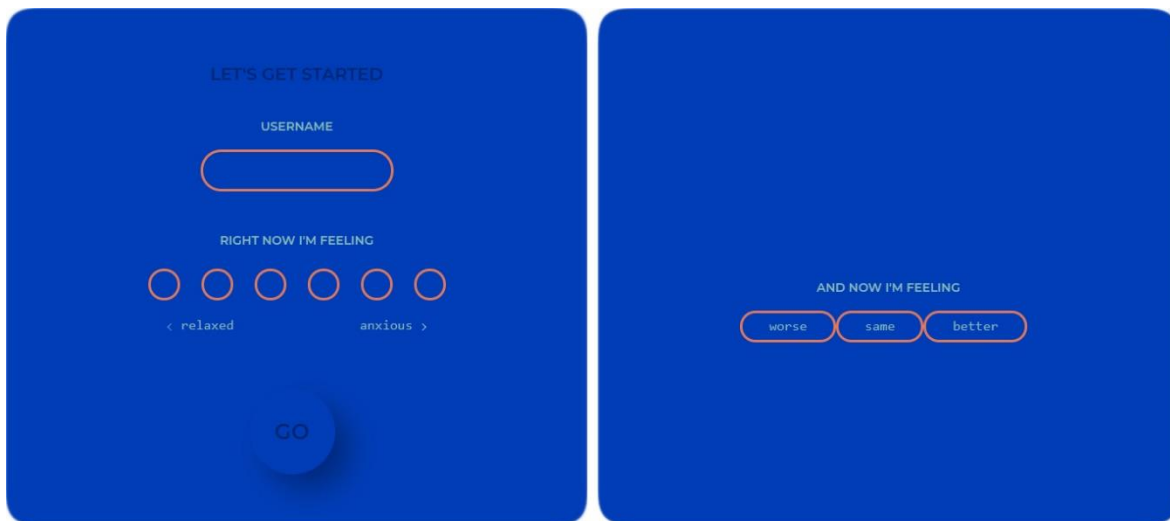


Figure 17. Detail of the app's landing page (left) and last screen (right).

A six-point Likert scale was selected to help prevent users from choosing a neutral response while selecting how they feel at the moment, where 1 represents a relaxed state of mind and 6 an extremely anxious state.

At the end of the breathing exercise, and in order to access the effectiveness of our approach and consequent feasibility of the wearable prototype, users are asked if they feel worse, the same, or better than before.

This divergence from the dominant reflective-based mobile approaches is exciting in the mental health domain, as it enables users to perform more manageable tasks seemingly unrelated to their condition.

4 Evaluation

Emotions can be produced just as much by the recall of reinforcing events as by external reinforcing stimuli.

Edmund T. Rolls

To assess the user's perception of the systems, and evaluate the feasibility of our approach, a set of tests were conducted. SCAARF was evaluated in a mobile, everyday life context and throughout multiple environments.

Participants who displayed higher levels of trait anxiety were chosen to evaluate the prototypes, since they tend to perceive stressful situations to be more dangerous and more threatening than they actually are. They are also more likely to develop General Anxiety Disorder (GAD, which is the clinical presentation of trait anxiety).

This was performed to ensure we obtained viable results, since some types of anxiety disorders can be too specific or associated with other conditions, such as depression and substance abuse.

In order to avoid inducing further stress in participants, we chose to leave out a daily notification asking them to complete the breathing exercise.

Since the evaluation process lasted a total of 3 weeks (for each subject), all participants were compensated with a 10€ gift voucher for their time and effort.

Data Collection

Participants were recruited via a computer-based survey (see Appendix D), where they were asked to complete a Portuguese version of the State-Trait Anxiety Inventory (STAI), adapted by Silva and Correia from Spielberg (1983).

The STAI is a 40 item self-report questionnaire used to measure state (form Y-1) and trait anxiety (Y-2), where each item is rated in a 4-point Likert scale, and higher scores indicate higher levels of anxiety.

From 32 individuals who completed the survey, 18 volunteered to test the prototypes. Among the 18 volunteers, the ones who scored higher levels of trait anxiety (M=49.3, SD=8) were selected, but only 7 (6 females and 1 male, with a mean of 31 years old, SD=13.2) signed the informed consent form (Appendix E). The ones who did were given a personal code to test the mobile app (Appendix F).

For 5 days, the mobile app recorded the subject’s state of mind prior and after the breathing exercise (Figure 18), and primed users to associate a previous neutral stimulus – in the form of an audio clip – with a positive unconditioned response, so that the results could be later compared to the use of the wearable.

Database: wowsyste_anxietyapp,

Table: mood, Purpose: Dumping data

Table: feeling_after_test, Purpose: Dumping data

id	description
1	relaxed
2	somehow relaxed
3	not relaxed
4	not anxious
5	somehow anxious
6	anxious

id	feeling
1	worse
2	same
3	better

Figure 18. Example of data recorded in the SQL database.

After testing the mobile app, participants received the SCAARF wearable prototype, together with instructions on how to use it (Appendix G), and were asked to test it once a day, for at least 10 minutes, for the same amount of time (Figure 19). At the end of the three week-long trial, a series of semi-structured interviews with the participants were conducted (Appendix H), in order to assess, among other issues, the usability, comfort and intrusiveness of the prototype, as well as to better understand whether the

approach had been actually subliminal – below the threshold of conscious perception – or not.

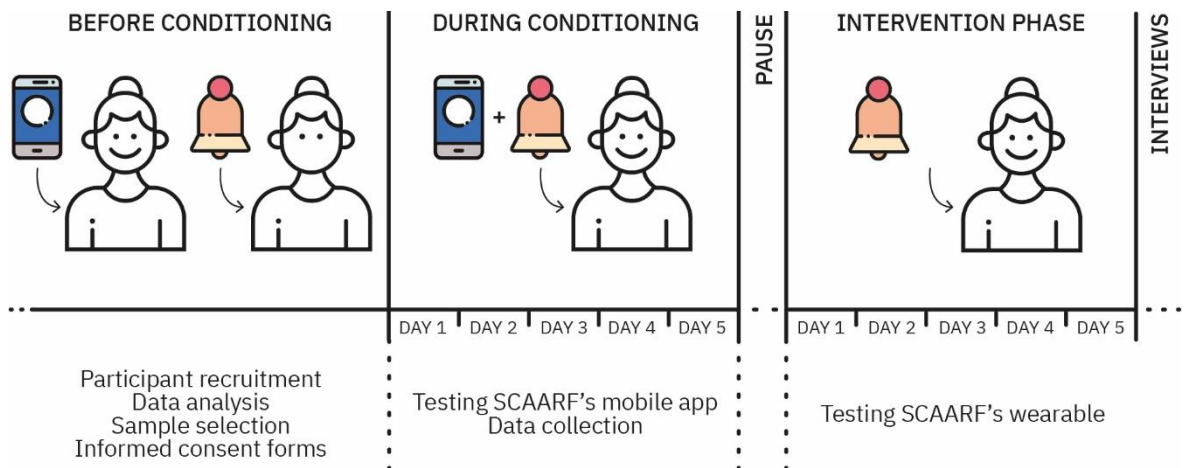


Figure 19. Evaluation timeline.

4.1 Results

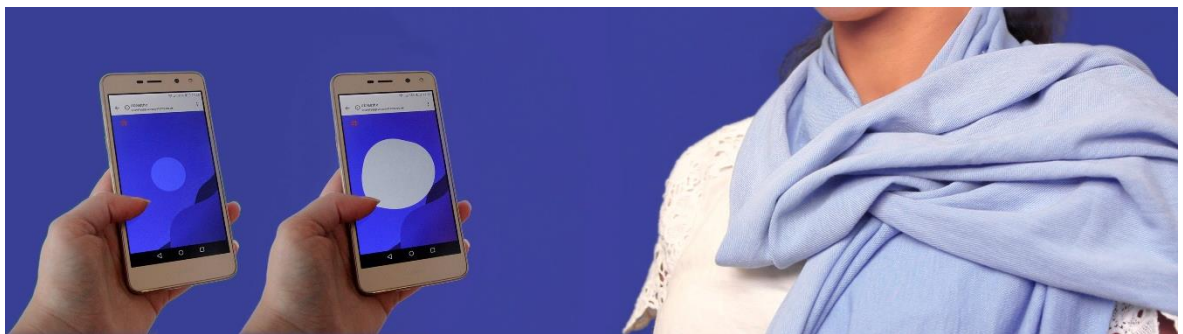


Figure 20. SCAARF's mobile and wearable prototypes.

The initial evaluation results suggest that the SCAARF mobile app is indeed effective in helping users cope with anxious states (Table 1). 77.1% of the time, users reported feeling better after the breathing exercise. The cases in which this was not true, and the emotional state remained the same, users reported feeling either relaxed or mildly relaxed prior to using the app, with the exception of day 4 for user 7.

Those findings are in line with the comments at the time they received the wearable prototype, when they stated “focusing on the movement during

the breathing exercise made me not think about anything else” and “made me feel calmer afterwards”.

The only time one of the participants (user 6) reported feeling worse after using the app was because he felt the pace of the breathing exercise was too fast, and the increase of his breathing rhythm had a negative impact on his previous (already relaxed) state of mind.

Table 1. Average mental state reported, prior and post conditioning, per user, where 1 represents a relaxed state of mind and 6 an anxious state (prior to the breathing exercise), and 1, 2 and 3 represent a deterioration, preservation and improvement of the user’s condition after being exposed to the positive audio reinforcement signal.

User	1	2	3	4	5	6	7
Day 1: Prior	2	4	4	3	3	5	2
Post	3	3	3	3	3	3	3
Day 2: Prior	2	1	4	3	6	3	1
Post	2	2	3	3	3	3	3
Day 3: Prior	3	2	4	4	5	3	2
Post	3	3	3	3	3	2	2
Day 4: Prior	1	1	5	3	4	2	5
Post	3	2	3	3	3	1	2
Day 5: Prior	2	3	5	2	2	2	5
Post	3	3	3	2	3	3	3
Median Prior	2	2	4	3	4	3	3
Median Post	3	3	3	3	3	3	3

User Feedback

Initial feedback shows that participants are receptive to the idea of using the wearable, considering “it’s already something I would wear in real life” and “something I feel comfortable wearing”. Participants also acknowledged feeling “more relaxed” and “calmer” after wearing the prototype, since “the sound is tranquilizing”.

User Experience

When asked to describe the experience of wearing the scarf in different contexts, all participants stated having used it indoors and alone. While two of them wore it mainly “during the night, whenever I felt overwhelmed” and at home, one of the participants also used it “at the office, seen that I gravitated towards it at times when I felt more anxious”.

Users described the wearable as easy to use, comfortable, light, soft, satisfying, practical and simple. When asked what they liked best, user 2 said it “was the feeling of comfort the scarf provided”, and “the tactile part [of the scarf], mainly the button part, because it worked as a distraction for me, and helped me calm down” (user 3).

Although participants said they would wear the scarf, users 1 and 3 also stated their favorite part of the experience was the breathing exercise, since “it made me really focus on what was happening” and “the graphics had calming colors. I also liked that there was an animation to follow and helped me breathe”.

The only participant who described a completely different interaction with the prototype was user 6. Instead of focusing on the tactile parts of the wearable, he saw the smart scarf as a challenge, and was interested in “what the scarf had to offer” and focused on “trying to discover the scarf mechanism” (i.e., how the sound was triggered, and if there were other sounds that could be played).

This deviation from the norm is interesting, since user 6 was the only male participant of the experiment. Nevertheless, he also described the scarf as comfortable and saw it as a way to “disconnect for 20 or 30 minutes from daily worries”.

Awareness

When asked how aware they were of the scarf, user 1 said she was mostly unaware “because I was doing other things [while wearing it]”, whereas user 3 said she “was aware, because when I feel anxious I like having something to touch and play with”. Similarly, user 2 reported being “very aware of the scarf when I stopped to use it and focused on it. However, when I wore it while I was at the computer, sometimes I would forget it wasn’t just a normal scarf”.

Regarding participant’s awareness of the sound, they acknowledged having immediately recognized the sound as the same one played after the breathing exercise of the mobile app. Interestingly enough, the user’s perception of the sound was what made them feel more relaxed, seeing that it acted as an immediate reminder to stop and breathe.

The only participant who had not realized the sound was the same as the one played in the app was, again, user 6. Even though he did not make the connection between the two interfaces, he was still aware of the sound in the wearable prototype.

4.1.1 Discussion and limitations

As previously stated, our aim for the SCAARF wearable is that, in the long run, it can act almost as a placebo, helping users unconsciously regain control (when faced with a possible threatening situation) in their daily lives, and ultimately become ubiquitous.

Even though at this stage users are still aware of the positive audio reinforcement signal, only after long-term exposure to the system will we be able to understand if such conscious perception can eventually disappear and become a part of the user’s tacit knowledge (Polanyi, 1966; Weiser,

1999), which can only be achieved through further (longitudinal) evaluation of the system.

Nevertheless, one of the current major limitations of the SCAARF evaluation is related to the small sample used to test the system. Although preliminary results seem promising, and the feedback received from psychologists during the wearable's various iterations indicate the SCAARF system has potential to help mitigate anxiety symptoms, further long-term evaluation is needed to support the actual effectiveness of our hypothesis.

To accomplish this, we need to recruit a larger number of participants to be able to test the final version of the wearable against a baseline condition (e.g., a version without sound).

Another limitation has to do with the decision of leaving out a daily notification asking users to complete the breathing exercise. Although our choice to do so prevented inducing further stress in participants, it also meant some of them did not use the app during the 5 consecutive days. This not only extended the (already time consuming) evaluation, but also meant some of the nonresident participants (users 4 and 5) were not able to test the full system (i.e., the wearable prototype).

Conclusion

Anxiety disorders affect a significant part of today's society. Current wearable technologies hold the key to bringing more effective digital interventions. This dissertation reviews the state of the art of wearable technologies used to help improve mental health and brings to evidence some gaps and limitations of current approaches that the SCAARF system aims to fill. However, it is not our focus to replace therapists, psychologists or drug-based approaches to mitigating the symptoms. Instead, we explore the design space of wearable technology to address this problem and focus on discovering new approaches based on the subconscious processes of the human mind.

Although at this stage our results are still preliminary, and based mainly on qualitative analysis, informal observation and interviews (with both psychologists and individuals who suffer from anxiety conditions) performed throughout the development of the wearable prototype, they raise two main implications to the design of subtle interfaces for mental health.

First, the development of subliminal, unobtrusive approaches for mitigating anxiety symptoms are harder to design than the ones based on “reflective mind”, since the exposure period to such technologies must be longer (i.e. more than just a few weeks) in order to achieve solid results.

Second, the combination of a mobile conditioning phase with the SCAARF's wearable provides a less-invasive portable solution to mitigating anxiety symptoms that can be worn anytime, anywhere. The scarf form-factor helps reduce stigma and brings convenience to users, since it protects them from

having to expose their condition, which is extremely important in the mental health domain, especially in anxiety disorder cases.

This work also raises important ethical and privacy concerns, which should be discussed by the HCI community: how can designers balance the opaqueness inherent to subconscious approaches while maintaining the necessary ethical transparency? And how can new interfaces be conceived in the mental health domain in such a way they do not increase societal stigma in users?

Future Work

As previously stated, part of our future work is to extend the evaluation of the SCAARF system. This requires alterations to be made to the existing prototypes, that take into account user feedback:

Mobile app

To ensure the results are consistent, a daily notification should be added, to remind users to complete the daily breathing exercise. Since some users reported feeling the same after completing the exercise, and one of them stated they felt worse, a possible improvement could be delivering a slower paced animation when the user's state of mind is already relaxed prior to the breathing exercise.

Wearable prototype

Although the current high-fidelity prototype works, some adjustments could potentially improve its effectiveness: (i) increasing the area of the conductive thread – which would allow for a more effortless interaction with the wearable–, or (ii) developing something similar to I/O Braid (Olwal *et al.*, 2018), where the actual fabric responds to different inputs (e.g., touch, tap, pull). This could be an interesting way to sense stressful patterns (Alonso, Keyson and Hummels, 2008; Karlesky and Isbister, 2016), allowing us to deliver the positive audio reinforcement signal only when needed.

Another possibility would be to replace the actual headphones with Bose frames⁷, for example. This no-cable alternative would make the interaction with the smart scarf even less intrusive, and possibly more unconscious, as the audio sunglasses do not obscure ambient sounds.

⁷ [bose.com/en_us/products/frames.html](https://www.bose.com/en_us/products/frames.html)

A/B testing

The evaluation of the current wearable prototype against a baseline condition is a necessary part of our future work, which could be done by simply using a version of the scarf without sound.

Nevertheless, and since work done by Stylios and Chen (2016) show dynamic textile patterns can help induce calming, relaxed states of mind, another solution could be to continue to develop the first iteration of the wearable prototype with an approach similar to the one used by Ghandeharioun and Picard (2017) on BrightBeat.

The subtle visual intervention, that resembles respiratory biofeedback (sharing affordances with the mobile app), would also help us to compare and better understand which of the two approaches (auditory vs. visual) is more subliminal, and thus effective.

Further evaluation

Even though the current version of the SCAARF wearable does not use sensors, for reasons previously explained, it could be interesting to use them (Muse 2⁸, for example) for evaluation purposes. This would allow us to collect biofeedback data from participants, which would contribute to determine the actual effectiveness of our system.

⁸ choosemuse.com

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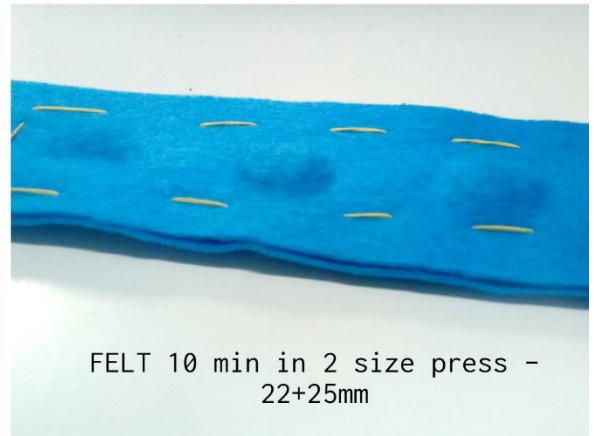
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Appendix

Appendix A



FELT 10 min in 2 size press -
22+25mm



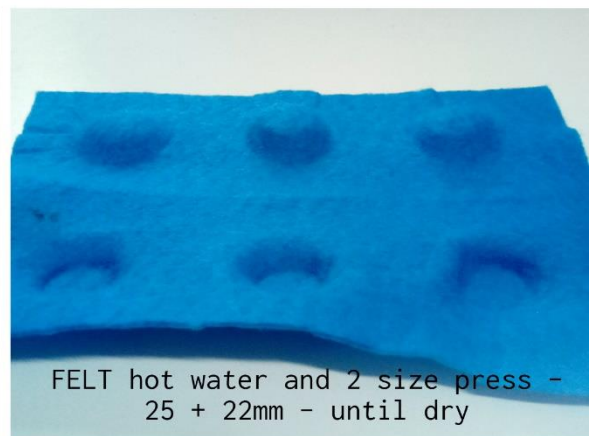
FABRIC shibori3d - 25 min in
boiling water



EVA - pre boiled and 2 size
press-25+22mm - until dry



FELT shibori3d - 20 min in
boiling water



FELT hot water and 2 size press -
25 + 22mm - until dry

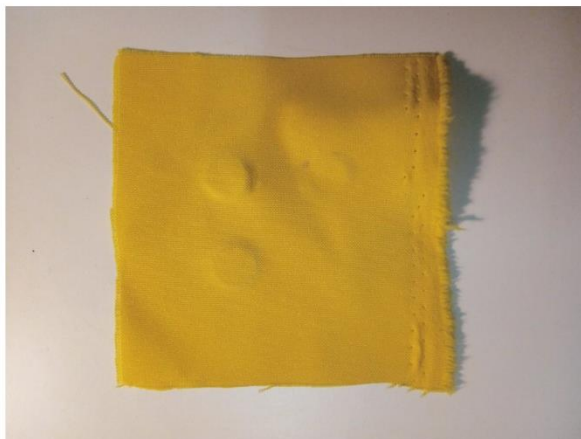
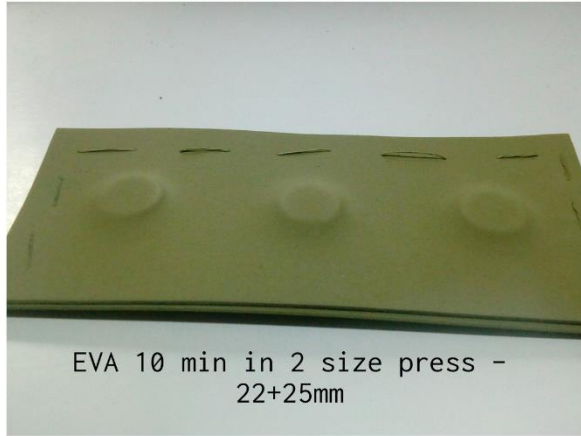
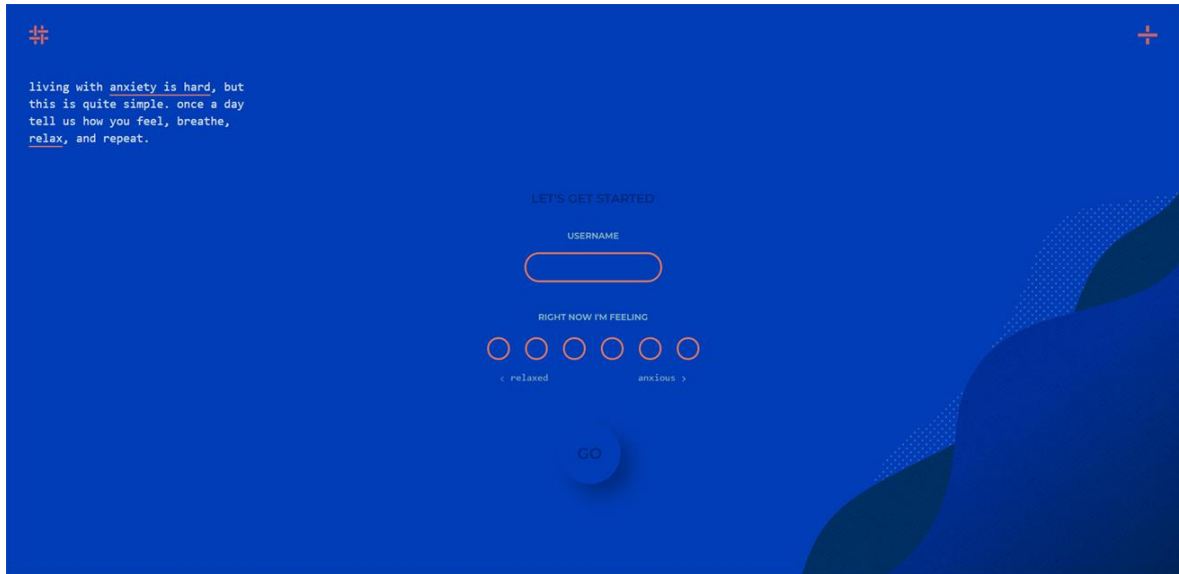
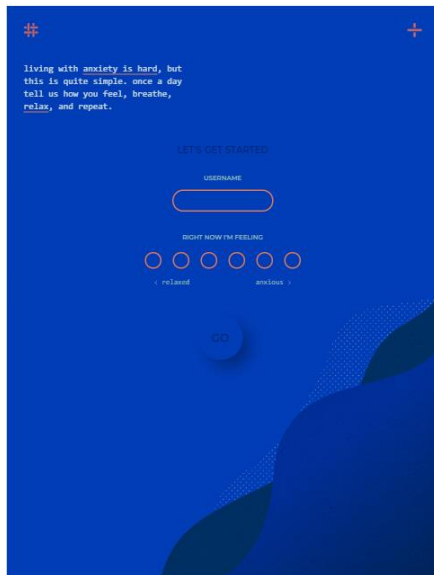


Figure 21. Testing different material's reaction to heat for the development of the second version of the wearable prototype.

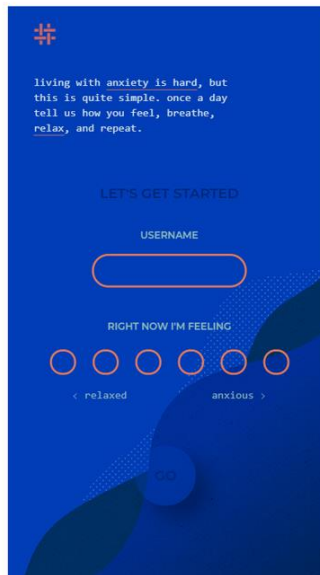
Appendix B



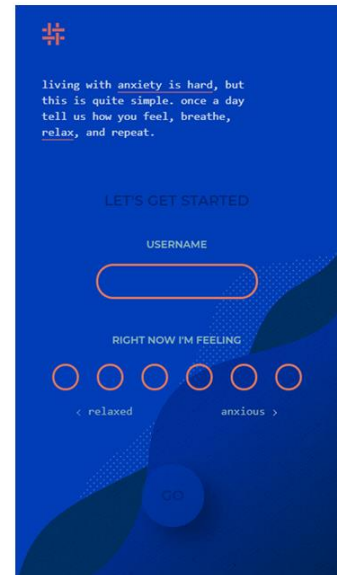
desktop



iPad



iPhone 6/7/8



Galaxy S5

Figure 22. The different versions of the responsive website.

Appendix C

Database: wowsyste_anxietyapp,
Table: user,
Purpose: Dumping data

id	username
1	me
2	
3	
4	
5	
6	
7	
8	
9	
10	

Database: wowsyste_anxietyapp,
Table: mood,
Purpose: Dumping data

id	description
1	relaxed
2	somehow relaxed
3	not relaxed
4	not anxious
5	somehow anxious
6	anxious

Database: wowsyste_anxietyapp,
Table: feeling_after_test,
Purpose: Dumping data

id	feeling
1	worse
2	same
3	better

Database: wowsyste_anxietyapp, Table: test, Purpose: Dumping data

id	user_id	mood_id	feeling_after_test_id	datetime
1	1	5	2	2019-03-19 15:56:11
2		2	3	2019-04-
3		5	2	2019-04-
4		5	2	2019-04-
5		4	2	2019-04-
6		5	2	2019-04-
7		4	2	2019-04-
8		4	3	2019-04-
9		5	3	2019-04-
10		2	2	2019-06-
11		4	3	2019-07-
12	2	6	1	2019-07-
13	3	4	2	2019-07-
14	4	2	3	2019-07-
15		2	2	2019-08-
16		3	3	2019-08-
17		1	3	2019-08-
18		2	3	2019-08-
19		4	3	2019-08-
20	5	4	3	2019-08-
21	6	4	3	2019-08-
22		1	2	2019-08-
23		2	3	2019-08-
24		4	3	2019-08-
25		1	2	2019-08-
26	7	3	2	2019-08-
27		3	3	2019-08-
28		4	3	2019-08-
29		2	3	2019-08-
30		5	3	2019-08-
31		5	3	2019-08-
32		3	3	2019-08-
33		4	3	2019-08-
34		3	3	2019-09-
35		5	3	2019-09-
36		2	3	2019-09-
37		2	2	2019-09-
38	8	3	3	2019-09-
39		6	3	2019-09-
40		5	3	2019-09-
41		4	3	2019-09-
42		2	3	2019-09-
43		3	3	2019-09-
44		4	3	2019-09-
45	9	5	3	2019-10-
46		3	3	2019-10-
47		3	2	2019-10-
48	10	2	3	2019-10-
49		1	3	2019-10-
50		2	1	2019-10-
51		2	2	2019-10-
52		2	3	2019-10-
53		5	2	2019-10-
54		5	3	2019-10-

Figure 23. SQL database.

Appendix D

#scarf: subtle technologies for mental health

This questionnaire is part of a research being conducted, as part of a Master Thesis in Interactive Media Design, that aims to understand how different technologies can help improve mental health in the future.

It will take you less than 10 minutes to complete it, and all your answers will be anonymized and remain confidential.

If you have any questions about this study, feel free to contact us at lais.lopes@m-iti.org.

* Required

Self-Assessment Questionnaire (Y-1)

Abaixo encontram-se uma série de frases que as pessoas costumam usar para se descreverem a si próprias.

Lê cada uma delas e escolhe como te sentes AGORA. Não há respostas erradas.

1. Neste preciso momento *

Mark only one oval per row.

	Nada	Um pouco	Moderadamente	Muito
Sinto-me calmo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me seguro	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estou tenso	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me esgotado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me à vontade	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me perturbado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Presentemente ando preocupado com desgraças que possam vir a acontecer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me satisfeito	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me assustado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estou descansado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me confiante	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me nervoso	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estou inquieto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me indeciso	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estou descontraído	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me contente	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estou preocupado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me confuso	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me uma pessoa estável	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me bem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Self-Assessment Questionnaire (Y-2)

Abaixo encontram-se uma série de frases que as pessoas costumam usar para se descreverem a si próprias.

Lê cada uma delas e escolhe como te sentes EM GERAL. Não há respostas erradas.

2. Geralmente *

Mark only one oval per row.

	Quase nunca	Algumas vezes	Frequentemente	Quase sempre
Sinto-me bem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me nervoso e inquieto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me satisfeito comigo próprio	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quem me dera ser tão feliz como os outros parecem sê-lo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me um falhado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me tranquilo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sou calmo, ponderado e senhor de mim mesmo	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto que as dificuldades estão a acumular-se de tal forma que as não consigo resolver	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Preocupo-me demais com coisas que na realidade não têm importância	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sou feliz	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tenho pensamentos que me perturbam	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Não tenho muita confiança em mim	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sinto-me seguro	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tomo decisões com facilidade	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Muitas vezes sinto que não sou capaz	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Estou contente	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Às vezes, passam-me pela cabeça pensamentos sem importância que me aborrecem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tomo os desapontamentos tão a sério que não consigo afastá-los do pensamento	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sou uma pessoa estável	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fico tenso quando penso nas minhas preocupações e interesses mais recentes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Skip to question 3.

Thank you very much!

We are looking for volunteers to test our prototypes and help us improve our research. If you have any questions feel free to drop us a line at lais.lopes@m-iti.org.

3. Want to test our prototype? Just write your email here so we can get in touch.

Figure 24. The questionnaire used to recruit participants for evaluation is a version of the original STAI self-evaluation questionnaire.

Appendix E

Participant Information + Informed Consent Form

Thank you for answering our questionnaire! You have been invited to take part in a research study. Before you decide if you want to participate, please take time to read the following document in order to understand why the research is being done and what the study will involve.

Any study-related questions can be sent to and clarified by the researcher(s) – contact details can be found below.

* Required

What is the purpose of this research?

The purpose of this research is to understand how different technologies can help reduce anxiety symptoms, which will allow us to develop new, better technologies to help improve mental health in the future.

The results of this research will be used by Laís Lopes to obtain a Master degree in Interactive Media Design, and the ANONYMIZED data collected will be used for publication purposes.

Researcher contact information

Laís Lopes (Researcher)
Master's student at University of Madeira
lais.lopes@m-iti.org

Pedro Campos, PhD (Supervisor)
Professor at University of Madeira
pedro.campos@m-iti.org

What will happen if I decide to participate?

In order for you to participate in this study, you need to understand and sign this informed consent with your name and e-mail address. In case of any questions, feel free to contact the researcher at lais.lopes@m-iti.org.

After you submit the informed consent, the following steps will be performed:

Stage 1:

You will receive an e-mail with a personal code (username) and a link to a website, where you will be asked to:

- a) fill in your username (personal code).
- b) tell us how you feel at the moment.
- c) do a quick guided breathing exercise (that takes less than a minute to complete).
- d) tell us if you feel any different.

Stage 2:

After you complete the first stage of the experiment, you will receive another e-mail to set up a date where you will be given a wearable prototype to test.

3. After the end of the experiment you will be asked to return the wearable and answer some questions about your experience.

What is the duration of the study?

The FIRST STAGE of the experiment will take FIVE DAYS to complete, where you will need to access the website and follow the above mentioned steps once a day.

The SECOND STAGE will also take FIVE DAYS to complete, and you will be asked to use the wearable prototype for at least 10 minutes a day, every day.

How will my data be used?

Your ANONYMIZED data will contribute to publications that can inform the scientific community. All personal information you provide us is strictly CONFIDENTIAL and the data collected by the website will remain anonymous, as you will be assigned a unique personal code.

What are the possible benefits and risks of participating?

When you deliver the wearable prototype, by the end of this research, you will be rewarded for your time with a 10€ fnac voucher.
Your participation will also contribute to publications that can inform the scientific community and possibly help develop new technologies for improving mental health.
There are no risks involved in participating in this study.

What will happen if I want to withdraw from this research?

You are free to withdraw from this study at any time, no questions asked. If you decide to do so, we ask you to please notify a member of the research team before you withdraw.

Informed Consent Form

Please read the following conditions and confirm they have been met

- ✓ I have read and understood the provided information
- ✓ I have had the opportunity to ask questions and discuss the study
- ✓ I have received satisfactory answers to all my questions
- ✓ I understand that an anonymized copy of my data will be used for publication purposes
- ✓ I understand that I am free to withdraw from the study at any time without giving a reason

1. Please confirm the above conditions have been met *

Check all that apply.

- I confirm the above conditions have been met

Please confirm your consent to the following procedures

- ✓ I consent to the use of my anonymized data in the current study
- ✓ I agree my anonymized data to be shared with researchers not yet to be known.
- ✓ I agree to participate in the study

2. Please confirm your consent to the above procedures *

Check all that apply.

- I consent to the above procedures

3. Please write your full name here, understanding that this is your digital signature for giving consent to participate in this study *

Signature of researcher performing the study

Lais Lopes

lais.lopes@m-iti.org

Figure 25. Participant information and informed consent form sent to users.

Appendix F



Lais Lopes <lais.lopes@m-iti.org>

#scarf app

1 message

Lais Lopes <lais.lopes@m-iti.org>

To: [redacted]

Hi!

Before you start using the app, we would like to go over the steps with you again:

Once a day, for five days, when you feel you need to relax, go to http://anxietyapp.wowsystems.co.uk/public_html/ in your mobile phone or computer (it works on both) and:

1. insert your username: **xxxxx** (this code is personal, so please don't share it)
2. tell us how you're feeling at the moment
3. remember to **check if the sound** on your phone/computer **is on**
4. do the guided breathing exercise
5. tell us if you feel any different

And that's it.

If you have any questions, don't hesitate to contact us.
In the meantime, we would like to underline how valuable is for us your participation.

Best,
Lais

--

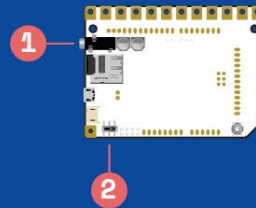
Lais dos Santos Lopes
Master's student at **University of Madeira**
Research Assistant at **Madeira ITI**

Figure 26. Email sent to users with their personal code, instructions and website (2019) to access the breathing exercise.

not sure how to use our #scarf? we hope this helps you.

Once a day, for five days, when you feel you need to relax, go get your scarf and:

1. Plug in your headphones
2. Switch on the board
3. Wear it for at least 10 minutes



When you're done, remember to turn off the board so the battery doesn't run out.

pro tip: don't be afraid to touch the scarf, it works best if you do!





Figure 27. Instructions given to participants, together with the wearable, on how to use the prototype.

Note: A demo video (Lopes, 2019b) explaining how to use the mobile app was also sent to participants before they started testing the SCAARF system.

Appendix H

Interview guide:

1. Age.
2. Can you describe your experience of wearing the scarf in different environments (e.g., public vs. private, outdoors vs. indoor) and contexts (during social activities or alone, work vs. play, morning vs. night)?
3. Did you think the wearable prototype was easy to use or required some effort? Was it satisfying or annoying? Why?
4. Was the scarf comfortable or uncomfortable? Why?
5. Were you aware of the scarf (i.e., did you reflect about what was happening) while you were wearing it? Why?
6. What did you think about the sound?
 - 6.1. Did you realize that the sound of the scarf was the same as the one played in the app when you finished the breathing exercise? When?
7. Can you describe how you felt after wearing the scarf (e.g. more or less calm)? Why?
8. What did you enjoy most / made you feel more relaxed throughout the experience? What did you like least? Why?
9. Do you feel that the prototype's form-factor can be considered an asset to help reduce stress? Why?

