Designing for Kinaesthetic Experience: A Somatic Approach to Developing Soft Wearable Prototypes to Support Self-Regulation

by

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Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

a. human research ethics approval from the Simon Fraser University Office of Research Ethics

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Abstract

This exploratory Research-through-Design thesis investigates a design for self-regulation using kinetic, textile-based feedback to mediate participants' felt experience of stress-release. Through a somatic approach to designing for self-regulation, my thesis presents insights on how to mediate rich communicative qualities from physical movement into embodied aesthetics to cultivate and deepen a user's kinaesthetic understanding with their emotions and body cues. The human capacity for kinaesthetic empathy, is a great resource that is underutilized. The ability to sense and train kinaesthetic cues can support greater somatic awareness for self-regulation. Not only are they rich in a meaning-evoking way, they can incite for aesthetic, meaningful experiences that can transform our physical state. This is particularly useful in situations where stress-release is needed. This thesis engaged three iterative design projects that included four design studies and the development of 19 material prototypes, 3 on-table functional tactile prototypes, and 2 upper-body soft wearable design prototypes.

Keywords: kinaesthetic awareness; soft wearable design; kinetic feedback modality; self-regulation; somatics; embodied interaction design

Dedication

To my beloved family and friends. Thank you for your patience and faith in me.

It's been a long time coming, but we made it!

Acknowledgements

Firstly, I would like to express my gratitude to my senior supervisor, Dr. Thecla Schiphorst. Thank you for your guidance, confidence, and belief in my ability as a designer and researcher. Yourpassion and advocacy for a designer's sensibility and perspective in the design-research process have been inspirational and instrumental to my work and design practice.

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List of Acronyms

HCI	Human Computer Interaction
PMR	Progressive Muscle Relaxation
RtD	Research-through-Design
S-MA	Sensory Motor Amnesia
SFU	Simon Fraser University

Chapter 1.

Introduction

This exploratory Research-through-Design (RtD) program investigates a design for self-regulation using kinetic, textile-based feedback to mediate participants' felt experience of stress release. Through a somatic approach to designing for self-regulation, my thesis presents insights on how to mediate the rich communicative qualities from physical movement into embodied aesthetics to cultivate and deepen a user's connection and understanding with their own emotions and body cues. The human capacity for kinaesthetic empathy, is a great resource that is underutilized. The ability to sense and train kinaesthetic cues, especially ones that are self-managed, can support greater somatic awareness for self-regulation. Not only are they rich in a meaning-evoking way, but they can incite an aesthetic, meaningful experience that can transform our physical state. This is particularly useful in situations where the release of stress is needed.

1.1. Designing for Self-Regulation

1.1.1. Self-Regulation of Stress

Self-regulation of stress is the ability to modulate one's attention and emotion to ameliorate the experiences of stress. Health research highlights a growing emphasis towards one's ability to self-regulate as an integral component for self-care, recovery, and long-term well-being. Using a somatic approach to self-regulate stress, Progressive Muscle Relaxation (Anxiety Canada, n.d.; Healthwise Staff, 2017), Somatic Experiencing (Payne et. al, 2015), and Mindfulness-based Stress Reduction (Healthwise Staff, 2017; de Vibe et al., 2012) assist participants to direct self-awareness towards their felt inner state when assessing and mitigating perceived symptoms of stress and discomforts. Through developing an embodied understanding of how their own bodies react to stress, participants are able to strengthen their kinaesthetic cues to efficiently detect and engage appropriate strategies to manage stress.

To alleviate stress and assist with relaxation, the aforementioned treatments encourage practices of deep breathing, tense + release, and visualizations (BC Mental

Health & Addiction Services, 2014). These relaxation techniques are also explored through combinations of on-screen visuals, light, haptic, and auditory stimuli within tangible interaction design-research for applications and technologies that support stress reduction and relaxation (Alonso et al., 2008; Alonso et al., 2012; Wongsuphasawat, 2012; Yu, 2018; Zhu, 2017). Investigating across the domains of cognition, emotion, and behaviour in self-regulation, the design of these alternative methods helps develop users' ability to self-appraise their felt stress so they can modulate how they think, feel, and act to improve their perceived body state.

While there is a breadth of commercial products and existing research projects that support self-regulation for stress reduction, design-research on soft wearables, and kinetic feedback modality for self-regulation are rather limited and underexplored. Related soft wearable projects do highlight the potential for affective reflections and somatic engagement for well-being. SWARM is a wearable scarf that uses light, vibro-haptic, and auditory expressions to reflect and convey the wearer's emotional state (Williams et al., 2015). The Active "Hugging" Vest is a wearable that uses compression to mediate deep touch pressure to reduce anxiety for children with sensory processing disorder (Duvall et al., 2016). Ref is a wrist-based soft wearable design that detects the wearer's pulse as an indicator for stress (Dyvik, 2010). The "pet-like" wearable utilizes the tactile touch of nuzzling up and down the wearer's arm as a prompt and guide for deep breathing. In particular, Ref showcases the possibility to integrate the tactile touch and kinetic movement to encourage self-regulation of breathing to release stress.

The use of kinetic movement and tactile touch can appeal to the kinaesthetic sense and help transform our felt inner state. Additional research on shape changing surfaces reveals design inspirations to use movement and touch for exploration and expression, shaping the overall aesthetic experience. Bodanzky (2012) discusses the concept of expressivity and movement patterns to support the design of kinetic interfaces. Through Kukkia and Vilkas, Berzowska and Coelho (2005) perceived the sculptural forms and kinetic movement as an extension of self. The dresses map motions to the natural rhythms of breathing and heartbeats, and facilitates a reflective conversational space between the garment and the wearer. Awakened Apparel showcases the use kinetic movement, characterized as 'morphing', to represent our affective state based on our social interactions (Perovich et al., 2014). Sprout I/O through its texturally rich soft interface, affords tactile touch with a kinetic display for a multi-sensory engagement (Coelho et al., 2008). Walking City showcases an integration of pneumatics, interactive technologies and movement (Gao, 2006). The three garments simulate the impression of breathing through their expanding and contracting movement. Monarch's shoulder-based wearable foregrounds the act of tensing and releasing to extend the intuitive body language (Hartman, 2015). These design projects reveal a research opportunity in which Research-through-Design can be used to explore kinetic feedback through soft wearable designs that support the understanding and communicating one's own felt experience of releasing stress. Through designed prototypes, Research-through-Design can assist users achieve their own sense of calm and relaxation.

1.1.2. Stress-Induced Muscle Tension

To position the value proposition of this Research-through-Design thesis, it is important to understand the design impact of supporting self-regulation of stress-induced muscular tension, which is the focus of my research. Stress is a prevalent concern to Canadians. According to the 2010 General Social Survey by Statistics Canada that focuses on working adults between ages 20-64, 27% of Canadians experience extreme stress on a daily basis (Compton, 2011). Stress can affect both the physiological and psychological well-being (Seaward, 2014; BC Mental Health & Addiction Services, 2014). A common physiological symptom associated with stress is muscle contractions, which protect and make the body more agile and resilient in stressful situations. However, sometimes when tension is not released following contraction, the body loses its capacity to adapt. Muscle tension can remain long after when stress-triggered situations have been resolved. Persistent muscle tension can cause pain, stiffness, discomfort, and lead to more severe musculoskeletal disorders. Resulting effects like sleep difficulties, limited mobility, and pain can impact a person's ability to focus, make decisions, and feel confident. This can have a negative impact on one's personal and professional relationships (CCOHS, 2019).

1.2. Research Goals, and Questions

My research thesis stems from the challenges of articulating and accessing the tacit nuances of the felt inner state when experiencing physical stress within the body. The inability to accurately capture how one senses and feels during stress can be detrimental. This can lead to difficulties to achieve somatic and affective attunement, resulting in ineffective and inefficient treatments, and also impedes personal well-being. Thus, through my thesis, I explore how the under-explored design space of kinetic feedback as a modality can help wearers to connect and communicate their felt experiences of releasing stress. Human touch and movement are intuitive and contain rich communicative qualities. Schiphorst (2007) introduces the concept of “Seeing is Touching” to enrich the way we can learn and interact. She highlights the use of touch as a way to tap into our inner felt sense and reveal meaning from our lived experiences. Aligning with Schiphorst’s motivations to consider the bodily aspects in HCI, Larsse, Robertson, and Edwards (2007)’s discussion of the “feel dimension” promotes how touch and movement can help users establish a multi-layered dialogue to understand the purpose and significance of their embodied interaction. Schiphorst’s multiple research collaborations with Loke (2018), Corness (2013), and Andersen (2004) further showcase the value of somatic approaches to design-research. By bringing the focus back to the body, design-researchers can leverage the kinaesthetic experiences to develop embodied cues that can promote greater empathy and sensibility to how users can engage and understand their surroundings. In particular, Tomico and Wilde (2016) motivates the use of soft wearables as an alternative to screen-based interactions to revitalize the user’s engagement to their bodily experiences. Tomico motivates the use of soft wearables to support an individual to sense, understand, and respond meaningfully that is more present and connected. Using Research-through-Design, I gather insights on how to mediate the expressive qualities of physical movements through a soft wearable design to support the wearer for greater kinaesthetic understanding of their body.

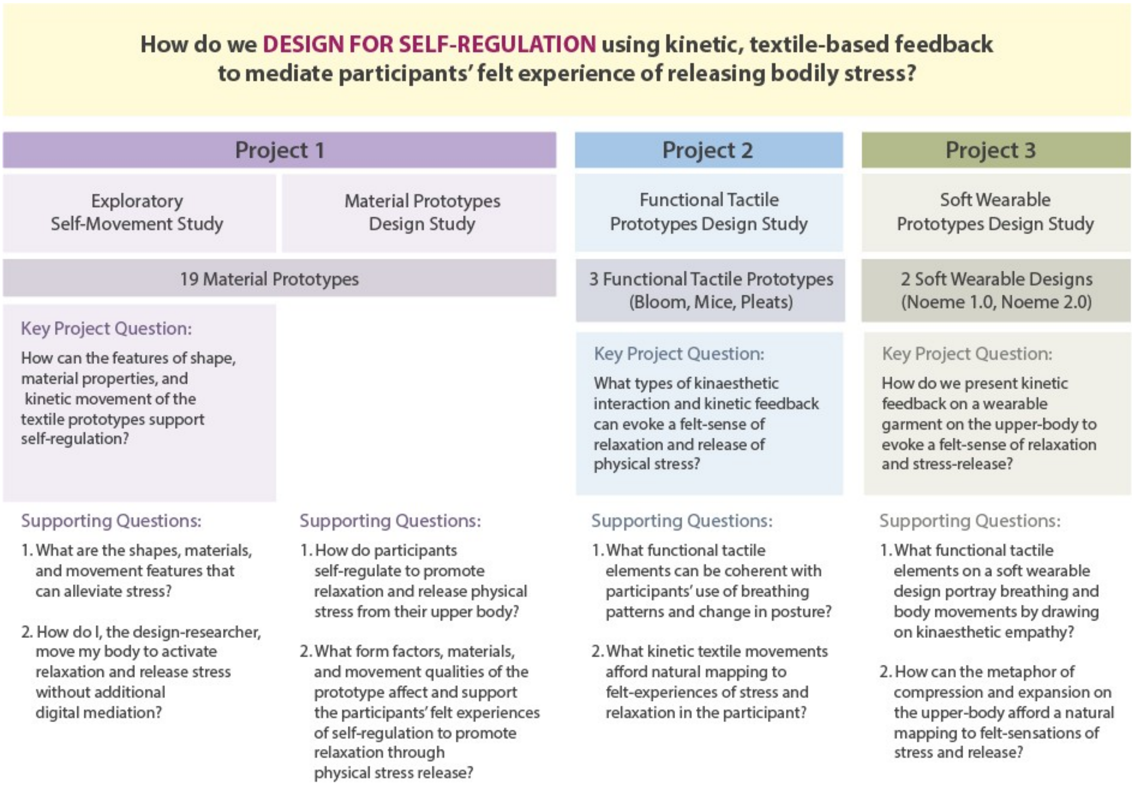

Figure 1.1. Research Questions & Supporting Questions across Projects 1-3.

As my thesis explores the design space of self-regulation, the overarching research goal of my thesis is therefore to investigate the felt experience of kinetic stimulation as a metaphor for relaxation responses on the body to support helpful self-modulation of stress and develop greater self-agency for personal well-being. To address this research goal, my thesis is guided by the primary research question:

RQ: How do we design for self-regulation using kinetic, textile-based feedback to mediate participants' felt experience of stress release?

With consideration to the material experience and somatic qualities in my design-research process, two secondary research questions are also included:

1. What form factors, materials, and movement qualities of the prototype affect the felt experience of stress release for the wearer?
2. How do wearers self-regulate the release of stress from their body?

Using a Research-through-Design approach, I examine the research questions through 3 design projects. These 3 design projects are comprised of 4 design studies supporting 3 types of iterative design prototypes: 1) material prototypes, 2) on-table functional tactile prototypes, and 3) on-body soft wearable prototypes. The overarching and supporting research questions are further modified into project questions to guide the design and evaluation of my prototypes (Figure 1.1).

1.3. A Research-through-Design (RtD) Approach

My thesis advocates the importance of considering material experience and somatic dimensions in the design and development of soft wearable prototypes for self-regulation. With a Research-through-Design process, I am able to explore and iterate emerging ideas and concepts that can support wearers to develop greater self-empathy and agency for personal well-being when experiencing stress. I employed the designs of material prototypes, on-table functional tactile prototypes, and upper-body based soft wearable prototypes to investigate the use of kinetic modality for relaxation responses that can kinaesthetically resonate with potential wearers.

1.3.1. Overview of my RtD Journey

My thesis engages in Research-through-Design across three projects to address my research goals and questions. I first pursue a self-movement pilot study to develop a somatic sensibility and kinaesthetic understanding on how I relax to alleviate stress-induced tension. The auto-ethnographic study informed the design of project 1, which is comprised of 19 material prototypes that simulate qualities of expansion, compression, and support the act of massage (rubbing, pressing, kneading). With the material prototypes, I conducted a participatory design study with 10 participants that include a qualitative semi-structured interview, prototype explorations, reflective breathing exercises, and body mapping activities. Study participants were adults who have chronic experiences with stress-induced tension and regularly work in a desk-based environment for at least one hour at a time. Subsequent follow-up conversational interviews in Project 2 and Project 3 also engaged individuals who have participated in Project 1's design study. Through qualitative analysis coding using NVivo 12, the insights gathered from the material prototypes help determine the visual, tactile, and functional qualities that can support the use of breathing and movement to promote relaxation and stress relieve.

Project 2 integrates the visual, tactile, and functional qualities into the design of three on-table, functional tactile prototypes that explore the use of kinetic feedback to evoke a sense of relaxation and stress release. The design of Bloom, Mice, and Pleats are guided by an adapted *Somaesthetic Framework of Touch* (Schiphorst, 2009). Each of the functional tactile prototypes generates a kinetic expression through textile manipulation using miniature rotational motors. Based on the *Somaesthetic Framework of Touch* (Schiphorst, 2009), I conducted conversational interviews with seven participants. Based on these interviews, I refined the selection of visual, tactile, and functional elements that can be implemented on a soft wearable design to support a natural mapping toward the practice of breathing and change in posture that support relaxation and stress release.

Project 3 is the design and evaluation of two high-fidelity, soft wearable prototypes that investigated the display of kinetic expression on the upper-body to support for relaxation responses. The design and development of Noeme 1.0 and Noeme 2.0 are also guided by an adapted *Somaesthetic Framework of Touch*. I conducted conversational interviews with six participants based on the Somaesthetic Design Framework. The resulting evaluation was used to elicit somatic and affective impressions to support the design of the two wearable prototypes. The elicited feedback was examined using qualitative coding analysis and revealed opportunities for design refinement on the wearable prototypes to better support a wearer's kinaesthetic understanding towards the use of breathing and posture to promote relaxation and stress release.

1.3.2. Documentation Process

Documentation is an essential part of Research-through-Design as it allows the researcher to actively self-reflect and evaluate their positionality throughout the design-research process. Cognizance of the purpose to my design explorations and my research goals ultimately promotes greater design-researcher accountability to understand how my biases may impact the design-research process. In my thesis, I use *Bardzell's framework for RtD documentation (Bardzell, 2016)*, detailing what my documentation mediums are, how they work, and how they support each stage of my design-research. By highlighting my RtD documentation process, I hope to contribute to the RtD discourse on soft wearable design for self-regulation by presenting this thesis as a case study for documenting multidisciplinary design-research that integrates somatic considerations with textiles and technology.

1.4. Thesis Structure

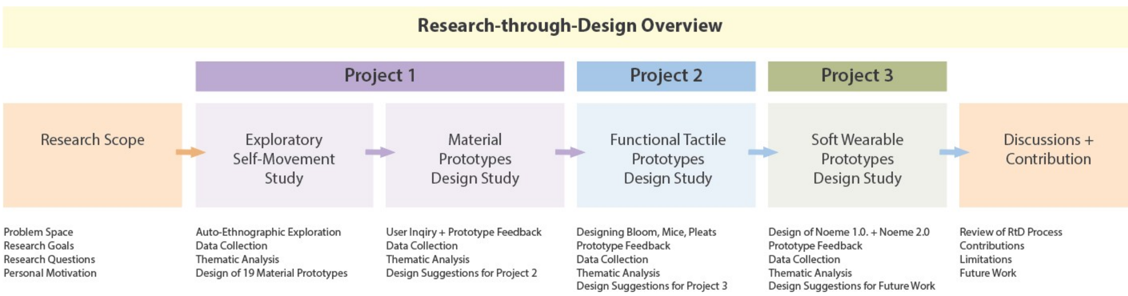

Figure 1.2. Research Journey Map.

In my Research-through-Design (RtD) thesis (Figure 1.2), I examine self-regulation as a design space through the course of three projects, producing a total of twenty-five design artefacts in the process. This design-research shifts between states of digital and physical, highlighting the material experiences of the design-researcher and potential wearer. By engaging the bidirectional relationship of material as data, and data as material, considerations of craftsmanship and embodiment are interwoven in the tactile experiences of the designer to enrich the design exploration and meaning-making process. This approach allows the meaningful translation of technical and experiential information into embodied aesthetics within the material and design research of a soft wearable design. My iterative design-research is organized into 7 chapters. Each chapter documents the inspiration, research, creative synthesis, implementation, evaluation, analysis, and reflections of my 3 projects. A detailed overview of each chapter is provided below.

Chapter 1 - Introduction of Research Scope & Methodology Overview

In Chapter 1, I provide an overview of my thesis and present contextual information that form the basis of my design-research. I introduce the design space of self-regulation, highlight the challenges to releasing bodily stress, and identify the design opportunity to leverage the human kinaesthetic cues. These three elements inform my research purpose to investigate the use of kinetic modality in a soft wearable design to support the alleviation of stress. I provide details of my motivations, goals and key questions that guide the design-research. I discuss the use of Research-through-Design and elaborate on the documentation process in this thesis. This chapter prepares for an in-depth reflection and explanation of personal, practical, and intellectual goals that led to my research topic within Chapter 2.

Chapter 2 - Discussion of Research Scope & Conceptual Framework

In Chapter 2, I reflect on personal motivations and review existing literature to formulate my researcher positionality and theoretical foundation for this design-research thesis. I present an auto-ethnographic account of my 2 year-jaw realignment and recovery journey and discuss how the difficulty to assess, articulate, and relate with my felt experience of tension have shaped my approach to the design, implementation, and evaluation of my design artefacts. With a detailed analysis on related projects and research work, I highlight the potential to use kinaesthetic feedback in tangible and embodied interaction design for greater awareness and empathy towards bodily stress. I describe my design approach to translate rich communicative qualities of movement to kinetic, textile-based expressions to support self-regulation for alleviating stress. This chapter provides a foundational explanation on the research context and design process to guide the ideating and crafting the material prototypes, the functional tactile prototypes, and upper-body based soft wearable design prototypes.

Chapter 3 - Exploratory Self-Movement Pilot Study, and Design of Material Prototypes (Project 1, Part A)

In Chapter 3, I detail an explorative, self-movement pilot study seeking insights into my somatic and affective experiences when addressing stress, and describe the design development of the material prototypes. This reflexive approach primes the design-researcher to engage and develop sensibility towards materials and movement. I elaborate the use of researcher diary and video recordings to document reflections and emerging realisations, and discuss findings that inform a set of interaction parameters for designing the material prototypes. I provide an in-depth description of 19 material prototypes, highlighting their intended interactions, materials, and functional characteristics. This chapter focuses on the first half of project 1, featuring the design development of material prototypes which will be used as research prompts to investigate how materials and kinetic properties of textiles can support stress reduction.

Chapter 4 - Material Prototype Study (Project 1, Part B)

In Chapter 4, I present an explorative, participatory design study with the material prototypes as research prompts to investigate (1) how participants self-regulate the release of stress from their upper body, (2) what and how form factors, materials, and movement qualities of the prototype affect the participants' felt experiences of stress release. A total of 10 design studies were conducted with adults who have chronic experiences with stress-induced tension. Through a series of semi-structured interviews, prototype explorations, reflective breathing exercises, and body mapping activities, I examine and discuss the key findings to reveal two main themes: prototype interactions that support felt experiences of stress release, and the use of breath + movement to support design for self-regulation. These somatic and affective insights are used to formulate design concepts and aesthetic qualities to support the design of functional tactile prototypes. This chapter focuses on the second half of project 1, a design inquiry with material prototypes to identify visual, tactile, and functional qualities that can support the use of breathing and movement to promote relaxation and stress relieve.

Chapter 5 - Functional Tactile Prototypes: Bloom, Mice, Pleats (Project 2)

In Chapter 5, I present the second project in this thesis based on the Somaesthetic Framework of Touch, detailing the concept development, design formation, materiality, and interaction semantics of three functional tactile prototypes: Bloom, Mice, and Pleats. Project 1 identified visual, tactile, and functional properties that have potential to support for relaxation responses. Project 2 integrates these elements into kinetic feedback to explore how it can evoke a sense of stress release. 7 conversational interviews were conducted to gather information on what functional tactile elements can resemble breathing and posture, and afford natural mapping to the states of stress and relaxation. Guided by the *4 Themes of the Somaesthetics of Touch,* I reflect on (1) Connecting with the Felt-Experiences of Stress and Relaxation, (2) Poetics of Breath and Body Movement, (3) Materials for Relaxation Responses, and (4) Kinetic Feedback towards Stress Release and Self-Regulation and discuss key findings focusing on spatial, conceptual, behavioural similarities between material, the inner felt state, and interactions of tension and relaxation. I also highlight challenges and difficulties in the design and experiential process. I specify design concepts, and visual, tactile, and functional elements that will be further refined and developed into on-body soft wearable design prototypes. This chapter presents design-research from Project 2 to provide insight on how to translate visual, tactile, functional properties onto a wearable design to support a wearer to self-regulate the release of bodily stress.

Chapter 6 - Wearable Soft Prototypes: Noeme 1.0 & Noeme 2.0 (Project 3)

In Chapter 6, I present the third project of this thesis to understand how kinetic expressions can be displayed on the upper body to evoke the release of stress through two high-fidelity soft wearable prototypes. I describe the design principles, crafting + development process using soft and technical materials, and interaction semantics of Noeme 1.0 and Noeme 2.0 using an adapted *Somaesthetics Framework of Touch*. 6 conversational interviews were conducted based on the *Somaesthetic Design Framework of Touch* to gather insights from participants' kinaesthetic experiences when interacting with Noeme 1.0 and 2.0. I discuss key findings to highlight the similarities and differences of visual, tactile, and functional elements between the functional tactile prototypes and the upper-body soft wearable prototypes. I also reflect on the challenges and difficulties in the design and experiential process of this project. This chapter presents the design-research and development of two upper-body-based soft wearable prototypes that support potential wearers for better attunement to their breathing and posture for relaxation and feeling of stress release.

Chapter 7 - Discussions and Future Work

In Chapter 7, I conclude my thesis with an overview of my research-through-design, summarizing my research goals, key findings, and contributions to self-regulation design and the HCI community. I reflect on my four studies and three projects to reveal limitations that might hinder my analysis and prototype development. I discuss design implications and opportunities for further refinement and potential applications of my work.

Chapter 2.

Research Scope and Literature Review

Chapter 2 Overview

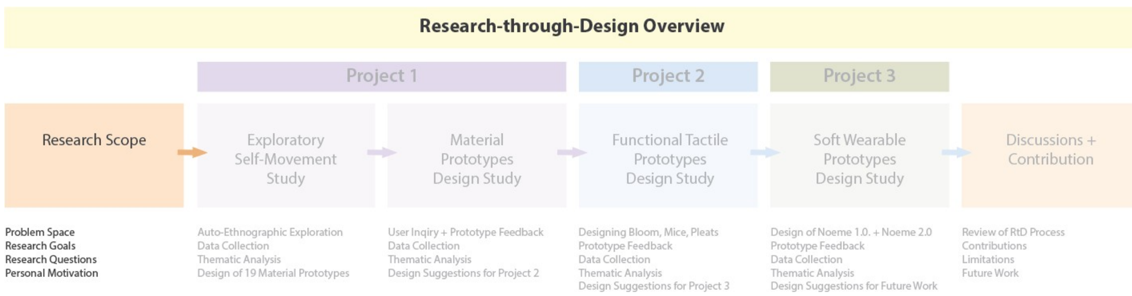

Figure 2.1. Chapter 2 Research Scope and Literature Review.

Chapter 2 presents my personal motivation and literature reviews that form the theoretical foundation of my research-through-design thesis. This chapter is presented in 5 sections. Section 2.1 introduces my personal motivation which was precipitated by a painful jaw realignment experience that provided personal experience, revealing the challenges of accessing and articulating my own felt experiences of tension. In Section 2.2, I extend my conversations from ***Chapter 1.1.1 Self-Regulation of Stress*** to discuss the application of breath and muscle relaxation as design materials that incite and inspire the design and development of my prototypes. In Section 2.3 I explore how existing tangible interfaces and mobile applications may overlook the applications of kinaesthetic feedback in supporting chronic tension in regulating stress on the body, and how the use of kinaesthetic feedback as an underexplored design strategy has potential for developing participants' awareness and empathy towards stress. In Section 2.4, extending my review in ***Chapter 1.1.1 Self-Regulation of Stress***, I elaborate on the use of design materials including kinetic movement and kinetic textiles to support the design of kinaesthetic feedback. Lastly, in Section 2.5, I discuss and explore the use of a somatic approach that considers the experiential and technical processes in the development of my prototype designs.

2.1. Personal Motivation that Impacted my Research Topic: My 2 Year Jaw Realignment Journey

The desire to pursue research that can support individuals' access to and articulate of their felt experiences of stress reduction through self-regulation was precipitated by a lengthy and physically uncomfortable medical procedure requiring my jaw to be realigned over a two-year period. This procedure resulted in a longitudinal set of experiences in which I was challenged to convey my symptoms during this period. My most momentous personal challenges stemmed from my own feelings of ineptitude in connecting with and consequently conveying my symptoms during this two-year jaw realignment treatment. Symptoms are lived experiences associated with the changes in body function, while signs are empirical, objective indicators of body function (Wefel, 2003). I often encountered difficulties in accurately characterizing my felt sensations of joint pain and muscle soreness from my jaw splints with the physician. Specifically, during the bi-weekly medical pre-assessments and evaluations, it was a common occurrence to be misunderstood in my conversations with the physician, as I lacked the words to report the level of pain, the type of muscle tension and how the tightness and pain traveled along my body at any particular time. I also felt misrepresented from the pain ratings and diagram charts as they were unable to capture the fluidity and intensity of my muscle tension and soreness and their radiation to other parts of the body. The inability to obtain an accurate representation of my symptoms led to a trial-and-error process when determining suitable treatment strategies for my diagnosed condition. As a result, there were many sessions of inadequate physical therapy, over reliance on relaxer injections, and persistent tensions during the prolonged recovery time. At times, the tensions accumulated to pain and numbness across my face, hindering my conversations and eating. During the period of my jaw realignment, I lost close to 20 pounds, which was 16% of my initial body weight.

While my story is unique, the challenge to assess and articulate one's symptoms is not. Clinical researchers have recognized the discrepancies that exist between patient and physicians' understanding of similar symptoms (Wefel, 2003; Olson et al, 2010, Bhimani, 2016). Bhimani et al. elaborated through her research on symptom experiences with muscle tension, that a lack of conceptual clarity on a symptom between the clinician and patient can have detrimental impacts on patients' overall wellbeing and quality of life (Bhimani et al, 2016). The inability to accurately describe my symptoms also led to lapses in my own embodied connection with my affective and somatic state. As a designer who is entrained to look for ways to make things better, especially through experience, I sought and explored ways during my treatment process to better represent the dynamic quality of my symptoms by making adapted drawings and annotations on the scales and diagrams. However, the process of abstracting temporal and spatial qualities of my felt-sensations into static representations ultimately led to a disconnect from my own felt-senses of tension and pain, where the nuances of my kinaesthetic experiences were disregarded.

While there were challenges to assess and communicate my felt-sensations through paper charts and diagrams, there were two instances when I was able to connect and articulate parts of my symptoms with the physician. The first instance included the use of movement and gestures to show the direction and intensity of my jaw tension. The use of gestures and movement helped to express the temporal and spatial aspects of my tension, at which point my doctor was able to perceive and provide an appropriate suggestion to address my symptoms. The second instance included the use of a physical model in conjunction with physical movements. Through demonstrating the translation of the jaw joint, I was able to better understand why I was still feeling the tension. My jaw realignment journey served as the initial point of inspiration for my research interest. Reflecting upon my jaw realignment journey and the problem of stress-induced tension contributed to my current interest on self-regulation for stress-release. With the potential to utilize the rich communicative qualities of physical movement, I am interested in further exploring the use of kinetic movement to support participant users to access and articulate their felt-sensations of stress-release. In the next sections, I will discuss research that supports the use of kinetic movement as a feedback modality can be used for self-regulation for stress-release.

2.2. Self-Regulation through Breathing and Muscle Relaxation to Reduce and Manage Stress

Self-regulation of stress is the ability to recognize and shift one’s focus and feelings to manage stress and self-cultivate for relaxation. In addition to the somatic approaches and projects mentioned in ***Chapter 1.1.1 Self-Regulation of Stress***, I elaborate on the use of breath and muscle as design elements as inspiration towards the design and development of soft material prototypes.

In self-regulation, breathing techniques are simple and accessible tools to implement for stress reduction and relaxation exercises. They can be applied to maintain a balance with the autonomic nervous system, and entrained to be adaptable to stress to help minimize its negative impacts on one's health (Jerath et al, 2015). Through self-regulation, we can develop bodily awareness of our breath, which is also known as mindful breathing. Zhu et al. (2017) characterized this breathing as "deep and conscious". The use of deep breathing, also known as diaphragmatic breathing, engages the contraction of the diaphragm muscle. The practice of deep breathing can stimulate for relaxation responses and is widely adopted in complementary and alternative medicine (Ma et. al, 2017). Karlesky et al. (2016) highlighted that breathing can be controlled voluntarily or involuntarily, and can influence both affective and cognitive states of a person. Homma et.al (2008) further highlighted the connection between breathing patterns and emotions, indicating a person's emotional change can greatly alter his/her respiratory rate.

When engaging in progressive muscle relaxation, groups of muscles are progressively selected, tensed and relaxed in conjunction with deep breathing (Healthwise Staff, 2017). Research highlighted a strong correlation between muscle tension, emotions, and body posture (Anxiety Canada, n.d.). Posture, how the body is aligned, can correlate with a person's inner affective state. Karlesky et. al (2010) indicated "stretching, standing, slouching, and light calisthenics, yawning present opportunities for HCI self-regulation design."

2.3. The Gap: Lack of Kinaesthetic Feedback for Awareness and Empathy Towards Stress on Body

Kinaesthetic awareness is defined as the perception of your body's position and movement (Candau et al., 2018), which allows a person to feel situated and connected within a space. Sensing and perceiving are interconnected.

> "Sensing is the mechanical aspect involving stimulation of sensory receptors and sensory nerves, while Perceiving is one's personal relationship to the incoming information." (Cohen, 1993)

Cohen (1993) elaborated that while we may have similar senses, our perceptions are unique. Understanding the relationship between sensing and perceiving helps to frame and guide my sensibility within the exploration, development, and reflection of soft material prototypes within my Research-through-Design process. Kinaesthetic empathy is the ability to understand and respond to another's felt-experience through body movement sensing (Fischman, 2015; Jerak, 2018). In the context of this thesis, the skills for awareness and empathy can support greater somatic awareness for self-regulation of stress.

With the diverse sensing capabilities of commercialized tangible interfaces and mobile applications, the feedback modality is primarily limited to on screen data visualizations[1], light notifications[2], auditory sound effects[3], and vibro-tactile stimuli[4]. While the aforementioned tools and applications can support self-regulation for stress reduction, they may not resonate with individuals who have chronic muscle tension and pain, as they are often unable to perceive and sense their bodies accurately (Williamson, 2007; Flor, 1992). In Somatic terms, this condition is referred to as sensory-motor amnesia (S-MA) (Hanna, 1991), or kinaesthetic dysfunction (Williamson, 2007). Somatic educators explained a person's kinesthetic sense, or muscle sense, can lessen and become skewed due to chronic tension, poor body alignment, pain, injury, and stress (Hanna, 1992, Williamson, 2007). Hanna (1992) further indicated that S-MA is interrelated with most illnesses, therefore everyone's kinaesthetic senses are affected to some degree. When an individual with chronic tension from stress cannot sense whether their muscles are relaxed, tensed, or exerted, their ability to intuitively activate their body to practice progressive muscle relaxation and deep breathing is compromised. Williamson (2007) also described engaging muscle activity through an impeded kinaesthetic awareness can lead to further strains, which can accumulate to pain.

To address S-MA and restore the ability to sense the body, Hanna (2012) suggested the practice of somatic learning, the engagement of self-awareness through touch and movement, to recondition and rehabilitate the soma. This process redirects the individual's awareness to the affected body area to reinvigorate the lost connection, allowing the body to regain sensory feedback, and restore movement. Similarly, Cohen (1993) also advocated the connection between touch and movement as a fundamental

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[1] Spire Stone, Bellabeat Leaf Urban, Fitbit Iconic, Garmin Vivosport, Apple Watch Series 3, Pip, Caeden Sona Bracelet, Headspace App

[2] Vivosport, Fitbit Iconic, Emvio

[3] Muse, Headspace App

[4] Thync Vibe, Lief

part of how we sense our body. Thus, using touch and movement for a tactile-kinaesthetic experience holds potential for users to access and understand their felt-sensations of stress.

The tactile-kinaesthetic feedback has also been used within physical therapy and performance training to facilitate movement patterning (Carr et al., 2008). Studies have shown the application of tactile-kinaesthetic stimulation can support attention and muscle function and movements, which incite calmness, muscle tension, and regulate breathing (Field et.al., 1986). For training and skills development, the use of visual-kinaesthetic feedback can support kinaesthetic memory, where one is able to recall the movements and positions of the body for task completion (Pizon et al, 2016). In the design for haptic interfaces, Pérez et al. (2016) advocated the use of a combined kinaesthetic and tactile system for a more realistic and immersive interaction experience. The observations across different disciplines propose the value of using kinaesthetic feedback to engage and develop the body for self-regulation. Although kinaesthetic feedback can improve somatic awareness for well-being, its use for self-regulation of stress is currently underexplored. This creates a gap, revealing a design-research opportunity to leverage the use of touch and movement for a tactile-kinaesthetic experience that supports for self-regulation of stress.

2.4. My Approach: Translating Rich Communicative Qualities of Movement to Kinetic Textile-Based Expressions to Access and Articulate Felt Experience of Stress

2.4.1. Movement for Kinaesthetic Awareness

Movement is not only functional, but expressive. It becomes a living narrative by presenting the expression of the mind through the body. Cohen (1993) highlighted that qualities of movement is a reflection on how the mind is situated within the space. Cohen expressed that a symbiotic relationship exists between movement and mind, where a change in one can initiate a shift in the other. In Loke's discussion on movement (Loke, 2009), she acknowledged Merleau-Ponty's assertion that the moving body is influential in acts of perception within his *Phenomenology of Perception*, while highlighted the concept of kinaesthetic sense and its importance to perceiving our own movement. These observations are critical and even profound for this thesis, as movement can be used to affect a user's kinaesthetic understanding of their stress and relaxation experiences.

Within HCI, many researchers in movement-based interactions have explored concepts related to the moving body. In particular, Hummels et al. (2007) highlighted the meanings generated from interaction is applicable for users and also for the designer in their design-research process. Klemmer et al. (2006) presented aspects of embodied engagement that can inspire for new ways to shape human experiences across digital and tangible mediums. Fogtmann et al. (2008) introduced a conceptual framework to harness the bodily potential for designing new kinaesthetic experiences. Schiphorst and DiPaola's collaboration with Cuykendall (2016) showcased an interactive system that translates the kinaesthetic experience of movement into expressive poems. The explorations on movement in the design process, across new interactive experiences in tangible and digital mediums, and use as computational poetics have also expressed potentials and values of the moving body to facilitate meaningful experiences.

Inspired by Cohen's *Body Mind Centering* (Cohen, 1993), the experience between the wearer and prototype design should focus on facilitating a process of dialogue between how the wearer can access and how they can articulate their felt-experiences of stress and relaxation. When we use movement to design for the experience and not for the interaction, we emphasize on the notion of expressivity and the meaning behind movement qualities. Moen (2007) further motivated the importance to consider how the movement qualities may influence the users' experience. Thus, with my prototype designs, users review the movement qualities to reflect on the somatic and affective dimensions of their felt-sensations to stress and relaxation.

2.4.2. Kinetic Textiles

Kinetic materials have an ability to change in form over time, thus share the same considerations as physical movement, in that their spatial and temporal dimensions can appeal to the human kinaesthetic cues. Bengisu et al. (2015) explained the use of kinetic materials can affect the user experience as they change the way we sense and perceive digital interactions. Thus, for my thesis, the use of kinetic, textile-based expressions presented a space where users can explore their lived experience through touch and movement. The inclusion of kinetic expressions through textiles offer a new but familiar way for interaction. Textiles can behave in a variety of ways based on its structure, fluidity, ornamentation, expansion, and compression (Baugh, 2011), and the process to design the textiles are driven by "emotive, haptic, sensorial, and tactile properties" (Valentine et al., 2017). Their functions and forms are culturally laden. O'Mahony (2011) and Tomico (2015) both described that textiles and the wearer can establish an intimate relationship as they are in close contact with the skin, the largest sensory organ. Tomico (2015) further elaborated that the use of fabrics in wearable designs offer soft qualities of interaction which ridgid gadget-based wearables are unable to. When coupled with technologies, smart textile materials can generate a new product and form new user behaviours, bringing a new perspective or opportunity for users to understanding unfamiliar and complex concepts (Berglin, 2005). Schiphorst's *exhale* allowed the wearers to map and share their breath data with others through shifting their attention, awareness, and body state (Schiphorst, 2006). *Breath with Touch*, using tactile touch, allowed participants to develop a natural mapping to the kinetic-tactile interface, prompting for intuitive breathing for relaxation (Yu et al., 2015). In my thesis, through kinetic textile-based expressions on a soft wearable design, it provides users a new way to understand their breathing and body movements when experiencing stress and relaxation.

2.5. A Somatic Approach to Materiality and Somaesthetics of Touch: Bridging the Experiential and Technical Process of Soft Wearable Design

Tomico (2016) situated soft wearables between the design of garments and products. He highlighted five considerations: *material, the moving body, context, form,* and *function* towards designing experiential soft wearables (Tomico, 2016). My thesis explores how I engage the moving body as a material towards a soft wearable design for self-regulation. A somatic approach can encourage one to access and articulate their felt sensations through a process of self-inquiry. When applied as a design approach, it provides an experiential opportunity for the designer to empathize and design better for the potential wearer (Loke et al, 2018). Nunez-Pacheco and Loke highlighted the ability to access and manage our inner felt-state, and emphasized the consideration of somatic awareness and self-cultivation for designing wearables for well-being (Nunez-Pacheco et et al., 2014). Through a soft wearable design for self-regulation, I create an intimate space that facilitates bodily self-awareness for wearers to develop an attunement with their body and emotions. With an embodied understanding of their affective and somatic states to stress, the wearer can choose the appropriate body mechanism for self-regulation to release stress. Gendlin introduces the practice of *Focusing*, to access the implicit, tacit dimensions of our lived experiences to formulate *felt senses*, a bodily awareness (Gendlin, 1999; 1992). The developed bodily awareness are rich materials that can inform the design of metaphors, which when integrated into the visual, tactile, and functional properties of materials, can bring the implicit explicit. To guide my exploration for metaphors, I was inspired by the concept of "knowing bodies", which uses movement as a way to reconnect ourselves with our body in the design-research process (Wilde et al, 2011). By *designing through movement* (Wilde et al, 2011), my research-through-design thesis engages in movement exploration, active touch, and the practice of making to gather somatic and affective qualities of tactile-kinaesthetic experiences. Tomico (2016) elaborated the exploration and crafting process as "designing for the senses through the senses", which can reveal new interaction opportunities for multi-sensory experiences.

A Practical Somaesthetic Design Exploration

Shusterman (2008) defines *Somaesthetics* as the use of our living body for aesthetics appreciation. Höök (2015) further elaborates Shusterman's emphasis on how our bodily movements are reflections of who we are and how we think, therefore it is important to understand our attitudes that underlie our interactions and meaning-making process. In Human Computer Interaction, somaesthetic research explores how we can understand our somatic experience to improve the quality of how we perceive, respond and present through our body (Shusterman, 2013).

Embedding practical somaesthetics within soft wearable designs for self-regulation is valuable as it emphasizes on the cultivation of bodily awareness during self-inquiry. For this thesis, my work engages in practical somaesthetics through a design and development of soft material prototypes that focuses on improving one's ability to access and articulate their felt-sensations for stress-release.

Schiphorst (2009) further advocates the use of somaesthetics to foreground the quality of our attention and awareness, which can incite for self-reflection to an experience through technology. *soft(n)* (Schiphorst, 2009) and *tendrils* (Schiphorst et al, 2010) are two of Schiphort's work that engages through the somaesthetic approach through her

Somaesthetic Framework of Touch (2009). This framework supports the application of practical somaesthetics to designing quality of the interaction experience that considers how soft circuit technology is integrated with soft materials.

To reveal insights for designing expressive qualities in tactile-kinaesthetic interaction, Schiphorst's *Somaesthetics of Touch Framework* (2009) guides the design, development, and analysis process for the functional tactile prototypes and soft wearable designs in this thesis through the four themes of *self-experience*, *poetics of interaction*, *materiality*, and *interaction semantics*. For this thesis, the themes are adapted to consider the (1) Felt-Experiences of Stress and Relaxation, (2) Poetics of Breathing and Body Movement, (3) Materials for Relaxation Responses, and (4) Kinetic Feedback towards Stress-Release.

2.6. Chapter Two Summary

In this chapter, I reflected on the challenge to access and articulate my felt experiences of tension, examined the application of breath and muscle relaxation for regulating stress, and highlighted the use of kinaesthetic feedback as a design strategy for developing self-awareness and empathy towards stress. This background literature review synthesized key information to reveal a design opportunity to use kinetic feedback modality to engage users' kinaesthetic cues to connect and convey their felt experiences for releasing stress. Before I can explore the potential values and experiences of kinetic feedback modality to self-regulate for relaxation and the release of physical stress, I will need to determine the visual, tactile, and functional properties of materials that afford relaxation responses for the design of kinetic feedback. In the next chapter, I will describe the initial stages of my Project 1, where I engaged in an auto-ethnographic pilot study through two design activities to gather insight towards the design of textile-based material prototypes that support the experience of self-regulation for relaxation. This stage is important for me, as a design-researcher to develop my kinaesthetic awareness during my design-research process and foster greater empathy with my research participants when describing their own experiences of self-regulating stress.

Chapter 3.

Exploratory Self-Movement Pilot Study and Design of Material Prototypes (Project 1, Part A)

Chapter 3 Overview

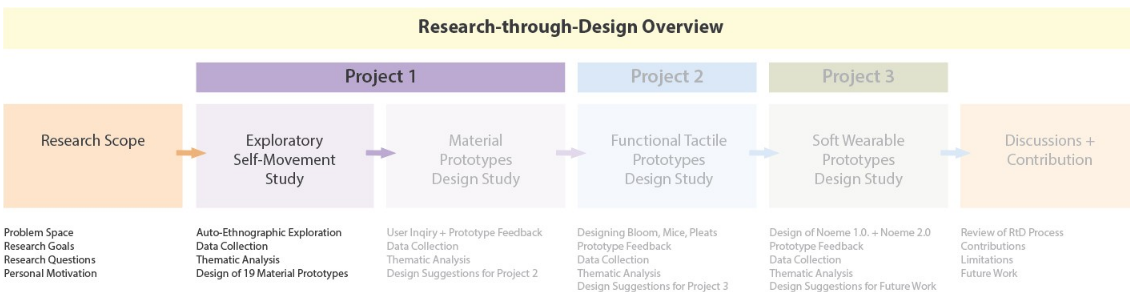


Figure 3.1. Chapter 3 focuses on the exploratory self-movement study and the design of the 19 material prototypes.

In this chapter, I present an Exploratory Self-Movement Pilot Study which includes the design of a series of material prototypes that make up the initial stages of Project 1 (Figure 3.1). Project 1 is the first of three iterative projects in this Research through Design (RtD) thesis. This chapter documents an auto-ethnographic exploration through two personal researcher design activities. The purpose of these explorations is to inform the design of textile-based prototypes that support the experience of self-regulating relaxation of stress-release. In these exercises, the design-researcher focused on how the features of shape, material properties and kinetic movement of the textile prototypes could support self-regulation. As a result of the two design activities that inquired into the design-researcher's experience of her somatic and affective responses to self-regulation of stress and relaxation, nineteen (19) material prototypes were developed. In the following **Chapter 4**, the nineteen (19) material prototypes will be used as research prompts with a group of ten participants to identify the visual, tactile, and functional properties of materials that can release stress and support relaxation. In this chapter, a reflection of this autoethnographic RtD is presented, highlighting the rationale for conducting this exploratory self-movement study along with two personal design activities. The two autoethnographic personal design studies were guided by two supporting questions (Figure 3.2): (1) What are the shapes, materials, and moving features of textiles that can alleviate stress, and, (2) How do I, the design-researcher, move my own body to activate relaxation and release stress without additional digital mediation?

These two personal design activities are: 1. A 15-minute self-movement exploration exercise, and, 2. A researcher journal activity conducted over a 3-day period. The collected movement data was examined according to *Laban's Eight Effort Qualities* (Schiphorst, 2009), and the researcher's journal was analyzed through thematic analysis.

In this chapter, I discuss and present 4 key design considerations that were utilized in the design and development of the 19 material prototypes. I present the rationale for engaging in an autoethnographic exploration to initiate my Research-through-Design thesis. I present and rationalize the use of the two design activities in this exploratory pilot study, describe each design activity, discuss my analysis, and present the four (4) key design considerations that inform the 19 material prototypes. This chapter concludes with a description of each prototype, noting their visual, tactile, functional properties and the potential intended interactions that can support self-regulation for relaxation and physical stress-release.

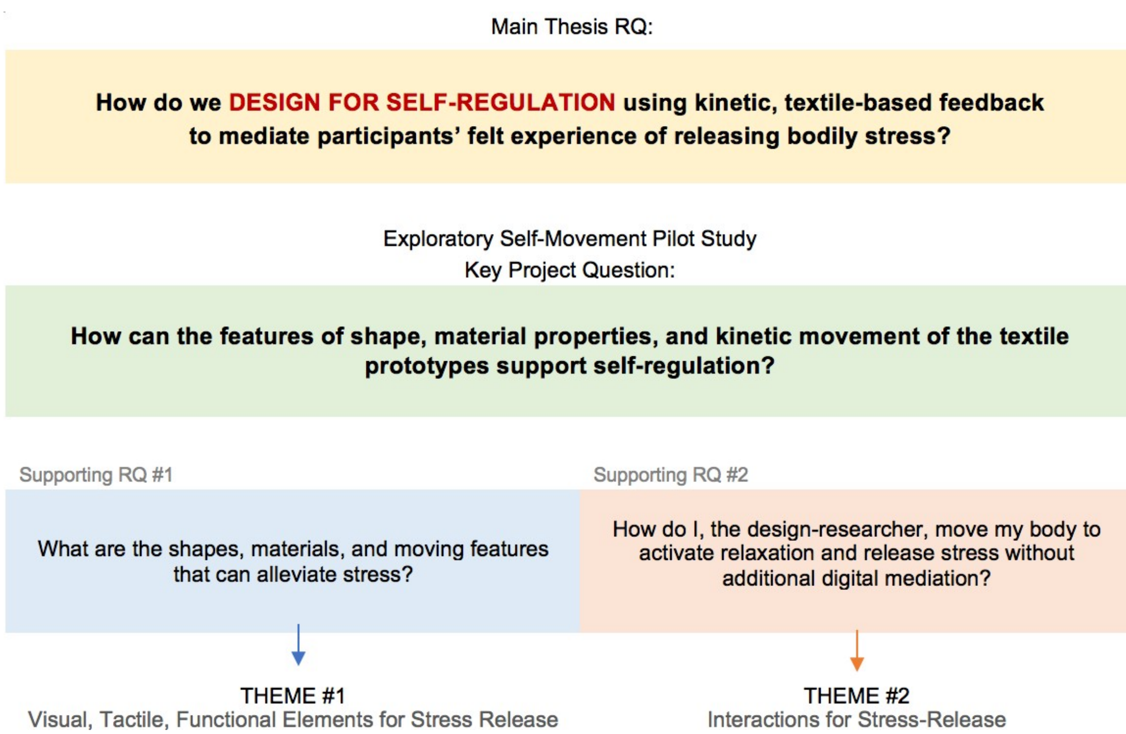


Figure 3.2. Exploratory Self-Movement Pilot Study Questions and Themes.

3.1. A Research-Through-Design

This exploratory self-movement study was conducted to allow me, the design-researcher to engage in the practice of reflexivity in the early stages of my research-through-design thesis. Mills et al. (2010) highlighted the practice of reflexivity to support a researcher in developing greater self-awareness on how their own assumptions and preconceptions may impact all stages of their research. With an emphasis on somatic and material considerations in my research-through-design, it was crucial for me as a design researcher to develop a cognizance of my attitudes in how I perceive my own bodily experiences in relation to the research objectives. The two personal design activities act as spaces to engage in my own subjective experiencing and reflections on existing and past experiences with relaxation and physical stress-release. Using an autoethnographic approach to movement exploration, I referenced Núñez-Pacheco et al.'s focusing approach (2015) to find inspiration from my felt-senses of stress and relaxation towards selecting materials that can enhance greater somatic awareness for self-regulation.

3.1.1. Researcher's Journal

Nadin et al. (2006) highlighted the use of a research diary as a way to create spaces for reflexivity. The use of annotations in a portfolio can reflect how recorded artifacts are situated in the design space to inspire for possible design and research opportunities (Gaver et al., 2012). Inspired by Núñez-Pacheco et al.'s emphasis on the bodily experience in autoethnographic exploration (2015), the initial 3-day researcher's journal provided a space to gather contextual relations, body reflections, and emerging realisations of my felt-senses to stress and relaxation with materials in the context of my everyday life. The use of a researcher's journal allowed me to collect data beyond a single lab session or interview. The ability to iteratively update and make amendments during my journal activity, through the process of writing texts, drawing physical connections with tangible materials reflect the fluid and on-going changes to how material, the body, and the context are inter-connected.

3.1.2. Movement Exploration Exercise

The Movement Exploration Exercise took initial inspiration from Anxiety Canada's self-help strategy guide (Anxiety Canada, n.d.) to support my reflection process to understand how my body feels during self-regulation for relaxation to reduce physical stress. The strategy guide's emphasis on bodily awareness and explorations aligned with Gendlin's focusing technique (Gendlin, 1999). Núñez-Pacheco et al. (2015) also motivated the use of focusing as a self-practice to reveal tacit bodily knowledge. Adapting this approach in my Movement Exploration Exercise, I utilized a think-aloud to describe my process in finding coherence between my bodily perception and sensation to relaxation and stress.

With the study, I engaged in using *Laban's Eight Efforts* (Schiphorst, 2009) to evaluate my body movements. This process allowed me to review and reflect on the underlying intentions of my movements, which provided insight towards how my affective and somatic state can impact my tactile-kinaesthetic understanding to stress and relaxation. This strategy helped to develop my kinaesthetic awareness to better connect with the analysis process, the design development of the material prototypes and also increased my kinaesthetic empathy with my participants during the subsequent design studies.

3.2. Procedure

3.2.1. Description of Design Activities

To gather my affective and somatic responses to felt-experiences of stress, I conducted two design activities.

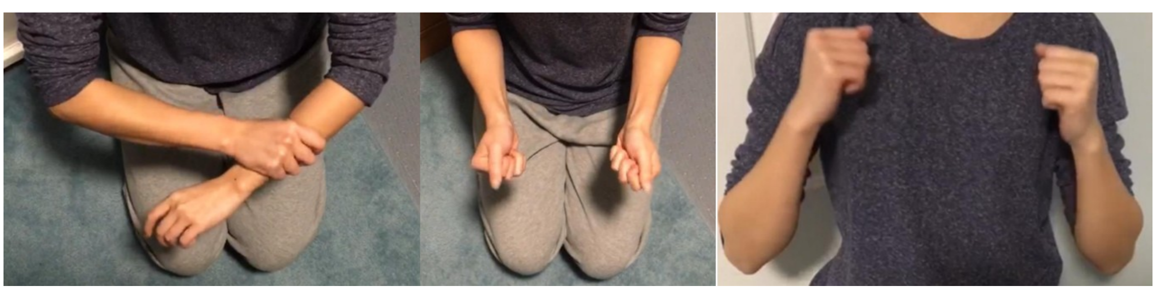


Figure 3.3. Screen Captures - Video-recording of Self-Movement Exploration

Activity One was a 10-minute movement exploration exercise (Figure 3.3) that was video-recorded. For this exploration exercise, I utilised a focusing approach (Núñez-Pacheco et al., 2015) to perform a think-aloud, movement process toward a scenario question *“How do I engage my body when I feel stressed?”*. The exploration exercise was conducted in an enclosed office room at my own residence.

Activity Two was a 3-day process in which I created a researcher’s journal (Gaver et al., 2012) that noted materials, objects, interactions in everyday surroundings that could help me reflect upon how i personally physically relax my body or how I personally sense and/or feel a sense of relaxation and/or stress-release. Using a focusing approach (Núñez-Pacheco et al., 2015), the diary (Figure 3.4) collected quick notes, materials, sketches, and pictures that emphasized on my felt-sensations with the objects or experience of my own body.

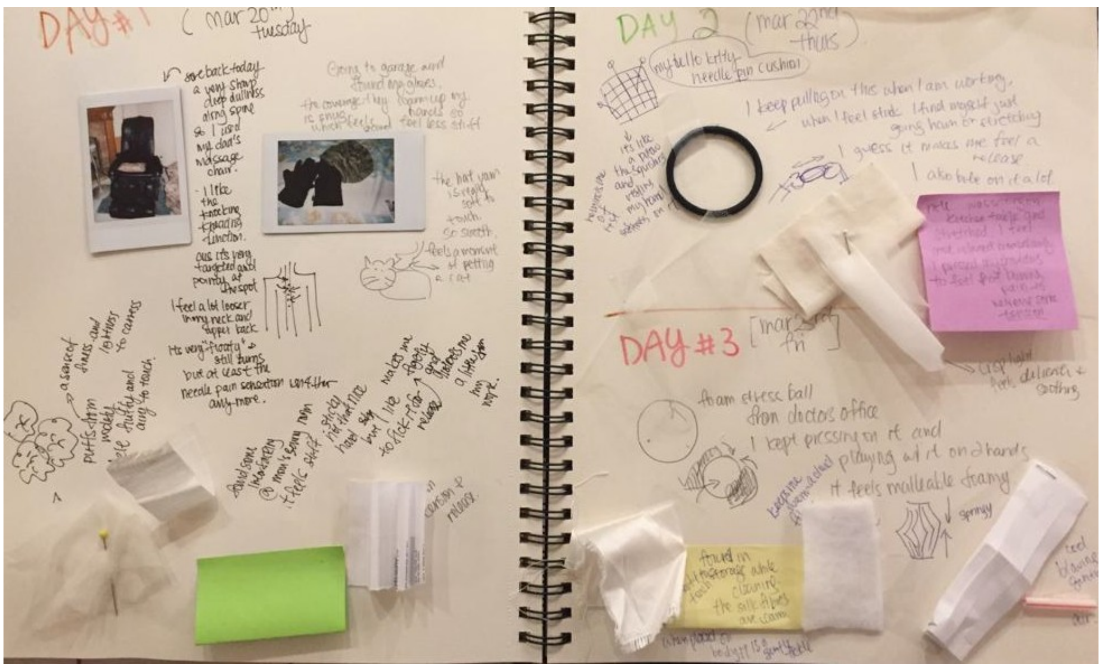


Figure 3.4. Snapshot of 3-day researcher's journal in progress.

3.3. Analysis

The exploratory, self-movement study explored ways to abstract my own movement and my interaction with the kinetic movement of textile objects to inform the designs of shaping material properties, selecting material properties and moving material features of a textile-based form to invoke or suggest physical body relaxation or stress-release. Using two personal design activities, I examined: 1) shapes, materials, and moving features of textiles that can alleviate stress, and 2) how I move my own body to activate relaxation and release stress without additional external mediation. During the personal movement exploration exercise, I conducted a video analysis of my own movement using *Laban's Effort Qualities* (Tsachor et al., 2017; Subyen et al., 2011; Schiphorst, 2009) to characterize my somatic responses in a clear, understandable and natural manner. I applied a thematic analysis with the data set sourced from text, video, drawings and materials. My experiential data from the two personal designer activities were intended to be exploratory and suggestive. It is important to acknowledge and note the findings were generated through an iterative analysis and interpretation process that included reflections of my past experiences with self-regulation for relaxation and stress-release.

3.3.1. Findings and Discussion

Video Analysis

From the video analysis, I identified four main actions on 3 parts of the upper body (Table 3.1). The observed actions include: squeezing and pressing on the forearms, pressing fingers and palms together, loosening wrist, and flailing the arms and hands.

Through my process of squeezing and pressing onto my forearms, my arms most aligned with the effort quality of "Press", which is direct in direction, sustained in speed, strong in weight, and bounded in flow. I observed that my upper arms and shoulders tend to be sorer than my forearms as my "Presses" are relatively more emphasized. The pressing of fingers and palms together was also characterized with "Press". When describing (1) the squeezing and pressing on the forearms, and (2) pressing fingers and palms together, I referred to them as "acts of massage".

With loosening of my wrist, this movement most aligned with the effort quality of "Wring", which is indirect in direction, sustained in speed, strong in weight, and bound in flow. I also observed the practice of flailing my arms and hands, which most aligned with the effort quality of "Flick", which is indirect in direction, sudden in speed, light in weight, and free in flow.

		The Four Components			
Observed Actions from Movement Exercise	Effort Quality	Direction	Speed	Weight	Flow
• Squeezing & pressing on the forearms/ shoulders, pressing fingers and palms together	Press	Direct	Sustained	Strong	Bound
• Loosening wrist	Wring	Indirect	Sustained	Strong	Bound
• Flailing the arms & hands	Flick	Indirect	Sudden	Light	Free

Table 3.1. Describing the Observed Actions through Laban's Effort Qualities

Materials of cotton yarn, silk organza, polyester tulle, silk chiffon, natural cotton, polyester felt, dupioni silk, were selected for their softness. In particular, for silk organza and dupioni silk were noted for their smooth and crisp texture. I described the tactile experiences to be soothing and calming. Polyester felt was associated with warmth and insulative quality. All the textiles in the diary were either in white or shades of off-white.

Interactions for Relaxation

Caress and rubbing were used to describe the act of touch with soft textiles. The act of being covered, or being enclosed was associated with feelings of security and warmth. As well, the interaction of squeezing, pressing, and pulling inward on objects, where a force was applied to feel a sense of release was mentioned.

Movements of Compression and Expansion

Objects such as cushions, accordion pleats, stress balls, that can deform through compression and expansion were mentioned in the diary. These items were described with the ability to absorb the “pressure and provide release”, which provided an affect of stress relief.

Feeling for Release

While most materials were soft, I did include two stiffer materials: Interface and accordion pleated paper strip. These two materials offered a springy, “flick-like” feedback when stroked, resulting in a feeling of quick release, which could infer a release in stress/pressure.

3.4. Discussions

Through video analysis and review of my own movements and reflections from the researcher's diary that explored ways to abstract movement and objects to inform the shape, materials, and moving features of a textile-based form to reduce stress, key findings were revealed in two themes to address (1) What shapes, materials, and moving features of materials and material design can support relaxation for stress-release, and (2) How do I move my body to release stress without considering an external mediating object? And how can my movement inform the design of tactile-based kinetic movement applied to the design of soft-wearable-digitally-mediated-objects?

Interactions for Stress-Release

Four main actions were used to relax and release stress on the upper body, they include: (1) squeezing and pressing on the forearms, (2) pressing of fingers and palms together, (3) loosening wrist, and (4) flailing the arms and hands. Forearms, shoulders, and hands were the three main upper body regions that held and therefore felt stress. This aligned with Núñez-Pacheco et al.'s description that the felt sense is usually perceived from the upper torso (2015). When pressing along my arms to shoulders, the weight of my own presses on the shoulders were greater (heavier) than the ones on my forearms. I recognized that this may be caused by habits of hunching over when I work. When referring to "acts of massage" to release stress, the movements include different combinations of presses and wrings. The massage movements include: rubbing, kneading, and pressing. Rubbing/caressing were also highlighted as an interaction for relaxation in the researcher's journal.

Visual, Tactile, Functional Elements for Relaxation and Stress-Release

Cotton yarn, silk organza, polyester tulle, silk chiffon, natural cotton, polyester felt, dupioni silk are *soft* materials that associate with relaxation. Smooth and crisp textures can afford a soothing and calming tactile experience. Lighter neutral colours are more associated with relaxation. Objects that can absorb pressure and provide a release can infer a feeling of relaxation and stress release. Integrating elements that have more tactile structure to produce a springy, "flick-like" feedback quality when stroked, can result in a feeling of quick release of pressure. This release can be felt as an alleviation of stress.

3.5. Design and Interaction Suggestions for Material Prototypes

Four key findings are proposed to guide the design and development of material prototype. These findings are based on personal auto-ethnographic design activities that engaged the practice of focusing (Núñez-Pacheco et. al, 2015) to foreground the bodily explorations and felt-experiences of self-regulation for relaxation to release physical stress.

Key Finding #1 - The act of massage through pressing, kneading, and rubbing (caress) can be used as interactions for stress-release (Figure 3.5).

Key Finding #2 - Lighter Neutral coloured materials of cotton yarn, silk organza, polyester tulle, silk chiffon, natural cotton, polyester felt, dupioni silk can be used to provide a relaxing visual-tactile experience.

Key Finding #3 - Objects that deform through compression and expansion may be able to incite a feeling of stress-release.

Key Finding #4 - Objects that can express a flick-like response may be able to convey a feeling of quick release in pressure. To create a flick-like quality, consider the movement quality of: indirect (space), light (weight), fast (time), free (flow).

3.6. Overview of Material Prototype Designs

Premised upon the four key findings outlined above, I engaged in a process of developing conceptual and material sketches (Figure 3.5) based on the somatic and affective associations with relaxation and stress that were identified in the two experiential design activities I explored in my researchers' auto-ethnographic study. From this study and its key findings, nineteen (19) material prototypes were created that integrated visual, tactile, and functional elements to support self-regulation for relaxation and stress-release.

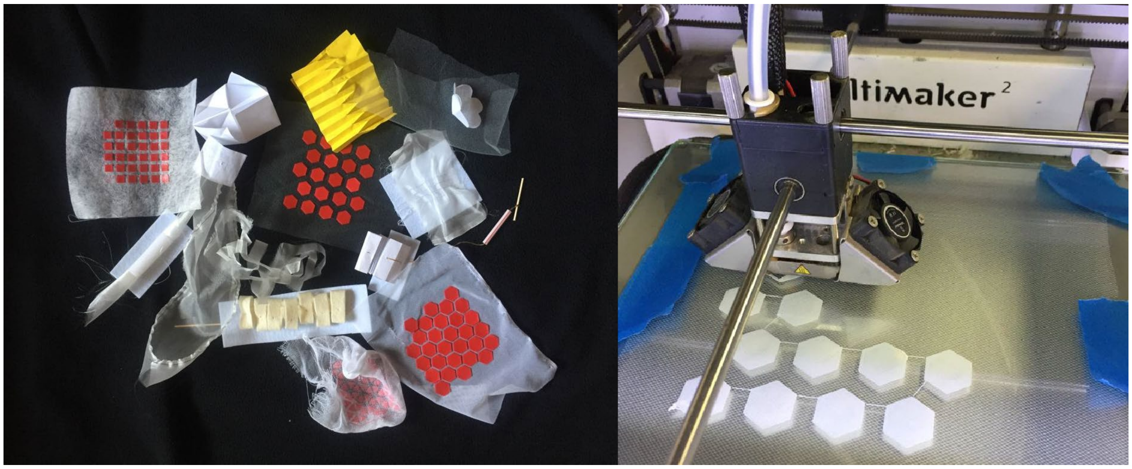


Figure 3.5. (a) Material Sketches and
(b) In-progress 3D test printing on tulle for prototype #12

Wallace et al. (2013) defined design probes as “tools for design and understanding”, and that they should be small-sized, and made to be “gentle, provocative, and creative” to help participants form their responses to a proposed scenario or question. To support for participants’ exploration and reflective responses, the 19 material prototypes were created to be neutral in colours that support relaxation, ordinary to support for familiarity, and evocative in their texture and form for engagement. They are also palm-sized, soft in form with tactile elements that can deform through physical manipulations. The materials for the prototypes were constructed mainly from the textiles recommended in Key Finding #2 in **Chapter 3.3.3.3 Design and Interaction Suggestions for Material Prototypes**.

The material prototypes act as research prompts (Frances et al., 2009, Leech, 2002) to inquire on participants’ felt-experiences of stress and relaxation. Reflecting on the relaxation strategies based on Key Findings # 1,3,4 in **Chapter 3.3.3.3 Design and Interaction Suggestions for Material Prototypes**, I referenced Schiphorst’s *Laban Tactile Modes* (Schiphorst, 2009; Schiphorst et al, 2005) as inspiration to design kinetic properties and materials that can simulate qualities of expansion, compression, and support the acts of massage (rubbing, pressing, kneading) (Figure 3.6).

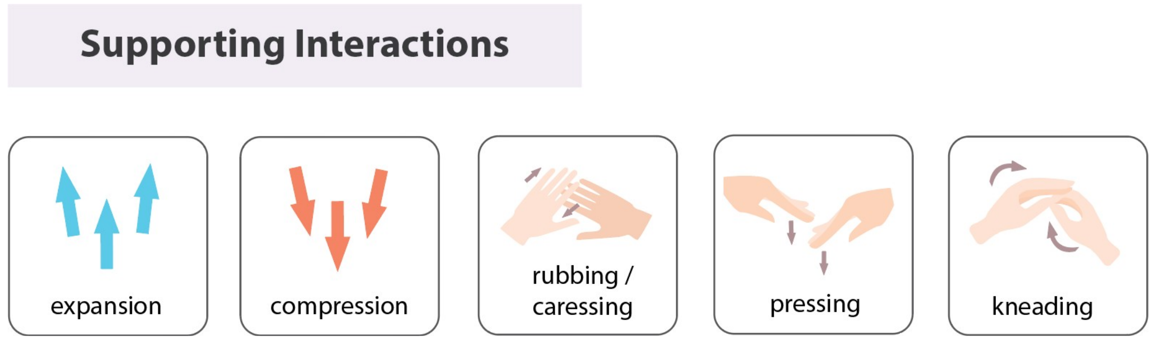


Figure 3.6. Qualities of Interactions for Relaxation and Stress-Release

In the following sections, I provide a visual glossary (Table 3.2) of each prototype design, highlighting their materials (Table 3.3) and supporting interactions for relaxation and stress-release.

Prototypes are organized into sections based on their supporting qualities of interactions.

1. Qualities of expansion and compression (Figure 3.7)
2. Qualities of expansion and compression, with acts of rubbing/caressing and pressing (Figure 3.8)
3. Qualities of expansion and compression, with acts of rubbing/caressing and kneading (Figure 3.8)
4. Qualities of expansion and compression, with acts of rubbing/caressing, kneading, and pressing (Figure 3.9)
5. Acts of rubbing/caressing, kneading, and pressing (Figure 3.9)
6. Acts of rubbing/caressing, and pressing (Figure 3.10)
7. Acts of rubbing/caressing, and kneading (Figure 3.11)
8. Acts of rubbing (Figure 3.11)

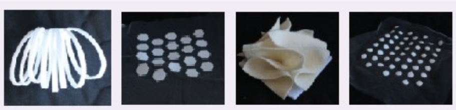
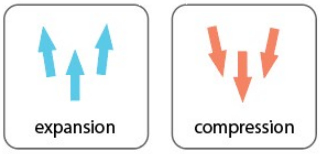
Visual Glossary Overview	
Prototypes	**Qualities of Interaction**
	expansion, compression
	expansion, compression, rubbing / caressing, pressing
	expansion, compression, rubbing / caressing, kneading
	expansion, compression, rubbing / caressing, pressing, kneading
	rubbing / caressing, pressing, kneading
	rubbing / caressing, pressing
	rubbing / caressing, kneading
	kneading

Table 3.2. Visual Glossary of Material Prototypes and their Supporting Interactions.

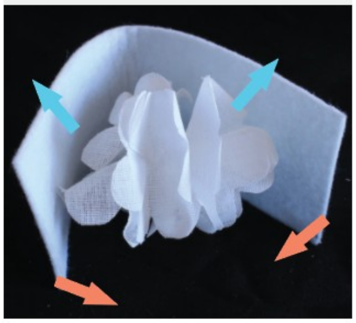
			Supporting Interactions				
#	**Prototype Description**	**Materials**	**Caress/Rub**	**Knead**	**Press**	**Expand**	**Compress**
1	3D printed cylinder on tulle	NinjaFlex 3mm snow filament, polyester tulle	✓		✓		
2	Sharp tubular spine structure	Polyester interface & felt	✓		✓		
3	Pop out floral ball	Polyester interface & felt				✓	✓
4	Accordion fan	Polyester interface & felt				✓	✓
5	Pillow	Polyester felt & filling	✓		✓	✓	✓
6	Soft ridges on felt ringlet	Polyester lining & felt	✓		✓		
7	Stretchy gathering strip	Silk, elastic strip	✓	✓		✓	✓
8	String-pulled flower	Foam, polyester felt, cotton string, wooden dowel				✓	✓
9	Tine strips	Cotton-polyester interface, polyester felt	✓		✓		
10	Circle appliques	Polyester felt	✓	✓			
11	Organza and chiffon puffs	Silk organza & chiffon, polyester felt	✓	✓			
12	3D printed hexagons on tulle	NinjaFlex 3mm snow filament, polyester tulle	✓	✓	✓		
13	Square pin-wheel grouping	Polyester felt	✓	✓	✓		
14	3D printed dots on tulle	NinjaFlex 3mm snow filament, polyester tulle	✓	✓	✓		
15	Multi-ringlet	Polyester felt	✓	✓	✓		
16	Crochet ball	Silk yarn with polyester filling	✓	✓	✓	✓	✓
17	Push & pull strip	Polyester felt, plastic straw, metal wire, tape				✓	✓
18	Glove	Cotton	✓				
19	pleats	Polyester organza, metal wire, polyester felt				✓	✓

Table 3.3. Chart of Material Prototypes with their Material Properties and Supporting Interactions.

Supporting Interactions

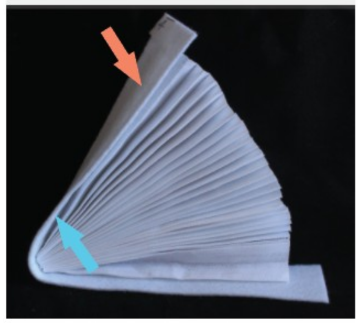


Prototype # 3
Pop out Floral Ball



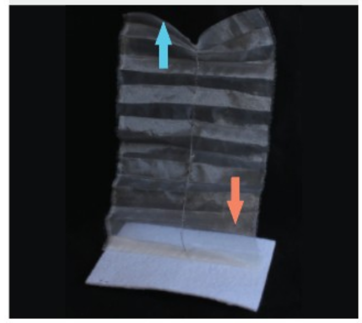
- Floral element made from polyester interfacing, outer flaps made from polyester felt
- Pops in and out when side flaps are pulled apart

Prototype # 4
Accordion Fan



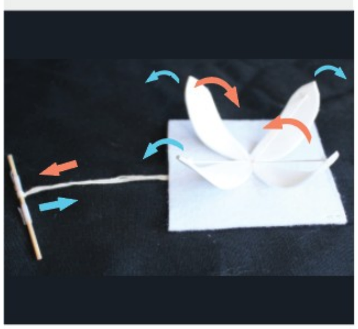
- Inner pleats are made from polyester interfacing, outer flaps made from polyester felt

Prototype # 19
Pleats



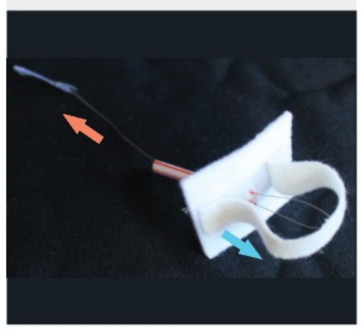
- Can be pulled inwards toward base through a thin metal wire. Pleats unfolds when wire is released.
- Pleats are made from polyester organza, base made from polyester felt.

Prototype # 8
String Pulled-Flower



- Pull wooden dowel with the string to close-up the floral element
- Floral element made from craft foam, based made from polyester felt.

Prototype # 17
Push & Pull Strip



- A strip that can be pushed and pulled toward the base using the metal wire
- Strip and base made from polyester felt

Figure 3.7. Material Prototypes that Support for Expansion and Compression.

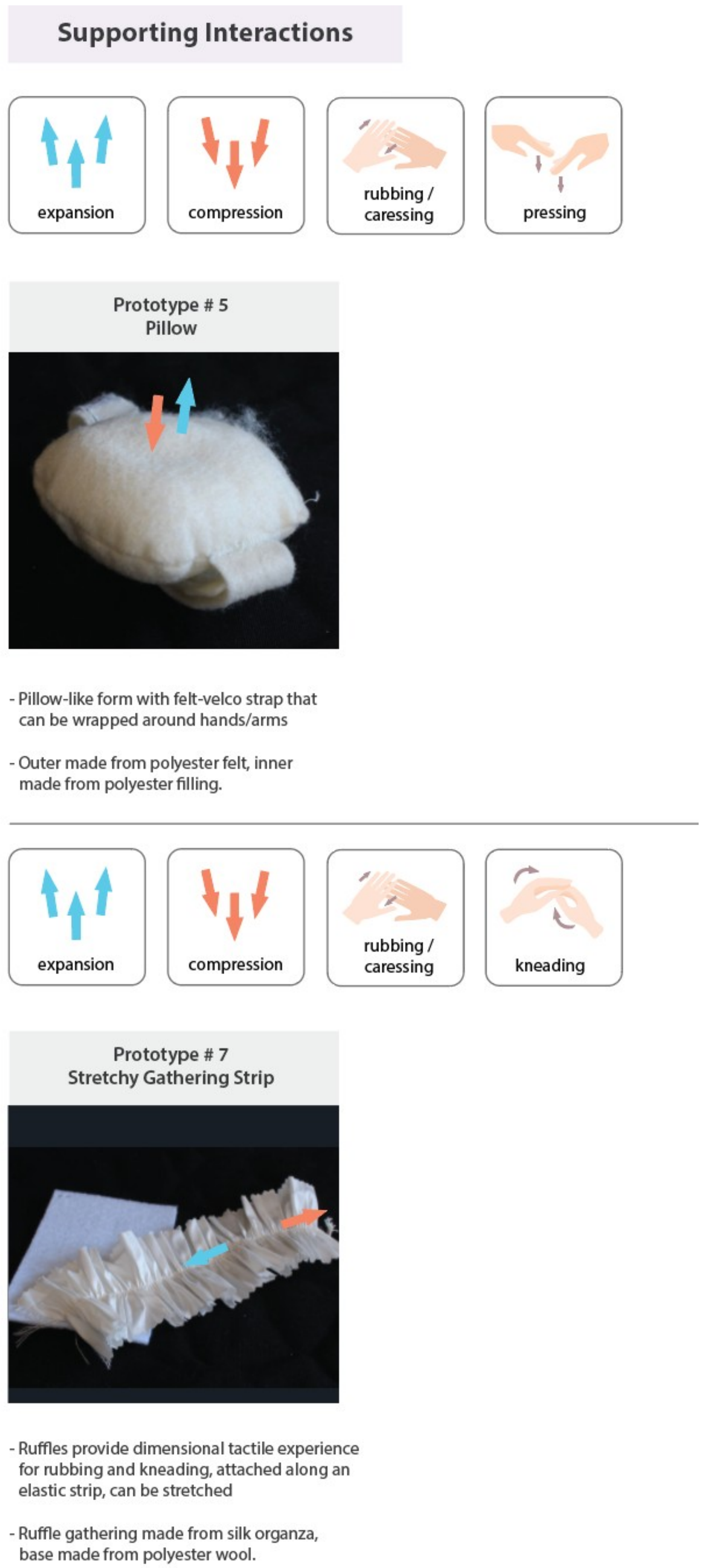


Figure 3.8. **Material Prototypes that support for expansion and compression with acts of rubbing/caressing, kneading, and pressing.**

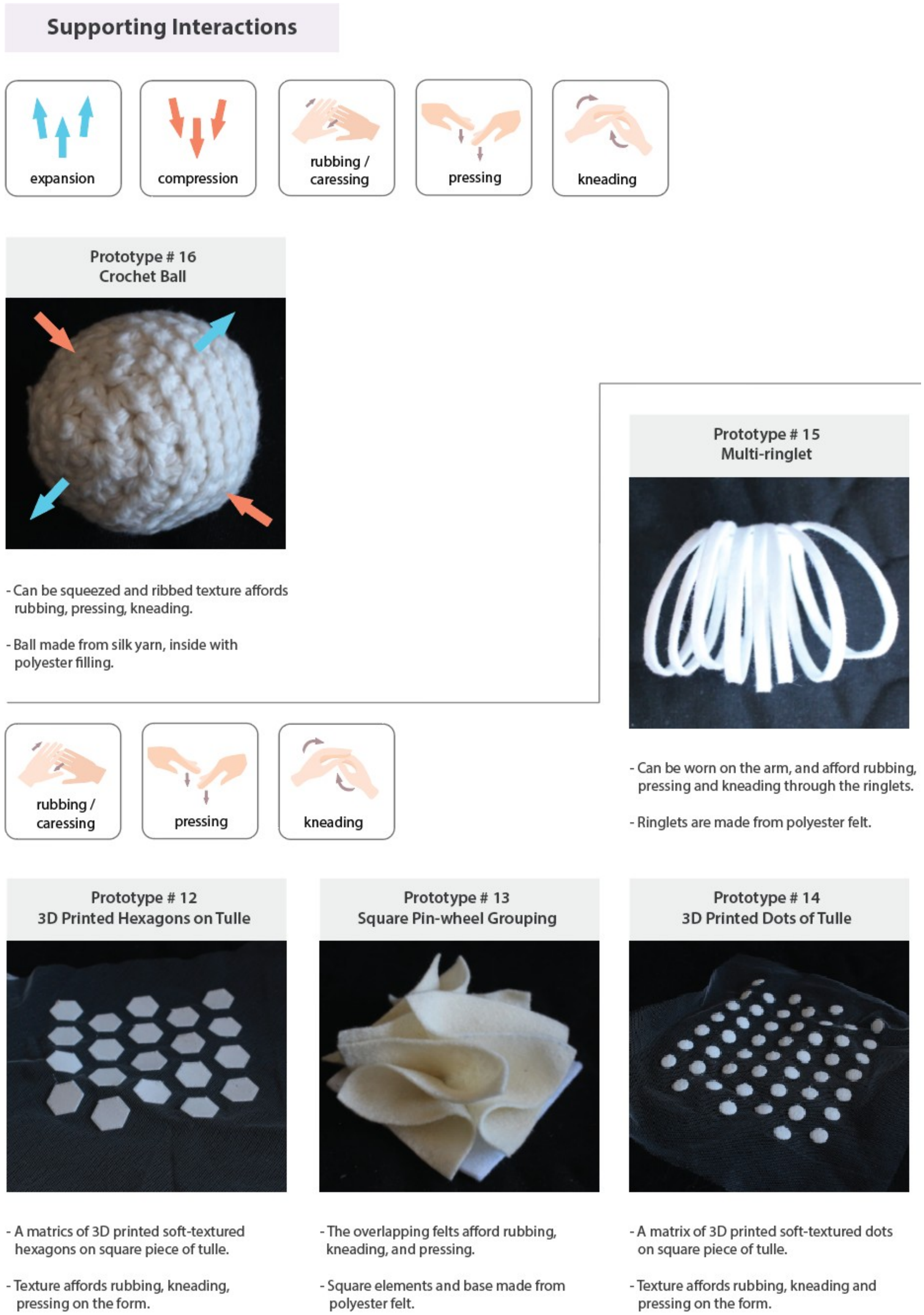
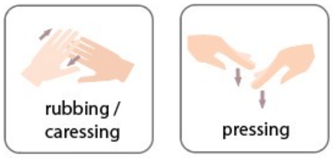


Figure 3.9. **Material prototypes that support expansion, compression, rubbing/caressing, kneading, and pressing (top), and Material prototypes that support rubbing/caressing, kneading, and pressing (bottom)**

Supporting Interactions



Prototype # 1
3D Printed Cylinder on Tulle

- A matrix of 3D printed cylinders on a square piece of polyester tulle.
- Soft textured malleable cylinders afford rubbing and pressing.

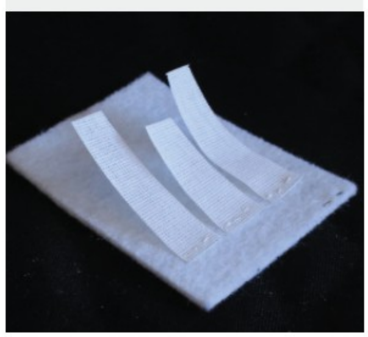
Prototype # 6
Soft Ridges on Felt Ringlet

- Can be worn on arms, is wrapped with a polyester ribbing all around to afford rubbing and pressing.
- Ringlet made from polyester felt, ribbing made from polyester liner.

Prototype # 2
Sharp Tubular Spine Structure

- Visual-tactile element produces a flick-like response when rubbed and/or pressed.
- Overall texture is rough and sharp, provides contrasting tactile experience with other soft materials to prompt for reflections on felt-experiences of stress. This can provide contextual info to understand felt-experiences of relaxation.
- Spine sculpture made from polyester interface, based made from polyester felt.

Prototype # 9
Tine strips



- Strips produce a flick-like feedback when pressed or rubbed.
- Strips made from polyester interface, base mad from polyester felt.

Figure 3.10. Material prototypes that support rubbing/caressing and pressing.

**Figure 3.11. Material prototypes that support rub/caress and kneading (top)
Material prototype that supports rub/caress (bottom)**

3.7. Chapter Three Summary

In this chapter, I engaged in an auto-ethnographic exploration through two design activities to inform the design of textile-based prototypes that support self-regulation for relaxation and the release of physical stress. Using a researcher's journal and a movement exercise, I examined the shapes, materials, and moving features that can provide support for relaxation responses to release stress, and also aligned with how I engage my body to release and self-regulate stress. Referencing Fallman's pragmatic account to design-oriented HCI research (Fallman, 2003), this step in my Research-through-Design allows me to engage in a thoughtful interpretation of materials in my everyday life, and to reveal the tacit knowing of my body when experiencing stress. Aligning with Schön's "reflection-in-action" (Schiphorst, 2009; Schön, 1983), I situate myself directly within the process of making to interweave my understanding of relaxation and stress relieving practices into tangible soft material prototypes. By engaging in my own subjective experiencing, I utilized my own experiential data as primary evidence to incite for some initial explorations that will be evaluated and developed further in **Chapter 4**'s participatory, material prototype design study, in which participants that have real-world experience with chronic work related-stress to explore, experience and evaluate these prototypes.

Chapter 4.

Material Prototypes Design Study (Project 1, Part B)

Chapter 4 Overview

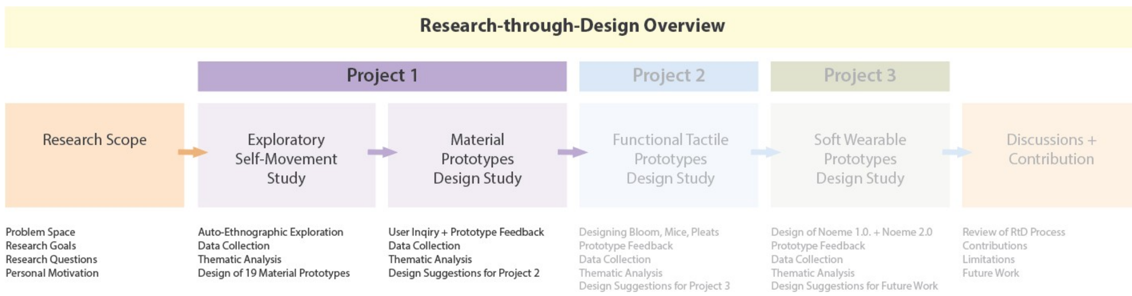


Figure 4.1. Chapter 4 reports on a 5-part design study to understand participants' felt-experiences of stress and relaxation and their feedback on the 19 material prototypes.

In this chapter, I describe the Material Prototypes Design Study, which emerged from the initial autoethnographic design process I began in Chapter 3, the previous Chapter of this Thesis. The Material Prototypes Design Study comprises the second part of Project 1, in this three-part Project Research Through Design Thesis.

Chapter 4 details an exploratory, participatory design study based upon 19 material prototypes articulated through my initial material explorations. This exploration as research utilizes the material prototypes to identify visual, tactile, and functional qualities that can support the use of human breathing and movement as resources for self-regulation to promote relaxation and to release physical stress.

The Material Prototypes design study is guided by two supporting thesis questions which were clarified through this study: (1) How can participants self-regulate to promote relaxation and reduce/release physical stress from their upper body, and (2) What form factors, materials, and movement qualities of the prototype affect and support the participants' felt experiences of self-regulation to promote relaxation through physical stress release (Figure 4.1)?

The Material Prototypes design study consists of five design activities:

1. General Demographic Inquiry,

2. Guided Prototype Interaction,
3. Narrative Inquiry with a Focusing Exercise,
4. Body Scanning with Material Prompts and PMR, and
5. Body Mapping Worksheet.

Ten Material Prototype design studies were conducted with adult working professionals with chronic stress-induced experiences of physical tension. The goal of the design studies was to gather affective and somatic insights of participant experiences with stress and relaxation. Participant responses were gathered through qualitative semi-structured interviews. The data qualitative interviews were transcribed and then analyzed through thematic analysis.

In this second phases of Study 1, I examine and discuss the key findings to reveal two main themes: prototype interactions that support felt experiences of stress release, and the use of participant's breath + movement to support design for self-regulation.

The key findings produced three implications: (1) a clarified understanding of the need for an embodied communication design for self-regulation, (2) an in-depth articulation and understanding of felt sensations of stress and relaxation, (3) a framework of design considerations and practical design suggestions for designing tangible soft wearable prototypes for self-regulation.

In the next sections of this chapter, I present an in-depth reflection on my R-t-D for the material prototype study. I highlight the documentations and somatic strategies used within each of my five design activities, explaining their purpose and contributions to the design-research process. A general description of the participants is provided along with an overview of the recruitment process.

I account for the study procedures and report on the study findings through a thematic analysis. As a result of the thematic analysis, I discuss two central themes that emerged through the analysis and suggest three design implications and directions for my wearable design prototypes in Projects 2 (in Chapter 5) and Project 3 (in Chapter 6).

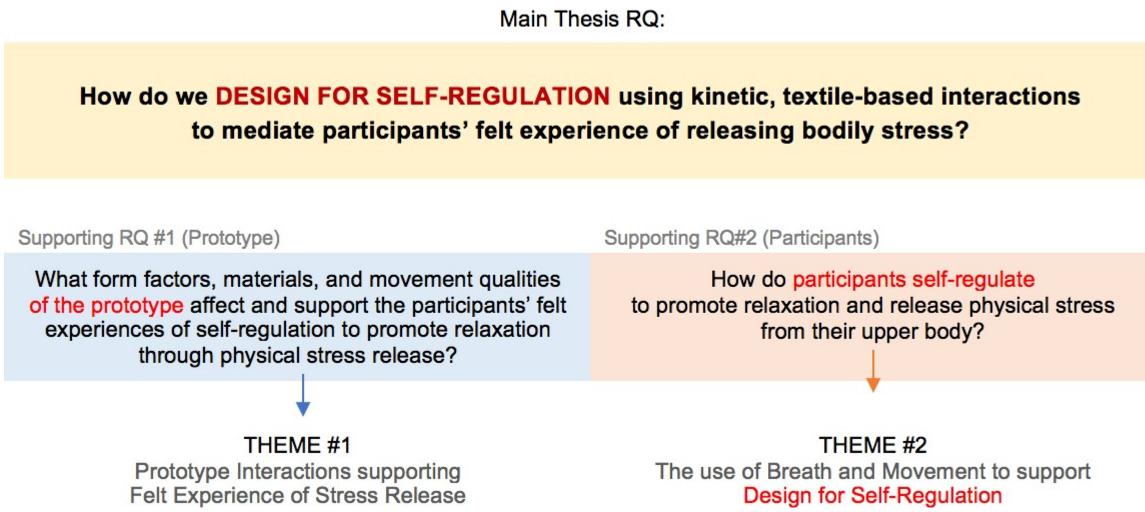


Figure 4.2. Material Prototypes Design Study Supporting Research Questions and Themes.

4.1. Research-through-Design

This explorative, participatory design study explores how materials and kinetic properties of textiles can support self-regulation to promote relaxation through physical stress reduction/release. This study was run as a one-on-one experiential exploration that incorporated, qualitative, and semi-structured open-ended questions during the participant's experience. As this design-research places an emphasis on somatic sensibility, a one-on-one experiential exploration and interview method was chosen to support the collection of in-depth data of participant's experience and perspectives of self-regulation to promote relaxation and stress reduction (Frances et al., 2009). Participants are guided through a 5-part study, which includes a 1) general demographic inquiry, 2) prototype exploration, 3) narrative inquiry using a focusing exercise, 4) body scanning with material prompts and progressive muscle relaxation exercise, and 5) a body mapping activity (Table 4.1). The activities are designed to scaffold participants' and design-researcher's familiarity with the material prototypes and the focusing approach. Through the process of sensing, feeling, and reflecting, participants share how the look and feel of the prototypes may affect for their relaxation responses. The insights gathered from this study inform the next stage of the design of Project 2 which resulted in the 3 on-table functional tactile prototypes which will be discussed in the following Chapter 5.

	Part 1	Part 2	Part 3	Part 4	Part 5
	General Demographic Inquiry	**Guided Prototype Exploration**	**Narrative Inquiry with a Focusing Exercise**	**Body Scanning with Material Prompts and PMR**	**Body Mapping Worksheet**
Purpose	To investigate How participants become kinaesthetically awareness to stress, and How they address the sense of stress.	To investigate What somatic and affective information on material prototype's texture, structure, and form relate to stress and relaxation.	To explore Participant's felt-experiences of stress and relaxation.	To reveal participant's process for kinaesthetic understanding of tensing and relaxing, and Reveal how visual, tactile, functional properties of materials can be applied to the body to support the felt sensing of tension and relaxation to release stress.	To reveal how participants' felt senses are associated with different body parts.
Goal	To reveal contextual (social and spatial) information on how work environments act as a stressor to trigger for participant's upper body-based muscle tension experiences.	To highlight visual, tactile, and functional properties from material prototypes that can affect the stress release experience to support relaxation.	To reveal the implicit nature of participants' embodied experiences of stress and relaxation.	To identify visual, tactile, and functional properties from the material prototypes that can either augment the felt-sense or hinder participants from connecting with their felt-inner state.	To reveal design opportunities on the upper-body for presenting expressions that convey stress release.

Table 4.1. Overview of 5-Part Design Study

4.1.1. Mediums of In Situ Researcher Documentation

During the participant study process and as a part of the research study observation process, I collected my own handwritten notes and visual drawings during the study, and in addition recorded video and audio archival footage during the entire length of the study. Handwritten notes in particular were used to mark down my own in situ observations and note points of interest that emerged during the process. The immediacy of note-taking allowed me to visually draw connections between text and sketches and organize my observations and notes spatially on the paper. Throughout this process, I was able to iteratively generate initial points of interest from the activities and feedback or the participants, and also develop 'just in time' questions which enabled me to seek further elaborations and clarifications from the participants. Video and audio recordings were intended to support data triangulation for analysis. Video recordings in qualitative research allows the collection of non-verbal data that cannot be transcribed into words (Bowman, 1994), and provides an opportunity to re-examine for data that may have been missed during the study (Bloor, 2006). Specifically, video recordings allowed me to review the physical gestures performed by the participants, and reveal how movement was used to guide participants' descriptions of their sensing, feeling, and reflecting and in particular sensing and/or feeling changes over time. These sensory and temporal design insights helped to inspire the design of visual, tactile, and functional qualities of Project 2 and 3 prototypes covered in Chapters 5 and 6.

4.1.2. Part 1 - General Demographic Inquiry

To initiate the study, a general demographic inquiry was conducted to gather details providing contextual information on how work environments act as a stressor to trigger participant's upper body muscle tension experiences. For the participants, this inquiry also served as a warm-up exercise to ease into the reflective and explorative process.

As a part of the demographic inquiry, participants were also asked to sketch and annotate a visual representation of their workspace. Coloured pencils and blank, white paper were provided. The visual drawings provided a spatial context in understanding the attitudes and perspectives of participants based on their social and physical interactions within their workspace.

4.1.3. Part 2 - Guided Prototype Exploration

4.1.3.1. Generation of Prototypes

During this Material Prototypes study, the material prototypes are designed to be used as prompts in Part 2 (Guided Prototype Exploration) and Part 4 (Body Scanning using Material Prototypes and PMR) to highlight the visual, tactile, and functional properties of the prototypes, and in particular those properties that can support self-regulation to promote relaxation by affecting the stress release experience. Within qualitative research, prompts are tools that are used to re-engage and assist the interviewee to elaborate on the topic of conversation (Frances et al., 2009, Leech, 2002). The 19 material prototypes were created to be neutral, ordinary, evocative, and are used as prompts for exploration and reflection. They are approximately palm-sized, soft objects with elements that can move when physically manipulated by the participant through touching, squeezing, pulling, pressing, etc. The prototypes do not have electronics and are primarily made from felt, cotton, silk, polyester, nylon, and spandex materials. The material prototypes are designed with kinetic properties and materials to simulate qualities of expansion, compression, and support the act of massage (rubbing, pressing, kneading). These 3 qualities are based on the relaxation strategies to alleviate stress that were identified through self-movement pilot study in Chapter 3.

4.1.3.2. Using Active Touch for Material Prototype Exploration

Research expresses the importance of touch (Loomis et al., 1986). How touch is approached can alter the experiential dimensions, and meaning-making process of our interaction (Chapman, 2008; Torres et al., 2015; Kayseri et al., 2012). As a result, it is important to consider and articulate how touch is used in this design study. To evaluate how visual, tactile, and functional properties of the material prototypes can affect self-regulation to promote relaxation and release physical stress, participants engaged in a practice of active touch. Active touch, or touching, can generate both cutaneous and proprioceptive feedback, also known as haptic feedback (Chapman, 2008; Gibson, 1962). When active touch is engaged when examining an object, users focus not on momentary sensations but seeks differences in changes across time and space to characterize and make sense of the object (Gibson, 1962). To guide the use of active touch, we suggested to participants "...to stroke, caress the surface; shape your hands over the form; hold, weigh the object in your hands; squeeze and press…". These instructions were adapted from Lederman and Klatzky's Exploratory Procedures, which through using hands, considers lateral motion for texture, pressure for hardness, unsupporting holding for weight, enclosure and density for volume, and contour following for global shape (2009). The study of participants' active touch experiences can reveal the visual, tactile, and functional aspects of materials that may contribute to the design of the "feel aesthetic" that reflects felt-relaxation and felt-stress. Torres et al. defines the "feel aesthetic" as the haptic qualities that frame the functional and aesthetic value of an object (2015). The insights generated through active touch with material prototypes can inform towards designing "the right feel" to support for relaxation responses in subsequent prototype designs.

4.1.3.3. Sensory Attributes of Fabrics

The subjective hand in fabric evaluation within the textile industry shares many similarities to the use of active touch. To assist with the description of soft materials in the semi-structured interviews, I referenced the descriptors of sensory attributes used in the subjective evaluation of fabric properties, also known as the fabric handle (Kayseri et al., 2012). These descriptors helped bridge emotive terms to practical references to characteristics of textile; revealing potential connections of felt-senses with sensory attributes of soft material. This guided the selection of soft materials in the creation of soft wearable designs that support for stress release.

4.1.4. Part 3 - Narrative Inquiry using a Focusing Exercise

This activity is inspired by the psychosomatic technique of focusing (Gendlin, 1999) to reveal the implicit nature of participants' embodied experiences of stress and relaxation. Participants were guided to use and narrate their bodily explorations for meaning-making. Participants were introduced to a focusing exercise that was adapted from Bebe Simon's *Love Exercise* (Lou, 2018, July 25) to engage in a body scanning process to recall, reflect, and share their past relaxation experiences to release stress on the upper-body. The process of body scanning helps to condition participants' mind-body, focusing on feeling their inner self for creative exploration (Núñez-Pacheco et al., 2015). The activity guided participants to sense-aloud to reflect how they can represent their bodily experiences with stress, and how they address the stress. Through foregrounding the tacit knowledge in participants' felt sensations of tensing and releasing, the felt sense (Gendlin, 1999) can inspire for design of embodied metaphors that afford a natural mapping to stress release.

4.1.5. Part 4 - Body Scanning with Material Prompts and Progressive Muscle Relaxation Exercise

4.1.5.1. Material Prototypes as Prompts

Building on participants' familiarity with the material prototypes and the practice of focusing, participants engaged in a facilitated PMR to intently focus on their body and using a material prototype to access their felt-sense of tensing and relaxing. Núñez-Pacheco et al. (2017) highlights a potential for combining a wearable stimulus and the practice of focusing as a joint-system for self-observation. This activity allowed the design-researcher to identify visual, tactile, and functional properties from the material prototypes that can either augment the felt-sense or hinder participants from connecting with their felt-inner state.

4.1.5.2. Progressive Muscle Relaxation Exercise.

Progressive Muscle Relaxation (PMR) are stress management techniques widely adopted by healthcare professionals to control stress and anxiety, relieve insomnia, and reduce symptoms of chronic pain (Anxiety Canada, n.d.). The facilitated PMR exercise taught participants how to relax their mind-body through progressively tensing and relaxing selected muscle groups coupled with deep breathing. PMR was selected as it could be easily learned and practiced by non-experts, which allowed participants to connect with their embodied awareness to stress, develop a kinaesthetic understanding to tensing, and apply the skills of tensing to release stress. A somatic facilitation (Schiphorst, 2011) supports the design-researcher as facilitator or guide to empathize and support meaning-making from participants' self-regulation of developing agency through relaxation and physical stress reduction, enriching my design process in creating metaphors of relaxation using visual, tactile, and functional properties.

4.1.6. Part 5 - Body Mapping Worksheets

Inspired by Schon's *Reflection-in-Action* (Vissier, 2010; Schiphorst, 2009), this body-mapping activity applies an in-the-moment, thinking-through-doing approach to encourage participants to apply the focusing approach to reflect on how they can visually represent their embodied experiences of stress and relaxation. The activity consists of leveraging the use of body-mapping as a strategy for participants to further elaborate and discuss their self-interpretation of felt-stress and felt-relaxation on the body. Using my body-maps as a research tool (Coetzee et al., 2019), the inclusion of body-maps supplements my in-depth semi-structured interviews, providing a layer credibility to my research findings. The observation and conversation process with the participants revealed design opportunities on the upper-body for presenting expressions that conveyed stress release.

4.2. Participants

As mentioned in Chapter 1, working adults in Canada do experience the most stress on a regular basis (Compton, 2011). Therefore, for this explorative, participatory design study, adults are selected as the target interviewees, and will be the primary demographic for the high-fidelity soft wearable designs. From the self-movement pilot study and researcher's diary, I identified that working long hours at my desk did contribute to my feelings of stress. Further research confirms that long work hours are a major contributor to work-place stress (Bhui et al., 2016). According to Canadian Centre for Occupational Health and Safety (2019), working in prolonged sedentary working environments do have serious health and safety implications.

Based on the contextual considerations described in the demographic description of participants for this study, target participants are adults who work at a desk-based environment and regularly remain stationary for an extended period of time (at least an hour). From their work, participants have experiences with long-developing symptoms of muscle tension particularly experienced on their upper body for at least three months, at which their condition may be considered as chronic (NINDS, 2019). These chronic conditions enable participants to have some familiarity with concepts of tensing and relaxing their body. Participants should have prior experiences (that range from minimal to extensive) with addressing their symptoms of muscle tension through self-care and/or with a healthcare practitioner. This is the preferred participant background as the study involves learning and understanding how any given participants perceives and responds to the muscle tension and relaxation experiences. The treatment experiences may be viewed as positive, negative, or neutral, and the treatment outcomes may have been successful, unsuccessful, or neutral.

In order to recruit participants, a snowball sampling method through word-of-mouth and email was used. Aside from the parameters set by the research scope, participants were selected equally with regards to their cultural, social, and physical background. A total of 10 individuals, consisting of 3 males and 7 females were recruited, with an average age of 28.2 years (Table 4.2). All participants work primarily in a sitting position at a desk, working approximately 9 hours a day. Two participants work regular hours (9am-5pm) as per their employment contract, while 8 participants work "flexible" hours, and do not follow the contract work hours. Participants with flexible hours end up working far more than their allocated work hours from 9am-5pm. Participants spend approximately 2 hours at their desk per sitting.

Gender	Age	Occupation	Total Daily Work Hours	Primary Stationary Position	Time (Hour) per Sitting/Standing
Male	30	Designer, Educator	8-10	Sitting	2
Male	29	Digital Product Designer	9	Sitting	1-2
Female	29	Marketing Manager	10	Sitting	1-2
Female	28	Program Manager	6 – 11	Sitting	2
Female	28	Medical Office Assistant/Scribe	8	Sitting/Standing	1-4 (standing) 2-3 (sitting)
Female	27	Quality Assurance Supervisor	8	Sitting	1-3
Female	25	Multimedia Designer	8	Sitting	2
Male	29	Journalist	10	Sitting	2
Female	29	Program Manager	10	Sitting	1-4
Female	28	Marketing Coordinator	10	Sitting	1-5

Table 4.2. Participants' Demographic Information

4.3. Procedure

4.3.1. Setting

The study sessions were conducted in two locations, both were enclosed office spaces with ample floor space with a large table and chairs. The two locations: 1) the researcher's lab space at SFU Surrey Campus and 2), a study room at SFU Harbour Centre, were selected to accommodate the schedule availability and travel constraints of participants. The enclosed rooms were private in order to facilitate the one-on-one sessions between the design-researcher and participant. The duration of the study sessions ranged between 90 minutes to 120 minutes.

4.3.2. Data Collection

Multiple forms of data were collected across the 5-part design study (Table 4.3) using audio, video, photographs, hand-written notes, and visual diagrams. Audio-recording and hand-written notes were used to document the interviews through the entire study. Participants were video-recorded for part 1, 2, 3, and 4 to capture the initial impressions and behavioural interactions. Some photography was taken in part 2, the Guided Prototype Exploration, to document the participant interactions with prototypes. Drawings of the participant's workspaces and body-mapping diagrams were used to record participants' visual representations of self-regulation experiences for relaxation and release of physical stress. During the study, the digital audio-recording device was placed on the table while a DSLR camera on a tripod was placed at the opposite end of the table facing the participant.

		Data Collection Methods				
Part	Activity	Audio-Recording (Zoom H4n)	Video-Recording (Rebel SL1)	Photography (Rebel SL1)	Hand-written Notebook	Visual Drawings
1	General Interview Inquiry	✓	✓		✓	✓
2	Guided Prototype Exploration	✓	✓	✓	✓	
3	Narrative Inquiry using the Focusing Exercise	✓	✓		✓	
4	Body Scanning with Material Prompts and Progressive Muscle Relaxation Exercises	✓	✓		✓	
5	Body Mapping Worksheets	✓			✓	✓

Table 4.3. Overview of Data Collection Methods

All written and digitally recorded interviews were transcribed by the researcher. All physical diagrams were scanned into electronic files. To maintain participant confidentiality, an alpha-numeric indicator was assigned to each data file. All digital files are stored in a secured file space on SFU Vault in addition to an encrypted external hard-drive. The hard-drive and physical data materials (body mapping worksheets, visual drawings) are stored in a designated password accessed locker in the researcher's lab room.

4.3.3. Description of Study Activities

Pre-study Arrangements:

Once the participant was screened as a suitable candidate for the study, a meeting date and time for the study was confirmed through email and text messages. A project overview and consent form were provided to the participant to review ahead of time.

Pre-study Consent and Orientation:

Participants are presented with a physical consent form to review and sign for verification that they have provided consent and understand the nature, benefits, and potential risks of the study. Once the form was signed and additional questions were addressed, participants were introduced to the study with an overview of the study activities, recording equipment, and tools.

Part 1 - General Demographic Inquiry:

In Part 1 of the Materials Prototype Design Study, ***General Demographic Inquiry,*** basic demographic information (age, gender, professional background) were collected. The interview was semi-structured with open-ended questions to gather information on the physical and social aspects of participant's work environment. Participants are also asked to draw and annotate their workspace. Within their role, participants share stressors that have led to feelings of stress and their experiences with addressing the stress on the body. The questions provide preliminary insights on how participants become kinesthetically aware of stress, and subsequently identify the process to address their felt sense of stress.

Part 2 - Guided Prototype Exploration:

In Part 2 of the Materials Prototype Design Study, ***Guided Prototype Exploration*** (Figure 4.3), participants are presented with 19 material prototypes and a scenario question: "Imagine you are stressed at work, which elements from these prototypes may help you relax?" Participants are allocated 10 minutes to freely explore and interact with the prototypes using an adapted version of Lederman and Klatzky's Exploratory Procedures (2009). Participants are asked to: "...stroke and caress the surface, shape your hands over the form, hold/weigh it in your hand, squeeze and press, pull, bend, and look at each prototype."

After the free exploration, a semi-structured interview was conducted with open-ended questions to gather somatic and affective information on the material prototype's texture, structure, and form in relation to the theme of stress reduction for relaxation. The questions are guided by the Somaesthetic Framework of Touch, which focuses on their (i) felt experience when relaxing to alleviate tension, (ii) the meaning-making and interpretations of their felt experiences between touch and body movement, (iii) the visual, tactile, and functional properties of the prototypes to support their understanding and expression of tacit information from their experiences, and (iv) the semantics of self-regulation for relaxation and stress release.

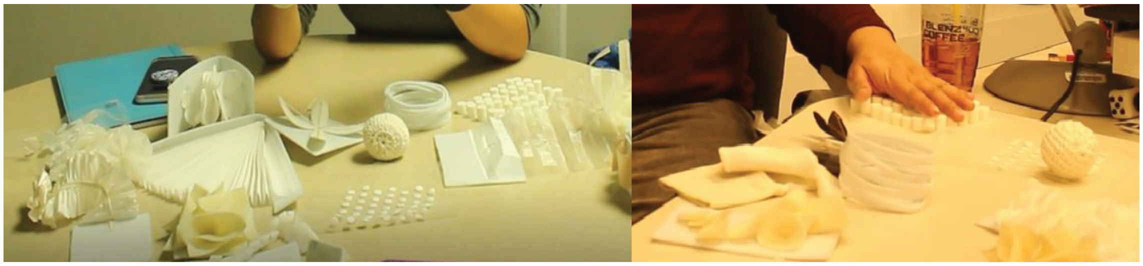


Figure 4.3. Participants during the guided prototype explorations.

Part 3 - Narrative Inquiry using a Focusing Exercise:

In Part 3 of the Materials Prototype Design Study of the Materials Prototype Design Study, ***Narrative Inquiry Using a Focusing Exercise***, participants engaged in a process of recalling and reflecting on their past relaxation experiences through their body using a guided Focusing exercise. Guided by 3 open-ended questions, participants were asked to narrate one specific example of stress in their workspace and their process to achieve relaxation through their body. During the reflection, participants were encouraged to express their sensations aloud as they focus and connect with their inner felt state. This exercise provided an opportunity to explore the participant's embodied experiences of stress and relaxation.

Part 4 - Body Scanning with Material Prompts and Progressive Muscle Relaxation:

In Part 4 of the Materials Prototype Design Study, ***Body Scanning with Material Prompts and Progressive Muscle Relaxation***, participants are guided through an adapted Progressive Muscle Relaxation (PMR) exercise to learn and progressively relax their body through mindful tensing and relaxing. A series of open-ended questions are asked relating to participant's embodied experiences for relaxation. Similar to Part 3, ***Narrative Inquiry Using a Focusing Exercise***, participants are encouraged to use the sense-aloud method as they focus and connect with their felt inner state. The adapted PMR exercise is performed twice; once with and once without a material prototype. The material prototype is used as a prompt to support the participant's felt-sensing process. This activity focuses on revealing two particular insights: (1) how a participant develops a kinaesthetic understanding of tensing and relaxing, and (2) how visual, tactile, and functional properties of materials can be applied to support the felt sensing of tension and relaxation to release stress.

Part 5 - Body Mapping Worksheets:

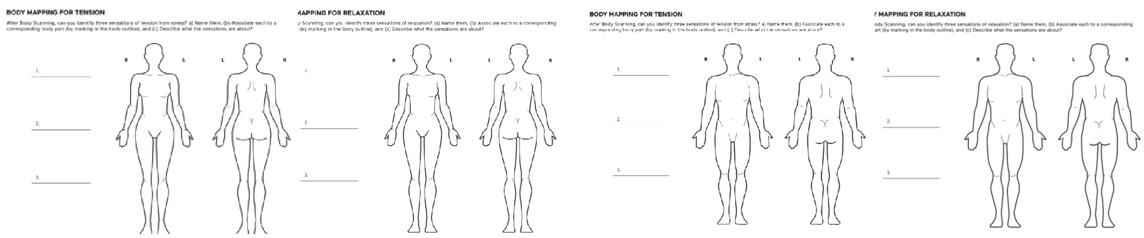


Figure 4.4. Body Mapping Worksheet for Stress-Tension and Relaxation (Female and Male Version)

In Part 5 of the Materials Prototype Design Study, ***Body Mapping Worksheets***, participants were guided to complete 2 body diagrams that map out participant's experiences and feelings of relaxation and tension within the body. One body map focused on relaxation, and the other body map focused on tension. Participants were provided either a female or male version of the worksheets to complete depending on their biological gender (Figure 4.4). Participants identified three sensations of either stress/relaxation, associated each sensation to a corresponding body part, and described how the sensations were felt (location, orientation, spatial expansion, contraction, temporality, intensity, quality). By visually representing their kinaesthetic, tactile, and felt experiences and feelings of relaxation and tension within the body, the intention is to reveal how the participants' felt senses are associated with different body parts. The felt senses revealed through the body-mapping activity are used as inspiration towards developing soft wearable designs that support for relaxation responses in Projects 2 (Chapter 5) and Project 3 (Chapter 6). Key questions which the body mapping experiential design exercise helps to address are: (1) Where on the upper body should the wearable design be based upon? (2) What are primary physical bodily sensations that represent relaxation and tension?

4.4. Results

4.4.1. Data Analysis Process

This exploratory, participatory design study aimed to identify visual, tactile, and functional qualities of material prototypes that support the use of breathing and movement to promote self-regulation for relaxation and stress release. Through a scaffolded approach in the 5-part study, we examined how participants self-regulated the release of upper-body stress, and observed what and how form factors, materials, and movement qualities of the prototypes affected participants' felt-experiences of self-regulation for relaxation and stress release. With an emphasis on somatic considerations, handwritten notes, visual drawings, audio-, video-recordings, and photos were collected. The inclusion of visual data provided contextual information to reveal insights on how participants interpret and focus their behaviours (Allen, 2017). Using both traditional hand-coding methods and computer-assisted qualitative data analysis software (CAQDAS), a thematic analysis was conducted to address the two-secondary thesis RQs. Thematic analysis is a process of identifying and interpreting patterns in data, where its approach is flexible and not bound by any particular theoretical perspectives (Braun et. al, 2006). Thematic analysis complements the somatic inquiry as it focuses on the human experience, placing an importance to consider the cognitive, affective, and lived moments of participants.

Hand-written notes, audio, and video-recordings of interviews were transcribed through NVivo12. Visual drawings and body mapping worksheets are also scanned and uploaded into the software for coding purposes. Each activity in the design study had a specific purpose and goals to address specific aspects of the two supporting research question (Table 4.1). With that in consideration, data was analyzed by design activity. Participants' responses and reflections were coded into categories of Self-Regulation, Relaxation Sensations, Stress-Tension Sensations, Relaxation Strategies, Causes of Stress-Tension, Visual/Tactile/Functional Properties of Materials, and Upper Body Parts. The coding scheme was not predetermined, and these categories emerged through the process of analysis. The following sections highlight how the coding process was applied to each design activity.

General Demographic Inquiry coded the visual drawings of the participant's workspace to indicate areas that causes participants stress-tension, and attached analytic memos noting the stress-tension sensations. Interviews are also coded to self-regulation, strategies for relaxation, the stress-tension and/or relaxation sensations, and causes of stress-tension.

Guided Prototype Exploration coded the interview transcripts to indicate the Visual/Tactile/Functional Properties of Materials that are associated with stress-tension sensations and relaxation sensations.

Narrative Inquiry using a Focusing Exercise interviews were transcribed and coded participants' reflections to stress-tension sensations, and relaxation sensations.

Body Scanning using Material Prompts with PMR, interviews were transcribed and coded participants' impressions of each prototype to reveal which material prototypes and material properties could be associated with stress-tension and/or relaxation sensations.

Body-Mapping Worksheet data was transcribed and coded according to participants' written entries into a data set table. NVivo12 enabled the application of matrix coding, and word frequency queries on participants' descriptions of stress-tension and relaxation sensations with upper body parts.

4.4.2. Research Findings

4.4.2.1. Causes of and Recognizing Stress on the Body

Workshop participants reported numerous causes of and recognizing stress on the body. The major causes of stress within participant's workspace included long work hours, lack of ergonomic considerations in workspace furniture (chair and desk) and large workloads under tight deadlines.

> "My shoulders are strained due to my monitor and laptop setup, I don't have a stand, so I would look over here, look over there. It is not the ideal height so the set-up is affecting that." - P10

> "The chairs at the office, the old chairs look nice, but they were not really suited for long working hours." - P8

> "I would say we have 6 or 7 major projects that last 5 very intense weeks at a time. Of those five weeks, I get maybe 2 weeks plus of extreme muscle tension and pain." - P9

Almost all participants expressed an awareness of stress on their body through recognizing changes to their posture and breathing. Participants elaborated shortness in breath, tightness in chest, while some indicated stiffness and tightness in the neck and shoulders.

> "The inability to foreshadow this makes me even more stress and I feel a tightness in my chest, I feel like I am not taking deep breaths" - P9

> "I feel strain on shoulders and light head. My posture is affected." - P10

> "Your shoulders get raised up, starts clenching." P8

Although participants expressed an awareness of stress, they would often prioritize task completion over personal well-being, resulting in prolonged sedentary behaviour in their workspace. Participants further indicated that while they do use stress-management tools, they often ignore the notifications to take a move and break.

> "Yea, I work through the notification, I kinda take a mental note on how many times I have been buzzed during the day...it may buzz me 5-6 times [a day]" - P9

> "I have one [Fitbit], but nah, don't really it. I used to use it to keep track but it didn't really do much for me…" - P6

> "I have an application on the web browser [Momentum], it tells me to get up and move. I will walk a bit at times, but work dictates so I don't usually follow it." - P1

It is noted that participants who are more active through taking regular breaks and regular exercise feel less physical stress-tension than those who are more sedentary.

4.4.2.2. Materials for Relaxation Responses

Top Descriptors Associated with Relaxation and Stress-Tension Sensations (Word Frequency Query on Body Map Worksheets)	Light, Loose	Tightness, Stiff	
	Relaxation Sensations	**Tension-Stress Sensations**	
Shape/Form	thin, light-weight (density), soft	tightness, hardness, stiff/rigid heavy-weight (density)	Sensory Attributes
	loose, flexible, has-drape		
Materials/Textures	smoothness, fineness, silkiness, soft, plush	prickliness, scratchiness, roughness, coarseness, itchiness, sharp	
Moving Features of Expansion and Compression	spread, fullness, expansion, "springy" (high elasticity/bounce, stretchiness)	compression, low elasticity/bounce, taught (not stretchy), weighted	
Participant Interaction with Prototypes	The act of squeezing Caressing something that is soft	Caressing something that is itchy, prick	

Table 4.4. Sensory Attributes associated with Relaxation and Tension-Stress Sensations for Material Prototype Properties

Through the guided prototype exploration and interaction, the research analysis identified sensory attributes that can be associated with relaxation and stress-tension sensations when describing the overall form/shape, materials/textures, and moving features of expansion and compression (Table 4.4). In the interviews, participants' descriptions of the material properties are usually combined together rather than as an isolated layer. For example, participants often consider the overall shape/form with tactile and/or functional qualities.

> "In terms of things that are stressful, things [that are] hard [are] not nice to hold and feel [points to prototype #2, #9]." - P6
>
> "something that looks harder, rigid, sharper, scratchy [refers to prototype #2] ..." - P2
>
> [Holding prototype #7] "This would be not bad of representation, it has some form, it stretches, its less pressed, its less crinkles, whereas when you are stress[ed], it [be]comes bunched, it becomes tight, lots of wrinkles…" - P6

When describing the shape/form, descriptors that align with relaxation include: "thin", "light-weight", "soft", "has-drape", "flexible", "loose"; and descriptors for stress-tension include: "tightness", "hardness", "stiff/rigid", and "heavy-weight". In particular, participants focused on (1) how shapes/form deform in relation to the body, as well as (2) its density, or thickness. Several participants associated shapes that are "pillow-like", which can be characterized as soft (can easily deform when pressed) and light-weight in density to be more relaxing.

> "[puts prototype #5 on the wrist] I can rest on it and its soft say when I am doing something on the desk like typing..." - P8

> "for [prototype] #5, [the] foam pillow, it's nice, pillowy…." - P2

This observation was further affirmed when all 10 participants indicated prototype #16, a yarn crochet ball, can support for relaxation responses as it was (1) easily deformable and light-weight, (2) resembles a stress ball (3) affords the act of squeezing to release stress-tension.

> "for the ball prototype [#16], again the pillowiness, offers the compression feeling [squeezes hand], the outside pattern was a bit harder [referring to the yarn]. A bit of both, something soft and rigid combination is nice." - P3

> "[prototype] 16 reminds me of stress ball, something like this for me as a fidgeter is nice." - P6

> "This one [Prototype #16] reminds of a stress ball, like a pre-existing market item. [P9 presses down and release with her fingers and palm continuously on Prototype 16] [It is] softer than a stress ball though, and it's kinda nice. It's softer in terms of texture, and feeling." - P9

When describing the material/texture properties, sensory attributes of "smoothness", "fineness", "silkiness", "soft", "plush" were used for relaxation; while "prickliness", "scratchiness", "roughness", "coarseness", "itchiness", "sharp" were used for stress-tension sensations. Participants expressed an appreciation for some textural contrasts in the tactile experience as prompts to further exploration and reflection on their felt-experiences. Participant 1 indicated a variety of 2-3 textures as a balance to "keep things interesting" without a sensory overload in the tactile touch. This suggestion aligned with the initial impressions of other participants who engaged with prototype #11, a cluster of suffolk puffs made from three different silk textiles.

> [caresses prototype 11] "Nice. [There are] different textures in the flower things, softer ones, there are contrast." - P5

> "I like touching this [referring to prototype 11], there are different fabrics in this" [rubs fingers through] - P7

When describing moving features of expansion and compression, sensory attributes of “spread”, “fullness”, “expansion”, “springiness” mapped to relaxation sensations; descriptors of “compression”, “low elasticity”, “bound”, “taught” mapped to stress-tension sensations. With functional features on the material prototypes, the ability to spread, expand freely most aligned with the concept of relaxation.

> “For relaxation, in terms of expansion, anything to get your body to bigger, wider, or anything just really to letting go can work.” - P3

Participants also highlighted using expansion and compression to convey a sense of stretching could be relaxing as well. Participant 9 indicated the act of stretching is a practical way to relieve muscles that are tight and “helps to make you feel good." Participant 2 elaborates “the act of pulling and activating the muscle, to help stretch it in some way” can help generate for relaxation responses.

Through reviewing the transcribed data and behavioural data, in addition to the act of squeezing, a caress as a touch interaction with the material prototypes could also afford with for relaxation or stressful responses. Participants who engaged in a caress of soft forms and textures can incite a positive affect, that can also be therapeutic.

> “I enjoy this because [referring to prototype #11] it’s soft and fluffy, when I run my hands over it, it feels plush and soft so I like that a lot” - P7

> “Picking up the squishy prototypes, that is tension relieving for me, as well as the stroking of the puff prototype [#11].” - P6

> “Relaxing to me would be stroking this. [prototype #11]” - P3

> “I tend to think, harder materials are less relaxed, it doesn't feel good. Whereas, vice versa, softer material is nice to touch and makes me feel good.” - P2

From the various textiles used for the creation of material prototypes, the FELT textile produced the most mixed reviews. Some participants found the texture to be rough to touch, therefore causing stressful responses.

> “anything really with heavy felt, because it gave me that irritative, itchy composition to it” - P1

> “The felt maybe more associated with tension, because it's dense and thick, whereas the silk is more relaxing as it is light, translucent, softer, not as thick as the felt.” - P7

Some participants appreciated the thickness of the felt textile as it provided a sense of security, warmth, and comfort.

> "Heavy [-weighted] felt, reminds me of comfort, somewhere cozy…" - P2

> "The heaviness reminds me of a security blanket." - P5

Participants 1,2,3,4,6 all expressed an understanding of the felt textile used as a soft material base to frame most of the material prototypes. On a practical perspective, the heavy-weight felt material provided a good structural support that that contains insulating abilities.

4.4.2.3. Accessing Felt-Experiences of Stress-Tension and Relaxation-Release

Participants were considered as non-experts in the practice of focusing. Of the 10 participants, only 1 participant had prior experience with body-scanning and mindful breathing. Participants relied heavily on the use of metaphors to connect and describe their bodily senses of stress-tension and relaxation-release.

> "So, my desk is constricted, I end up constricted myself, so the world is shrunk even more, unless I get up and open up my heart, and open up my body space. That' s when I feel more relaxed. Once I am like this, I am closing my body, closing my heart, even body is restricted. So, the feeling of tension increases and the more I close myself" - P3

> "It feels like a tinkle on my left elbow, fingers hurt, maybe that is [because] I hurt it or something, I feel some tension [in] my back. I feel like sort of restless, maybe a ball in my hand, just kind of there." - P7

> "I am going to use the term knot, because that's how doctors always call it. you have a knot in your shoulders, and back. It really does feel like a knot that needs to be untangle, but in saying that it doesn't reflect how it actually feels. You are right that it's not being able to find a word to accurately, it is like separating the muscles around the knot and me stretching it, strangles the knot and it's not helping to relieve the knot" - P10

When participants felt a lack of vocabulary to accurately reflect the dynamic quality of their embodied sensations, they utilized the physical gestures and material prototypes to demonstrate. This approach added clarity to their explanations, and assisted participants to achieve an inward bodily attention to their feelings of stress and relaxation.

> "With my wrist pain maybe, cus when it feels tense, I can't really rotate it, so these bones rubbing against each other and doesn't slide and rotate like they want to [uses #15 to twist the ringlets]. In terms of my head, [grabs #3 pop out floral ball], there is this pressing, or maybe the stress ball [# 16], like a pressure in the head and not being released…" - P7

> "When I had the prototype on, I was more aware of the area, but when I took it off, I don't have much awareness to the area anymore." - P1

Participant 2 also highlighted a temporal element in their felt-sensations, elaborating how stress was transpired on the body across a period of time. This finding suggested that felt sensations is not simply a static state, but a fluid process.

> "As time progresses, my shoulders would start caving in a little. I feel a little tension in the trapezius muscles. It just hurts, hard as a rock, doesn't feel good. It kind of slowly snowballs, would kind of be radiates, it kinda just gets harder and harder." - P2

The use of a material prompt provides another tool for the design-researcher to begin kinesthetically empathize to a participant's felt-experiences to stress. Participant 8 demonstrated the felt-pressure by placing prototype #16 on the trapezius, in-between the neck and shoulder, just above the collarbone. Participant 8 would press and roll the crochet ball upwards to demonstrate the direction which the pain radiated across a period of time. Subsequently, I, the design-researcher mirrored Participant 8's demonstration on my own body. Through this body-tracing, visceral approach allowed me to understand the intensity of participant 8's felt-sensation of pressure.

While connecting with their past felt-experiences with stress and relaxation, participants also shared their existing strategies to relax. All 10 participants mentioned the use of deep breathing as an accessible method to feel a release of stress. Even if the results are momentarily,

> "I would wipe my hands on my pants because my hands are sweaty and take a few deep breaths…" - P5

> "After breathing out, I felt a bit of [a] head rush. a good head rush. a release happening throughout the body, not just in the head. [I] felt it on the shoulders to the lower back." - P1

> "When you are breathing, there is no tension, the air fills up your chest slowly. back is nice and straight, chest is nice and high. Shoulders are relaxed and back." - P2

Participants also mentioned the use stretching to address stress-induced muscle tension to alleviate stress.

> "It actually feels kind of nice, it's like a gentle expansion, and I think stretching is good for you, so I think there is definitely a psychological component to it. So I would think this is good for me." - P9

> "I would try to do an inverse to my caving in. I would stretch both sides. kind of stretching out the tension essentially. So it is tight, but you are stretching the other way." - P2

> "It's the whole muscle that is affected, one thing I just realized [is] that I just did that unconsciously, I will bend my head forward to elongate everything back there to give it a stretch." - P6

4.4.2.4. Expressing the Felt-Sense on the Body

The intention of the body mapping activity was to reveal the participants' felt senses associated with different body parts.

	A : Relaxation Sensations	B : Tension Sensations
1 : Lower Body	7	7
2 : Upper Body Parts	38	28
3 : Back	12	3
4 : Chest	8	3
5 : Head	10	7
6 : Jaw	0	1
7 : Temple	0	2
8 : Midsection	7	0
9 : Neck	9	13
10 : Shoulders	8	11
11 : Upper Limbs	10	5
12 : Arms	3	3
13 : Hand	1	3
14 : Wrist	2	3
15 : Lower Back	2	3
16 : Upper Back	5	6

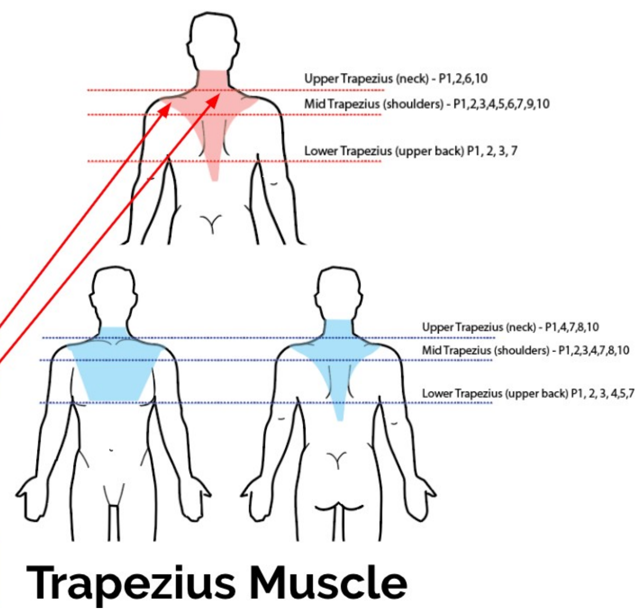


Figure 4.5. Felt Sensations of Stress-Tension and Relaxation on the Body

A matrix coding and word frequency queries through NVivo12 revealed the upper body areas that are most susceptible to stress-tension sensations, and relaxation sensations. The Body-Map worksheet data revealed that stress-tension sensations initiates primarily in the neck and shoulder, while relaxation sensations can be felt on a wider area that includes the Back, Chest, Head, Neck, Shoulders and Upper Limbs (Figure 4.5).

Felt-sensations of “tightness” and “stiffness” were found most on the trapezius region when participants experienced stress-tension; while felt-sensations of “lightness” and “looseness” were most common when participants experienced relaxation on the trapezius region. (Figure 4.6)

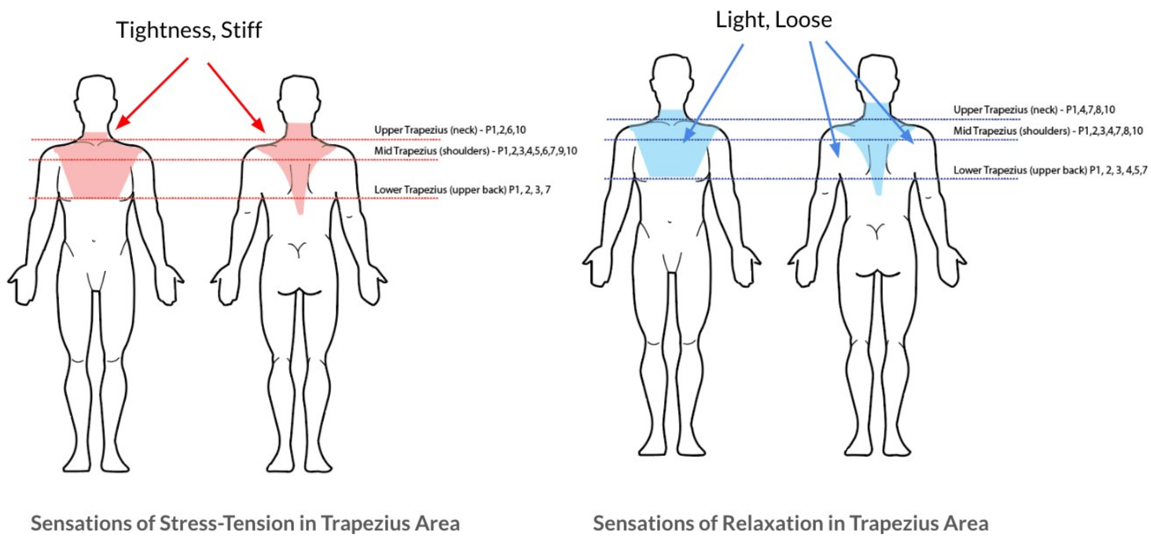


Figure 4.6. Top 2 Mentioned Sensations of Stress-Tension and Relaxation on the Upper Body

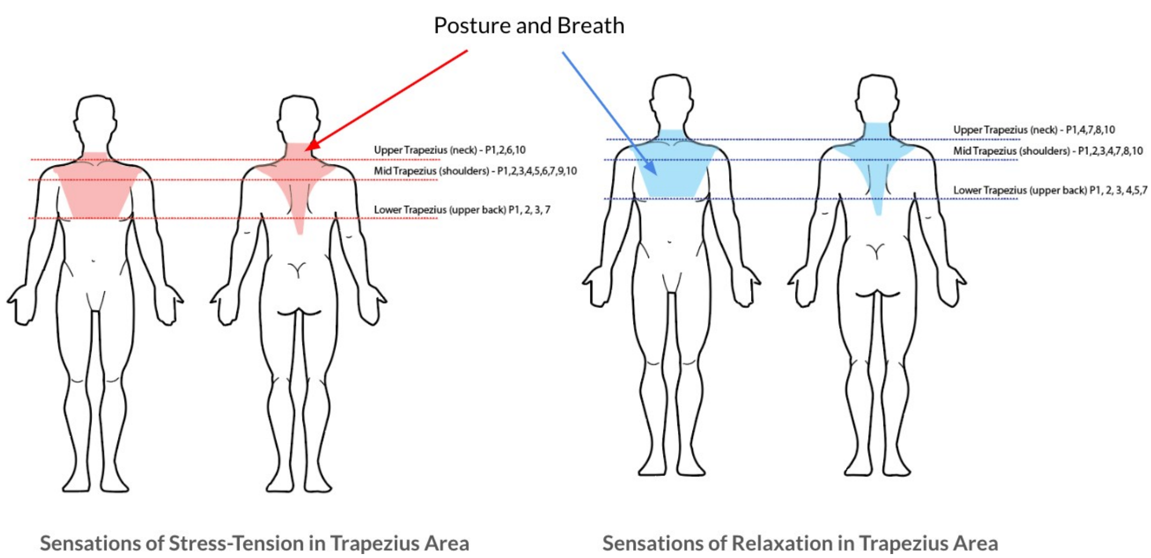


Figure 4.7. Where Posture and Breath are impacted on the Upper Body

From the transcribed interviews and worksheet entries, complaints on posture due to stress-tension are found in the trapezius region. When participants experience relaxation, conversations related to breathing are focused on the chest region. (Figure 4.7)

4.5. Discussions

The Materials Prototypes Design Study consisted of a 5-part design study, that incorporated 5 design activities, (1) General Demographic Inquiry, (2) Guided Prototype Exploration, (3) Narrative Inquiry with a Focusing Exercise, (4) Body Scanning with Material Prompts and PMR, (5) Body Mapping Worksheet, to produce key findings, which were organized into two particular themes to address the two supporting thesis questions: (1) How participants self-regulate the release of stress from their upper body, (2) What form factors, materials, and movement qualities of the prototype affect participants' felt experiences of stress release.

Engaging adult working professionals who have chronic experiences with stress-induced tension highlighted problems for self-regulation to reduce stress. While participants recognized the existence of stress, which primarily impacted their breathing and posture, participants often prioritized task completion over their own health and well-being. This resulted in a low self-agency for personal well-being. Some minor uses of applications and wrist-based notifications were mentioned but feedback was often ignored. Participants also displayed a level of disengagement and lack of embodied connection to their felt state with these external tools.

With a scaffolded approach to immerse participants for somatic reflections, material prompts and focusing exercises were used. Participants initially described their awareness of stress and their alleviation of stress using an extrospective approach, which were anchored on the ability to complete a task or action. Through the use of material prototypes as prompts for inner bodily reflections, we were able to observe a change toward responses that were more attuned to participants' affective and somatic states. This RtD process identify a potential value of using tangible soft wearable prototypes to support the development of embodied connections for self-regulation to promote relaxation and release of physical stress.

4.5.1. Prototype Interactions that Support Felt-Experience of Relaxation

The temporal and spatial dimensions to self-regulation for relaxation and release of physical stress revealed that a felt-sensation is not a static state, but a fluid and dynamic process. The lack of feedback to articulate and facilitate this fluid and dynamic process presented a gap in embodied communication design. The rich communicative qualities articulated from physical movement, through kinetic feedback, could potentially serve as a dynamic form of tangible representation for felt-experience data. The design of tangible soft material prototypes with kinetic feedback can appeal to participant's kinaesthetic cues, guiding them to enhance their connection with their emotions and body when experiencing stress. By developing a kinaesthetic understanding of their somatic and affective states when stressed, participants can determine the best way to engage a bodily mechanism to initiate the self-regulation process to shift their inner affective and physical state.

4.5.1.1. Practical Design Suggestions

To guide the design of tangible soft wearable prototype that uses kinetic feedback that supports relaxation, these study findings produced several considerations to the form factors, materials, and movement qualities that can afford greater access to relaxation responses. Shapes that are soft, characterized as light-weight in density and can be easily deformed are more relaxing to interact with. Including materials to produce a 2-3 variety of textures can be useful to engage participants for creative exploration and ground them for reflection. Moving features that expand and compress to convey a sense of stretching can be relaxing as well. Creating opportunities that allow for the act of squeezing and caress with soft materials can incite a positive affect on users when interacting with the prototype. Silk and felt, which convey qualities of softness and warmth are recommended as textile materials for the design of soft wearable prototypes.

4.5.2. Using Breath and Movement to Support Design for Self-Regulation

The self-regulation process of stress allows individuals to modulate their own attention and emotion to ameliorate their stress experiences. Through becoming more attuned with how their bodies react to stress, users can strengthen their kinaesthetic cues to determine the appropriate body mechanisms to engage with for stress management.

Participants highlighted the interrelated relationship between breath and posture when experiencing stress. Poor posture can attribute to breathing difficulties. Participants who were sedentary for a prolonged period elaborated on rounded chest, shrugged shoulders, and forward head tilt, resulting in various muscle tensions to appear on the upper body. In particular, participants mention tightness in chest, causing restricted breathing. This presented a design opportunity to further explore the use of breathing patterns and body movements on the upper body to reflect the felt-experiences of stress and relaxation. In response to their stress, participants engaged in the practice of deep breathing and stretching to achieve a sense of stress release. Breathing rhythm affects both affective and cognitive states of a person. Posture, how the body is aligned, can incite with a person's inner affective state. Participants highlighted the use of metaphors as a helpful approach to assist with accessing and describing their felt-senses of stress and relaxation. Thus, by embedding metaphors of breathing and posture through kinetic feedback of breathing and movement patterns, users can develop an embodied connection to their felt experiences of stress, and engage in deep-breathing and stretching for stress release and relaxation. Key findings further indicated the trapezius region as the main body area for felt-stress, while felt-relaxation was most prominent around the front chest. This revealed potential areas where kinetic feedback can be displayed on soft wearable designs for self-regulation.

4.6. Implications and Design Directions

This explorative, participatory design study, ***Material Design Prototypes Study***, through 5 design activities: (1) General Demographic Inquiry, (2) Guided Prototype Exploration, (3) Narrative Inquiry with a Focusing Exercise, (4) Body Scanning with Material Prompts and PMR, (5) Body Mapping Worksheet, produced important findings on the visual, tactile, and functional qualities of material prototypes that can support the use of breathing and movement to release stress and promote relaxation. Guided by the two supporting thesis questions, two themes were developed to reveal (1) a clarified understanding towards a need for an embodied communication design for self-regulation, (2) in-depth understanding on the felt-experiences of stress and relaxation (3) a set of design considerations and practical design suggestions for designing tangible soft wearable prototypes for self-regulation.

Participant's disengagement with their screen-based and wrist-based notifications for stress management revealed challenges to accurately convey the temporal and spatial dimensions to their felt stress, which contributed to a lack of embodied connection with their felt-stress. Without truly understanding how their body responds to stress, ineffective strategies were used to treat their felt-stress. Through the interviews, participants engaged the use of movements and gestures with soft material prompts to convey the dynamic quality of their experiences of stress. By integrating the rich communicative qualities of movement with soft materials, this revealed a design opportunity to utilize kinetic feedback through a tangible soft wearable design to assist participants in accessing and communicating their own affective and somatic states. The ability to attune to how the body responds to stress empowers users to select the most appropriate self-regulation method to alleviate stress.

Participants expressed the impact of stress on their breath and posture, resulting in restricted breathing and body movement. The changes in breathing rhythms and body movements are interconnected and can reflect a person's affective and cognitive state when experiencing stress. The study highlighted the use of metaphors as a helpful approach for participants to connect and elaborate on their felt-senses of stress and relaxation. Adapting this approach into kinetic feedback, users are able to enrich their kinaesthetic understanding of their felt-experiences of stress through breathing and movement patterns. Various areas on the body were revealed to be most prone to felt-experiences of stress and relaxation. In particular, key findings indicated that stress initiates primarily in the neck and shoulder, while relaxation can be felt on a wider area.

This study produced a set of design considerations and suggestions towards the design of a soft wearable prototypes to support self-regulation. I presented a framework (Table 4.4) that bridges emotive terms with practice references to soft materials. This framework of sensory attributes associated with relaxation and stress-tension sensations will guide the consideration of visual, tactile, and functional elements to develop into soft prototype designs that can enhance users' kinaesthetic understanding of felt-stress and felt-relaxation. I also proposed a set of practical design suggestions (in **Chapter 4.5.1.1.**) on developing form factors, materials, and movement qualities that can afford for relaxation responses.

4.7. Chapter Four Summary

In this chapter, I engaged in the Material Prototypes Design Study through 5 design activities to better understand how felt-experiences of self-regulation for relaxation and stress-release transpired on 10 participants. The study indicated that stress initiates primarily in the neck and shoulders, while relaxation can be felt on a wider area on the upper body. Key findings revealed (1) a design framework of sensory attributes associated with relaxation and stress-tension sensations, (2) the integration of soft, shapes that are light-weight, and easily deformable, (3) and kinetic metaphors of stretching using compression and expansion, can afford for relaxation responses. Also, integrating two to three variations of textures, creating interaction opportunities for squeezing and caress with soft materials like felt and silk can enhance the relaxation experience. These key findings are utilized in Design Projects 2 (Chapter 5) and Project 3 (Chapter 6) to develop working prototypes that articulate material and interactive possibilities to support self-regulation for relaxation and stress-release.

Chapter 5.

Design of Functional Tactile Prototypes: Bloom, Mice, Pleats (Project 2)

Figure 5.1. Bloom (Left), Pleats (Centre), Mice (Right)

Chapter 5 Overview

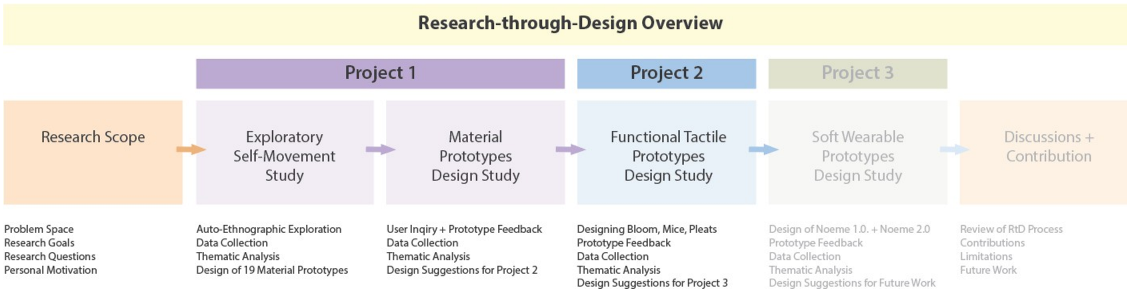


Figure 5.2. Chapter 5 describes the development process and a design study on 3 Functional Tactile Prototype Designs (Bloom, Mice, Pleats).

Figure 5.3. Bloom (Left), Mice (Centre), Pleats (Right)

In this Chapter Five, a set of three newly designed Functional Tactile Prototypes are presented. The prototypes are named: Bloom, Mice and Pleats, and are comprised as my Project 2 of this RtD Thesis. Chapter 5 details the design development and the design study of these 3 functional tactile prototypes based upon the outcomes of the Exploratory Materials Design Study presented in Chapters 3 and 4. These functional prototypes: Bloom, Mice and Pleats investigate the types of kinaesthetic interaction and kinetic feedback that can evoke a felt-sense of relaxation and release of physical stress.

To reiterate the design trajectory of this thesis, and to remind the reader of the current goals: Project 1 was described in Chapter 3 (Auto-ethnographic Exploration) and Chapter 4 (Participatory Design Material Design Evaluation) which together identified visual, tactile, and functional properties of materials that can support relaxation responses. This Chapter 5 describes Project 2, ***Design of Functional Tactile Prototypes***, which builds upon these findings to develop three new functional desk prototypes named Bloom, Mice and Pleats, which are inspired by the Project 1 findings from Chapters 3 and 4, and which integrate and explore participant responses to their use through a Somaesthetic Design Framework (Schiphorst, 2009) to support their design and development.

Bloom, Mice, and Pleats describe their kinetic, material and movement aesthetics with considerations to (1) Connecting with the Felt-Experiences of Stress and Relaxation, (2) Poetics of Breathing and Body Movement, (3) Materials for Relaxation Responses, (4) Kinetic Feedback towards Stress Release and Self-Regulation. The three prototypes support the process to refine the selection of visual, tactile, and functional elements that can afford natural mapping to the application of breath and change in posture to support self-regulation for relaxation and stress-release. The refined collection of visual, tactile, and functional elements will be implemented towards the design and development of soft wearable prototypes in Chapter 6.

The Bloom, Mice and Pleats prototypes are evaluated in a design study, which is guided by two supporting questions: (1) What functional tactile elements can be coherent with participants use of breathing patterns and change in posture, and (2) What kinetic textile movements afford natural mapping to felt-experiences of stress and relaxation in the participant? (Figure 5.2). The design studies are comprised of an experiential session with the prototypes and an open-ended conversational interview.

This ***Functional Tactile Prototypes*** Chapter is organized in two major sections, the first section focusing on the design and development of the three functional tactile prototypes: Bloom, Mice and Pleats, and the latter focusing on the design study. In the first design and development section, the design and construction of the 3 functional tactile prototypes (Bloom, Mice, Pleats) is described through four somaesthetic framework design themes. In the second section, the design study of the three prototypes is presented. This includes an explanation of the participant recruitment and selection process, a description of the study procedures and a review the study findings through a thematic analysis. This ***Functional Tactile Prototypes*** chapter of Bloom, Mice and Pleats concludes with two thematic discussions according to the research questions and three main design directions are revealed for Project 3.

The design study was conducted, through one-on-one sessions with seven participants selected from the original material prototype study conducted in Chapter 4. The collected data was analyzed through thematic analysis that with considerations to the

Somaesthetic Design Framework. The key findings are examined and discussed according to two central themes: Poetics of Breathing and Body Movement, and Kinetic Expansion and Compression for Stress Release. The design study of the Functional Prototypes Bloom, Mice and Pleats resulted in three primary design implementation implications: (1) prototypes were best represented through a combination of two design combinations of visual, tactile, and functional properties to represent breathing and muscle movement patterns, (2) prototypes presented unique kinetic feedback of the use of how compression and expansion can be implemented to convey felt-experiences of stress and relaxation, (3) technology considerations were identified that inform the design and development iterations of soft wearable designs for self-regulation in Project 3.

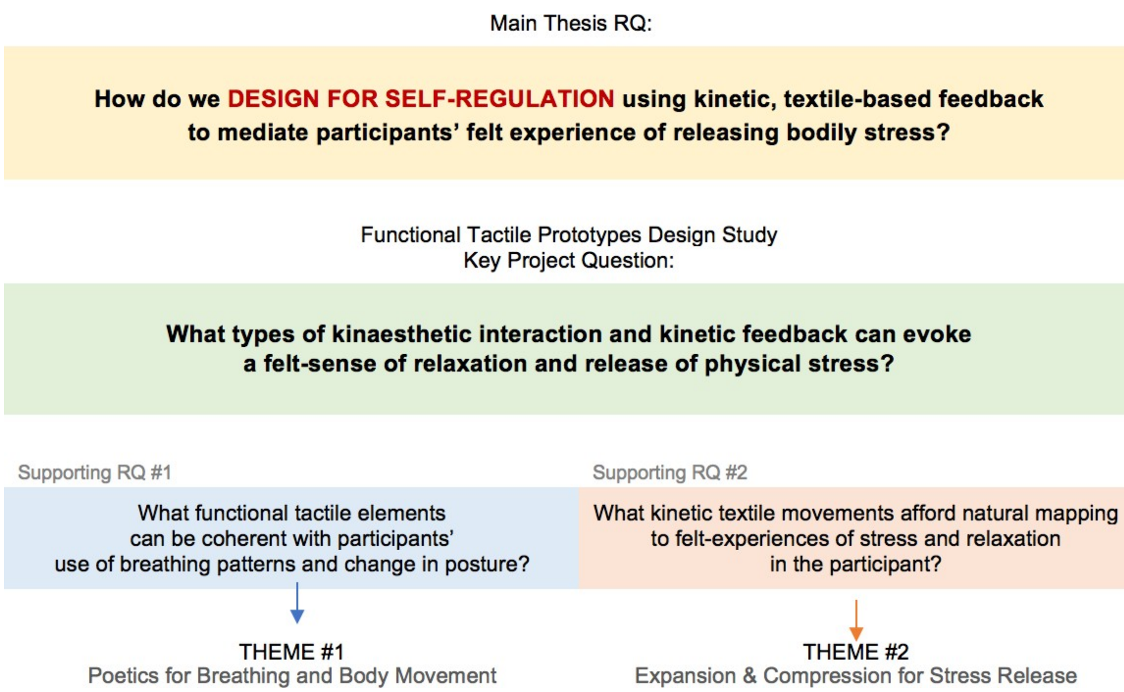


Figure 5.4. Functional Tactile Prototypes Design Study Questions and Themes

5.1. Design & Construction of Bloom, Mice, Pleats

5.1.1. Connecting with Felt-Experiences of Stress and Relaxation

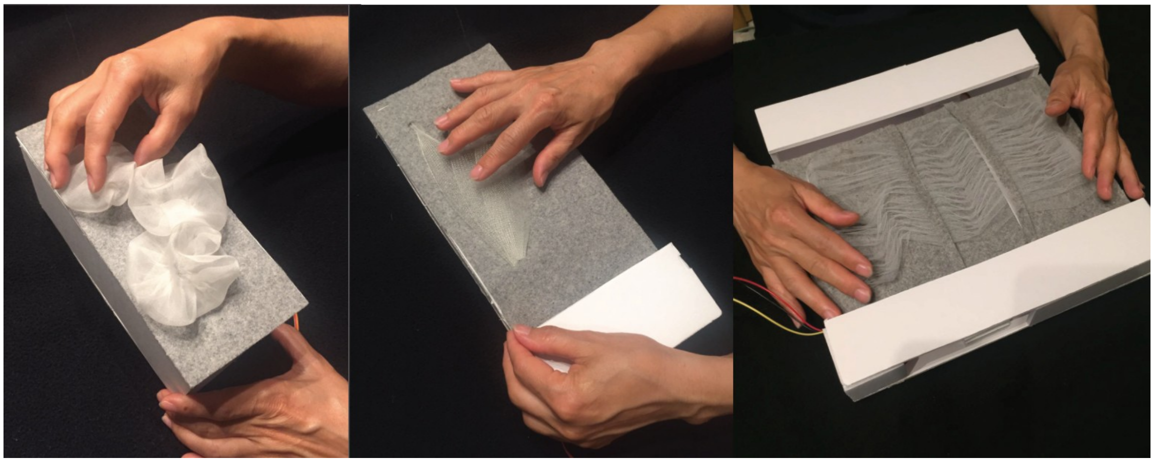


Figure 5.5. Touching the functional tactile elements on Bloom (Left), Mice (Centre), Pleats (Right)

The designs of Bloom, Mice, and Pleats were developed to support participants' ability to access and articulate their felt-experiences of stress and relaxation. Through combining the rich communicative qualities of movement with soft materials, the tangible prototypes present kinetic feedback of compression and expansion to prompt participants' visual-tactile senses. Through the experiential session with the 3 functional tactile prototypes, participants are engaged to observe, to "actively touch" (Schiphorst, 2009), and reflect on their own affective and somatic states when experiencing stress and relaxation. From the experiential session with Bloom, Mice, and Pleats, we can observe how visual, tactile, and functional properties of the prototypes can direct participant's attention and reflection in their meaning-making process between the sensations of the materials and their own felt-sensations.

5.1.2. Poetics of Breathing and Body Movement

The material prototype study's findings revealed a design opportunity to utilise breathing and body movement as tangible kinetic metaphors to assist participants in accessing and articulating their felt-sense of stress and relaxation. The design of the 3 functional tactile prototypes thus explored the poetic notions of felt-stress and felt-relaxation through breathing and body movement. This research engaged in a process of conceptual and material sketches based on somatic and affective associations with breathing and body movement (Figure 5.6) that were mentioned from the self-movement study and the material prototype study. Abstractions were made with references to the inhalation and exhalation of air, the muscle fibres, and the feelings of tightness.

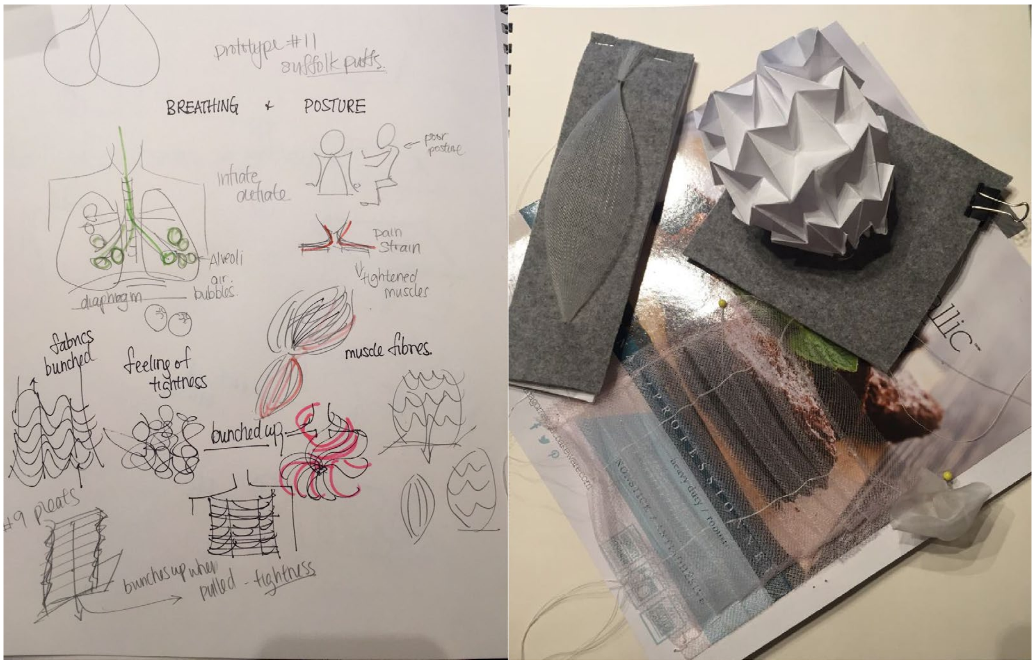


Figure 5.6 Conceptual (left) and material ideation (right) sketches towards Bloom, Mice, and Pleats.

For the design of Bloom, the functional tactile element embodied the concept of inhaling and exhaling air through puff-like forms. Coupled with silk organza, the translucency and crispness of the textile captures an aesthetic quality of airiness, lightness, and ephemeralness. For the design of Mice, the functional tactile element embodied the concept of muscle fibres through elongated, elliptic forms. Coupled with polyester horsehair (crinoline trim), the smooth netting fabric captures an aesthetic of flexibility, volume, and thread-like. For the design of Pleats, the functional tactile element embodied the concept of the feelings of tightness through a pleating form. Coupled with polyester tulle, the textile captures an aesthetic quality of floating, bunched up, and restricted.

When simulated deformations are applied to the forms, it has the potential to represent a change in the breathing rhythms and body movements. Bloom's elements will "inflate and deflate" like lungs in the process of inhaling and exhaling air, Mice's elements will “tense and release” like muscles in the process of stretching (Figure 5.7), and Pleats' elements will “scrunch and uncompress” in the process of the bidirectional pull. These changes can reflect a person's affective and cognitive state when experiencing stress and relaxation.

Figure 5.7. “Tense and release” like muscles from Mice's functional tactile elements.

5.1.3. Materials for Relaxation Responses

Using the framework of sensory attributes with material properties that support relaxation and tension sensations (Table 4.4), four soft materials for the design of Bloom, Mice, and Pleats were explored and selected (Figure 5.7). The suitability of the 4 materials was determined by the practical design suggestions (in **Chapter 4.5.1.1**) from the material prototype study. The design suggestions act as a guideline to support the design development of the form factors, textures, and movement qualities that can support for relaxation responses.

5.1.3.1. Soft Materials

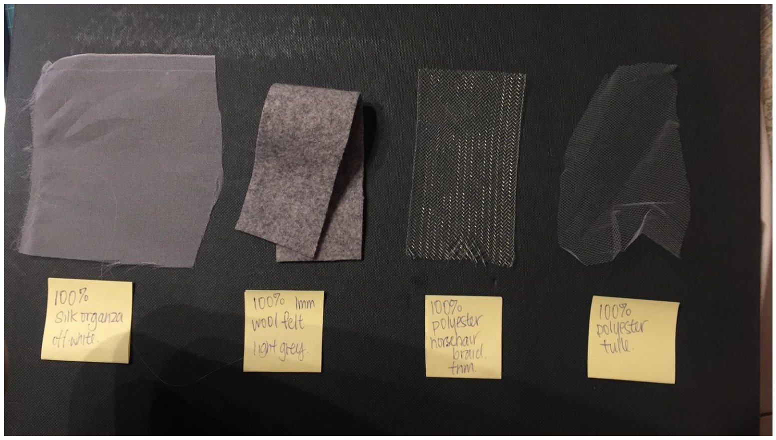


Figure 5.8. Fabric swatches of the four soft materials used on Bloom, Mice, and Pleats

Figure 5.9. Close up of the textural contrasts between wool felt with silk organza (Bloom), horsehair (Mice) and tulle (Pleats).

In Project 1's Material Prototypes design study, silk and felt were recommended as textile materials to use for the next prototype designs for their qualities of softness and warmth. Bringing this suggestion into the design of functional tactile prototypes, grey wool felt was selected as a base material to foreground lightness and softness of the white functional tactile elements on the three prototypes. While the felt material was fibrous in texture, its combination with another soft material provided a textural contrast to form an engaging tactile experience. For Bloom, the wool felt was combined with silk organza; for Mice, the wool felt was integrated with polyester horsetail; for Pleats, the wool felt was coupled with polyester tulle. The varying textures stimulated participants' tactile senses for reflection and creative exploration of their felt-experiences.

Silk organza, polyester tulle, and polyester horsehair were selected for their soft texture, and their ability to generate functional tactile elements that are soft, light-weight in density, and could be easily deformed. The design of these elements supported for relaxation responses through providing participants' an opportunity to caress with soft materials, which could incite for a positive affect through the tactile experience.

5.1.3.2. Technical Implementation and Integration

Each of the functional tactile prototypes generated a kinetic expression of expansion and compression. This was implemented through a textile manipulation of pull and release using 8lb. clear fishing lines that are connected to rotational motors (Figure 5.10, 5.11, 5.12). The overall technical implementation for Bloom, Mice, and Pleats are similar. Specifically, Bloom and Mice's technical system design involved one motor while Pleats used two motors (Figure 5.13). An Arduino Uno microcontroller was used to control the 180-degree micro-servo (s) through Pulse Width Modulation (PMW). The feedback cycle consisted of a 2-second compression and a 2-second expansion, which was mapped to a normal adult respiration rate of 15 breaths per minute (Russo et. al, 2017).

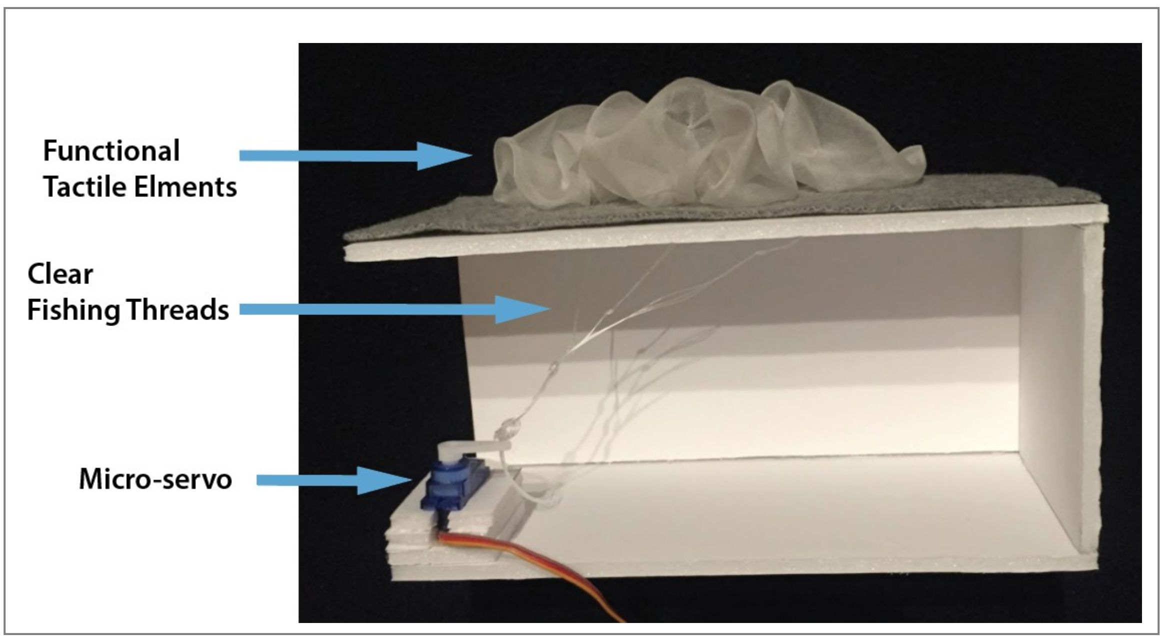


Figure 5.10. Technical and Textile Integration of Bloom

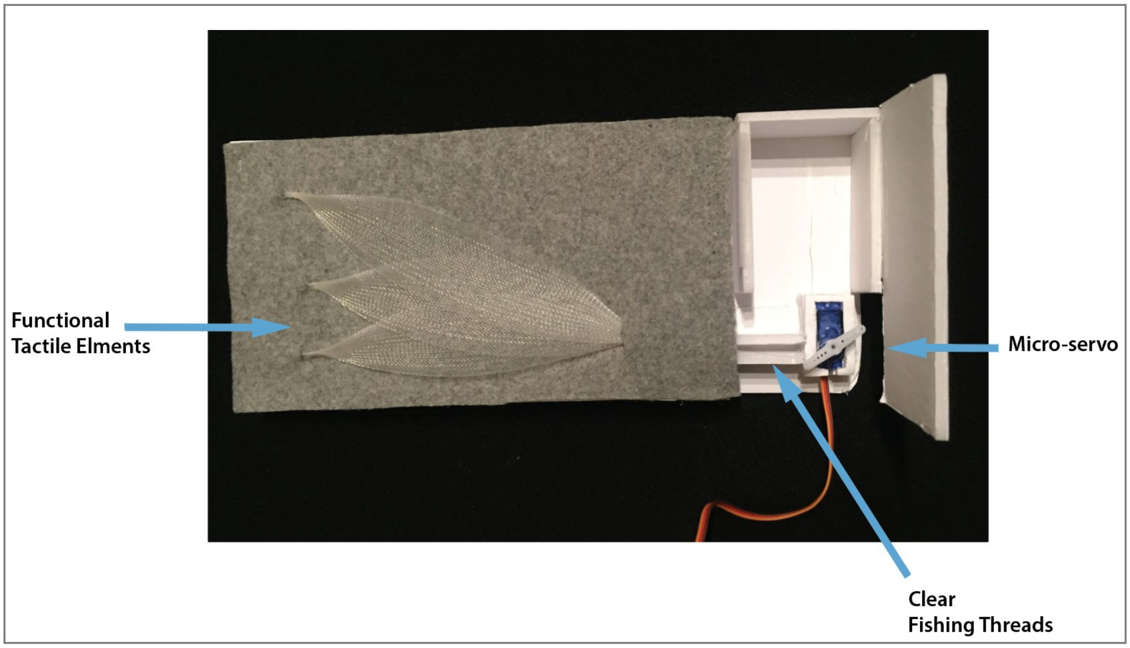


Figure 5.11. Technical and Textile Integration of Mice

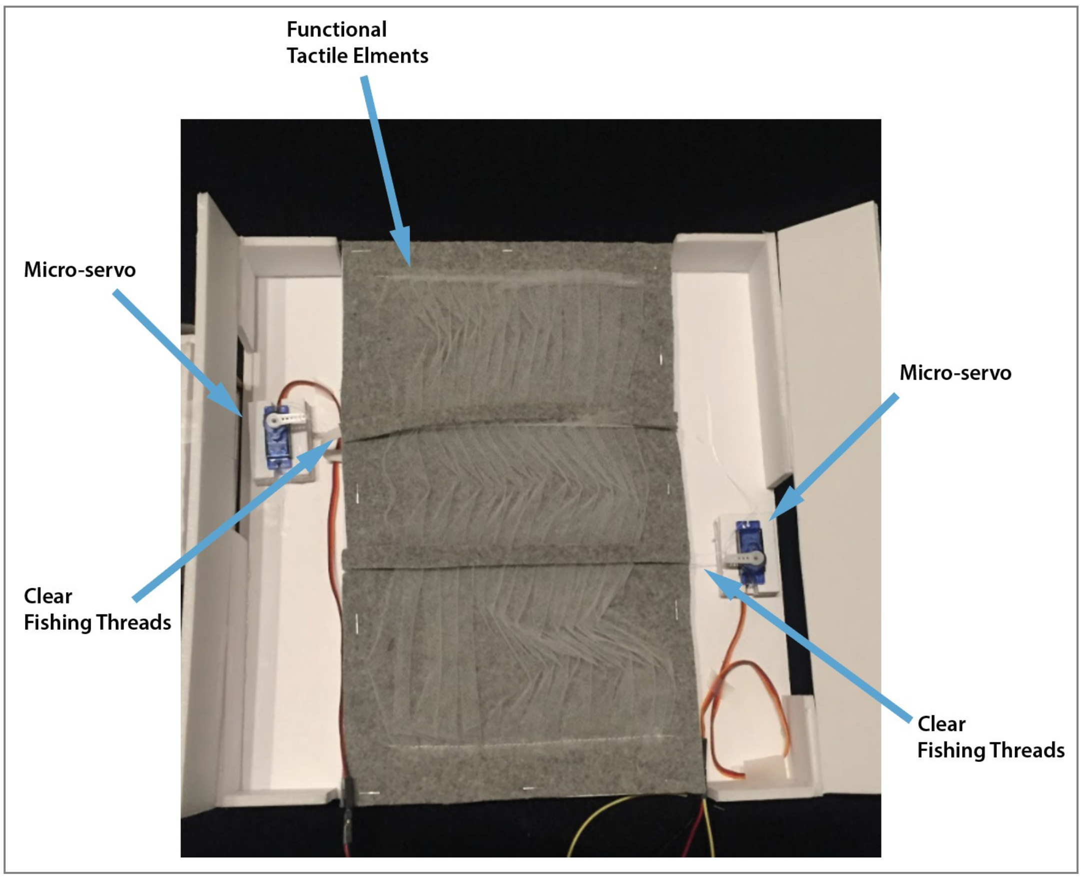


Figure 5.12. Technical and Textile Integration of Pleats

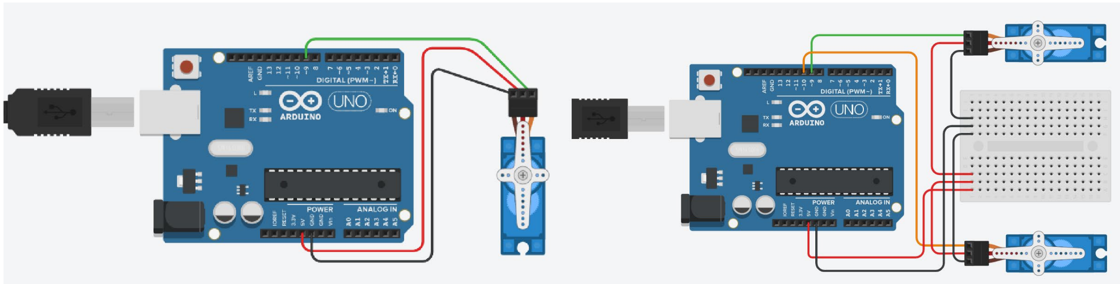


Figure 5.13. Pictorial Circuit Diagram of Bloom/Mice (left). Pleats (right). [created through Autodesk Tinkercad]

The structural bases for the three prototypes were constructed with white foam core to provide a light but sturdy foundation to host the functional tactile elements. The functional tactile elements are placed on an elevated platform, while the electronics are placed below in a semi-covered casing. This allowed the technology to not be visually distracting while still providing accessibility to the components.

5.1.4. Kinetic Feedback towards Stress-Release and Self-Regulation

The design of Bloom, Mice, and Pleats explored the kinetic movement of compression and expansion to convey a sense of stretching, which was associated as a relaxation response. Three characteristics of stretching were implemented across the prototypes: Bloom used a radial compression and expansion, Mice used a directional compression and expansion, and Pleats performed a bi-directional compression and expansion. Bloom and Mice's movement on the functional tactile elements were designed in unison while Pleat's movement on the functional tactile elements were staggered. The varied forms of kinetic movements displayed on the prototypes helped to determine how temporal and spatial dimensions can be integrated together to generate associations to felt-stress and felt-relaxation. Through the process of appealing to participants' kinaesthetic cues, the prototypes' kinetic feedback can create an opportunity to observe the meaning-making process between the visual-tactile experiences to participants' emotions and body cues. By observing the kinaesthetic interaction process, it was possible to identify the appropriate temporal patterns of kinetic feedback displays that could engage breathing or muscle movement patterns to initiate a self-regulation process in the participant to shift their affective and physical state.

5.2. Conversational Interviews and Experiential Session with Bloom, Mice, Pleats

5.2.1. Participants

Participants were recruited using convenience sampling from the pool of participants who partook in the material prototype study and had provided consent to be contacted for follow-up interviews. The decision to recruit participants from the material study was to leverage their familiarity with the focusing exercise and the topic of my study. In total 7 individuals from the material prototype study agreed to participate in this design study. Participants consisted of 1 male and 6 females, with an average age of 29.4 years. A physical consent form was provided to each participant to sign for verifying that they have provided consent and understood the nature, benefits, potential risks of the study. Once the form was signed and additional questions have been addressed, participants are provided with an overview of the study.

5.2.2. Procedure

5.2.2.1. Setting

Similar to the Material Study Setting, the study sessions were conducted in a private, enclosed office spaces or rooms that had ample floor space with a large table and chairs. The locations ranged from the researcher's lab space at SFU Surrey Campus, a study room at SFU Burnaby Campus, or at the residences of the participants. The locations were selected to accommodate the schedule availability and travel constraints of participants. The study sessions were one-on-one between the design-researcher and the participant. The duration of the study sessions ranged 20 to 30 minutes.

5.2.2.2. Data Collection

For this design study, open-ended conversational interviews were conducted. Lavrakas (2008) highlights the use of conversational interviews can provide participants an opportunity to engage in extended discussions freely. This complements the experiential nature of the study, where participants engage in a process of observation and "active touch" (Schiphorst, 2009) between the 3 prototypes.

To start, warm up questions were asked to allow participants to become more attuned with their sensing bodies. Participants were asked to describe their breathing and posture when they are stressed and relaxed. Afterwards, they were presented with one prototype, and given 5 minutes to observe and touch the kinetic feedback. The functional tactile elements all initiated from the neutral state. The kinetic feedback was mapped to a normal adult respiration rate of 1 breath every 4 second intervals (Russo et. al, 2017), which mapped to 15 breaths per minute. After the experiential session, participants were asked questions focusing on their 1) initial impression to the materials, 2) initial impression to the kinetic feedback, 3) their interpretation of the kinetic feedback, 4) its resemblance to the concept expansion and compression, 5) their process on mapping the kinetic feedback to felt-experiences of stress and relaxation, 6) their impression of the sound. This process was repeated for the two other prototypes. For consistency purposes across the interviews, the functional tactile prototypes were shown in the order of Bloom, Mice, and Pleats.

5.2.3. Results

5.2.3.1. Data Analysis Process

This design study on the 3 on-table functional tactile prototypes (Figure 5.15) aim to identify the types of kinetic feedback that can evoke a felt-sense of stress release. Through open-ended conversational interviews and experiential sessions with the prototypes, I examine what functional tactile elements can be coherent with breathing patterns and body movement, and determine what kinetic movements afford a natural mapping to felt-experiences of stress and relaxation. Natural mapping can be broken down to conceptual, spatial, and behavioural similarities (Sherwin, 2018). Hand-written notes and audio-recordings of the interviews were collected, transcribed, and coded through traditional hand-coding using highlighters and post-its groupings of similar observations (Figure 5.14). With an emphasis on the sensorial and expressive aspects of the visual, functional, and tactile properties of and the experiential qualities of interactions, I conducted a thematic analysis with considerations to the somaesthetic framework of touch (Schiphorst, 2009), and examine the data according to interrelated themes of (1) Expansion and Compression for Felt-Experiences of Stress and Relaxation, (2) Materials for Relaxation Responses, (3) Poetics of Breathing, Movement, and the Body, (4) Impressions to Technology Sound.

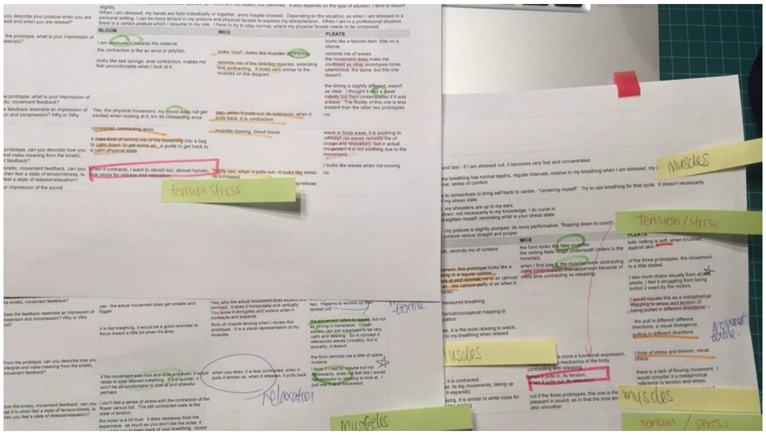


Figure 5.14. Snapshot of Initial Coding Process

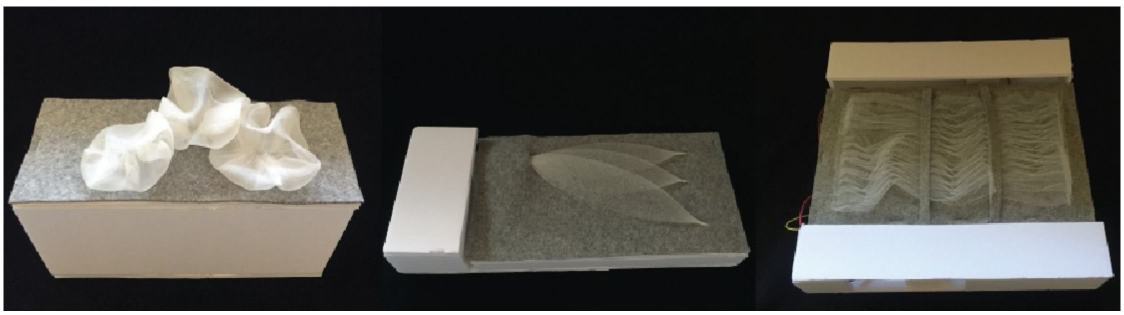


Figure 5.15. Bloom (left), Mice (centre), Pleats (right)

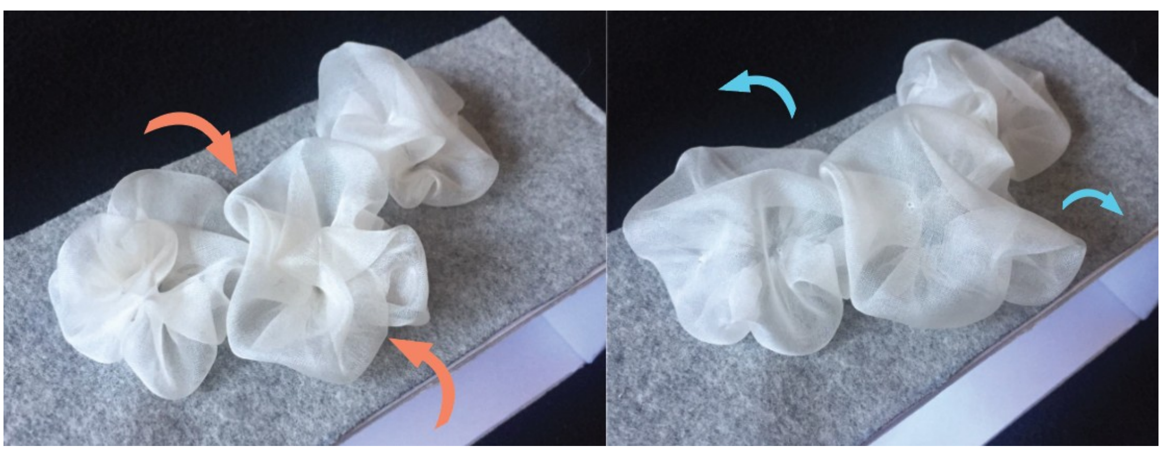


Figure 5.16. Bloom in compressed state (left), and Bloom in expansion (right).

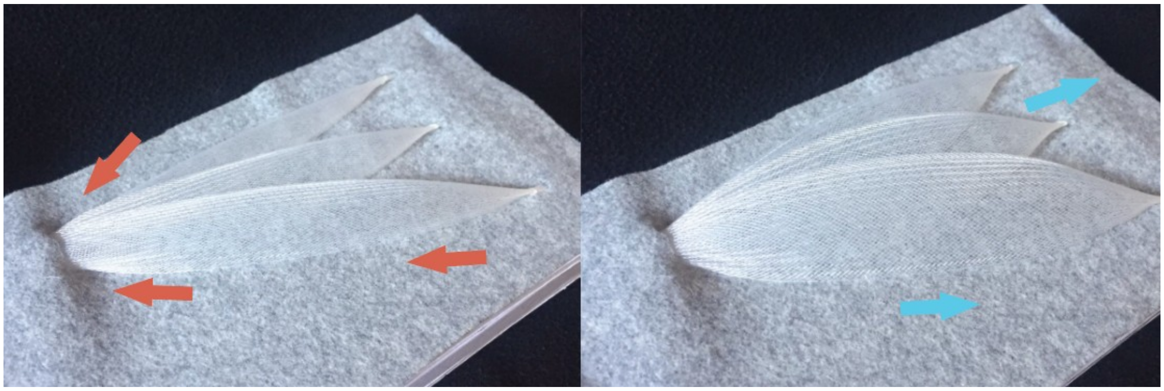


Figure 5.17. Mice in compressed state (left), and Mice in expansion (right).

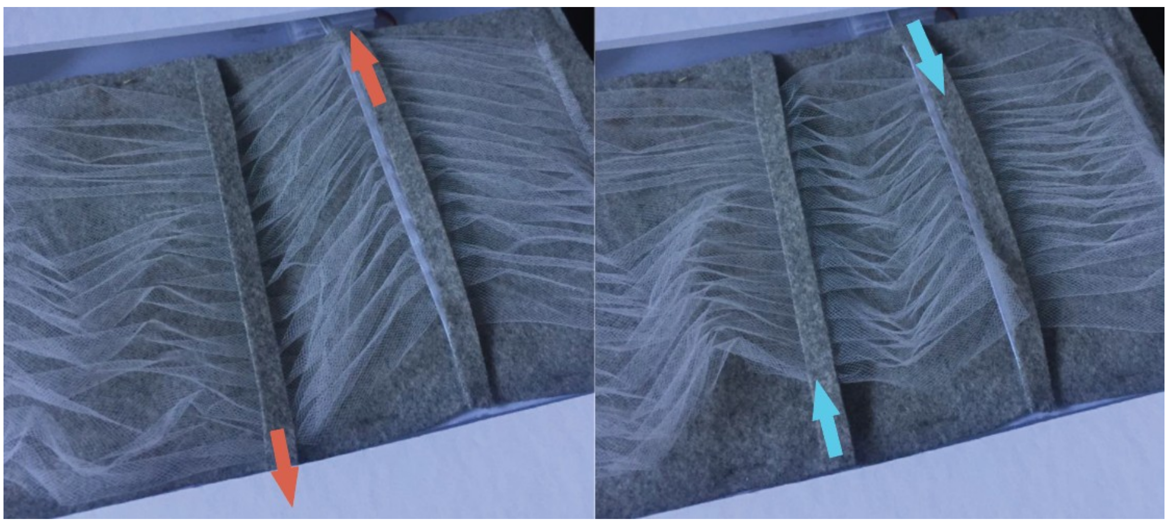


Figure 5.18. Pleats in compressed state (left), and Pleats in expansion (right).

5.2.3.2. Findings

5.5.3.2.1. Expansion and Compression for Felt-Experiences of Stress and Relaxation

For Bloom and Mice, all participants were able to recognize a kinetic movement of compression and expansion (Figure 5.16, 5.17). Participants conceptually mapped the kinetic movements of compression and expansion with felt-experiences of stress and relaxation under three main observations.

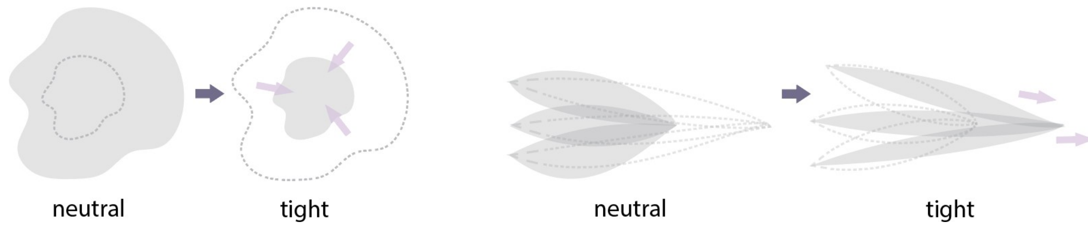


Figure 5.19. Bloom (left) , Mice (right) - kinetic compression

Observation 1: The kinetic compression (Figure 5.19), from a neutral state to tight state, was conceptually mapped to felt-experiences of stress. Participants upon observing the prototype, developed a visceral feeling of stress.

> "When it [Mice] contracts, I want to clench too, almost hypnotic, vice versa for release and relaxation." - P3

> "when it pulls in, [Bloom] it's tension...when I feel tense, [refers to Mice] it is contracted." - P1

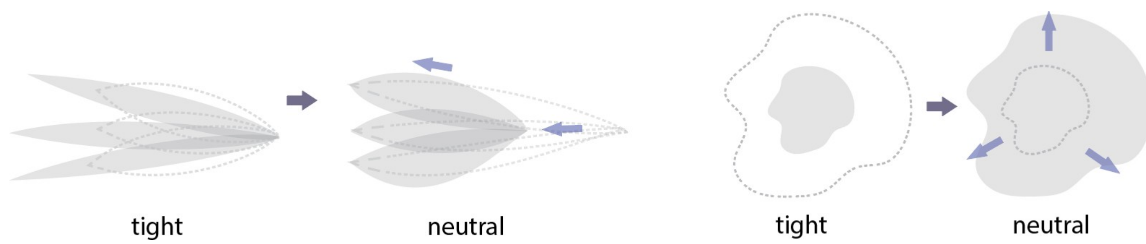


Figure 5.20. Mice (right), Bloom (left) - kinetic expansion

Observation 2: The kinetic expansion (Figure 5.20), from a tight to neutral state, was conceptually a mapped to felt-relaxation. Participants also associated a visual spatial expansion to the concept of relaxation.

> "when it pulls out [referring to Mice], its relaxation." - P1

> "when it stretches out, I feel it is more tense, when it releases and is relaxed, it expands." - P7

Participants further described the ability to physically and spatially expand was representative of a relaxed state.

> "when I feel relaxed, its big movements, taking up space (like when it expands)". - P1

> "definitely see how this prototype is stretching. When it condenses, its tight and tense, when it expands, it relaxes and releases." - P6

Observation 3: Participants indicated slow and even movements were more relaxing while quick and uneven movements were more stressful.

> "if the movement was nice and slow and even, it would relate to slow relaxed breathing. If it is quicker and more sporadic, it won't be as comfortable to look at and stressful perhaps." - P4

> "yes, I think it reminds me of how lungs expand and collapses, it has a rhythmic flow to it. there is a sense of organicness in them" - P6

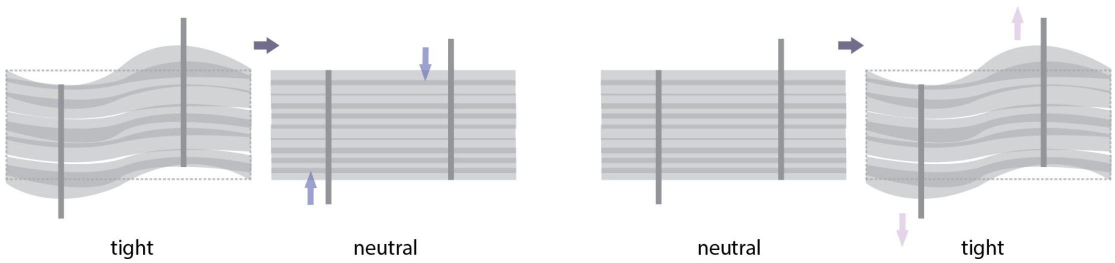


Figure 5.21. Pleats - the birectional movements

While the functional tactile elements on both Bloom and Mice's moved in unison, Pleats' kinetic movement was designed to be staggered and bidirectional simultaneously (Figure 5.21). Some participants viewed the movement as "visually chaotic" (P1), "interesting" (P5, P6), ambiguous and confusing (P2). Participants did not map the movement to an expression of expansion and compression, but did relate its bidirectional movement to stress and relaxation.

> "I would equate this as a metaphorical mapping to stress and tension. It [when my muscles] are being pulled in different directions." - P1

> "Yes, when both sides are pulled away, I don't see that as expansion, but see it as tension. When it comes back to original form, it is seen as released." - P6

> "When it moves [pulls away], I feel tense, but when it slows down [to original form] , I would feel relaxed." - P2

In their process to make sense of the kinetic movement, Participants 3, 4, 5, 6 mentioned its resemblance to waves. All elaborated that waves do relate to relaxation, but Pleats' movement was not relaxing. Additionally, Participant 7 described the movement with metaphors of "slither like a snake", and "rolling up and down [the] opera curtains".

5.2.3.2.2. Materials for Relaxation Responses

Four types of soft materials were used for designing the 3 on-table functional tactile prototypes: wool felt, polyester tulle, and silk organza, and polyester horsetail. Based on the framework of sensory attributes associated with relaxation and stress-tension sensations (Table 4.4), participants provided descriptions to the form and textures, and moving features of expansion and compression that were associated with relaxation.

> "Tulle netting is soft, when brushed against skin. The silk is soft, the silk reminds me of curtains." - P1

> "I like it [Bloom]. The material [silk organza] is the softest [comparing with Mice and Pleats]." - P2

> "The materials [silk organza] are soft and light with the form". -P7

> "[Bloom's] materials feel delicate, has a springy property to it, where it springs back to their place." - P5

Participant 5 also acknowledged use of textural contrast with the soft materials during the tactile experience of the prototypes.

> "The materials are fine, nice contrast in different textures being used, keeps the tactile experience interesting." - P5

For all the participants, the visual contrast between the grey and white allowed the participants to focus on the moving shapes on the prototypes.

> "Only grey and white were used, which is simple and makes things look clean" - P3.

> "The grey felt kind of frames and presents the white flowers, or muscles on the prototypes." - P7

When considering the visual-tactile experiences without the kinetic movement of the three prototypes, participants identified Pleats had the most visually complex texture of the three prototypes with its repetition of folds, and creating a visually engaging experience (P6).

In particular, for the functional tactile prototypes, 6 of 7 participants were neutral to the tactile experience with the grey wool felt on Bloom, Mice, and Pleats. However, participant 2 did express discomfort with the wool felt and indicated that it may be itchy when worn on the body.

When evaluating the form, textures, with the moving features of compression and expansion, Participants mostly associated Bloom's functional tactile elements with living beings and natural objects that are more organic in shape. Some associations include: sea octopus (P7), jellyfish (P1, P3), a "growing mushroom", sea anemones (P5), clouds (P4), and flowers (P2, P4). Participant 5 further described the moving shapes on Bloom as "feeling alive", with a life-like quality through its "breathing".

When reviewing the form, textures, with the moving features of compression and expansion, Participants associated Mice's functional tactile elements as muscles (explained in the following section).

5.2.3.2.3. Mapping to Breathing and Movement, and Body

Participants found the functional tactile elements on Bloom most aligned with breathing, the process of inhaling and exhaling air.

> "It [Bloom] looks like it is breathing, from the shape, the motion on when it goes up and down. It is very even, not jerky." - P4

> "Lungs is a stretch, but the concept of air going in/out of something." - P1

> "Breathing is the same way, when lungs are filled up. When you are breathing, the lower part goes tighter [like diaphragm]. When air goes in, your clothes feel tighter on the chest cavity, you feel restricted, and vice versa for releasing air out to relax." -P5

Notably, participant 3, while observing the kinetic movement of Bloom, highlighted on the potential to use the prototype's simulated breathing as a guide for matching one's own breathing to return to a relaxed physical state. Participant 1 further correlates prototypes simulated breathing with relaxation as "it is the most relaxing to watch, the pace is similar to my breathing when relaxed."

Participants found the functional tactile elements on Mice most aligned with the contraction and release of body muscles.

> "[Mice looks] kind of strange, reminds me of muscles in a way it freaks me out when it goes in there [the hole]." - P4.

> "Yes, because it is mimicking muscle movement tense & release. [Mice] feels like prototype is stretching itself so it compacts and extends." - P6

> “[This] looks "cool", looks like muscles contracting. [Mice] reminds me of the limb/leg muscles, extending and contracting. It looks very similar to the muscles on a body diagram.” - P3

> “I think of muscle tensing when I review this prototype. It is a visual representation of my muscles.” - P4

Participant 1 considered Mice’s to have a practical aesthetic, where its functional tactile elements were “more a functional expression, mapping to the mechanics of the body contracting and releasing”. This is supported by Participant 5, who described applying the Mice’s moving shapes to a specific area on the body to demonstrate the felt sensation of a muscle strain.

> “...whereas, Mice applies to a specific area, like one direction or pinpointing a specific strain felt on the body.” - P5

> “The movement pattern is like looking at muscles moving and seeing its very elliptical in shape where it connects to one point. It is like attaching muscles, showing the end points and [creates] immediate reaction and relatability.” - P6

While Mice provided a good visual representation of muscles and a functional mapping to muscles tensing and releasing, Participant 1 and 4 indicated that Bloom’s functional tactile feature was aesthetically beautiful and was more suitable to represent the holistic feeling of the entire body.

5.2.3.2.4. Technology Impressions.

Bloom, Mice, and Pleats were presented to participants first without the view of the technology to allow the focus be placed on the functional tactile elements on the three prototypes. A few participants appreciated this and agreed that it allowed them to focus on the interaction and experience with materials.

> “Seeing [it] without the tech makes it feel alive and breathing, [like] a living organism. It was cool to see how it gets pulled, but then becomes a moving object.” - P3

> “I like that it’s [technology] hidden, makes everything look more clean in a way.” - P2

6 of 7 participants expressed an interest to review the technologies in an effort to understand how the kinetic feedback was produced on the three prototypes. Upon

reviewing the mechanisms that are used to manipulate the tactile elements, some participants began mapping the connections between the hardware and soft materials to the human musculoskeletal system.

> “So, it is like a joint, or those connective tissues to pull the muscles.” - P4

> “I can see how it is like the muscles along the shoulders, or even the blade area, like how they are connected into one….” - P5

Sound as a design element was not considered in the design of the on-table functional tactile prototypes, and therefore was an unintentional finding. From the rotational movement, the motors from all three prototypes produced sounds that were noticed and discussed by 5 of 7 participants.

> “Sound reminds me of someone snoring.” - P5

> “the motor is a bit loud. it does take away from the experience. as much as you don't like the noise, it does help you to keep track of your breathing. sound would help but not necessarily.” - P4

> “the motor sounds like nails on the chalkboard” - P6

> "the sound is terrible, it is destructive, annoying, loud obnoxious, but still interesting.” - P7

Participants expressed the sound did impact and takeaway from the overall interaction experience with the prototypes. For the next iterations, the sound as audio feedback will need to be considered in the design in-conjunction with the kinetic feedback.

5.2.4. Discussions

Through an experiential session and conversational interview on the 3 functional tactile prototypes (Bloom, Mice, Pleats) to explore what types of kinetic feedback can evoke a felt-sense of stress-release, key findings were organized into two particular themes (Figure 5.1) to address the design study’s two supporting questions: (1) What functional tactile elements can be coherent with breathing patterns and body movement? (2) What kinetic movements afford a natural mapping to felt-experiences of stress & relaxation?

Poetics of Breathing and Body Movement

The previous material study highlighted the use of metaphors to assist participants to access and articulate their felt senses of stress and relaxation. In the design of Bloom, Mice, and Pleats, we adapted the use of metaphors into a tangible design of three visual tactile functional elements. This study confirmed the use of tangible metaphors and further revealed two main observations that can support the design of the moving shapes to specifically associate with breathing and body movement. With consideration to the framework of sensory attributes with material properties that support relaxation and tension sensations, the study showcased the use of rotund, organic shapes that are soft, light-weight in density, and can be easily deformed through a radial compression and expansion can afford a natural mapping to breathing, or the process of inhaling and exhaling air. Secondly, the use of leaf-like, elongated shapes that are light-weight in density, that can be deformed through a springy, directional compression and expansion can represent body muscles are tensing and releasing. Participants further noted a possibility in using the visual functional tactile elements to incite for motor mimicry of relaxation responses, which can become an affective contagion towards feeling the release of stress.

Kinetic Expansion and Compression for Stress Release

A design suggestion from the material study was using compression and expansion to convey a sense of stretching for relaxation responses. This was implemented within the design of the functional tactile elements on Bloom, Mice, and Pleats. This study confirmed that the kinetic movement of compression and expansion presented on Bloom and Mice can be mapped to the felt experiences of stress and relaxation. We further revealed how kinetic expressions of compression and expansion can represent felt-stress and felt-relaxation. A kinetic compression, from a neutral to tight state, can emulate a felt-sense of tension. A kinetic expansion, from a tight to neutral state, can emulate a felt-sense of release. For the rate of movement, participants indicated a slow and even rhythm most aligned with a relaxed state, while a quicker and uneven pace conveyed a stressed state. Furthermore, for both radial and directional compression and expansion, the kinetic movements should be in unison for clarity.

5.2.5. Design Directions for Project 3

This design study, through an explorative experiential session and conversational interviews with 3 functional tactile prototypes, several design insights from the material study were evaluated and further refined to identify the types of kinetic feedback that can evoke a felt-sense of stress-release and promote relaxation. Guided by two supporting research questions, I examine the findings under two interrelated themes to reveal (1) two design combinations of visual, tactile, and functional properties to represent breathing and muscle movement patterns, (2) how kinetic feedback of compression and expansion can be implemented to convey felt-experiences of stress and relaxation, (3) technology considerations that will inform the design and development of two soft wearable designs for self-regulation in Project 3.

Tangible, kinetic metaphors of breathing and muscle movement patterns have the potential to incite a mimicry of inhalation and exhalation, tensing and releasing towards a felt-experience of self-regulation for relaxation and stress-release. Referencing the framework of sensory attributes with material properties that support relaxation and tension sensations, I propose two design suggestions: (1) Rotund, organic shapes that are soft, light-weight in density, with a radial compression and expansion can be used for the kinetic textile metaphor of breathing. (2) Elliptic, elongated shapes that are soft, light-weight in density with a springy, directional compression and expansion can be used for the kinetic textile metaphor of muscle movement.

To implement the kinetic, textile movement of compression and expansion that can represent felt-stress and felt-relaxation, these design considerations were proposed: (1) A felt-sense of stress can be expressed by a transformation from a neutral to tight state, while (2) a felt-sense of release can be expressed by transforming from a tight to neutral state. Furthermore, a slow and even rhythm for the kinetic movement of compression and expansion is most aligned with a relaxed state while a quicker and uneven pace maybe more stressful. When multiple functional tactile elements are included, a uniformed transformation can add clarity to communicating the felt-experience of stress and relaxation.

Lastly, to support the development process of functional tactile elements on a wearable design, there are several design considerations towards the integration of soft materials with electronics. Specifically, sound needs to be further explored as a design element as the auditory feedback resulting from the electronics did impact the overall interaction experience between participants and the prototypes. As well, the physical display of electronics on the wearable design should not be distracting. For the selection of specific textiles, the visual-tactile contrast of white silk and polyester horsehair braid/ crinoline trim with grey wool felt provided a textural contrast that engaged participants for further creative exploration through touch. This can be further investigated within the soft wearable designs in Project 3 (Chapter 6).

Chapter 6.

Design of Soft Wearable Prototypes: Noeme 1.0 & Noeme 2.0 (Project 3)

Figure 6.1. Noeme 1.0 & Noeme 2.0

Chapter 6 Overview

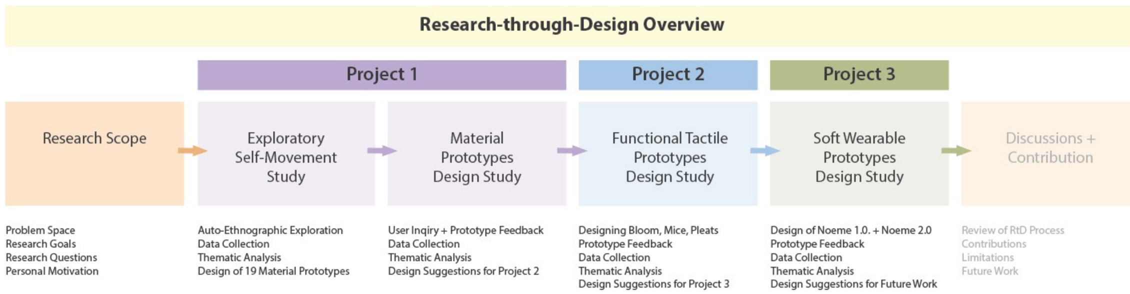


Figure 6.2. Chapter 6 describes the development process and design study on 2 soft wearable prototype designs (Noeme 1.0 and Noeme 2.0).

In chapter 6, the *Design of Soft Wearable Prototypes: Noeme 1.0 & Noeme 2.0* Project 3 (Figure 6.1), the final project of my research-through-design thesis, is presented. Chapter 6 details the design development and the design study of 2 soft wearable designs (Noeme 1.0 and Noeme 2). This final Project is based upon an iterative exploratory RtD process that was initiated through an autoethnographic design process (Project 1, Chapter 3 Design & Chapter 4 Evaluation) that explored provided visual, tactile, and functional properties of materials that could potentially support self-regulation feedback relaxation responses, followed by Project 2 (Chapter 5) Bloom, Mice, Pleats, that identified types of kinetic feedback that could evoke experiential felt-sense of stress-release for relaxation (Figure 6.2). In this Chapter, we review Project 3, through Noeme 1.0 and Noeme 2.0, which explores how kinetic feedback can be presented on a wearable garment worn on the upper-body to evoke a felt-sense of relaxation and stress-release. Guided by *Somaesthetic Design Framework* (Schiphorst, 2009), Project 3 reflects upon the (1) Felt-Experiences of self-regulation for relaxation and stress-release, (2) Poetics of Breathing and Body Movement, (3) Materials for Relaxation Responses, (4) Kinetic Feedback that supports Self-Regulation for Relaxation and Stress Release and in the design and development of Noeme 1.0 and Noeme 2.0. The design study, includes an experiential session with the wearables, Noeme 1.0 and Noeme 2.0, and an open-ended conversational interview. This RtD project is guided by two supporting questions: (1) What functional tactile elements on a soft wearable design can portray breathing and body movements by drawing on kinaesthetic empathy, and (2) How can the metaphor of compression and expansion on the upper body afford a natural mapping to felt-sensations of stress and release (Figure 6.3)? The Soft Wearable Design Prototypes Design Study was completed with 6 participants from Project 2's Functional Tactile Prototypes Design

Study. Using a thematic analysis with considerations to the Somaesthetic Design themes, I reviewed and discussed my findings through two main themes: (1) Poetics of Breathing and Body Movement, (2) Somatic and Affective Responses for Stress-Release. This chapter concludes with a proposal of five design considerations toward future explorations and iterations on soft wearable designs for self-regulation.

Chapter 6, the ***Design of Soft Wearable Prototypes****:* Noeme 1.0 & Noeme 2.0 is divided into two major sections, the first section focuses on the design and development of the two soft wearable prototype designs, Noeme 1.0 & Noeme 2.0, and the second section reports on the design and evaluation study. Noeme 1.0 and Noeme 2.0 design and development are introduced through a somaesthetic framework. The Noeme 1.0 and Noeme 2.0 RtD presents five design considerations for future explorations and iterations that can be applied to soft wearable design for self-regulation.

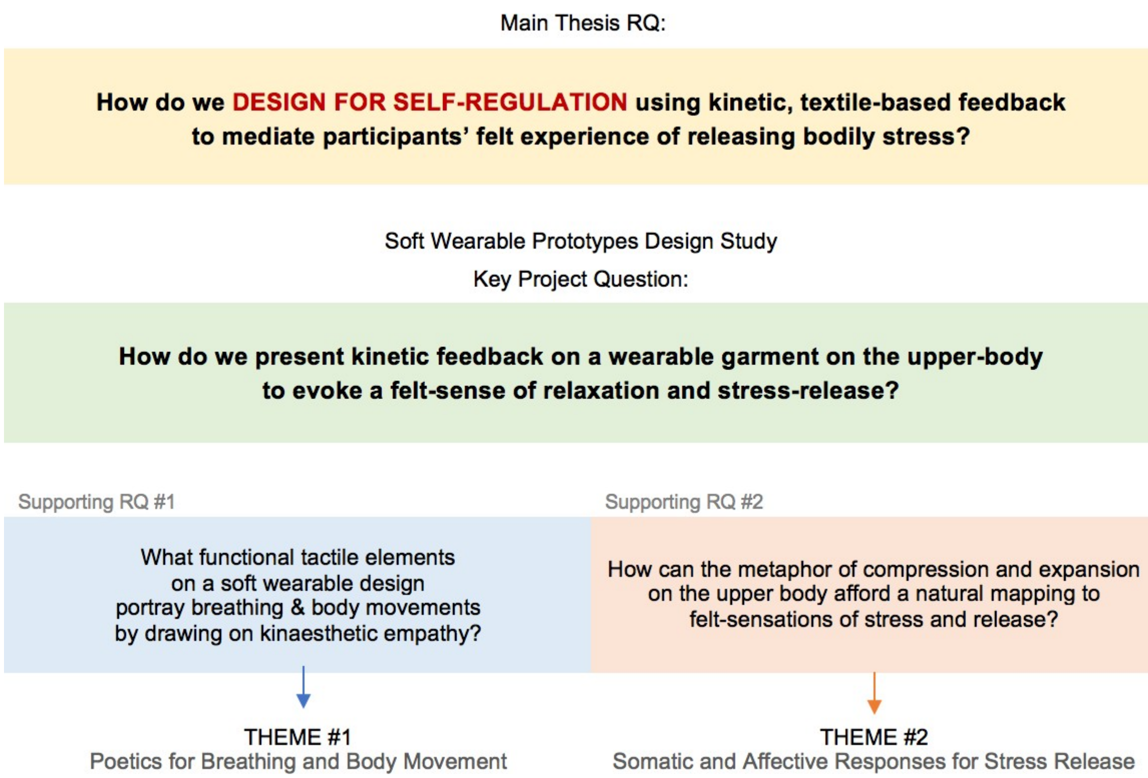


Figure 6.3. Soft Wearable Prototypes Design Study Research Questions and Themes

6.1. Design and Construction of Noeme 1.0 & Noeme 2.0

6.1.1. Connecting with Felt-Experiences of Relaxation for Stress-Release

Similar to the table-prototypes of Bloom, Mice, and Pleats, described in the previous chapter 5, the designs of the two soft wearable prototypes, Noeme 1.0 and Noeme 2.0, provide a visual-tactile-kinaesthetic experience that support participants' connection with and articulation and communication of their felt-experiences with self-regulation for relaxation and stress-release. Participants engaged in an experiential session with two soft wearable designs, Noeme 1.0 and Noeme 2.0, using the process of observation, "active touch" (Schiphorst, 2009), and their in-situ reflections to bridge their own felt-sensations with the visual, tactile, and functional qualities of the prototypes with their felt-experiences of stress and relaxation. In this design study, a focus on the chest and trapezius area on the body was emphasized based upon research conducted earlier in this thesis in Project 1 to reveal how the soft wearable designs can guide participant's meaning-making process between the visual-tactile experiences of materials and felt-sensations in using breathing and muscle movement for relaxation.

6.1.2. Poetics of Breathing and Body Movements.

Based on the key findings of Project 2's Bloom, Mice and Pleats, I the design of Noeme 1.0 and Noeme 2.0 explored the placement of the visual, tactile, and functional elements that represented breathing and muscle movement on the body to assist participants access, articulate and communicate their felt sensations of relaxation and stress-release. I engaged in an iterative design exploration through conceptual and material sketches (Figure 6.4), which proceeded to paper draping and blocking on the mannequin, and physical prototyping with soft materials and textiles (Figure 6.5, 6.7). Initial concepts were based on somatic and affective associations between self-regulation of stress, relaxation, breathing, and body movements. I also referred to the key findings from the Project 1's Body Mapping activity to determine the areas that are most affected through stress and relaxation.

For the design of Noeme 1.0, the design mapped the leaf-like, elongated shapes that are light-weight in density around the chest. With an up-and-out compression and expansion, the design represented the engagement of intercostal muscles around the ribcage to facilitate the process of inhaling and exhaling air.

For the front design of Noeme 2.0, the design utilized a cluster of rotund, organic shapes that are soft, light-weight in density in the centre chest, loosely forming an abstracted outline of lungs. The silk-organza puffs, with a radial compression and expansion, also represented the alveoli, signifying an exchange of oxygen and carbon dioxide, or the process of breathing.

For the back design of Noeme 2.0, the design placed the leaf-like elongated shapes that are light-weight in density in an inverted triangle on the upper back. With a directional compression and expansion, the horsetail shapes represent the muscles tensing and releasing, resulting in changes of one's posture.

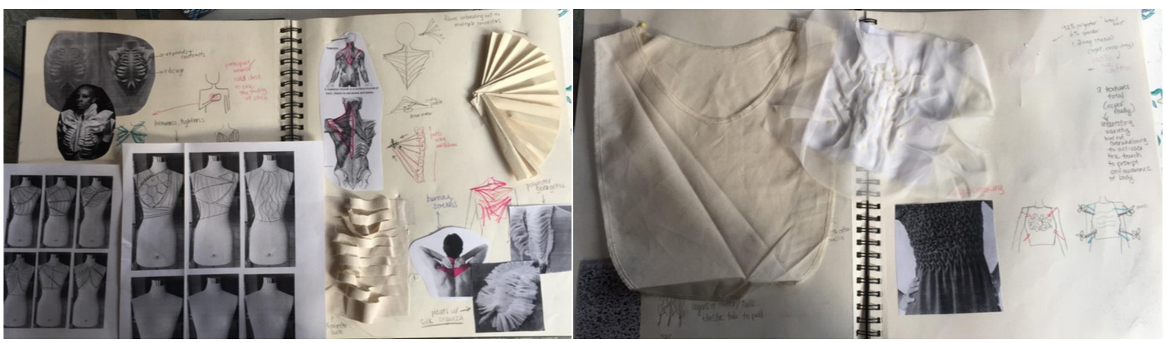


Figure 6.4. Conceptual and Material Sketches.

Figure 6.5. Progression of Noeme 2.0 (Front Design)

Figure 6.6. Final Design of Noeme 1.0 (Front Design)

Figure 6.7. Progression of functional tactile elements on Noeme 2.0

Figure 6.8. Final Design for Noeme 2.0 (Front Design)

6.1.3. Materials for Relaxation Responses

6.1.3.1. Soft Materials

Four materials (Figure 6.9) were explored and used for the construction of the two soft wearable designs. The selection of the materials was based on Project 2's design study, which recommended grey wool felt, silk organza, polyester horsetail braid (crinoline trim). Due to the contrasting feedback with wool felt, a grey heavy-weight cotton jersey was also sourced with consideration to the framework of sensory attributes with material properties that support relaxation and tension sensations (Table 4.4).

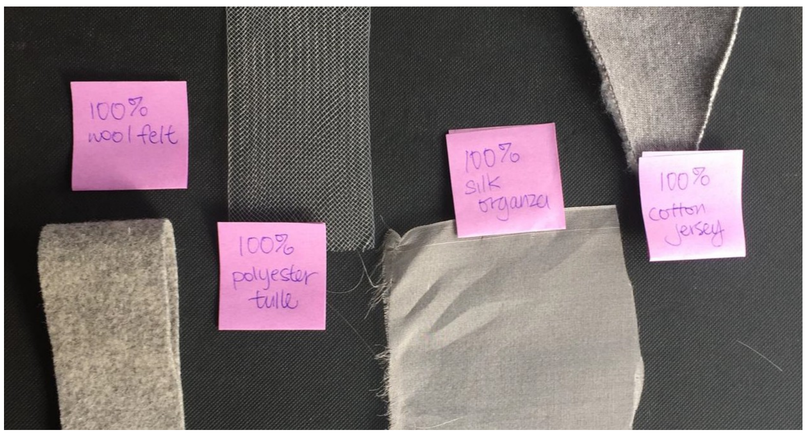


Figure 6.9. Swatches of Wool Felt, Polyster Tulle, Silk Organza, Cotton Jersey

The material combinations provided a visual-tactile contrast and textural contrast to engage participants for creative exploration and reflection through touch. The grey coloured textiles were used as the base layer to foreground the white functional tactile elements. Noeme 1.0 used grey wool felt as base with horse hair, while Noeme 2.0 used grey cotton jersey as base with silk organza (front) and horse hair (back). The characteristics of these materials can generate functional tactile elements that are soft, light-weight, and easily deformed.

6.1.3.2. Technical Implementation and Integration

Noeme 1.0 and 2.0's kinetic movements were implemented a similar system involving textile manipulations of pull and release using 8lb. clear fishing lines that were connected to rotational motors. Noeme 1.0 uses two 180-degree micro-servos while Noeme 2.0 uses one 180-degree micro-servo and one 180-degree standard servo. An

Arduino Lilypad microcontroller was used to control the servo motors through PMW in each of the prototypes (Figure 6.10b). Two modes of feedback are programmed into the system. Mode 1's feedback cycle consisted of a 2-second compression and a 2-second expansion. This was mapped to a normal adult respiration rate of 15 breaths per minute (Russo et. al, 2017). Mode 2's feedback cycle consisted of a 5-second compression and 5-second expansion. This correlated to a deep breathing respiration rate of 6 breaths per minute (Russo, et. al, 2017).

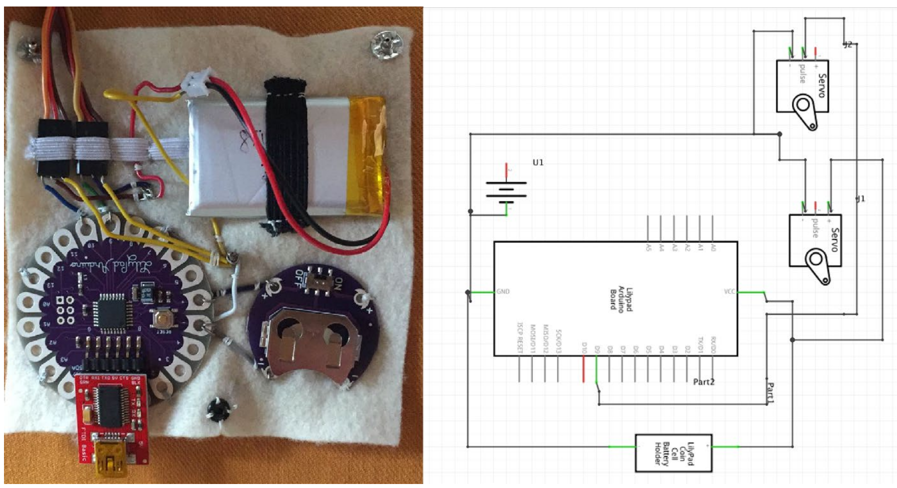


Figure 6.10. (a) Photo of Felt Panel with Lilypad Microcontroller & Power Source (b) Schematic Diagram

For Noeme 1.0, two servos are placed parallel on the front chest. 6 horsehair elements connect to each rotational motor, with three attached on the collarbone, and 3 attached on the side. For Noeme 2.0, the system is divided into front and back. For the front, one standard servo was placed on the bottom left-side of the top. 10 silk-organza elements are connected from the underside to this rotational motor (Figure 6.12). On the back, one micro-servo is placed on the mid back of the top (Figure 6.13). 5 horsehair elements connect to this micro-servo. For both soft wearable designs, the rotational motors are connected to a felt panel that houses the Lilypad microcontroller, a 3V Lilypad coin-battery, and a Lipo-battery unit (Figure 6.10.a). The felt panel is placed on the underside of the soft wearable top.

Figure 6.11. Paper draping and pattern creation for base layer

FIgure 6.12. Design process of rotational motor housing.

Figure 6.12. The back design for Noeme 2.0.

6.1.4. Kinetic Feedback towards Stress-Release and Self-Regulation

The design of Noeme 1.0 and 2.0 (Figure 6.6, Figure 6.8) explored kinetic metaphors of breathing and muscle movement on the chest and trapezius through three variations of kinetic compression and expansion to represent felt-sensations of stress and release.

Noeme 1.0 applied horsehair-based, elliptic, elongated shapes that were soft, light-weight in density. Twelve elements were placed on the chest, and were presented through springy, up-and out compressions and expansions. Noeme 2.0 had two different designs. For the front, silk organza-based, rotund, organic shapes that are soft, light-weight in density were used. Ten elements on the chest are applied with radial compressions and expansions. For the back, horsehair-based, elliptic, elongated shapes that are soft, light-weight in density. Five elements are placed on the upper-back, and displayed through springy, directional compressions and expansions. Through the three kinetic feedback designs, the researcher-designer observed participants' affective and somatic responses through their kinaesthetic interaction process and examined how the kinetic feedback designs affect their meaning-making process between their visual-tactile experience and felt-sensations of stress and release.

6.2. Conversational Interviews and Experiential Session with Noeme 1.0 and Noeme 2.0

6.2.1. Participants

Participant	Sex	Age	Breaths per Minute
P1	F	29	20
P2	F	28	10
P3	F	30	18
P4	F	30	14
P5	M	30	22
P6	F	29	15

Table 6.1. Participants Demographics

Participants were recruited through convenience sampling from the pool of participants involved in Project 2's design study (Chapter 5), and were therefore familiar with using active touch, focusing and familiar to the topic of my study. In total, 6 participants from Project 2's design study were recruited, comprised of 5 females and 1 male, with an average age of 29.3 years, and an average normal respiration rate of 16.5 breaths per minute (Table 6.1). Each participant provided consent and indicated that they understood the nature, benefits, and potential risks of the study through a physical consent form. Upon signing the form, additional questions were addressed and an overview of the study was provided for the participants.

6.2.2. Procedure

6.2.2.1. Setting & Data Collection

The one-on-one design studies were conducted in private, enclosed rooms with ample floor space, a large table, and chairs. The locations included the researcher's lab space at SFU Surrey Campus, a study room at SFU Burnaby Campus, or at the residences of the participants, based on schedule availability and travel constraints of participants. The duration of the study sessions ranged between 30 to 45 minutes.

The conversational interviews were audio-recorded through a mobile audio-recording application, while observations of participants' interactions with the prototypes were documented through hand-written notes. The collected recordings were transcribed by myself and stored in an encrypted external hard-drive and locked in the locker in the researcher's lab room. All data files are labelled with an alpha-numeric identifier to maintain participant confidentiality.

6.2.2.2. Description of Study Activity

Similar to Project 2 format (Chapter 5), this study was conducted through open-ended conversational interviews to allow for extended conversations and explorations with the two soft wearable design prototypes, Noeme 1.0, and Noeme 2.0.

Quiet Observation and Visual Breath Count

As a warm up, participants were asked to sit in front of Noeme 1.0 and Noeme 2.0, which were presented on the mannequin, side-by-side. The prototypes were non-functional at this time. Participants were prompted to take 1 minute to visually assess the prototypes while sitting in a chair. During the 1-minute quiet observation period, the design-researcher sat directly behind the participant to visually assess their chest activity to count their respiration rate. To ensure that their normal respiration rate was collected, participants were not informed until after the breath count was taken. The collection of their respiration rate provided a contextual understanding on what their 'normal' is during the conversational interviews.

Experiential Sessions with Noeme 1.0 & Noeme 2.0

Participants were then given up to 10 minutes to freely explore the two soft wearable designs on the mannequins. For the first 5 minutes, the kinetic feedback presented on both designs are mapped to the normal adult respiration rate of 15 breaths per minute, then mapped to a slow deep breathing rate of 6 breaths per minute (Russo et. al, 2017).

Open-ended Conversational Interviews

After 5 minutes, with Noeme 1.0, and 2.0 still functioning, participants are asked a series of questions that asked questions that focused on 1) their process on assessing and actively touching the materials, kinetic elements, and the overall form of the wearable designs, 2) its resemblance to an expression of compression and expansion, 3) their interpretation to the kinetic movement pattern, 4) their natural mapping to own breathing and body movement. 5) their natural mapping to felt-experiences of stress and relaxation Throughout the entirety of the conversational interviews, participants are encouraged to actively touch and talk-aloud their experiential process, felt-sensations, and emerging ideas.

6.2.3. Results

6.2.3.1. Data Analysis Process

The design study on the 2 soft wearable design prototypes aim to identify how kinetic feedback can be presented on the upper-body to evoke a felt-sense of stress release. Using data from 6 open-ended interviews and experiential sessions with the prototypes, I analyzed what functional tactile elements on a soft wearable design portray breathing and body movements, and identified how compression and expansion on the upper-body can afford a natural mapping to felt-sensations of stress and release. Hand-written notes and audio-recordings of the interviews were transcribed, coded, and analyzed using a thematic analysis with considerations to the Somaesthetic Framework of Touch (Schiphorst, 2009) to examine the somatic and affective qualities of participants' tactile-kinaesthetic experience to reveal insights for designing quality in kinetic, soft wearable design for self-regulation. The findings are presented under the emerging themes of (1) Felt-sensations of stress and release (2) Poetics of Breathing and Body Movement (3) Materials for Relaxation Responses (4) Self-Regulation of Breathing for Relaxation (5) Impressions to Technology and Sound.

6.2.3.2. Findings

6.2.3.2.1. Felt-sensations of Stress and Release

With the Noeme 2.0's back design, four of six participants were able to associate the directional kinetic compression and expansion with felt sensations of stress and release on the trapezius and shoulder region. The kinetic compression (neutral to tight state) mapped to a felt sensation of stress-tension, and the kinetic movement of expansion (tight to neutral) mapped to a felt-sense of release.

> "I would say the back part, definitely feeling the connection together, between the back part of this prototype and the lower area, you become more stress, you feel more tense and tighter at the back. making that connection." - P6

> "For the back, tightening and loosening, to describe it, it's a good representation of muscles being stretched out and being relaxed." - P2"

> The back [because] of the material, it's a really good representation the pull and the way the netting stretches, as a person who has a lot of shoulder tension, this definitely demonstrates when you are really tense, the way that it is it's more muscle tensing and relaxing." - P1

> "It's better done on the top shoulder areas, when you are tense, itfeels strapped down, when you are not stressed, anxious, it slightly looser. So, kind [of]like shoulders moving up and down." - P3

While Noeme 2.0's back design generated somatic responses that mapped to felt-stressed and felt-relaxation, the kinetic compression and expansion of Noeme 2.0's front design incited and reflected participants' affective responses to felt-sensations of stress and relaxation.

> "for the front, uneven, nervous. The way it contracts in, makes me nervous. it's not just the elements, but the shirt as well, everything contracts up which adds to amplifying the feeling" - P4

> "The front [of Noeme 2] makes me angry, it is scrunching up like when I am angry, I scrunch things." - P5

> "The movements on this one [Noeme 2.0] can make me feel anxious in a way now that I have seen it for a while. It is kind of like those deep cringes I get when I get nervous." - P2

Participant 5 also identified the kinetic movement expansion and compression on Noeme 1.0's design could also incite and reflect one's own affective states when experiencing stress and relaxation.

> "When it [Noeme 1.0] pulls in like this, it makes me a bit stressed. When it releases, I am a bit at ease, so like my body, my body pulls in, when it expands my chests goes out." - P5.

> "The smooth expanding movement makes me feel relaxed." - P2

Between the two soft wearable designs, Participants found Noeme 1.0 and Noeme 2.0's back design provided a more practical expression of felt-stress and felt-relaxation, while Noeme 2.0's front design provided a more artistic expression of the felt-stress and felt-relaxation.

> "Noeme 2.0 is aesthetically beautiful, but Noeme 1.0 is more functional. It [Noeme 2.0] is more an artistic way of express[ing] what I am feeling, which makes it more aesthetically pleasing. More like an art installation. The other one [Noeme 1.0], is relatively more a technical visual on what I feel, I can see it eventually being some form of a diagnosis thing." - P2

> "This one [Noeme 2.0] looks very fashionable aesthetically. That one [Noeme 1.0] and the back this [Noeme 2] looks more like it serves a purpose, functional, whereas Noeme 2.0 [touches the front] is more aesthetically pleasing" - P4

> "In the current way, it [Noeme 2.0] is attractive to look at, but it won't necessarily give the feeling of release and contract to help someone regulate their breathing, where as this one [Noeme 1.0] provides a guide, with the whole upper body movement to go on. [Referring to Noeme 2.0] The blooms are randomly placed. Its visually calming to look at. Would be lovely to respond to on a wall piece, to look at to help you feel calmer. But the back is kind of like Noeme 1." - P3

6.2.3.2.2. Poetics of Breathing and Body Movement

When evaluating the form, textures, and the moving features of expansion and compression on Noeme 2.0's front design, many participants associated the silk organza-based elements as flowers (P3, P1, P6), jellyfish (P2, P3), and a ball (P2). These associations aligned with some of the tangible metaphors from Project 2, focusing on living beings and natural objects that are more organic in shape. When the silk-organza elements were reviewed with consideration to its placement on the chest, participants would use “blossoming flowers” as an allegory for a calm state of breathing. Participants further described breathing as a living quality.

> “Resembles a sense of breathing, to me it looks like flowers, it reminds me flowers and plants and breathing, it’s kind of cool in that moment everything is alive. Breathing and flowers and alive.” - P1

> “I really like the bigger flower puffs. It’s very pretty and relaxing to look at. It’s like a big jellyfish.” - P3

Participants expressed the presentation of kinetic compression and expansion on the body for Noeme 1.0 provided a good visual representation of inhaling and exhaling. The kinetic movements with the horsehair elements on the side reflects the transverse movement of a ribcage.

> “Definitely the movement is very organic, it’s a good translation of breathing, you actually see the expansion and contraction of the ribs, you see the center kinda moves.” - P1

Additionally, Participants 1 and 5 made an observation on Noeme 1.0’s form where the pulling of felt-wool fabric between the motors created a physical inflation and deflation of the chest, which amplified the concept of breathing.

> “I really like this part here, the open space between the two motors. There, it seems whenever someone is breathing, this grey open area pulls up, like your chest when you inhale.” - P1

> “The part here, not sure if it was intentional, but it goes up when it breathes. It kind [of] is what my chest does.” - P5

6.2.3.2.3. Materials for Relaxation Responses

Participant feedback affirmed the designerly intention in using light grey fabric to foreground the focus to the white functional tactile elements. Participants’ descriptions of the colour aligned with relaxation responses.

> “The grey is nice, it’s neutral enough, calming. I can see the white things on the front. The whole look is soft.” - P1

> “Grey is neutral, has a nice aesthetic to it with the white puffs (Noeme 2.0)” - P2

> “I think it is very pretty, I think the ruffles, reminds of a blouse design, the combination of colour and the fabric of the white material gives it that''prettiness.” - P4

When considering the two base textiles, Participant 1 and 2 expressed a preference for the cotton jersey for its softer tactile experience, while Participant 2 further elaborated a preference for the wool felt for its visual structure.

> “The material T-shirt jersey is nicer [Noeme 2.0] to touch. From a seamstress perspective, [the] wool felt, it’s structured [Noeme 1.0], I think that would visually will add a nice aesthetic if it was on this one [Noeme 1.0]” - P2

> “...Material [cotton jersey] is softer, I like this material more than the other [wool felt], its softer.” - P1

For the functional tactile elements, participants highlighted an association of polyester horse hairs with a physical muscle. They described the texture to be soft and smooth, which can be mapped as relaxation sensations.

> “First obviously, horsehair, the leaf-like shapes caught my eye on there, visually it’s very smooth looking. They definitely remind me of a magic school bus episode, it’s showing what the muscles look like, but this one to me looks like a chic modern one.” - P4

> “The horsehair looks stiff, but very smooth to touch. The texture of it is very uninformed and ordered. When I run my fingers through its smooth [touches on the horsehair] smooth, order, deliberate.” - P2

Participants 2 and 6 further elaborated how the form and its placement on the body can infer the meaning and purpose for the kinetic compression and expansion.

> “...I definitely caught on that the movement was like muscles contracting and expanding to help with breathing.” - P2

> “The horsehair is [a] good representation of muscle, it looks a lot like muscle. Looks like you would see muscles attached to the ligaments on where they attached.” - P6

While the horsehair-based functional tactile elements do resemble muscle, Participant 6 noted that there is a disconnect on how they are attached to the top versus how they are connected to the body.

6.2.3.2.4. Self-regulation of Breathing towards Relaxation

When asked on their overall impression with the wearable designs, 5 of 6 participants expressed the ability to use the Noeme 1.0's kinetic movement of compression and expansion to bring awareness to their breathing and act as a tangible visual guide for regulating their breathing to restore a sense of calm.

> "The visual representation of breathing, this is what you are doing now, and this is what you need to be doing, if you are wearing it, it would be a physical cue to slow down your breath, and this is [a] rhythm that you need to match." - P1

> "I see this [as] visual aids for calming breathing." - P2

> "If you are hyperventilating, this is what you want to be doing, [to] try to match your breathing to this [Noeme 1.0]." - P6

> "I think it makes me want to be more conscious of the rhythm of my breathing, makes me want to slow it down." - P4

Notably, Participant 3 commented that Noeme 1.0 was able to incite for an unconscious mimicry of breathing patterns and posture through the design study.

> "Initially when i start observing it, and over time I start following it with my breathing and posture and my slight movements." -P3

6.2.3.2.5. Impressions with Technology and Sound

For the design of Noeme 1.0 and 2.0, much of the motors were insulated and covered by the wool felt or cotton jersey material. While the sound of the motors were still audible, participants did find the sound to be less distracting when compared with the functional tactile prototypes.

> "I kind of like it, it's a hum, it's like a static hum, there is a noise going up and going down, the difference is soothing." - P6

> "The sound is more like white noise, snoring, low humming." - P1

Participant 4 associated the repetitive sound from the motor with a metronome, which enhanced their awareness to their own breathing rhythm.

For many participants, the placement of the two motors on Noeme 1.0 was associated to nipples. As a result, participants were distracted from the rest of the soft wearable design and their reflections on their felt-sensations.

> "Noeme 1.0's chest was aesthetically distracting up close from the attention-grabbing nipples. I try not to focus on the nipples, but the rotating nipples made slightly distracting." - P1
>
> "Visually, the massive box nipples, "ohhh girl" from a fashion standpoint, it's not necessarily the attractiveness." - P2
>
> "I just find these two things [motors] an odd placement, that's all. It's not ugly, I mean odd as in right on the nipples" - P5

When describing how they evaluated the wearable designs, all participants expressed the motors on Noeme 1.0 was the first element that attracted their attention before anything else. Participant 6 further expressed the visibility of the mechanics on the wearable can lower the overall aesthetic quality and draw your focus away from the rest of the wearable design.

6.2.4. Discussions

Through a design study on the two soft wearable design prototypes (Noeme 1.0, Noeme 2.0) to explore how kinetic feedback can be presented on the upper body to evoke a felt-sense of stress-release, key findings were revealed to address the study's two supporting questions: (1) What functional tactile elements on soft wearable designs portray breathing & body movements? (2) How do compression & expansion on the upper body afford a natural mapping to felt-sensations of stress and release?

Poetics of Breathing and Body Movement

This study revealed the placement of the visual, tactile elements on the body can define the meaning and purpose of the kinetic movements of compression and expansion. Three main observations were made from participants' evaluation of the horsehair and silk organza elements across the chest and the back (Figure 6.13). With the horsehair elements on the chest, through the up-and-out compression and expansion, participants associated it with as the transverse movement of a rib-cage for inhalation and exhalation. With the silk organza elements, when placed on the chest, through a radial compression and expansion, participants expressed concepts that represent a feeling of calm breathing. With the horsehair elements on the trapezius area, through a directional compression and expansion, participants associated it as muscles tensing and relaxing.

Figure 6.13. Kinetic Textile Movements of Compression and Expansion on Noeme 1.0 and Noeme 2.0.

Somatic and Affective Responses for Stress Release

Project 2 identified kinetic expressions of compression and expansion can represent felt-stress and felt-relaxation, and revealed two kinetic metaphors for breathing and muscle movement. These findings were implemented into the designs of the two soft wearable designs.

Noeme 1.0 integrated a springy, up-and-out compressions and expansions on the chest and sides through elliptic, elongated shapes that are soft, light-weight in density. This particular wearable design was able to raise participants' self-awareness to their breathing and act as a tangible visual guide for regulating their breathing to restore a sense of calm. 2 participants noted the wearable was able to support an unconscious mimicry of breathing patterns and posture during the study.

Noeme 2.0 contained a front and back design. For the front, a radial compression and expansion on the chest through rotund, organic shapes that are soft, light-weight in density can evoke affective-based response for stress-release. For the back, a springy, directional compression and expansion on the trapezius through elongated shapes that are soft, light-weight in density can evoke a somatic-based response, prompting for stretching and changes in posture to release stress.

6.2.5. Project Implications for Future Designs

Project 3's design study of two soft wearable designs, Noeme 1.0 and Noeme 2.0, explored how kinetic feedback can be presented on the upper body to evoke a felt-sense of stress release. Guided by two supporting questions, I discussed the findings under two themes and propose 5 design considerations for future design explorations and iterations on soft wearable designs for self-regulation that uses kinetic, textile-based feedback to mediate participants' felt experience of releasing bodily stress.

Design Consideration #1 - Applying elliptic, elongated shapes that are soft, light-weight in density with a springy, directional compression and expansion on the trapezius region can evoke a somatic-based response for stress release.

Textile suggestion: Polyester Horsehair (crinoline trim)

Design Consideration #2 - Applying elliptic, elongated shapes that are soft, light-weight in density with a springy, up-and-out compression and expansion on the chest can support participants to develop a self-awareness to their breathing and also act as a visual guide for regulating their breathing.

Design Consideration #3 - Applying rotund, organic shapes that are soft, light-weight in density, with a radial compression and expansion on the chest, can evoke an affective-based response for stress-release.

Textile suggestion: 100% Silk organza

Design Consideration #4 - To maintain visual structure while achieving a smooth, comfortable tactile experience - when designing with wool felt, integrate a lining on the inside of the soft wearable design.

Textile suggestion: 2 or 3mm 100% merino wool felt, polyester lining

Design Consideration #5 - The electronic mechanisms needs to be hidden as much as possible to foreground the functional tactile elements, textile insulation can help mitigate and soften the motor sounds.

In the following chapter 7, I will provide an overview of my entire research-through-design journey for my MA thesis. I present my contributions of my design-research for the greater HCI community, identify and discuss limitations within my design-development and design-studies. The chapter will conclude with a proposal of future works for my design-research.

Chapter 7.

Discussion and Future Work

Chapter 7 Overview

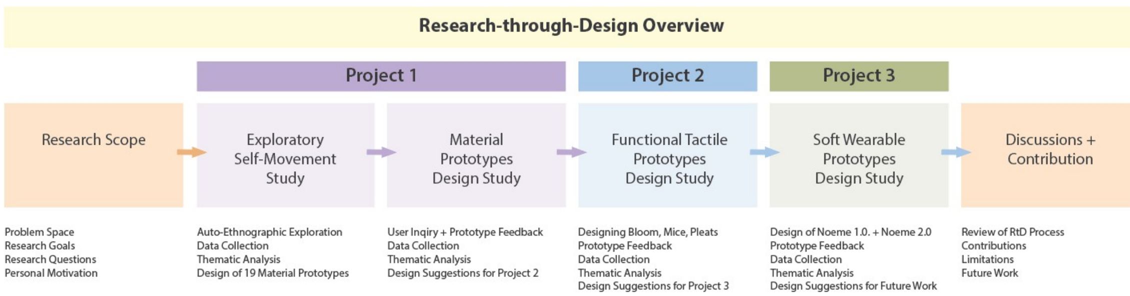


Figure 7.1. Chapter 7 provides a recap of my design-research journey.

This exploratory Research-through-Design (RtD) thesis investigated design for self-regulation using kinetic, textile-based feedback to mediate participants' felt experience of stress release. Using a somatic approach to designing for self-regulation, the research developed and designed for insights on how to mediate the rich communicative qualities from physical movement into embodied aesthetics to cultivate and deepen a user's connection and understanding with their own emotions and body cues. The human capacity for kinaesthetic empathy, is a tremendous design resource that is underutilized. The ability to sense and train kinaesthetic cues, especially ones that are self-managed, can support greater somatic awareness for self-regulation. Not only are they rich in a meaning-evoking way, but they can incite an aesthetic, meaningful experience that can transform our physical state. This is particularly useful in situations where the release of stress is needed.

In this final Chapter I recap my design research journey. In this journey, I explored kinetic textile-based feedback to mediate participant's felt-experience for self-regulation through soft wearable design materials. The RtD thesis project utilized an iterative cumulative and incremental design process that explored how the material and interaction properties of prototypes affected the felt experience of participants with the goal of supporting design for self-regulation using kinetic, textile-based feedback to mediate participants' felt experience of stress release. The thesis presented four studies on three categories of prototypes: Project 1 explored 19 exploratory material prototypes, Project 2 utilized material and interaction insights gleaned from Project 1's material prototypes to design and evaluate three (3) functional textile-based desk prototypes named Bloom, Mice, and Pleats, and finally, Project 3 iterated successful features of Project 2's outcomes to inspire design and evaluation of Noeme 1.0 and Noeme 2.0, two wearable upper-body torso prototypes. In total, 24 prototypes were iteratively generated and evaluated during the design process in this RtD thesis.

The remaining sections of this chapter include summaries of key findings from the design studies, and outline design and research contributions to the HCI community, opportunities for further refinement and development, and potential future applications of this research.

7.1. Summary of Research Designs and Studies

In the following section, I review my research studies and prototype design developments of this RtD thesis project (illustrated above in Table 7.1).

(Project 1) Design of Material Prototypes

My thesis research began with an intentional focus and commitment to using somatic and material considerations in my RtD process. It was crucial for me as a design researcher to develop a cognizance of my attitudes in how I perceived my own bodily experiences in relation to the larger overarching research objectives of this RtD program. Using an autoethnographic approach to movement exploration, I referenced Núñez-Pacheco et al.'s focusing approach (2015) to find inspiration from my felt-senses of stress and relaxation towards selecting materials that can enhance greater somatic awareness for self-regulation. The inability to accurately capture how one senses and feels during stress can be detrimental and can lead to difficulties to achieve somatic and affective attunement, resulting in ineffective and inefficient treatments, and also impeding personal well-being. The decision to frame my own experience as an integral aspect of bringing the focus back to the body, supports design-researchers ability to leverage kinaesthetic experiences to develop embodied cues that can promote greater empathy and sensibility to how user/participants can engage and understand their surroundings.

The first phase of the RtD in Chapter 3, details the exploratory, self-movement study which investigate how I, as the design-researcher abstract movements and textiles to inform the features of a textile-based object intended to support self-regulation of relaxation and stress-release. These features include the shape, material properties, and kinetic movement of the textile-based prototype features. The initial autoethnographic design study addresses two supporting questions: (1) What shapes, materials and moving features of the textile-based object (prototype) can support the user/researcher's imagination towards inciting self-regulation in order to support relaxation and alleviate stress, and (2) How do I, the design-researcher, move my own body to release physical stress without the aid of mediating objects? These two design activities, a 15-minute self-movement exploration exercise, and a 3-day researcher journal activity were conducted to explore these questions. The autoethnographic study findings were revealed under the themes of (1) Interactions for Stress-Release, and (2) Visual, Tactile, and Functional Elements to support Stress-Release. As a result of this autoethnographic exploration, four (4) key design considerations emerged to support the design and development criteria for 19 material prototypes. The autoethnographic study in Chapter 3 concludes with a categorization and description of the 19 material prototypes, specifying the visual, tactile, functional elements of each prototype, and categorizing the interactions that support self-regulation for relaxation and stress-release for each prototype. The outcomes of the autoethnographic study form an initial experiential basis for the three participatory design studies conducted with participants that have experienced chronic physical stress in the workplace. The feedback and evaluation of these participants' responses to a series of design prototypes form the basis for the data collected in the remainder of this thesis.

In Chapter 4, I detail an exploratory, participatory design evaluation study based upon the original 19 material prototypes that were inspired by the autoethnographic study described in Chapter 3. These nineteen (19) prototypes were analyzed to identify visual, tactile, and functional qualities that can support the use of breathing and movement to support self-regulation in promoting relaxation and releasing stress. The design evaluation study addresses two supporting questions (1) how participants self-regulate the release of stress from their upper body, and (2) what form factors, materials, and movement qualities of the textile prototypes affect the participants' felt experiences of relaxation and stress release. Ten participants each partook in one-on-one activities in the design study. The study consisted of individual semi-structured interviews across five design activities. The study reviewed key findings under two themes of prototype interactions that support self-regulation through felt experience of relaxation and stress-release, through the use of breath + movement. The key findings produced three implications: (1) a clarified understanding of the need for an embodied communication design for self-regulation, (2) an in-depth understanding on felt sensations of stress and relaxation, (3) a design framework of sensory attributes associated with relaxation and stress-tension sensations and practical design suggestions for designing tangible functional soft prototypes that support self-regulation for relaxation and stress-release. These practical design suggestions included (a) crafting soft shapes that are light-weight, and easily deformable, (b) implementing kinetic, textile metaphors of stretching through compression and expansion, (c) integrating two to three variations of textures, (d) creating tactile-kinaesthetic interactions of squeezing and caress with soft materials like silk and felt can elevate the relaxation experience.

(Project 2) Design of Functional Tactile Prototypes: Bloom, Mice, Pleats

In Chapter 5, I detailed the design development and the design study of three on-table based functional tactile prototypes (Bloom, Mice, Pleats) to investigate the types of kinetic feedback that can evoke a felt-sense of stress-release for relaxation. The design development of Bloom, Mice, Pleats were guided by the *Somaesthetic Design Framework* (Schiphorst, 2009). Seven participants partook in the design study which comprised an open-ended conversational interview and an experiential session with the prototypes Bloom, Mice, Pleats. The study was conducted to address two supporting questions: (1) What functional tactile elements can be coherent with the use of participant breathing patterns and changes in posture, and (2) What human breathing movements afford natural mapping to felt-experiences of relaxation and stress-release? Guided by the two supporting project questions, I examine the key findings under two interrelated themes (1) Poetics of Body Breathing and Body Movement, and (2) Kinetic Textile Expansion and Compression for Stress Release to reveal 6 design suggestions and considerations to support the design development of functional tactile elements on a wearable design in Project 3. Guided by the two supporting project questions, I examined the key findings under two interrelated themes (1) Poetics of Body Breathing and Body Movement, and (2) Kinetic Textile Expansion and Compression for Stress Release and proposed 6 main design suggestions and considerations to support the design of functional tactile elements on a soft wearable design in Project 3. To design functional tactile elements on a soft wearable design that can incite for a mimicry of deep breathing and muscle relaxation, (1) Rotund, organic shapes that are soft, light-weight with a radial compression and expansion can emulate kinetic textile metaphors of breathing, while (2) Elliptic, elongated shapes that are soft, light-weight with a springy, directional compression and expansion can be emulate kinetic textile metaphors of muscle movement. To implement kinetic textile movement of compression and expansion that can represent felt-experiences of relaxation and stress-release, (3) a transformation from a neutral to a tight state can infer a felt-sense of stress-tension, while (4) a transformation from a tight to neutral state can infer a felt-sense of release. When considering soft materials with electronics, (5) the auditory feedback from the rotational motors need to be mitigated, and (6) applying visual-tactile contrast of while silk and crinoline trim against grey wool felt can encourage for creative exploration through touch.

(Project 3) Design of Soft Wearable Prototypes: Noeme 1.0 and Noeme 2.0

In Chapter 6, I detailed the design development and the design study of two upper-body based soft wearable designs (Noeme 1.0 and Noeme 2.0) to explore how kinetic feedback can be presented on the upper-body to support self-regulation that evokes a felt-sense of relaxation and stress-release. The design development of the two soft wearable designs were guided by the *Somaesthetic Design Framework* (Schiphorst, 2009), reflecting on the (1) Felt-Experiences of Stress and Relaxation, (2) Poetics of Breathing and Body Movement, (3) Materials for Relaxation Responses, (4) Kinetic Feedback towards Self-Regulation for Relaxation and Stress-release. The design study was comprised of six participants, each consisting of an open-ended conversational interview and an experiential session with the wearables conducted to address two supporting questions: (1) What functional tactile elements on a soft wearable design portray breathing and body movements, and (2) How do compression and expansion on the upper body afford a natural mapping to felt-sensations of stress and release? The study produced key findings under two main themes: (1) Poetics of Breathing and Body Movement, (2) Somatic and Affective Responses for Stress-Release. Five design considerations were proposed for future explorations and iterations on soft wearable designs supporting self-regulation for relaxation and stress-release.

Main Thesis RQ: How do we **design for self-regulation** using kinetic, textile-based feedback to mediate participants' felt experience of releasing bodily stress?							
Chapter 3		Chapter 4		Chapter 5		Chapter 6	
Project 1				**Project 2**		**Project 3**	
Exploratory Self-Movement Study		Material Prototype Study		Design Study		Design Study	
1. Movement Exploration Exercise 2. Researcher's Journal		1. General Demographic Inquiry 2. Prototype Exploration 3. Narrative Inquiry with Material Prompts 4. Body Scanning with PMR and Material Prompt 5. Body Mapping Worksheets		1. Experiential Session with Prototypes 2. Conversational Interview		1. Experiential Session with Prototypes 2. Conversational Interview	
19 Material Prototypes				3 Functional Tactile Prototypes Bloom, Mice, Pleats		2 Soft Wearable Designs Noeme 1.0, Noeme 2.0	
Key Project Question: How can the features of shape, material properties, and kinetic movement of the textile prototypes support self-regulation?				Key Project Question: What types of kinaesthetic interaction and kinetic feedback can evoke a felt-sense of relaxation and release of physical stress?		Key Project Question: How do we present kinetic feedback on a wearable garment on the upper-body to evoke a felt-sense of relaxation and stress-release?	
Sub-Question 1: What are the shapes, materials, and moving features of textiles that can alleviate stress?	Sub-Question 2: How do I, the design-researcher, move my own body to activate relaxation and release stress without additional digital mediation?	Sub-Question1: How can participants self-regulate to promote relaxation and reduce/release physical stress from their upper body?	Sub-Question 2: What form factors, materials, and movement qualities of the prototype affect and support the participants' felt experiences of self-regulation to promote relaxation through physical stress release?	Sub-Question1: What functional tactile elements can be coherent with participants' use of breathing patterns and change in posture?	Sub-Question 2: What kinetic textile movements afford natural mapping to felt-experiences of stress and relaxation in the participant?	Sub-Question1: What functional tactile elements on a soft wearable design portray breathing & body movements by drawing on kinaesthetic empathy?	Sub-Question 2: How can the metaphor of compression and expansion on the upper body afford a natural mapping to felt-sensations of stress and release?
THEME 1 Visual, Tactile, Functional Elements for Stress-Release	THEME 2 Interactions for Stress-Release	THEME 1 The Use of Breath + Movement to Support Design For Self-Regulation	THEME 2 Prototype Interactions That Support Felt Experiences Of Stress Release	THEME 1 Poetics of Breathing and Body Movement	THEME 2 Kinetic Expansion and Compression for Stress Release	THEME 1 Poetics of Breathing and Body Movement	THEME 2 Somatic and Affective Responses for Stress-Release
IMPLICATONS		IMPLICATONS		IMPLICATONS		IMPLICATONS	
4 key design considerations were provided to the design and development of the 19 material prototypes.		1. a clarified understanding of the need for an embodied communication design for self-regulation, 2. an in-depth understanding on felt-sensations of stress and relaxation, 3. a framework of design considerations and practical design suggestions for designing tangible soft wearable prototypes for self-regulation.		1. two design combinations of visual, tactile, and functional properties to represent breathing and muscle movement patterns, 2. how kinetic feedback of compression and expansion can be implemented to convey felt-experiences of stress and relaxation, 3. technology considerations that will inform the design and development of soft wearable designs for self-regulation in Project 3.		5 design considerations were proposed for future explorations and iterations on soft wearable designs for self-regulation.	

Table 7.1. Overview of Key Research Questions, Themes, Implications of Projects 1-3.

7.2. Contributions to the Human Computer Interaction Research and Design

Through my initial reflections and research, I expressed a motivation to explore the use of kinetic movement with soft materials as a way to support users to better access and articulate their felt-sensations of stress.

7.2.1. Designing Soft Material Prototypes for Felt-Sensing

My use of material prototypes to assist participants to access their felt-senses for tensing and relaxing in Project 2's design study affirmed Núñez-Pacheco et al. (2017)'s motivation for the use of wearable stimuli and focusing for self-observation. In particular, my thesis's chapter 3 can be used as a case study on the use of autoethnographic experiential exploration as inspiration towards the design and development of material prototypes as prompts for creative exploration and reflection into kinaesthetic and somatic experience leading design strategies.

7.2.2. Framework of Sensory Attributes associated with Relaxation and Stress-Tension Sensations for Materials

Based on Project 2's design study, I formulated a framework of sensory attributes that can be associated with supporting self-regulation through relaxation and stress-tension sensations when describing the overall form/shape, materials/textures, and moving features of expansion and compression (Table 4.4). This framework was used towards the design and development of my functional tactile prototypes and soft wearable designs that can support for relaxation responses. I suggest that this framework can potentially support designers in the selection and integration of material properties to create functional tactile elements that can be convey relaxation or stress-tension sensations.

7.2.3. Kinetic Metaphors as a Design Resource

Design research indicates the aesthetic experience in the design for kinetic materials is still an underexplored space (Bengisu, 2018). Through this thesis, I utilized kinetic metaphors as a design resource for soma-kinaesthetic reflections to incite for somatic and affective responses of relaxation and stress-release. Extending beyond the conversation of soft wearable designs and into the greater HCI design-research community, the notion of how kinetic metaphors can be used in ways in which things move to provoke a certain kind of state and sensation can be a valuable resource in design. To highlight, the kinetic expressivity of shape changing interfaces in the context of environments and accessories can potentially enrich the users' and designers' kinaesthetic understanding and empathy to promote self-agency for well-being. This consideration within the design-research of intuitive user interfaces can generate new interaction and communication possibilities, such as determining dynamic affordances (Rasmussen et al., 2012) that can adapt to a user's somatic and affective state.

7.2.3.1. Kinetic Metaphors for Relaxation Responses

Guided by a *Somaesthetic Framework of Touch* (Schiphorst, 2009), and the framework of sensory attributes with material properties that support relaxation and tension, my research presented insights for designing quality in kinetic, soft wearable designs for self-regulation. I present design considerations that can be used to design kinetic metaphors for stress-release, breathing, and body movements. Bhimani et al. (2016) highlights educating patients on proper body alignment and correct breathing exercises can act as effective preventative and management strategies for muscle tightness. My research revealed tangible, kinetic metaphors of breathing and muscle movement patterns have the potential to incite a mimicry of inhalation and exhalation, tensing and releasing towards a felt-experience of relaxation and stress-release. Thus, the design of kinetic metaphors can be especially valuable for health and well-being, as they can be harnessed as a tool to educate and guide users for accessing and entraining their body cues to self-regulate their symptom experiences.

Kinetic Textile Metaphors of Expansion and Compression for Stress Release

To implement the kinetic textile metaphors of compression and expansion (Figure 5.19, 5.20) that can represent felt-stress and felt-relaxation: (1) A felt-sense of stress can be expressed by a transformation from a neutral to tight state, while (2) a felt-sense of release can be expressed by transforming from a tight to neutral state.

Kinetic Textile Metaphors for Breathing and Body Movement

To implement the kinetic textile metaphors of compression and expansion that can represent breathing and movement: (1) The use of rotund, organic shapes that are soft, light-weight in density, and can be easily deformed through a radial compression and expansion can afford a natural mapping to breathing. (2) The use of elliptic, elongated shapes that are light-weight in density, that can be deformed through a springy, directional compression and expansion can represent body muscles are tensing and releasing.

Additionally, Project 3 produced three design and material considerations for designing kinetic, textile-based feedback that can be further explored to mediate participant's felt-experience of releasing bodily stress.

Design Consideration #1

Applying elliptic, elongated shapes that are soft, light-weight in density with a springy, directional compression and expansion on the trapezius region can evoke a somatic-based response for stress release.

Textile suggestion: Polyester Horsehair (crinoline trim)

Design Consideration #2

Applying elliptic, elongated shapes that are soft, light-weight in density with a springy, up-and-out compression and expansion on the chest can support participants to develop a self-awareness to their breathing and also act as a visual guide for regulating their breathing.

Textile suggestion: Polyester Horsehair (crinoline trim)

Design Consideration #3

Applying rotund, organic shapes that are soft, light-weight in density, with a radial compression and expansion on the chest, can evoke an affective-based response for stress-release.

Textile suggestion: 100% Silk organza

7.3. Limitations of the Study

Limitations of Existing Technologies and Textile Materials

The design of the two soft wearable prototypes were met with some material limitations and technical challenges. Specifically, the micro-servos that were used, while small, were inconsistent in its gear teeth, which resulted in uneven rotations when applied with the same code, posing a challenge when two motors are required to move in sync simultaneously. The availability and options for high-quality rotational motors is limited, future iterations, with consideration for better integration with the soft wearable designs may consider the use of a linear servo instead. To support for wearability and aesthetic integration into the soft wearable designs, small lipo batteries were used, however, due to its small power supply, frequent battery changes were needed for one of the wearable designs.

Challenges to “Kinaesthetically Seeing” in comparison to “Kinaesthetically Wearing”

As proof-of-concept pieces, the two wearable designs Noeme 1.0 and Noeme 2.0 were worn and displayed on mannequins, not on the bodies of the participants. The experiential act of touching and observing without physically wearing the garments are very different experientially. This begs the question of how tactile kinetic expressions worn directly on the body can also have the potential to support self-regulation of relaxation and stress-release. Future iterations will need to consider additional explorations of “wearability” and the relationship between ‘feeling’ and ‘seeing’ to evoke kinaesthetically communicative textile interactions. The sense of touch, and the ability to see the interactions on the back will likely be the two focused areas in such explorations. A more in-depth understanding between ‘tactile-seeing’ and ‘tactile-wearing’ can have implications towards the development and integration of functional, visual-tactile components within the soft materials for a wearable prototype.

Challenges to Fit based on Sizing and Gender-specific Adult Body

The two upper-body based wearable designs Noeme 1.0 and Noeme 2.0 were proof of concept pieces created according to the size of the design-researcher. As a result, participants were not able to physically wear the prototypes on the body during the study due to fit restrictions and zero adjustability. As well, the design of Noeme 1.0 and Noeme 2.0 was created based on a female body, and when is placed against the male participants during the study, the original functional tactile elements became skewed out of its intended proportions. Future iterations will need to consider either creating a male and female version or base a design on a gender-neutral mannequin.

7.4. Future Work

Next Iterations for Soft Wearable Design for Self-Regulation

This thesis has demonstrated the potential in using kinetic feedback to mediate a user's felt experiences of releasing bodily stress. With the key findings and design considerations from Chapter 6, the next iteration will focus on the design of kinetic textile-based feedback to mediate slow breathing for self-regulation on a soft wearable design. Several key technical and material improvements are considered, which includes: (1) a pico-linear servo motor to replace a rotational servo motor to better integrate the technical and soft materials together due to its linear flat translation versus a rotational movement. (2) a 100% high quality merino heavy weight felt wool will be used instead of the current standard grade wool felt. The merino wool felt will provide a smoother tactile texture while preserving its structure. (3) wearability and adjustable fit for the soft wearable designs. Noeme 1.0 and 2.0 were proof of concept wearables that created with one size. To create wearables that can better resonate with the wearer, the option for sex-specific wear and option for adjustability in fit will need to be considered.

For this thesis, I focused on exploring the aesthetic quality of kinetic expressions to understand how to design kinetic metaphors on the body that can resonate with concepts of breathing and body movement to support for self-regulation. The respiration rates of Noeme 1.0 and 2.0 were pre-programmed into a Lilypad microcontroller, which were activated simply by an on/off switch. A possible consideration for future work is the inclusion of interactivity into the soft wearable design through a conductive stretch breath sensor or heart rate sensor will activate a kinetic feedback of deep breathing when stress is detected (ex. Heart Rate Variable)

Participants from Project 3's design study expressed a potential for Noeme 1.0 to support for an unconscious mimicry of breathing patterns and posture. More research will be required to see how this interactivity can affect self-regulation.

Assistive Tool for Breathing Exercises in Pulmonary Rehabilitation Program

From Project 3's design study, participants expressed Noeme 1.0 was able to raise their self-awareness to their breathing and act as a tangible guide for regulating their breathing to restore a sense of calm. Participants expressed an appreciation for a visual guide that can help them become attuned to their breathing versus “a feel and learn as you go” method. A soft wearable design or an on-table functional tactile prototype may be useful as an assistive tool to help patients to learn and practice pursed lip breathing exercises.

Future Development and Refinement of the Framework of Sensory Attributes to Material Properties for Relaxation and Stress Sensation.

A Framework was created with reference to Kayseri’s Subject Evaluation of Fabric Properties to help bridge emotive terms to practical references to characteristics of textile; revealing potential connections of felt-senses with sensory attributes of soft material. While it was useful towards my design-development across my projects with reference to the selection of shapes, materials, and moving features that are associated with either relaxation or stress-tension sensations, further evaluations are needed beyond just one case study (my thesis). This framework will need to be further analyzed and compared with existing Frameworks of Material Experiences (ex. The Ma2E4 Toolkit for material characterization for Performative Level).

7.5. Coda

Self-regulation of relaxation and stress is the ability to modulate one’s attention and emotion to ameliorate our experiences of stress release. While there is a breadth of commercial products and existing research projects that support self-regulation for stress reduction, design-research on somatically oriented practices and materials of soft wearables, and the kinetic feedback modality for self-regulation remain limited and underexplored. At the same time, Health research highlights a growing emphasis towards one’s ability to self-regulate as an integral component for self-care, recovery, and long-term well-being. Using a somatic approach to self-regulate stress, Progressive Muscle Relaxation (Anxiety Canada, n.d.; Healthwise Staff, 2017), Somatic Experiencing (Payne et. al, 2015, Schiphorst, 2009, 2011), and Mindfulness-based Stress Reduction (Healthwise Staff, 2017; de Vibe et al., 2012) assist participants to direct self-awareness towards their felt inner state when assessing and mitigating perceived symptoms of stress and discomforts. Through developing an embodied understanding of how both researchers and participants own bodies react to stress, participants are able to strengthen their kinaesthetic cues to efficiently detect and engage appropriate strategies to manage and ameliorate stress.

While this thesis contributes to design for self-regulation using kinetic, textile-based feedback to mediate participants' felt experience of stress release, it is the hope that these design explorations can contribute to the growing research that values how a somatic approach to designing for self-regulation can continue to develop greater design insights on how to mediate the rich communicative qualities from physical movement into embodied aesthetics and to cultivate and deepen both researchers' and participants' connection and understanding through their own sensing, feeling and body cues to increase our collective knowledge of design practice.

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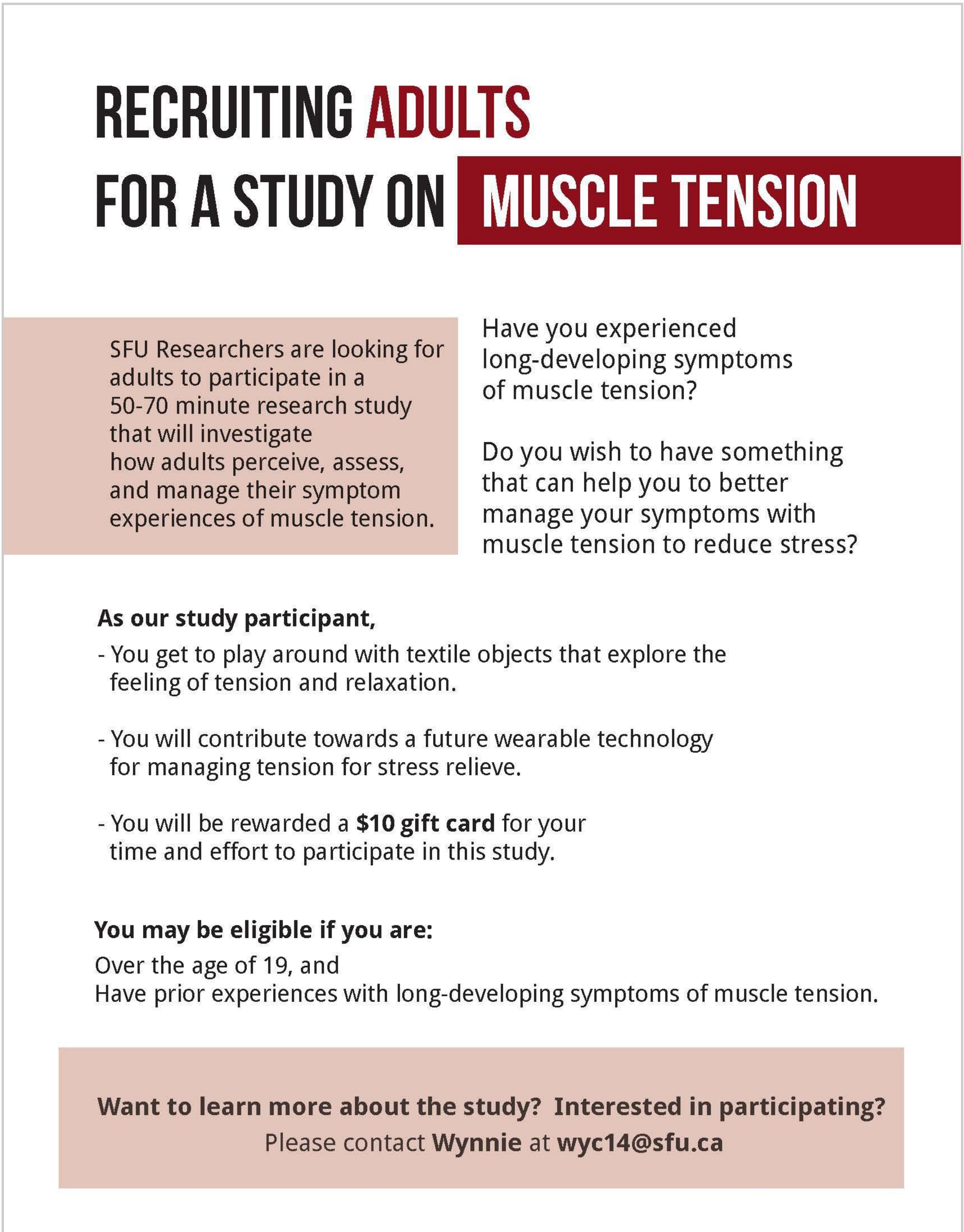
Appendix A.

Recruitment Poster for Project 1 Material Prototype Study



Appendix B.

Project 1 Material Prototypes Study Guide

Activity 1: General Demographic Interview

1. Age
2. What is your biological sex?
3. What is your professional role?
4. Can you elaborate a little on what you do in your capacity as a (role)?
5. Can you elaborate on your environment, the surroundings?
6. Can you take me through your typical work day (at your workspace)?
7. What are some stressful factors/elements in your role?
8. Can you tell me a time when you experienced upper body muscle tension?
9. Can you tell me a time when you had experiences that aggravated or worsened pre-existing upper body muscle tension?
10. At what point, When/how do you realize that you have upper body muscle tension?
11. Have you communicated with anyone about this condition?
12. How frequent does this happen?
13. How long have you experienced this muscle tension?

Activity 2: Prototype Exploration

In front of you are prototypes with kinetic properties and materials that simulate qualities of expansion, compression, and support the act of massage (rubbing, pressing, kneading). They are created under the concept of “ways that support relaxation to alleviate tension for stress reduction”.

Imagine you are stressed at work, which elements from these prototypes may help you relax?

In the next 5-10 minutes, I would like you to stroke/caress the surface, shape your hands over the form, hold/weigh it in your hand, squeeze/press, pull, bend, and look at each prototype. Note the texture, structure, and form.

If you are satisfied with exploring these prototypes before the end of 10 minutes, please let me know.

From the prototypes,

Q1a.

1. Can you show me and describe which overall form/shape may help you relax?
2. What is a positive feeling/sensation that you associate with the relaxation?
3. Why do you think this form/shape makes you feel relaxed?
4. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q1b.

5. Are there any overall form/shape which makes you tense/stressed?
6. What is a negative feeling/sensation that you associate with the tension/stress?
7. Why do you think this form/shape makes you feel tense (or tension) /stressful?
8. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q2a.

9. Can you show me and describe which material(s)/textures may help you relax?
10. What is a positive feeling/sensation that you associate with the relaxation?
11. Why do you think this material/texture makes you relax?
12. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q2b.

13. Are there any material(s)/textures which makes you tense/stressed?

14. What is a negative feeling/sensation that you associate with the tension/stress?

15. Why do you think this material/texture makes you feel tense (or tension)/stressful?

16. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q3a.

17. Can you show me/describe any moving feature(s) in terms of expansion and compression which may help you relax?

18. What is a positive feeling/sensation that you associate with the relaxation?

19. Why do you think this moving feature makes you relax?

20. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q3b.

21. Can you show me and describe any moving feature(s) in terms of expansion and compression which makes you tense/stressed?

22. What is a negative feeling/sensation that you associate with the tension/stress?

23. Why do you think this moving feature makes you feel tense (or tension)/stressed?

24. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q4a.

25. From the way you moved with the prototype,

26. Can you show me/describe any particular interaction (caress, squeeze/pressing, weighing, cupping over the form) that is relaxing to you?

27. What is a positive feeling/sensation that you associate with relaxation?

28. Why do you think this interaction makes you relax?

29. Do the sensation/feeling change or stay the same at different parts of your upper body?

Q4b.

30. Can you show me and describe any particular interaction which makes you tense/stressed?

31. What is a negative feeling/sensation that you associate with the tension/stress?

32. Why do you think this interaction makes you feel tense (or tension)/stressed?

33. Do the sensation/feeling change or stay the same at different parts of your upper body?

Activity 3: Narrative Inquiry using the Focusing Exercise

In the first part of this exercise, you are going to use the upper body as a starting point to explore your experience of relaxation. You will engage in a process of recalling and reflecting on your past relaxation experiences through your body. This process is called Body Scanning, which helps to condition your mind to your body, bringing attention to your inner self for creative exploration. This process will also help you to begin thinking about how you can represent your experiences of stress, and how you deal with tension.

I will be guiding you through a series of questions that will allow you to focus ("stay with") and connect with your inner sensations. As we go through this exercise, I will encourage you to "sense aloud", this means expressing your sensations that you feel aloud. I will be actively listening and reflecting what you are communicating to me to confirm your statements throughout this exercise.

Remember, If you feel tired and need a break, let me know. It is also important to let me know if you feel uncomfortable. You can stop at anytime without having to explain why.

(Body Scan Exercise Script)

Now, I want you to sit in a comfortable position and close your eyes.

1. Take a moment and imagine that you are at your usual workspace. Think about an object, memory, situation or activity

that was stressful and made you feel tense. Can you describe what you are thinking of?

2. Take a moment and think of one thing or activity you would do to relax when you felt that tension at your workspace. Pick a thing or activity. Simply select the first thing that comes to you. Can you tell me what you have picked?

3. Now, you are going to recall and reflect once more on that stressful situation which made you tense and how you used that [thing/activity] to relax. Pay attention to what your body is feeling when you are stressed and when you do the [thing/activity] to relax. I would like you to sense aloud your entire reflection process, from when you are stressed/ tense to when you are relaxed.

If investigator requires more information from the reflection, they can use these questions for more details and clarification.

- For the activity which you have selected, can you further describe what your body is sensing and how you are feeling when you are with the activity/thing that helps you to relax. Take a moment and find out what would describe that feeling. (Can be an image, symbol, phrase, word)

- What is that feeling like? Do I need something more? Do I need something less to describe it? Take a moment and find out what would describe that feeling (Can be an image, symbol, phrase, word) Feel free to think aloud or internally.

Activity 4: Body Scanning with Material Prompts and Progressive Muscle Relaxation Exercise

For this activity, I will be leading you through a progressive muscle relaxation exercise to help me to further understand how your body learns to relax. Also. you will be engaging with the Body Scanning process, which means focusing and sharing with me on what your body is feeling, and why your body is feeling that way.

Progressive Muscle Relaxation Exercises are stress management techniques widely adopted by healthcare professionals to control stress and anxiety, relieve insomnia, and reduce symptoms of chronic pain. These exercises teach you how to relax your mind and body by progressively tensing and relaxing muscle groups *throughout your entire body. By practicing these exercises, you will begin to understand what tensing feels like, and how to use tensing to relax.*

We will perform the progressive muscle relaxation exercises twice. Once with and once without a prototype. I will guide you with verbal instructions and open-ended questions to help you focus ("stay with") and connect with your inner sensations.

As we go through this exercise, I will encourage you to "sense aloud", this means expressing your sensations that you feel aloud. I will be actively listening and reflecting what you are communicating to me to confirm your statements throughout this exercise.

If you feel tired and need a break, let me know. It is also important to let me know if you feel uncomfortable at any point. You can stop at any time without having to explain why.

(PMR Exercise Introduction Script)

Begin by sitting in whatever position you are most comfortable with. This will be your neutral position. We will always start and end back to this neutral position.

The exercise will be very simple. You will start in your neutral position. Next, you will completely tense a group of muscles as you breathe in. You will hold the tension and breath for 8 seconds, then completely release the tension as you breathe out the same time. You will then relax for 15 seconds, and go back to the neutral position and rest for 20 more seconds.

Note, when you tense, you will tense hard, but not to the point of pain or cramping. For the activity, select a muscle group from your upper body that you feel comfortable to use for tensing and relaxing with. During the activity, if you experienced any pain or discomfort, stop immediately. I will guide you through with the instructions and with counting the seconds.

(PMR with breathing + muscles)

Select muscle group from Activity #1 or another upper body muscle group of participant’s choices. To help with selecting and informing how to engage with the muscle group, reference Muscle Group Chart.

Please go to your neutral position.

Allow your attention to focus only on your body. If you begin to notice your mind wandering, bring it back to the muscles you are working on. Remember to keep breathing.

Now, take a deep breath. As you breath in, tighten the muscles in the (muscle group) by (what to do) and hold for 8 seconds, 7, 6, 5, 4, 3 ,2, 1...

Now, breathe out completely and release the tension. Relax for 15 seconds ,14, 13, 12, 11, 10...3, 2, 1.

Go back to your neutral position and rest for 20 seconds.

Great work. How do you feel?

(PMR with prototype script)

We will perform this exercise once more, but this time, we will incorporate one of the prototypes which you have interacted with during our prototype exploration. Pick the prototype which you think will best help you focus on your inner body sensations and feelings.

I will encourage you to “sense aloud”, this means expressing your sensations that you feel aloud. I will be actively listening and reflecting what you are communicating to me to confirm your statements throughout this exercise.

Take your time and note the difference in your sensations and feelings between when you are tense and when you are relaxed.

Go back to your neutral position and rest.

1. Now, I want you to use your mind and scan your body in this resting phase. Take some time to define this experience. I want you to sense aloud what your body is sensing and how you are

feeling at this moment. Use words, phrases, metaphor, imagery to represent the sensations and feelings.

2. Shift this focus and scan the muscle group you were tensing and relaxing with earlier. Your muscle group should be resting. Take some time to define this experience. I want you to sense aloud what this muscle group currently feels to you. Use words, phrases, metaphor, imagery to represent the sensations and feelings.

3. Using the prototype, place it where you think you are feeling the sensations. If the sensation(s) are on multiple parts of the body. Please let me know. With the prototype, show me how this sensation starts and transpires. (If there are multiple sensations, ask the participant to show and demonstrate one by one.)

Go back to your neutral position and rest. Now, take a slow deep breath in and tighten your muscles. Hold the tension and focus on your muscle group for the next 8 seconds. (Investigator will count down from 8.)

Quickly breathe out and release the tension. Relax for 15 seconds. (Investigator will count down from 15.)

Go back to your neutral position and rest for 20 seconds. (Investigator will count down from 20.)

Take a moment and use your mind to scan that muscle group you had just tensed.

1. Take some time to define this experience. I want you to sense aloud what and how you felt when you were tensing. Use words, phrases, metaphor, imagery to represent the sensations and feelings.

2. Using the prototype, place it where you think you are feeling the sensations. With the prototype, show me how this sensation starts and transpires.

Go back to your neutral position and rest.

Let’s take another slow deep breath in and tighten your muscles one more time. Hold the tension for the next 8 seconds. (Investigator will count down from 8.)

Quickly exhale and release the tension. Relax for 15 seconds. (Investigator will count down from 15.)

Go back to your neutral position and rest for 20 seconds. (Investigator will count down from 20.)

Take a moment and use your mind and focus on that feeling of release.

1. Take some time to define this experience. I want you to sense aloud what and how you felt when you were relaxing. Use words, phrases, metaphor, imagery to represent the sensations and feelings.

2. Using the prototype, place it where you think you are feeling the sensations. If the sensation(s) are on multiple parts of the body. Please let me know. With the prototype, show me how this sensation starts and transpires. (If there are multiple sensations, ask the participant to show and demonstrate one by one.)

Go back to your neutral position and rest.

Take a moment to recollect. Think about how you had just tensed and relaxed your body. Can you walk me through once more on how you were tensing and relaxing that part of your body? Use gestures or movements, and the prototype to help you explain.

Activity 5: Body Mapping Worksheets

We are now going to visually represent these experiences and feelings of tension and relaxation within the body using a body map. This body map is a visual representation of your body. You will fill this map with images, symbols, words, phrases, colour to depict your experiences of tension/stress, and the ways you relax to deal with tension. Your body map can provide insight on the feelings and sensations across your body which may be further developed to simulate material experiences that support for relaxation responses.

(Body Map Exercise Script)

Take a moment and think about the body scanning exercise, focus on the sensations and feelings you had experienced. You have the next 20 mins to complete your body map diagrams. One focuses on Tension, the other on Relaxation. I will guide you through each step.

Remember, it is up to you on how you want to present your body in this drawing. If you feel tired and need a break, let me know. You can stop at anytime without having to explain why.

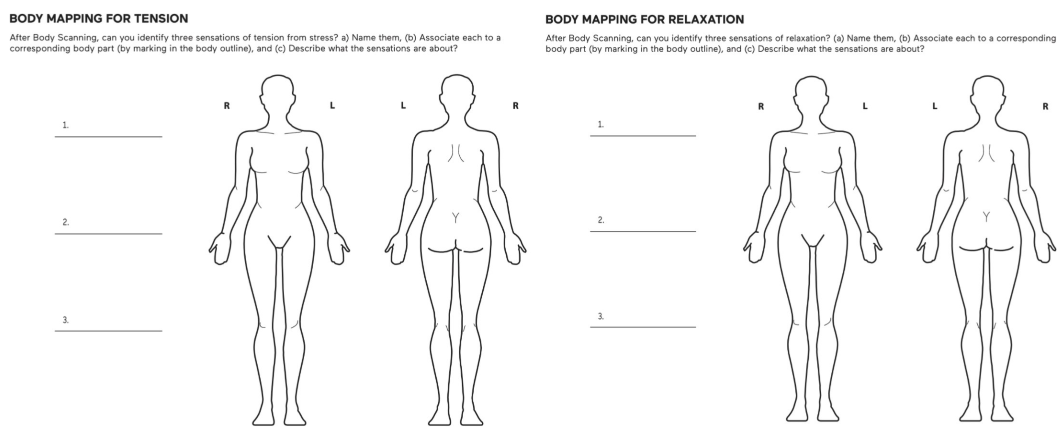


Figure B1. Body Map Worksheets for Tension and Relaxation (Female)

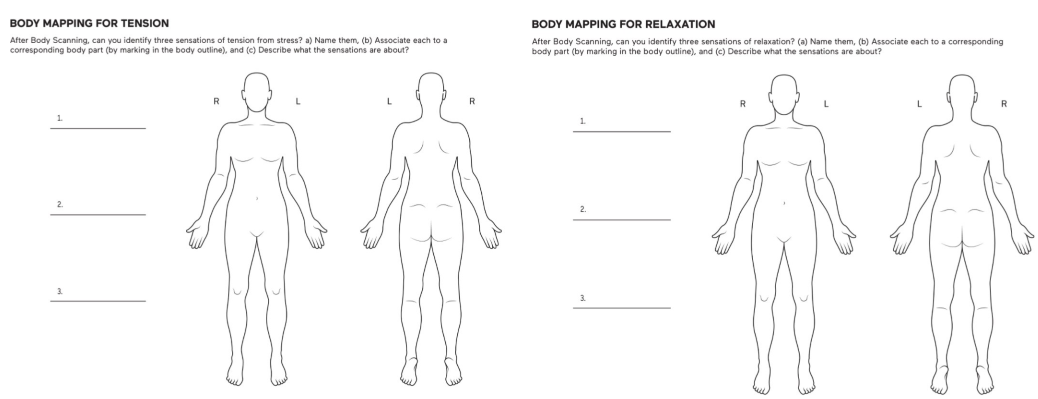


Figure B2. Body Map Worksheets for Tension and Relaxation (Gender Neutral)

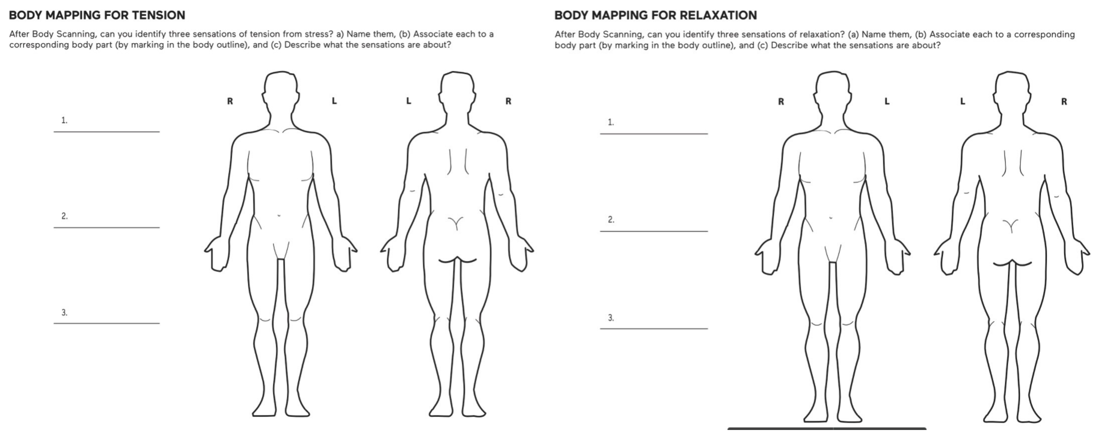


Figure B3. Body Map Worksheets for Tension and Relaxation (Male)

Appendix C.

Project 2 Functional Prototypes Study Questions

1.
    a. Can you describe your breathing when you are stressed/tense and when you are relaxed?
    b. Can you describe your posture when you are stressed and when you are relaxed?
2.
    a. From the prototype, what is your impression of the materials?
    b. From the prototype, what is your impression of the kinetic, movement feedback?
3. Does the feedback resemble an impression of expansion and compression? Why or Why not?
4. From the prototype, can you describe how you interpret and make meaning from the kinetic, movement feedback?
5. From the kinetic, movement feedback, can you map it to when feeling a state of tension/stress, to when you feel a state of release/relaxation?
6. What is your impression of the sound?

Appendix D.

Project 3 Soft Wearable Designs Study Questions

To begin, I would like you to sit in an upright position, and take 60 seconds quietly observing the soft wearable design.

Q1. To help me to understand your impression of the prototype, can you your process of evaluating the soft wearable design?

Q2. From the soft wearable design, from the kinetic movement, does it resemble an expression of expansion and compression?

- How so?

Q3. What words would you describe the kinetic movement pattern?

Q4. What meanings do you associate with the movement pattern?

Q5. How would you correlate the movement to your own breathing?

Q6. How would you correlate the overall form/ specific elements on the soft wearable design to your own posture and body (when breathing, when it is in a state of tension/stress, when relaxed.)

Q7. Now, feel free to touch the soft wearable design, using a talk-aloud process, can you describe to me your impression and feelings towards the materials of the soft wearable design?
What words would you use to describe the materials/elements on the soft wearable design?

Q8. How do you find the sound of the soft wearable design?

Q9. From viewing and touching the soft wearable design, how would you draw a connection from the soft wearable design (materials, movement, overall form) to your body when it is tense? and when it is relaxed?