Your Body of Water: A Somaesthetic Display for Embodied Reflection

by

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Your Body of Water:
A Somaesthetic Display for Embodied Reflection

By: Lee Jones MDes Digital Futures, OCAD University, 2016

Abstract:

In response to the Quantified Self movement, which uses body data for self-tracking and self-improvement, this thesis explores how aestheticized heart rate data can be used to get us more in touch with our bodies and how we are feeling. Utilizing somaesthetics, an interdisciplinary field with roots in philosophy that combines the soma (the living body) with aesthetics (our sensory perception and appreciation), this thesis explores how we can design interactions that help us to reflect on our embodied experience. Through a research through design process using somaesthetic appreciation design characteristics, I designed an interactive display that retrieved heart rate wirelessly with computer vision and then visualized one's heart rate as water. The display was evaluated for somaesthetic characteristics using system critiques, and this evaluation method was found to be a timely and resource-effective way of evaluating a device for self reflection and embodiment.

Keywords : Biofeedback, Biosensors, Ambient Display, Somaesthetics, Somaesthetic Reflection, Bodily Interactions, Embodiment, Affective Interaction, Aesthetic Interaction, Interactive Arts, Interaction Design, Media Arts

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1.0 Introduction

“Electronic products and services should enrich and expand our experience of everyday life rather than closing it down; they should become a medium for experiencing complex aesthetic situations” - Antony Dunne and Fiona Raby (2001) Design Noir, 45

This thesis project involves the design of a somaesthetic display that responded to wireless heart rate biofeedback for meditation and reflection. In particular, this artwork display uses water as an aesthetic and calming way of visualizing real-time biofeedback data and aims to show how heart rate can be used to reflect on experience and felt bodily states. The artwork aims to respond to how the user is feeling, but at the same time gives room for the participant’s subjective interpretation and reflection on their own experience.

In this thesis project I use a somaesthetic philosophy to design a display that responds to heart rate and aims to help us get more in touch with our bodies. Somaesthetics is an interdisciplinary field with roots in philosophy that combines soma, the living body, with aesthetics, our sensory perception and appreciation, for “creative self-fashioning” (Shusterman 2006; 2007; 2013; Hook et al 2015). The idea behind somaesthetics is that all experience is literally experienced through the body and is always embodied, and that by reflecting on our own felt experience we can train ourselves to get more in touch with our bodies.

Currently, we are surrounded by “smart” devices that give us data about our bodies. The various devices can track our movements, weight, calories, and heart rate among many other metrics. As researcher Kristina Hook poignantly states of these devices for the body: they frame it as a location “to be trimmed, perfected, and kept free from illnesses and bad influences [...]. By placing some sensors on our body and then having our data fed back to us, we are supposed to be able to change our bad habits, become healthy and beautiful, and live a long life” (Hook et al 2015). This movement towards measuring the body in all of its metrics, and particularly for self improvement, has developed into the concept of the Quantified Self.

The Quantified Self movement was a term coined by Gary Wolf and Kevin Kelly in a 2007 issue of *Wired Magazine* (Nafus 2014). The movement connects with the field of big data science, and is used to describe individuals involved in self-tracking and specifically with the proliferation of consumer tracking devices (Swan 2013). The goal with the Quantified Self is not just to know about one’s own data, but to use that data in order to act on it through behavioural changes. Quantified Self applications, and especially those that use gamification techniques, have helped many people achieve their health, fitness and personal goals (Whitson 2013). Overall, the aim of the Quantified Self is to improve the self through data. Though these devices have been helpful, the idea of the data body can be problematic, especially when we begin to trust the data over our own felt experience.

Last year shortly after starting the Digital Futures program I became interested in sleep trackers after reading a few articles on how our sleep patterns impact our waking hours. Curious as to what I would find, I purchased a Fitbit -- a wearable wristband that tracks movement and also has applications to track one's sleeping patterns. When I woke up the first morning after purchasing it I checked the application and was surprised to see the results. My Fitbit data said that I had only slept for a period of approximately three hours even though I had been in bed for eight. I didn't feel tired, but was curious at how I could be sleeping so ineffectively. The pattern continued in the days following, and after a few nights of less than three hours of effective sleep I did some research on the Fitbit forum -- the verdict was a sleep disorder.

At this point I became concerned, and as school work piled up the late nights began. But the bigger concern was that I was starting to think that I had a sleeping disorder. I discussed it briefly with my mother (a medical doctor) who conquered that yes three hours was not enough sleep and that I could ask my family doctor for a sleep study if I wanted to look into it. But before I was about to book the appointment I discovered something else. My Fitbit settings for the entire time had been on sensitive. This meant that when I moved my hand even just a little bit within my sleep, the Fitbit had considered this as time I had being awake even if I was not.

What struck me most about this experience wasn't the fluke of accidentally turning on a Fitbit setting, but rather how much trust I had put in the

data that came from it. I saw the data as knowledge and trusted it over my own felt experience. I wasn't feeling groggy in the morning (late schoolwork nights excluded), but the data had been showing that something was wrong and so it must be so. Even when in reality the only thing that was wrong was a setting on the device.

Interestingly, this is built into how the devices function. In one study it was found that those who use self trackers do not use them as a tool for introspection, or reflecting on how we are feeling, but rather as a tool to solve problems (Swan 2013). Through the data we aim to discover problems or find strategies on how to solve them. In particular, many devices that use biometric data see the body as somehow "instrumentally accessible" (Drayson 2011; 29). By strapping on a device that picks up on our body data we are suppose to be able to access objective information from our bodies. But when we are surrounded by these devices my main question becomes whether these devices really help us to *feel* and *know* our bodies. Our felt and experiential bodies carry so much knowledge, if we are willing to listen, so why are we focused so much on devices with quantitative data and employing them to override our subjective experience.

In their paper "Filling in the Interval: Bodily Intra-Actions with Biometric Devices", Paula Gardner and Barbara Jenkins (2015) discuss their interdisciplinary research creation project *Biomapping*. Their 4-year project on consumer grade biofeedback devices explored how users initially felt about the visualisation of data provided by the devices as well as experiments where they

were asked to aesthetically represent their own data and "exploit [the] tools transgressively." During initial user-testing trials many users found their interactions with the biofeedback machines to be frustrating and alienating. One key issue with biofeedback devices is that because they have been mainly used for medical reasons, culturally we associate interpretation of their data with medical expertise. But though the tools were initially alienating, the Biomapping team found that when participants were encouraged to transgress and explore the tools on their own terms, it became clear that biofeedback was a "process they could intervene in". Instead of relying on the 'expert' to define their experience, they were able to define their own experience with memories and feelings associated with wearing the devices and viewing the data. It was in this creative space that the use of technology and biofeedback became an embodied experience.

Furthering on the research that came out of the Biomapping project, this thesis will explore alternative ways of visualizing heart rate biofeedback through abstract visualizations that participants can "intervene" in and project their own subjectivity. This thesis project involves the design and prototyping of a display that illustrates different ways of visualizing heart rate biofeedback with interactive water, and addresses the following research questions:

a) Rather than using biometric devices for quantitative data, how can somaesthetic design be used to visualize aesthetic heart rate biofeedback in order to help us reflect on our lived experience and feel more embodied?
b) How can somaesthetic design appreciation characteristics be used to evaluate interactive devices?

This thesis project is inspired by the psychophysical model of the body where our thoughts influence our body, and in particular focuses on how heart rate is connected to our emotional response. For example, much research has been done on how heart rate increases when humans are stressed or excited, and also how it lowers when one is calm. In the display developed for this thesis entitled *Your Body of Water*, the visualization shows your heart rate as a body of water, but specifically provides a visualisation that gives participants a way to reflect upon how their body is feeling as a whole. The title of the work, *Your Body of Water*, is inspired by how muscle tension, moods, pain or joy all have an affect on one's heart rate, and therefore heart rate is an excellent way to reflect on how one's body feels. The focus of the work is not just on one's heart rate, but rather how participants are feeling as a whole.

Figure 1 - Somaesthetic display for self reflection

In daily life your heart rate rises, whether through stress, excitement, activity etc., and goes down when you are calm and relaxed. Through *Your Body of Water* the visualization of body data as flowing water will help to represent these emotional and felt bodily states through the liveliness of the water. The idea of the project is that this visualization would be available to give participants an abstract visualization of their felt experience for reflection, and will be a response to the Quantified Self movement. Rather than the data telling you about your experience, the visualizations created will be for the participants' own reflection and to tap into their own embodied knowledge.

In the following sections I address the context for this project: how the body is currently addressed in human computer interaction, how somaesthetics can play a role in designing interactive devices for embodiment, and how heart rate biofeedback has been visualized in the current state of the art. Then I go into the approaches and methodologies for this research including research through design using somaesthetic appreciation design characteristics, and how to navigate the evaluation methods of the combined fields of interactive art and human computer interaction using system critiques. Finally, I go into the lessons learned from these system critiques and how they will guide the future research and *in situ* evaluations that will occur outside of the scope of this thesis.

2.0 Context

“As ever more of our everyday social and cultural experiences are mediated by electronic products, designers need to develop ways of exploring how this electronic mediation might enrich people’s everyday lives” - Anthony Dunne (2006), Hertzian Tales, Preface

2.1 Introduction

In this section I cover the historical and theoretical context of somaesthetics and how heart rate biofeedback has been visualized in interactive art. First, I discuss some of the gaps in how the field of human computer interaction (HCI) has addressed (or failed to address) the body and felt experience. In recent years there has been a movement to correct this, as devices have moved into the home leading to an increased interest in felt experience called the “third wave” of HCI.

This third wave inspired the field of affective computing, which aims to detect and understand how humans are feeling, but this field is problematic in certain ways since felt experience is extremely subjective and therefore cannot not be viewed as “computable” information. In response to affective computing, the concept of affective interaction was developed, which focuses on affect as an interaction rather than just information.

In recent years there has been an aesthetic turn in HCI which has broadened the focus from affect to the entire perceived experience of interacting with a device. Importantly, this aesthetic turn has given philosophy and

embodiment a role within HCI, and in particular this thesis will be focuses on the application of the philosophy of somaesthetics and how it can be applied to interaction design. The main premise of somaesthetics is that we can train our body to become more aware of itself, and when applied to design we can use somaesthetics to develop devices that help us become more aware of our felt and lived experience.

In order to apply somaesthetics to this design thesis, I discuss somaesthetic appreciation design, which maps out characteristics of successful designs, and then I show how they have been applied through several examples. Finally, I review a state of the art on biofeedback artworks that visualize heart rate, and provide an analysis as well as learnings from their design decisions.

2.2 The Body in Human Computer Interaction Research

Within the field of human computer interaction (HCI), the alive experiential body has been notably absent. So far the history of the field has been limited to addressing the body in three main ways: ergonomics, cyborgs and the Quantified Self (Hook 2012). In all of these areas, the field of HCI has been criticized for only focusing on the functional aspects of interaction (Udsen et al 2005).

The first research area, ergonomics is a field that focuses on the physical body, and the space it uses (Hook 2012; Shusterman 2013). By measuring the

body both in its averages and extremes, the field has been able to design spaces and objects for functional use such as cockpits, houses, cars and chairs. The goal for the most part is to ensure that humans can be functional within these spaces. For example, so their hands can reach the steering wheel, so their feet can reach the floor when sitting, and so they can open doors and turn switches. Though this may sound like a simplification of an important field, it is clear that the main goal of ergonomics is to reduce human error and increase functionality. The human perception and lived experience is only important to ergonomics the extent that it can reduce error and receive vital information when needed.

The focus on cyborgs highlights how humans use technology as a tool to extend our abilities (Hook 2012). Some key example could be a blind person's use of a walking stick, or the fact that I am always carrying my mobile smart phone. In these examples the walking stick, or the mobile phone becomes an extension of ourselves and in a way becomes a part of our own body or self –for example, in the common phrasing of ***my*** cell phone, ***my*** walking stick. To a certain extent, the move towards cyborgs focuses on how we can "free" ourselves from our corporeal bodies or reality.

The Quantified Self is a movement that uses data as a way to understand and control the physical body (Swan 2013). Quantified self has been used for devices primarily for sport or physical activity such as activity trackers, pedometers, and smart scales. As Kristina Hook poignantly states of the movement: "These systems often treat our bodies as objects that we can study

from the outside, that can be trimmed and controlled" (Hook 2012, Trimming the Body). In these systems the data helps to inform us about our bodies, rather than our felt bodies themselves being the source of our knowledge. In many ways, this movement treats our bodies like machines that can be measured with all these goals and tasks to complete. Importantly, these goals can distract us from our felt experience. At the same time, these devices have also had many extremely positive health benefits, and have helped many people get to a healthy weight and become more active.

In recent years, some human computer interaction researchers have begun to design experiences that go beyond efficiency and goals and involve felt experience. This has been called the "third wave" of HCI, and is where this thesis research begins (Hook 2012).

2.3 Affective Computing and Affective Interaction

As the third wave of HCI began, human emotions became increasingly important to the field. One of the first strands of this was in affective computing. Affective computing systems try to identify emotional states in users and typically view this input as information (Stahl 2014; Hook 2013). For example, an affective computing system could look at muscular facial movements (such as a raised eyebrow or frown) and use this information to gauge how someone is feeling, or another affective computing system could look at one's heart rate and determine that they are stressed. This is troubling because even we as humans can at times

have difficulty deciphering how someone is feeling, and there is so much room for misinterpretation and different subjective readings. As Merleau Ponty states, the body is not an object (1962). Instead, bodies are subjective and help us to understand our experiences, and it's problematic to treat them as information that can be read.

In response to affective computing, Boeher and her colleagues developed the concept of affective interaction to highlight the importance of affect as an interaction rather than a source of information (Boeher et al 2005). Systems for affective interaction encourage users to express themselves with movement, biosensors or other various ways, and then use that input by representing it abstractly in ways that allow participants to interpret and make sense of what the system has presented (Stahl et al 2014). The key principles for affective interactions are that the system recognizes affect "as a social and cultural product", that it has flexibility in terms of interpretation, that it does not try to define experiences, and that it aims to create systems to help participants experience and understand their emotions (Boeher et al 2005; 66; Hook 2013). In terms of success, these systems are measured not for whether they can figure out the correct emotion, but rather whether they encourage reflection and awareness of one's emotional state (Boeher et al 2005).

2.3.1 Affective Loop

Within the concept of affective interaction is the goal of creating an affective loop, which will be used throughout this thesis. An affective loop is an idea coined by Kristina Hook that helps designers understand and create embodied interactive systems (Hook 2008; Hook 2009). In an affective loop, the mind-body becomes a part of an interactive system. A user expresses their emotions (whether actively through movement or through sensors such as biofeedback sensors), and then the system responds through affective expressions such as animations, visualizations or haptic touch. These visuals then affect the user and cause them to respond, to which the system continues to respond as well. When the two parties (the participant and the system) sync with one another the affective loop deepens. In the affective loop the emotions the participant experiences are viewed as affective interactions where the participant is active in the process and develops their own meaning from the system. Importantly, participants must recognize themselves in the system they are using for it to become an affective loop. Overall, these systems both influence and are influenced by participants (Hook 2009).

2.3.2 Evocative Balance and Interactional Empowerment

Members of the Mobile Life Lab at the Royal Institute of Technology in Sweden came up with the term evocative balance as a way to describe designs for affective interactions that empower users through these affective loops (Stahl et al

2014, Stahl 2014). Evocative balance comes about in designs that “evoke” or encourage reflection but are at the same time ambiguous enough that the participant can interpret the results as they wish. This process creates an ongoing sense of co-constructive meaning-making from both sides, which is where the sense of balance comes from. The ambiguity of the visualizations plays a very important role in whether evocative balance is achieved or not. If the visualizations are overly literal then there will be no room for the participants to create their own meaning. If the visualizations are too arbitrary and don’t coincide with what the participants are experiencing then participants won’t be able to create connections or meaning.

By creating an evocative balance in their design projects, the team supports its overall goal of creating what they have called “interactional empowerment” where participants can be expressive, reflect on their own experience, and create meaning for themselves (Hook et al 2008, Stahl 2014). This design goal focuses heavily on the participants’ own subjectivity. The goal is not to create a “correct” interpretation of the data (i.e., whether a certain heart rate indicates stress), but rather to provide a way for participants to reflect on how they are feeling and develop their own definitions and interpretations (Stahl et al 2014, Stahl 2014). So, for example, if we were to look at heart rate, an affective computing system would say that one is stressed if their heart rate is high, whereas an affective interaction system using evocative balance could instead tie different heart rates to different colour saturations and the participant would be

able to use this visual to derive their own meaning. The idea is that users will always be able to create a more accurate and relevant account of their own experience, and so it is both unnecessary and incorrect to think that a system could define participants better than they can themselves. Ultimately, systems with interactional empowerment through evocative balance empower users to make choices and judgements for themselves rather than to be told about their experience.

A key concept that came out of this research into evocative balance is the importance of ambiguity (Stahl et al 2014). Though ambiguity can come across as frustrating it also creates intrigue and demands that participants interpret the design for themselves (Stahl 2014). As they do so, participants begin to develop their own systems of interpretation and therefore develop a deeper and more meaningful connection with the interactive system. Ambiguity is something that has been very clearly avoided in HCI research, a field that very heavily focuses on user friendliness and clear interpretation.

2.3.3 User-unfriendliness and Slow Technology

If user friendliness is a result of HCI's focus on efficiency, then a turn to user-unfriendliness and aesthetics could be a form of "gentle provocation" that provides an alternative model of interactivity (Dunne 2006; xvii). As Kristina Hook states on HCI: "Perhaps [the field] has been a bit too obsessed with zero-learning time" (2012). Many aesthetic experiences in contrast take time to learn

and understand. For example, a type of user-unfriendliness is already present in other art forms such as poetry. Poetry isn't functional *per se*, it can take a while to get into and user efficiency isn't the goal, but it is a very aesthetic experience that explores how words sound, how they go together, and the emotional tone of a message.

In the same vein as user-unfriendliness, slow technology is the term used for devices that are meant to encourage reflection and moments of mental rest (Hallnas et al 2001a; b). Slow technology emphasises how our behaviours are changed by our environment and has roots in art and aesthetics. By amplifying an object's presence, the goal is to make it something more than just a functional object for task completion. This slowness is present both in how the object is understood and how it is used, as it is this exact slowness that gives people room to derive meaning as well as time to consider and reflect.

2.4 Aesthetic Turn in HCI & Aesthetic Approaches

Other art and design fields such as visual design, product design, interior design and architecture have always had aesthetics at the core of discussion, and it makes sense that interactive design should go the same way as it increasingly expands into everyday life (Lim 2007; Wright et al 2008). Today interactive devices have the ability to be more expressive and some focus on experiential qualities (Lim et al 2011). Aesthetics offers a way to research interaction beyond the previous focus on usability, but the tricky part with interaction is that it is not

as concrete and tangible as other forms of design so we need new ways of thinking about it conceptually (Udsen et al 2005).

Aesthetic interaction and the aesthetic turn is a position that encourages: "keenness of sensation, imaginative capacity, penetrating insight, good memory, poetic disposition, good taste, expressive talent, sympathetic identification with others, hope, intention, disposition, and an appreciation of and contribution towards consciousness as dynamic and emergent" (Bardzell 2012). How can we design for all of these things within an interaction? Wright proposes that where the key to usability was evaluation, the key to aesthetic interaction is understanding how someone makes sense of an object in terms of emotions, sensations and thought processes (Wright et al 2008). Udsen proposes that the HCI trend towards aesthetics can be divided into four categories: the cultural approach, the functionalist approach, the experience-based approach and the techno-futurist approach (see Figure 2) (Udsen et al 2005).

2.4.1 The Cultural Approach

The cultural approach stems from the humanities and fine arts and emphasises the importance of critical and reflective qualities of interaction design and new media art including literature and games (Udsen et al 2005; Lim 2011). As culture itself expanded to the web and new devices, computers interfaces became the conduit of aesthetics. Digital art can provide new ways of designing

and interacting with interfaces that go beyond usability. The cultural approach provides a way of critiquing and analyzing interfaces as cultural artefacts.

2.4.2 The Functionalist Approach

The functionalist approach focuses on user friendliness and usability and the role aesthetics has in meeting these goals (Udsen et al 2005; Lim 2011). The idea is that aesthetics can only help make an interface more beautiful and functional - “attractive things work better” (Udesen et al 2005; 209). But applying this concept can be difficult as aesthetics and beauty cannot be quantitatively measured within most usability methodologies.

2.4.3 The Experience-based Approach

The experience based approach highlights how meaningful a device becomes during an interaction or how the object affects our lives (Lim 2011). Experience focuses on an orientation towards our lives as “lived and felt in all its particulars” (Wright et al 2008; 3). The goal of many of these devices is to challenge and delight us. Many within this field see themselves as acting in opposition to HCI’s usability goals - such as Anthony Dunne’s work on “user-unfriendliness” (Udsen et al 2005). By creating “post-optimal electronic objects”, which focus less on functionality and more on commentary, they encourage us to reflect on the role and presence of technology in our lives and this becomes critical design.

2.4.4 The Techno-futurist Approach

The techno-futurist approach emphasizes the role of embodiment and expression in digital devices (Lim 2011). The techno-futurist approach comes from philosophy and is about how humans experience their environment (Udsen et al 2005). Philosophies from Merleau Ponty and other see the body as our way of experiencing digital technologies, and can help us theorize the experience. Because this approach is based in philosophy, it can be the most difficult to apply to design practice, but is also where important philosophies such as somaesthetics can be addressed.

	1. Cultural approach	2. Functionalist approach	3. Experience-based approach	4. Techno-futurist approach
Academic traditions	Humanities New media	Traditional HCI Usability	Interaction design	Philosophy
Type of interfaces	Non-informational spaces	Informational interfaces	Post-optimal objects	Ubiquitous computing environments
Theorists	Laurel Johnson Manovich Bolter & Gromala Walther Pold	Tractinsky Jordan Norman Karvonen Desmet	Blythe et al. Dunne Gaver et al. Löwgren McCarthy & Wright	Dourish Hallnäs & Redström Ishii & Ullmer

Figure 2 - Strands of the Aesthetic turn in HCI (Udsen et al 2005)

Overall, the aesthetic turn in HCI has allowed for philosophical and design approaches to influence HCI research. This change within HCI is important because of how it expands what the field considers knowledge. Previously, applying philosophy and design methods would not have been seen as compatible

with the field's strong affiliation with quantifiable research. Now, with the aesthetic turn in HCI, qualitative methods, and philosophies such as somaesthetics, can be applied to interaction design research.

2.5 Somaesthetics

Somaesthetics, the core philosophy used in this thesis, is an interdisciplinary field with roots in philosophy that combines soma, the living body, with aesthetics, our sensory perception and appreciation, for "creative self-fashioning" (Shusterman 2006; 2007; 2013; Hook et al 2015). The main premise of somaesthetics is that we can train our body to become more aware of itself. The idea behind somaesthetics is that all experience is literally experienced through the body and is always embodied. Somaesthetics explores how we can improve and cultivate our senses through a better understanding of our sensory appreciation (aesthesis). Somaesthetics considers the body to be our "tool of tools" (Shusterman 2013, *Genealogy and Emergence*) and sees the body as the central piece in artistic creation and appreciation. The soma body in this case is not just the flesh or corpse but the living and sentient body that is the source of all perception.

2.5.1 Historical Context of Somaesthetics

"To breathe deeply, sensing how one's blood is purified through its contact with the air and how one's whole circulatory system takes on new activity and strength, this is truly an almost intoxicating delight whose aesthetic value can hardly be denied."

- Jean-Marie Guyau (1884) cited in Shusterman (1999; 3)

Contemporary culture is full of external overstimulation and rapid communication. In contrast, somaesthetics aims to turn our attention inward towards our own felt experience (Shusterman 2008). Somaesthetics emerged in the mid 1990s from philosopher Richard Shusterman, whose philosophical focus was on pragmatist aesthetics, which is about bringing philosophy into practical use, and the "embodied art of living" (Shusterman 2013), but the concept of sensory aesthetics has been around for much longer.

Shusterman grounds somaesthetics in the aesthetics discipline that was coined by Alexander Baumgarten in the 1750s (Shusterman 1999). Current philosophical aesthetics primarily focuses on art, but Baumgarten derived the word from the Greek "aisthesis", which means sensory perception. The new field of aesthetics was meant to discuss sensory knowledge and to argue for the value of sensory perception as a way to improve one's life. In reincorporating Baumgarten's aesthetics into somaesthetics, Shusterman wanted to extend aesthetics from its focus on fine art and expand it to the rest of felt human experience.

Compared to distanced contemplation, somaesthetics is about active engagement and meaning-making. Shusterman's pragmatism sees the body as

central to both aesthetic creation and sensory appreciation, and in turn somaesthetics focuses on the soma as the source of all perception. Most importantly, somaesthetics focuses on lived experience and how by improving our awareness of our bodily senses and feelings we can better understand ourselves as embodied beings (Shusterman 1999).

The role of our bodily senses in meaning-making stems from Merleau-Ponty's idea of the lived body (1962). Merleau-Ponty's phenomenal body considers the idea that the world is not what one sees but what one lives through. We never move an "objective body" (106) but rather our phenomenal body perceives the world around us. Philosopher Mark Johnson goes even further to say that all meaning comes from our body and our bodily conditions in the world (Johnson 2007). We are not a mind and a body but one organic process where meaning is an embodied activity. Johnson argues that because of this, aesthetics is everything we experience and how we create meaning in our lives. Similarly, philosopher Alva Noë discusses perception as a thoughtful activity and argues that perceiving is a way of acting -- "it is something that we do" (Noë 2004; 1). Noë calls this active perception the "enactive approach" and states that our ability to perceive depends on our sensorimotor knowledge. We can only perceive based on our ability to perceive and Noë sees this as skillful bodily activity. We come to know things based on our perceptual bodily skills that are learned over time.

Unfortunately the Western philosophical tradition has had a generally negative view of bodily and has tended to instead privilege the mind (Shusterman

2008). As Descartes stated in 1637: “I think therefore I am” (Descartes 1999; 27). In doing so, he posited a theoretical separation of our thoughts from our physical selves. In this statement Descartes found the one thing that he could not doubt, his thoughts, and this has had a lasting impression on philosophy and has created strong hierarchies within the lived human body. The body has since been seen as a prison and the source of all evil, and this has been emphasized in religious philosophies that values the immaterial soul or spirit over the earthly body (Shusterman 2007).

In his book *Decartes' Error: Emotion, Reason, and the Human Brain,* neurologist and neuroscientist Antonio Damasio demonstrates through examples of various brain injuries and conditions how deeply the mind and body are connected (Damasio 2006). When physical aspects of the brain are missing or damaged this can greatly change not only one's functionality but also one's personality and values. Damasio also demonstrates the importance of emotion in our rational thinking processes, when people are missing the “emotional” parts of the brain, rationality also falters. Damasio also demonstrates the importance of feelings and emotion. He argues that a feeling is not a spiritual, elusive thing but rather something perceived through the body. The brain and the body are not two separate entities but rather deeply interconnected parts of one whole.

In contrast to the history of mind-body hierarchies, artists have spent a lot of attention to the body and bodily expression (Shusterman 2008), and many digital art installations place the felt body at the core of their work (Lee et al

2014). The philosophy of art also considers the experience of the felt body in traditional art forms. As philosopher John Dewey wrote *Art as Experience* in 1880, works of art are not just material objects but rather aesthetic experiences that personally affect our lives as viewers (Dewey 2005). Dewey uses functional psychology to state that all perception comes through the body and that this is how we are able to experience artworks.

2.5.2 Connection to HCI

Though somaesthetics originally began in philosophy, it has become a useful way to address the body in human computer interaction, and specifically in relation to design needs. When HCI originally started as a field it had very different goals (Bardzell 2012). At the time, computers were mostly used for work and task-related goals, but as computers have become more ubiquitous they've spread to our daily lives, into our homes, and onto our bodies (Hook 2012). With this spread, it has become important to address the lived experience in HCI and somaesthetic has become one way to do so. For example, somaesthetic practice has been used as a way to brainstorm how to address design needs and develop new interactive products (Lim 2012; Lee et al 2014). Somaesthetics helps reframe interaction design away from usability and towards new goals such as treating participants as learners, focusing on how they shape their own environment, and how they can become something else through their interactions (Bardzell 2012).

Somaesthetic comes to HCI at a time when there is also an increased need for design within HCI. HCI has a culture of objectivity and a focus on quantitative

results. This focus on the scientific contribution has unfortunately led to products that aren't very appealing in daily life, and products that are at times seen as "barbaric" from design standards (Bardzell 2012). Also, there has been a recent move from representational interaction with commands and text to more bodily interactions such as gestures or haptic touch (Stolterman 2012). As a result, the field is going through a shift to qualitative and design-oriented research. But though design and somaesthetics are greatly needed within HCI and they can help ground some of these bodily interactions into the research, it's not clear how somaesthetics would translate into design methods.

2.5.3 Connection to Design

Somaesthetics is a relatively new concept and there aren't many examples available that bring it into design practice. In their paper "Somaesthetic design", Hook and her colleagues discuss how they translated somaesthetic theory into practice. Their design stance was that the devices they designed should "not distract us from our own experience, but instead deepen our understanding and engagement with ourselves" (Hook et al 2015). The main goal of somaesthetics in design is to create devices and systems that encourage participants to look inward and focus on their own bodily sensations rather than external stimuli. This stance is similar to the practices of meditation or yoga where one is encouraged to focus inward on breathing or bodily movement (Shusterman 2013; Shusterman 1999),

and Hook actually emphasizes that it is important for somaesthetic designers to develop their somaesthetic expertise through such practices.

There are several challenges that come about when translating somaesthetics into design practice (Hook et al 2015). For example, whereas user friendliness for interface design can be tested quite easily with user testing, it can be much harder to do user testing for somaesthetics. Primarily, it depends on how familiar and sensitive one is to the sensations and feelings that their body has. If you sit at a desk for most of your day, it can be easy to ignore the body and become numb to its subtleties. And if you are a participant such as this, which is many of the people involved in our current economy, how long would you need to interact with a somaesthetic design in order to reconnect? For many people a simple 20 minute session would not be enough to achieve a somaesthetic experience.

Also, articulating what you are feeling or the sensations you are experiencing while interacting with a somaesthetic design can be even more difficult. As Hook and her colleagues noticed, even researchers who were developing the designs had difficulty articulating what it felt like (Hook et al 2015). Our bodily and felt experience can be difficult to express with language. One solution that Hook mentions is to encourage participants to explain their experience however they can, whether through talking, or drawing and focusing on the qualitative and subjective experience.

2.5.4 How to Design for Somaesthetics

Somaesthetics is particularly useful for interaction design for several reasons. Primarily, somaesthetics does not just focus on the physical body but how things feel and the context of the participant doing the introspection (Lee et al 2014). Somaesthetics also considers feelings on the outside of the body such as tactile, kinesthetic or haptic qualities. Finally, somaesthetic reflection gives us an awareness of how objects, artefacts and environments make us feel and how this changes our interactive experiences. Overall, somaesthetics gives us a way to consider the aesthetics of interaction (Lim et al 2007).

In terms of how to design ***for*** somaesthetic experience, Hook and her team have developed somaesthetic appreciation design, which they propose as the characteristics of successful somaesthetic projects (Hook et al 2016). Somaesthetic appreciation attempts to ground somaesthetic theories into design inquiries to create applications where the interaction helps participants turn inwards to focus on their own experience. These four characteristics include subtleness in how they encourage bodily inquiry, making space by shutting out the outer world and encouraging inward focus, intimate correspondence in how the feedback follows the rhythms of the body, and articulation in how the design help participants understand, learn and become more aware of their bodies and lived experience.

2.5.4.1 Subtle Guidance

Subtle guidance is a characteristic that focuses on how a somaesthetic design should direct a participant's attention inward (Hook et al 2016). This is one of the most difficult parts to designing a somaesthetic experience, because balance needs to be found between a noticeable feeling and a distraction, which can be a very grey area. The participant's attention needs to be subtly guided, but not grabbed. The design aims to keep interest and focus. A major part of this has to do with the speed of the interaction. Instead of just turning an element on or off, it's better to slowly increase and decrease certain elements.

2.5.4.2 Making Space

An important part of somaesthetics is the idea that you need to actively create space within your day for reflection (Hook et al 2016). This space is both physical and temporal. The characteristic of making space means to create an environment where you can feel calm and reflective, as well as maintaining focus for a specified time period within one's day.

2.5.4.3 Intimate Correspondence

Intimate correspondence is how closely the feedback and interaction follows how the participant is feeling and what they are experiencing (Hook et al 2016). This is where the accuracy of the sensors can be important. For example if you have a sensor with errors or your system has delays, and the input and visuals

do not correspond to how the user is feeling, then you will have a disconnect and the participant will not have a somaesthetic experience. This idea of intimate correspondence is very similar to the affective loop. You need to feel at one with the system and that it is responding to you as you are responding to it.

2.5.4.4 Articulation

Articulating the somaesthetic experience means creating visuals or responses that support reflection (Hook et al 2016). This can be through verbalization or discussions afterwards, but also in the feedback of the system. The system needs to help participants make sense of what they are experiencing. Similar to intimate correspondence, manners in which input is visualized needs to have the evocative balance where it allows participants to make their own meaning, but also has some visual mappings that make sense.

Though these four somaesthetic appreciation characteristics are helpful for designing and evaluating a system, because of how new the application of somaesthetic philosophy is to design, it was important to look at some of the design projects that utilized it in order to understand how the philosophy could be practically applied.

2.5.5 Somaesthetic Examples

Somaesthetics has been used for a few recent design projects including those that seek to explore active touch (Schiphorst 2009; Schripohorst et al 2010),

breathing (Hook 2015) (Ip et al 2014), muscle tension and stress (Schramm 2016). In this review of somaesthetic examples, the most significant characteristic was how each of the works did not use literal visual mappings to represent the data, such as red to represent stress, but instead used calming visuals such as pulsating light and relaxing colours in order to encourage and create space for bodily self reflection.

2.5.5.1 Soma Carpet and Breathing Light

Hook and her team from the Mobile Life lab at the Royal Institute of Technology in Sweden developed two designs that work together to create a somaesthetic experience.

Figure 3 - Soma Mat and Breathing Light (Hook et al 2015)

The Soma Mat and Breathing Light both aim to draw one's attention inward. The Soma Mat (Figure 3) directs a participant's attention with the subtle use of heat

(Hook et al 2015; Hook et al 2016). While on the mat participants listen to a guided meditation that asks them at certain points to focus on individual parts of their body and how each part feels. In sync with the recording, the mat gently provides subtle heat to the area of the body that the meditation is focusing on. So for example, when the meditation asks you how your foot is feeling, the mat will provide subtle heat to this area to help you focus on the sensations within that specific part of your body. The major difficulty that the team came across was getting the subtleness of the heat just right so as not to distract away from the meditation, but, at the same time, to be perceivable.

The Breathing Light (Figure 3) is a canopy that hangs over a participant (Hook et al 2015, Hook et al 2016). The canopy blocks out the visuals around someone as they lay down for a meditation, yet at the same time is see-through enough so that participants don't feel shut in or claustrophobic. As you lie within the Breathing Light your view is enclosed from the outer world and you are able to turn your attention inward. Inside the canopy, The Breathing Light contains a subtle light that glows in tune with the participants breathing as read by a breath sensor. When you close your eyes the ambient lighting can be subtly seen. The team also combined the Soma Mat with the Breathing Light and found that together they created a responsive and calming environment that helped participants feel "taken care of" (Hook et al 2015).

With both of these projects the team aimed to create the experience of turning inward, and found these devices to be successful in achieving that state

(Hook et al 2015). Their two most important findings were the importance of timing and subtly. Characteristics such as light and heat had to arrive and disappear slowly so as not to distract the participant from the experience. The team also found that it was important to limit the amount of stimuli so as not to bring attention outwards, for example, with the use of sound, and distract participants from their somaesthetic experience.

2.5.5.2 Wo.Defy

Figure 4 - Wo.Defy exterior design, circuit design and lighting (Ip et al 2014)

Wo.Defy is a bioresponsive garment that combines somaesthetics with feminist critique through a focus on intimacy, subjectivity and self reflection (Ip et al 2014). This project aims to explore how interactive garments can encourage us to pay more attention to how our bodies are feeling, both physically and emotionally. “Wo”, which means “I” in Chinese,... Wo.Defy acts like a second

skin on the body with biosensing technology, in particular a breath sensor, within the garment to promotes self awareness. The lights on the outside of the garment glow and the flowers on the dress contract and expand with the breath to emphasize shifts in breathing. The similarities to the Breathing Light project are immediately clear, and the use of glowing, pulsating and dimming was effective for this project. To evaluate the project they had six participants wear the garment and use a talk-aloud process to describe their experience, and found that the garment supported self reflection by focusing their attention on the breath and how they were feeling. The Wo.Defy team found that these qualitative methods were successful in evaluating the subjective nature of somaesthetic experience.

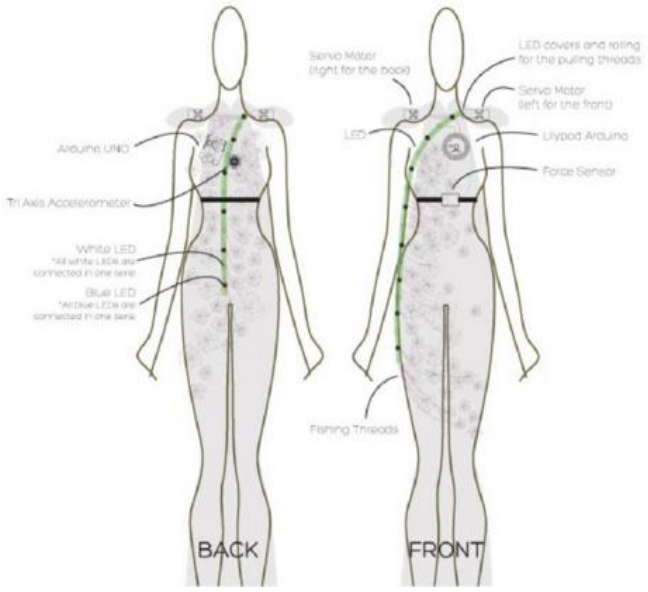

Figure 5 - Schematic for Wo.Defy (Ip et al 2014)

2.5.5.3 Stress Ball

Figure 6 - Stress Ball designed by Simone Schramm (Schramm 2016)

Stress Ball is a project from Simone Schramm's masters work in interface design at the University of Applied Sciences Potsdam in Germany (Schramm 2016). For her Masters thesis work Schramm designed a haptic ball that responds to stress levels as gathered from a skin conductance sensor. The project is a direct response to the Quantified Self movement with a focus on "less Quantified Self -- more qualified you" (Schramm 2016). As stress goes up the knobs smoothly come out of the ball in a fluent way so as not to imply fixed categories or levels of stress. By holding the ball during moments of reflection, participants will begin to draw their own connections between the haptic sensory input and how they are feeling. Throughout her descriptions of the project Schramm described the Stress Ball as a source of evocative balance. The project is designed to be open so that participants can insert their own meaning and use their "innate intuition" (Schramm 2016), yet at the same time gives them aestheticized, responsive feedback to respond to and interpret.

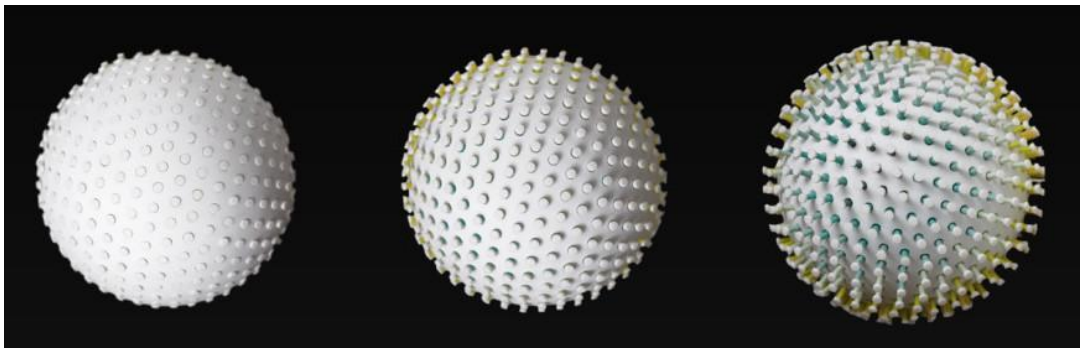

Figure 7 - Stress Ball as levels of stress increase (Schramm 2016)

2.5.5.4 Reflections on Somaesthetic Projects

These four projects are useful examples for thinking about how to apply somaesthetics to design. If we think back to Hook's characteristics of somaesthetic design—subtle guidance, making space, intimate correspondence and articulation—we can see all of these aspects within these designs (Hook 2016). The use of gentle heat, glowing lights and slow haptic feedback are all forms of subtly guiding the participant's attention towards somaesthetic reflection. Through the use of slow technology, as well as making physical space with the Breathing Light example, these projects help to make temporal space within ones day for bodily reflection and meaning making. The projects create intimate correspondence through their use of sensors such as breath sensors, pressure sensors and conductance sensors. Finally, the projects use articulation through visuals that map and correspond to the sensors: the heat focuses on a part of your body, the light breathes with you, the flowers open with your breath, and the stress ball expands with your stress response.

Though these physical products are different from the type of product I wanted to create, a display for self reflection, they are important examples in how they aestheticize the data in abstract ways. The use of colour to represent stress, and pulsating lights and opening flowers to represent breath, are ways of aestheticizing the data so that it can be felt but not numerically or literally read. The visual mappings are hinted at through gradients, movements and pulsating light but the room for interpretation is broad. Importantly, all these projects demonstrate how evocative balance can be created. Instead of hinting to literal mappings, such as red or orange for stress, they use soothing colours, lighting and heat to create a space for self reflection. These visual mappings for relaxation and reflection instead of literal mappings were important starting points for the design of this thesis project and in the thematic use of water. The visual choices were decided based on what would make room for reflection and relaxation, rather than literal mappings of heart rate.

2.6 The State of the (He)Art: Artistic Visualizations of Heart Rate Biofeedback

For my thesis project I am using heart rate biofeedback as input because it has been shown to be reflective of so many other physical and emotional aspects of bodily experience. In designing for a somaesthetic experience with heart rate biofeedback, it is important to first evaluate how heart rate biofeedback has previously been visualized. For this section I turn to the visual arts as a way to explore interface design and human computer interactions that are more sensuous

and palpable than many HCI interfaces (Munster 2011, Edmonds 2004). To a great extent, this literature review on artworks that use heart rate biofeedback was utilized to identify important aspects of participant interaction. These projects demonstrate the importance of real-time feedback, accurate sensors, room for reflection and environment to aestheticized heart rate visualizations.

Digital media artworks live in a creative space, and can therefore provide an opportunity for participants to explore their own biofeedback in productive and embodied ways. As the artist George Khut (2006) poignantly states in his Doctoral Exegesis "Development and Evaluation of Participant-Centred Biofeedback Artworks", art exhibitions provide an opportunity that is not available in the lab. He continues that art exhibits "provide a safe space for testing out new, unfamiliar or difficult subjectivities in a setting that is both intimate and social at the same time". The art gallery is a space that encourages subjective experience and response, or, more accurately, it is a place where we do not expect our experiences to be examined by medical experts for pathology.

2.6.1 Cube Life

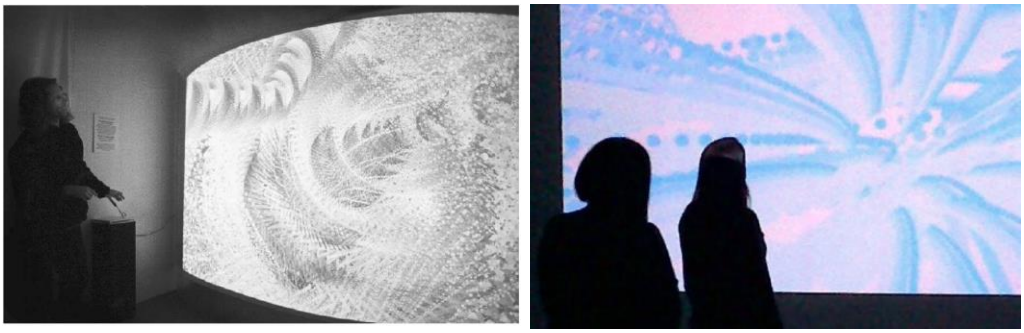

Figure 8 - CubeLife by Dave Everitt and Greg Turner (1999) (Edmonds et al 2004)

One of the first works to create the experience of embodied biofeedback data was the work *CubeLife* (1999). Dave Everitt and Greg Turner's *CubeLife* is a projected installation that responds to participants' heartbeats (Edmonds et al. 2004). For the installation, participants held onto a hand-grip heartbeat sensor that measured their heart rate. This data then triggered sounds and generated animated "magic cube" structures that were unique to the participant's unique pulse. The participant's individual magic cubes then interacted with the cubes created by other participants in the room to create a communal visualization. This resulted in an artwork where users could see representations of their own individual heartbeat as well as those of the community. Throughout, most of the technology to create the work was hidden behind the screen and all the participants could see was the pulse sensors and the visualizations.

Edward Edmonds (2004) suggests that *CubeLife* incorporated key innovations in biofeedback interaction (Edmonds et al. 2004). The team had four main goals for the interaction they wanted to develop that they built into the project from the start. First, the visualizations had to respond almost instantly

(low latency) in order for the participants to identify with the results. So when they saw their individual magic cube moving around they had to have the feeling of "that's mine". Second, the presence of new participants had to be detected so the installation could set up a new magic cube when it felt a pulse. Third, the program had to filter noise and the spikes in the data in order to maintain accuracy to how the participants really felt. Finally, the program had to recognize when no one was using the pulse sensor and go into sleep mode after a participant was done using it (Edmonds et al. 2004). Ultimately, all these technical goals demonstrated how the system could show participants that it recognized their presence and was ready to respond to them.

Overall, *CubeLife* demonstrates several important aspect of an embodied interaction with biofeedback visualizations. Through this experience the team concluded that there are three essential requirements for an embodied experience: ease of connection to sensors (input), the result must provide the participant with feedback they can understand (output), and, a sense of an intimate connection with the technology (Edmonds et al. 2004), or an affective loop. This means that the work must be easy to use so that participants do not get distracted by the technology, participants must be able to connect what they see to their biofeedback and their body, and there needs to be a sense that this is their individual and unique visualization so that they can reflect on their own experience. Though having other people's heart rate visualizations can be useful for comparison, it isn't helpful if your goal is for subjective self reflection. For

this reason it was decided that the prototype for this thesis project would be built to be used by one individual at a time.

2.6.2 The Work of George Khut

George Khut (2006) is an Australian biofeedback artist whose artworks address subjectivity as a physiologically embodied phenomenon. Khut's works come from a psychophysical framework of the body, which means that our mind and body are deeply connected. Instead of the dichotomy between mind and body, a psychophysical framework sees them as one entity. As the artist states, in contrast to our internet culture of "disembodied minds", he creates works that try to place us in our bodies and to reflect on this state of being in our body (2006). In his art practice he asks: "How can contemporary fine arts practice evolve in new ways of facilitating and representing experiences of subjectivity (and by inference, the self) as a physiologically embodied phenomena?" (Khut, 2006, 1). Khut places these questions into his work through a focus on our emotions and feelings and how they impact our bodily response and the resulted biofeedback. Overall, Khut's works are informed by the embodiment theory of Merleau-Ponty (1962) that "the body is our medium for having a world", and aim to use the biofeedback from our bodies for self-authored experiences and as a way of self-knowing (Khut 2006).

2.6.2.1 Res'onance-Body [box]

Figure 9 - Res'onance-Body [box] by George Khut (2003) (Khut 2006)

One of George Khut's earliest biofeedback works is *Res'onance-body [box] (2003)*, a collaborative project with Karina Clarke and Julia Charles that aimed to create an immersive environment with breath and heart rate biofeedback (Khut 2006, 2014). This participatory installation included a room with changing LED lights and a platform where participants were invited to lie horizontally. One by one, participants put a breath sensor around their chest and a pulse sensor on their index finger and were encouraged to calmly lower their breathing rate. A sound installation created by Khut's responded to the biofeedback data gathered from the sensors placed on participants. This sound installation emitted lower frequency textures in response to calm breathing patterns and higher frequency textures for faster breathing rates. At the same time as breathing patterns were measured heart rate was measured from the pulse sensor and resulted in short ping pulse sounds.

As Khut states (2006), the goal of the project was to explore breath rate and heart rate as potential sources for interaction in relation to meditative breathing techniques. Overall, the project went over well with participants who

expressed excitement about the possibility of being involved in a work that responded to their bodies' breath rate and heart rate. Though the participants expressed clear excitement about the piece, there were also some issues that arose in the interpretation of their biofeedback. Participants noticed a delay in the "ping" sound effect that responded to their heartbeat. When the pings were out of tune with the heartbeat they were feeling within themselves, the work began to feel out of synch with the rhythm of their bodies and impeded the installation from becoming an embodied experience. This delay in the calculation of the biofeedback and the sound response broke the affective loop. This blocked the participants from feeling that the work was an extension of themselves. They no longer felt in sync with the system.

Other technical issues arose with the use of the infrared pulse plethysmograph as a sensor. Though the external sensor, which is easy to slip on one's index finger, is less invasive and more convenient for public installations, at times the team found it to be unreliable. This was a result of the sensor's dependency on circulation, and the project team found that low circulation in certain participants led to inaccuracies in heart rate and therefore inaccuracies in the installation's programmed response. With a work like *Res'onance-body [box]*, accuracy is of great importance as without it participants lose any possibility of connection to the installation's interpretations of their biofeedback. If the participants do not see the connection between what they are experiencing in their own body and the visualizations then the affective loop is broken.

2.6.2.2 Cardiomorophologies v.1 and v2

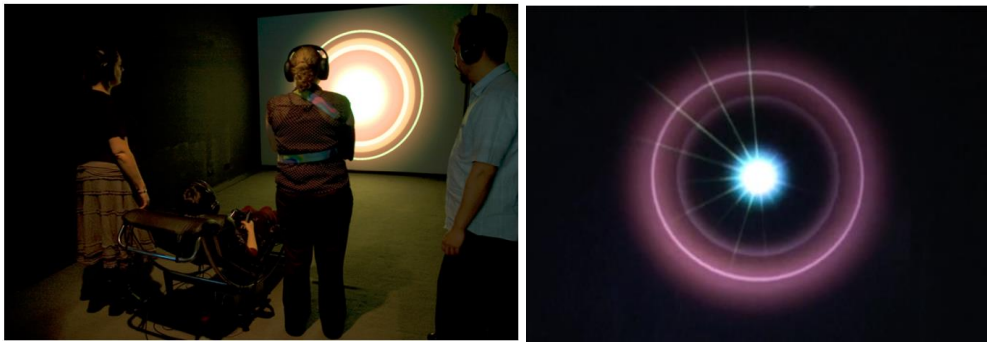

Figure 10 - Cardiomorphologies v.1 (2004) and Cardiomorphologies v.2 (2005) by George Khut (Khut 2006)

Khut's following installation, which incorporated both breath rate and heart rate, was a work of several iterations called *Cardiomorphologies v.1* (2004) and *Cardiomorphologies v.2* (2005) (Khut 2006, 2014) that expanded upon lessons learned from *Res'onance-body [box]*. For the *Cardiomorphologies* installations, participants were seated in reclined chairs in a gallery space with little to no light. In front of the participants was a large projection screen with circular pulsating visualizations of their biofeedback. While seated, participants wore a respiratory strain gauge around their chest in order to measure the rate of their breath, and held onto an electrocardiogram with their hands to measure their heartbeat. The visualizations of breath and heart rate were done through animated and responsive concentric circles inspired by hypnotic artworks of the 1960s.

Building off of *Res'onance-body [box]*, Khut once again incorporated sounds that responded to the participant's breath and heart rate. The heart rate from the electrocardiogram triggered a pulse sound similar to that of a heart (which is similar to what occurred in the previous installation). The breath rate

was translated into breathing sounds that were amplified or quieted to correlate with the participant's breath rate. The sound varied from a quiet hiss to a loud rumbling roar.

Just as the participants focused on the lighting in *Res'onance-body [box]*, with *Cardiomorphologies* the participants favoured the visual feedback over the auditory feedback. Another issue that arose was the colour representing the heartbeat in *Cardiomorphologies v.1*.. Some participants found the red circle representing their pulse to be threatening, which in turn created a cycle of constantly raising their heart rate whenever it pulsed. Considering how pulsating red lights are used in Western culture for warnings such as traffic lights and ambulance sirens this type of connection makes sense.

The second iteration of the project, *Cardiomorphologies v.2*., was similar to the first but aimed to understand the audience's experience of the work through user testing and use these insights in an iterative process of development. For this installation, Khut collaborated with Lizzie Muller, a practice-based academic in Human-Computer Interaction (HCI) and human-centred design research, and Greg Turner, an interaction designer and HCI researcher with a focus on media arts. Together they devised, within *Cardiomorphologies* 8 states that they wanted the participants to experience during the installation including: accuracy, sensuality, inwardly focused, explorative, instructive, meaningful, and enabling one to feel the physical changes (Khut 2006: 158). As previously mentioned, feeling that the work is accurately portraying your physical experience, and doing

so in real-time, is a key aspect of biofeedback works and creating an affective loop. The state of sensuality is about whether one feels heightened sensory and bodily perception while experiencing the work. Questions such as: Does it heighten their physical senses? Do they notice their body more? For inward focus, does the work cause them to think about their experience and reflect? Do the installations allow participants to explore their biofeedback, and does it provide with a meaningful experience? By that Khut means whether the participants are able to insert their own memories and experiences into the work.

Post-experience, the participants were questioned about their thoughts of the installation and their answers were recorded and evaluated against the project's goals. The results were that participants experienced heightened awareness of their bodies and were able to reflect on how they were feeling. Participants stated that they felt calm once they had settled into the experience and that they felt that the visuals and their biofeedback were extensions of themselves. The pulsating circles in the visualizations encouraged "experimentation and play" (Muller 2006), which also helped engagement in an affective loop. Users tested the limits of the work by raising their heart rate or thinking of certain happy or sad memories and felt that their reflective thoughts were represented in the work. As a result, the goals of explorative experiences and accuracy were met through these affective loops.

In the end, incorporating both heart rate and breath rate for *Cardiomorphologies* was once again too busy for inward focus and there was a

need to minimize the scope of the biofeedback collected in following installations. Khut (2006) found that though participants felt that they were able to control their breath rate in *Cardiomorphologies*, many felt they were less able to influence their heart rate. Though the cardiovascular system is a connected one, the more obvious action of physically slowing the breath might have taken participants away from the focus on their heart beat. Heart beat was of greater importance as it made participants focus inwardly, whereas breath can be controlled more easily.

In the paper "Creating Affective Visualizations for a Physiologically Interactive Artwork", Muller and the *Cardiomorphologies* team discuss the visualizations in the work (Muller 2006). As the authors state, they found that the ambiguity of the abstraction in the visualizations of *Cardiomorphologies* contributed to the artist's two main goals including a sense of the mind and body feeling integrated with the installation. Because the visualizations were ambiguous, participants could insert their own narratives through evocative balance and therefore develop a connection with the installation. These narratives included "intensely personal feelings and emotions" in terms of triggering subjective memories of past events, and helped participants to feel more connected to the work. As the author's poignantly state, "ambiguity creates space for people to create meaning" (Muller 2006). This very ambiguity in the visuals created evocative balance which allows for more personal and unique experiences.

2.6.2.3 The Heart Library

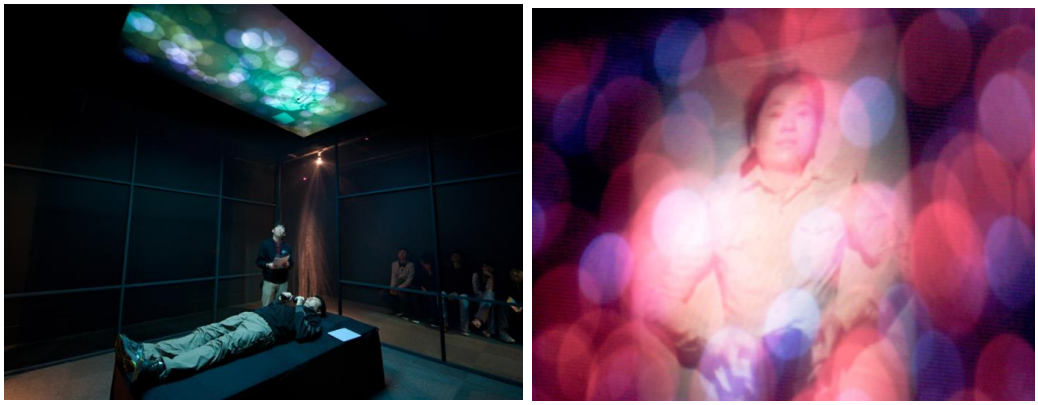

Figure 11 - The Heart Library by George Khut (2007) (Khut 2014)

From works that incorporate both breath and heart rate, Khut then moved to works that focused singularly on the heart in order to remove the lack of focus that came up when breath and heart rate were combined in previous works (Khut 2014). *The Heart Library* (2007) is an interactive art installation that uses video, sound and colour to represent participants' heart rate. Within a darkened room there is a platform where participants are encouraged to lie horizontally and look towards the screen above. A hidden camera presents the participant's mirror image on the screen and gives subjects the illusion of their own body floating in the air. The participant holds onto an electrocardiogram and their pulse is represented in the abstract animations above, which move to red for higher heart rates and move to blue for lower heart rates. One snippet from the transcripts of a participant at the exhibition at St. Vincent's Public Hospital reveals the powerful potential of the work:

> What really interested me was that if I had a thought that was self-critical – then all the dots went red – then when I said, "I accept myself" – it all went blue. I thought "how quick is that!" […] Just knowing that I'm capable of big things […] and at the moment I'm dealing with a life-threatening illness – so that's important for me – that I'm actually capable of stepping into another realm as well (Khut 2014).

What is so powerful about this response is how quickly the visualizations changed as a result of the changes in the body. Just as one moves to another room after deciding to, this work trains participants that they have a similar power over their body and how they are feeling. In contrast to the out of synch pings from *Res'onance-body [box]*, this work shows how important real-time and instantaneous feedback is for embodiment. The reason this participant felt a connection to the work was because of this time-based relationship. They felt a certain way and this was represented instantaneously both physically in their bodies and visually in the artwork.

Unlike Khut's earlier works, with *The Heart Library* participants reported that it was relatively easy to control, most likely because of its focus on heart rate alone. Rather than focusing on multiple (though connected) biofeedback channels like Khut's previous projects, the focus on the heart gave participants a clear indication of what was changing and when. This direct correlation to what the participant experienced and what occurred on screen allowed created a greater sense of connection with the resulting visualizations. When we think of the somaesthetic design characteristics of making space, having multiple stimuli

through several visualizations can be distracting, whereas focusing on one visualization gives room for reflection.

2.6.3 Projects from the Mobile Life lab at the Royal Institute of Technology in Sweden

Though the projects out of the Mobile Life Lab at the Royal Institute of Technology in Sweden are closer to interaction design projects than artworks, the aesthetic design and way the information was visualized were influenced by the artworks of George Khut (Stahl et al 2014). These projects are significant to this thesis because of how they demonstrate the importance of evocative balance and the interpretive aspect of aesthetic visualizations.

2.6.3.1 Affective Health

Figure 12 - Affective Health application (Stahl et al 2014)

Affective Health is a phone app that connects to biofeedback sensors for emotional self reflection (Stahl et al 2014). For the project, the participants wear

a pulse sensor, a skin conductance sensor for emotional arousal, and an accelerometer to monitor movement. The input from these sensors is then transformed into a visualization of colours and circles where users can abstractly see the input from the three sensors mapped onto their day. This gave participants the opportunity to reflect on how they were feeling at certain times of the day and engage in meaning-making as they mapped how they were feeling in relation to their bodily input.

The biofeedback sensors talk directly with the phone over bluetooth, which lets the participant see and reflect on their input in real time (Stahl et al 2014). Secondly, beyond seeing the changes within their day, they can also look at the patterns that have occurred over several days and reflect on how they were feeling at those times of the day, and how they might potentially like to make adjustments in their life. After using the system the research team noticed that people started to describe their days in term of the visuals. For example, saying they had an orange week, or how their mood went up or down according to the colour scale.

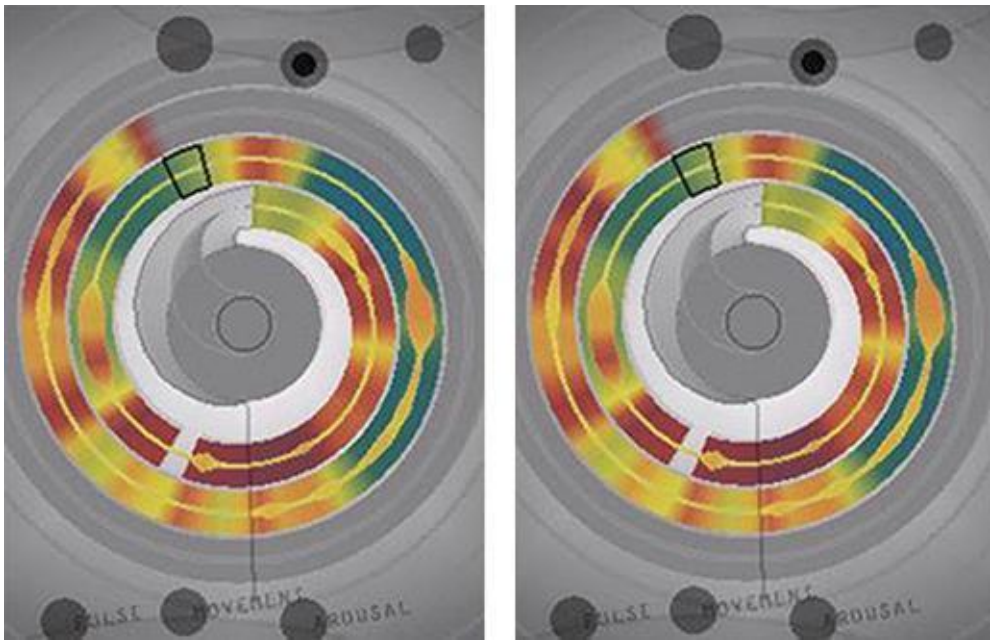

Figure 13 - Two mornings that looked similar but had different associations (Stahl et al 2014)

Another interesting aspect the researchers noticed was how participants could describe two similar looking days completely differently based on their subjective experience. One participant who had just gone through a divorce described two similar looking moments (Figure 13). In describing her day when the blue turned to orange and then red in one instance she said: "And then I talked to my husband again about this apartment-business", and in the other, "It was a somewhat more stressful morning than it is usually [...] other routines, made some calls, and that made it more rushed than usual" (Stahl et al 2014, Affective Health). This difference is significant because it demonstrates how the visuals themselves do not create the meaning for the viewer. Two almost identical days in terms of input mean different things based on the participant's subjective experience of that day. At the same time, the input is significant because it

demonstrates how the design can become a catalyst for reflection and meaning-making.

This project is a prime example of what the team has termed “evocative balance”, as the visual representations do evoke or encourage reflection, but at the same time allow for the user to define their experience based on their own subjective ideas about the heart rate visualization.

2.6.3.2 Metaphone

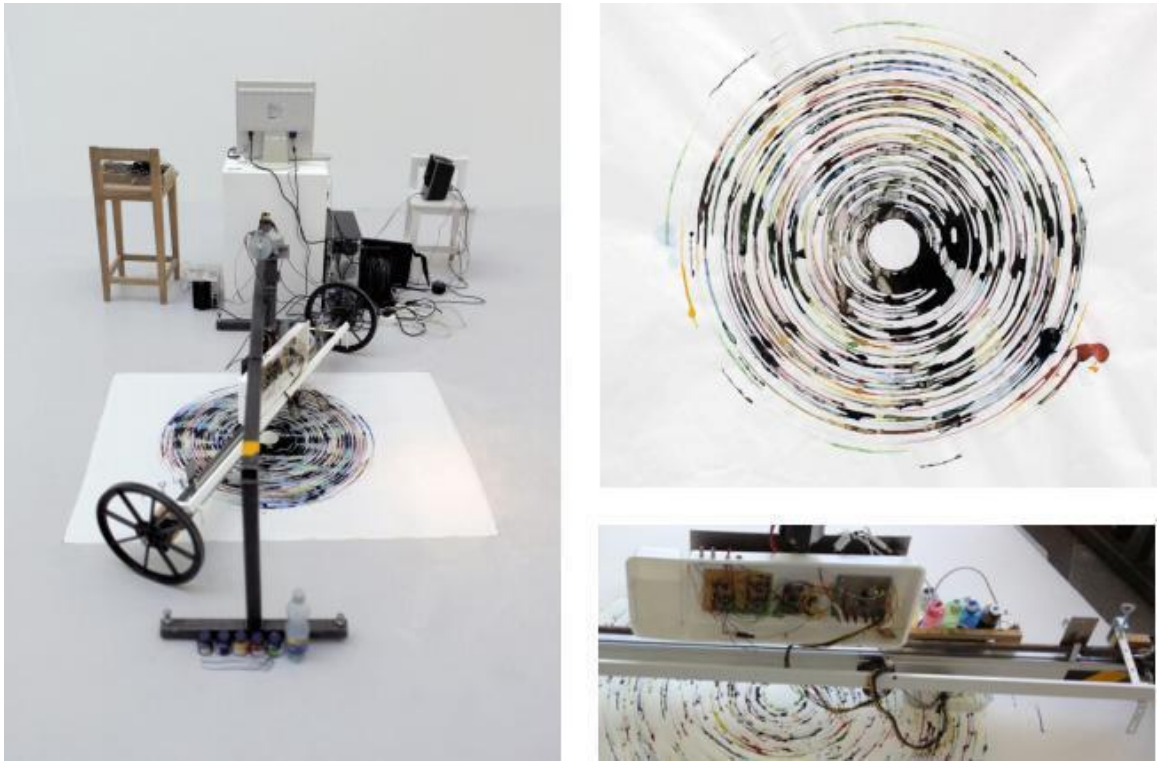

Figure 14 - Metaphone installation (Simbelis et al 2014)

Metaphone was another project out of the Mobile Lab that used heart rate as input (Simbelis et al 2014). For this art project the researchers used the same mandala shape and rotating circles as the Affective Health project, as well as the

use of the participant's biofeedback data through galvanic skin response and heart rate sensors. The interesting aspect of this work is that rather than being screen-based, the project is rather physical, like many of the somaesthetic design examples, and therefore is a good way to see how heart rate visuals could be created beyond the screen, and whether this is successful.

For this installation a participant would walk into a room and hold an object the team called a "bio ball", which captured biodata from the participants when they held it in their hand (Simbelis et al 2014). The bio ball would blink and glow in tune with their heart beat, and transformed the data into the visual representation made with the drawing machine. The drawing machine then squeezed out four different colours of paint based on the biofeedback input.

Red paint was released based on the signal from the heart rate sensor. Every time there was a beat this triggered the machine to release red paint. The yellow paint was connected with the beats per minute -- as the beats went up the mount of yellow paint increased. The galvanic skin response sensor, which can indicate emotional arousal or alertness when high, effected the green and blue paint. When the galvanic skin response sensor was high the blue paint increased, and as it lowered the green paint increased.

The team had six participants interact with the work throughout their user testing. When participants first entered the room their first impulse was to explore the limits of the device, and how it could be controlled. Most participants found it very difficult to control and as a result gave up trying, and this actually

encouraged feelings of relaxation. One participant stated that work captured their feeling and “You have a sense of machinery working for you and it makes me relax… someone is doing the work [for me]”(Simbelis 2014; 8). As one participant stated of the visuals -- the “shape of a circle, I associated it with relaxation Like a Buddhist’s circle (Mandala)” (8). The goal of the work was room for reflection and across the board all of them experienced this feeling of slowed down time.

3.0 Applying Somaesthetics to Design: Research Approach and Research Methods

3.1 Summary

The greatest challenge I had during this research was that I was combining the fields of art and design with HCI, and what these fields consider "knowledge" is not immediately compatible. As Hook and her colleagues discuss in the paper "Sense and Sensibility: Evaluation and Interactive Art", the methods and evaluation tools of art and HCI are difficult to combine (Hook et al 2003). Typically, artworks are evaluated using art criticism and in contrast HCI has tended towards formal user studies. Their greatest disconnect is that art is subjective whereas HCI has typically aimed to be objective. Interactive art currently lies somewhere in the middle in an ambiguous intermediary ground between the fields, but can also provide a way to "propel both fields forward" (pp 241). The difficult part lies within careful negotiation between research and evaluation methods.

To review, the research questions my thesis aims to address are:

a) Rather than using biometric devices for quantitative data, how can somaesthetic design be used to visualize aesthetic heart rate biofeedback in order to help us reflect on our lived experience and feel more embodied?
b) How can somaesthetic design appreciation characteristics be used to evaluate interactive devices?

As demonstrated in the theoretical review of somaesthetics (see section 2), somaesthetics is an interdisciplinary field that looks at the aesthetic experience of the lived body. As a field that focuses on self meaning-making and subjective experiences of the body, somaesthetics is a suitable way for addressing how interactive devices and heart rate biofeedback can get us more in touch with our bodies.

To address my two research questions I used the somaesthetic appreciation design characteristics as outlined by Hook (Hook et al 2016). These characteristics include subtleness in how they encourage bodily inquiry, making space by shutting out the outer world and encouraging inward focus, intimate correspondence in how the feedback follows the rhythms of the body, and articulation in how the design help participants understand, learn and become more aware of their bodies and lived experience.

For the creation process of this research project I used a research through design methodology as research through design has been effectively used in previous somaesthetic design work (Hook et al 2016; Ip et al 2014). To do so, I used a design log to document design decisions as they were made, and during each stage I considered whether the somaesthetic design characteristics were met.

For the evaluation of interactive artworks, Hook and her colleagues recommend using “system critics” (pp 248). Similar to how art criticism has a culture of experts doing art critiques for colleagues, the system critique would involve interaction designers who can evaluate a system using their background

knowledge. These types of system critiques have been useful for discovering and identifying problematic areas of the interaction while also discussing possibilities for improvements to the work (Mankoff 2003). As a result, the method that was used for the evaluation of this work was the system critique using the someasthetic appreciation design characteristics.

To implement this evaluation method I had critique sessions with system critics within the Digital Futures graduate program. For each of these sessions the participants got to use the system for as long as they liked while being asked for their informed critique of the work based on the somaesthetic design characteristics. The critique questions are available in the Appendix of this document.

3.2 Prototype Design Process – Research Through Design

3.1.1 What is research through design?

Research through design is a research approach that considers design practice as a legitimate form of enquiry. As Zimmerman states in his analysis of the practice, research through design is a "creative way of investigating what a potential future might be" (2010: 313). It allows designers to design on the way to developing theory. The idea of this research is approach is that designers have knowledge from practice that cannot be replicated across designers (in contrast to the scientific method where results should be able to be replicated). For example,

if you give several designers the same problem, they are likely to come up with different solutions, though potentially both could be equally suitable. As Donald Schon said in 1983 when he theorized about research through design:

> "I begin with the assumption that competent practitioners usually know more than they can say. They exhibit a kind of knowing-in-practice, most of which is tacit […] Indeed, practitioners themselves often reveal a capacity for reflection on their intuitive knowing in the midst of action and sometimes use this capacity to cope with the unique, uncertain, and conflicted situations of practice" (Frankel et al. 2010: 2).

At the same time, research through design is different from other research methods such as research through prototype in that the focus is not on the final product but rather the knowledge that comes from the design process. This gives design the ability to be a method to reflect and inquire, and as such was a suitable way to explore somaesthetic design for a display aimed for embodied reflection.

3.1.2 Issues

There are several known issues that can negatively impact the academic research rigor of research through design. As documented in the interviews by Zimmerman (2010), many interviewees mentioned how researchers using research through design can slip into a "romantic" (2010: 316) view of design based on flimsy use of intuition. Many interviews asked for "more rigorous documentation" (2010: 316) of the projects and how the researcher dealt with problems that arose. To add to this, research through design projects also suffer from the question of how to analyze success or failure once a project has been

completed. To amend for this I used a design log and somaesthetic appreciation design characteristics as a way to evaluate for success.

3.1.3 Solutions

Zimmerman (2007) has also proposed several ways of evaluating research through design project in the realm of interaction design. He proposes the evaluation criteria of process, invention, relevance and extensibility. By process, Zimmerman means thorough documentation of the process with rationale for design decisions. Invention means that the research must contribute something novel after a thorough literature review. Relevance means that the researcher must explain why the preferred states were chosen. Finally, extensibility means to build upon further research by leveraging the knowledge created from design of the artifact. These criteria was used to guide the research through design process. The process was documented in a design log as recommended in Owain Pedgley's article "Capturing and Analysing Own Design Activity" (2007).

In the article Pedgley (2007) discusses how writing a diary can be useful in practice-led design research, or research through design. As practice-led research is used to communicate new knowledge through a designer's individual practice, the research is highly personal and requires one to be reflective about their design practice. Pedgley offers practical tips for writing a research diary. These strategies include:

- Write each diary at the end of the day so that you can get candid reactions instead of rationalizing design decisions retroactively
- Discuss the reasoning behind your strategies and plans and how they change along the way
- Have ways of included sketches, log books, and models into your diary
- Describe the works in chronological order and use bullet points
- Keep the entries clear and focused

By completing the design diary at the end of each design session, I was able to account for many of Zimmerman's evaluation criteria including process, relevance and extensibility. Invention was worked into the research through design process by incorporating successes and failures of previous relevant work as captured from the literature review.

4.0 Iterations

4.1 Initial Design Decisions and Rationale

4.1.1 Colour

After researching how heart rate had been visualized in digital media artworks, I had some initial reflections on how the work had been presented. Primarily, most of the artworks had used the colour red to represent heart rate. Though there are visual mappings between heart rate and the colour red (i.e., anatomically hearts tend to be red, and the blood that flows through them is red), in terms of the experience red is a colour used to alarm, warn or halt. This is an understandable goal if you want someone to lower their heart rate or are trying to warn them when they reach a certain heart rate level, but if the goal is for them to experience their body as it is then alarming queues through the colour usage would want to be avoided.

This is where somaesthetics and the somaesthetic design examples played a major role. No matter whether the sensor input was high or low, the visuals used were still calming and created a safe space for reflection. Therefore instead of creating literal mappings between heart rate and the colour red, my goal was to use calming colours, such as blue, in order to create a relaxing environment for self reflection.

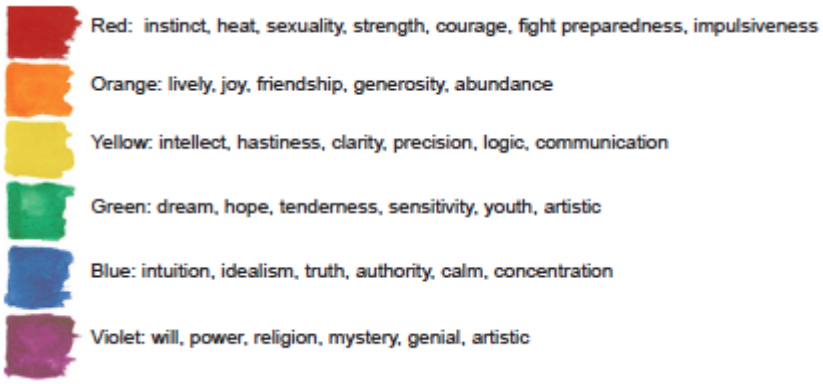

Figure 15 - colour choices and associations (Ryberg 1991)

4.1.2 Circular Shape

One visual aspect of the heart rate visualizations that had worked very effectively was the use of the mandala or circular shape (Khut 2006; Khut 2014; Stahl et al 2014; Simbelis et al 2014). Mandalas have a history of use in meditation and therefore could be useful for reflective somaesthetic practice (Cornell 2006). In particular, mandalas have been shown to reduce negative moods and help people relax and reflect (Babouchkina 2015). Through the use of the mandala shape for reflection, this would help the making space somaesthetic goal. As a result, I decided to use the mandala shape in the early prototypes of this research project.

4.1.3 Water Choice

The visualizations for this project were influenced by the water soundscape meditation developed by InterAxon. Similar to the colour choice to create a calming environment, the water choice also presented a way to create a

space for relaxation and reflection. The Muse by InterAxon is a electroencephalogram (EEG) headset that measures brain signals in order to determine a user's mental state (Bashivan 2016). The consumer Muse kit includes a headset and an app (see Figure 16). In order to use the device, the user puts on the headset, syncs it to the app, waits for the headset to calibrate and then begins a meditation session.

Figure 16 - InterAxon's Muse EEG Headset and app

Interestingly, the Muse's main meditation program aesthetically represents a user's brain waves as water sounds (ranging from a calm stream to a violent storm) depending on how relaxed and concentrated they are; the idea is that the stormier your mind, the stormier the water. So for example, if you begin a meditation session and find it difficult to concentrate, the app will play sounds of wind, rain and crashing waves. As your thoughts calm down so does the water and you will begin to hear a relaxing trickle of water going down a stream. If you stay in a calm state for a period of time, you will begin to hear birds chirping over the water sounds.

The soundscape version of this data, which the user experiences throughout the meditation session, is useful because it provides a metaphor for how the user is doing so that they can adjust themselves and improve their mental state in real time. Also, the intimate correspondence between distraction or lack of concentration and stormy water is a mapping that makes sense to users.

During my own self trials with the Muse meditation soundscape I had a good experience when my concentration levels were regular and when there were only sounds of water. Unfortunately when my concentration went higher or lower the program included other sounds on top of the water state (such as wind storms and birds chirping) that became incredibly distracting and actually caused my concentration and sense of calm to worsen. The problem wasn't that the water sounds changed, but rather how all these other sounds were added on top. This personal user testing, though it encouraged me to use water, also suggested that adding many different types of sounds or visuals was a distraction and something to be improved upon.

4.2 Research Through Design: Initial Prototypes

During this thesis I worked on two initial prototypes of *Your Body of Water*. These prototypes aimed to mock-up the way the program visualized the water in relation to the users heart rate. The displays were designed using the somaesthetic design characteristics of subtleness, making space, intimate correspondence and articulation.

Both prototypes focused on the way our mind and body are connected. The idea behind the project was that when you're excited or stressed your heart rate goes up, and when you're calm or meditating your heart rate goes down. The visualization responded to heart rate by increasing the speed that the water spun at and having louder wave sounds as your pulse increased. When no one was touching the work, the water went still. In this way, the water's movements and sounds became a visualization of how calm or excited the user was.

To evaluate the prototypes members of the digital futures cohort acted as system critics. They used the display for several minutes and then gave their informal critique on the interaction in terms of how it made them feel and what could be improved.

4.2.1 Prototype One

The first prototype of this project used a video projection of a bowl of water that spun at the rate of your heart. This prototype was made using the arduino pulse sensor, and was hooked up to an arduino that spun a servomotor holding a fishbowl of water (see Figure 17 for set up).

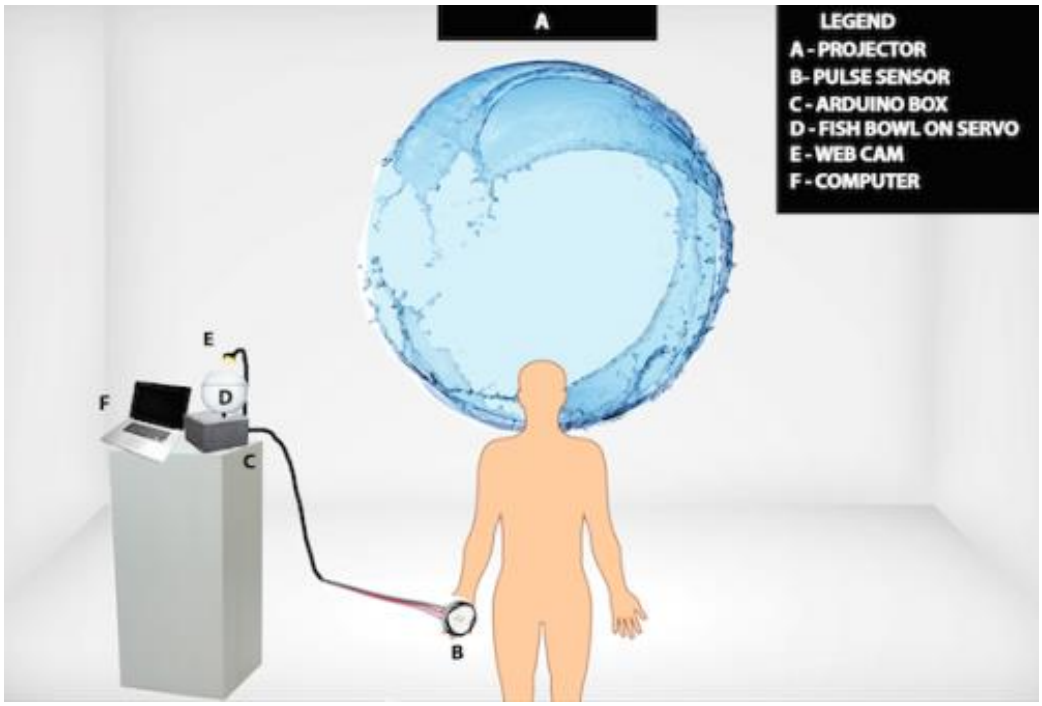

Figure 17 - Diagram of Your Body of Water prototype 1 setup

When a user turned on the machine with the toggle switch, a blue LED light turns on to signify to the user that the pulse sensor would now begin its readings. The user put their finger in the pulse sensor and then the pulse sensor read their heart rate and sent that to both the servo motor and the processing sketch. On the processing side, as your pulse increased, the webcam watched the bowl of water on the servo and projected that into a circle formation in front of the user. As the participant's pulse increased and the servo increased in speed, processing played a sound file of water elevating from a quiet stream to a loud storm (see Figure 18 for material set up).

Early on I noticed that because of the lights and the clear bowl, you couldn't clearly see the water as it moved. This made me realize that I needed to add more effects so that you would be able to see the water moving. To solve the

problem of the see-through water I added a blue light and pearls. The pearls made it easier to see the spinning motions and enhanced the visuals for the viewer. I used pearls because they are a common reference for thoughts (share your "pearls" of wisdom, etc). So in reference to the projects overall goal of measuring how stormy you are feeling, and the emotional aspects of heart rate, the pearls were a fitting solution for better visuals.

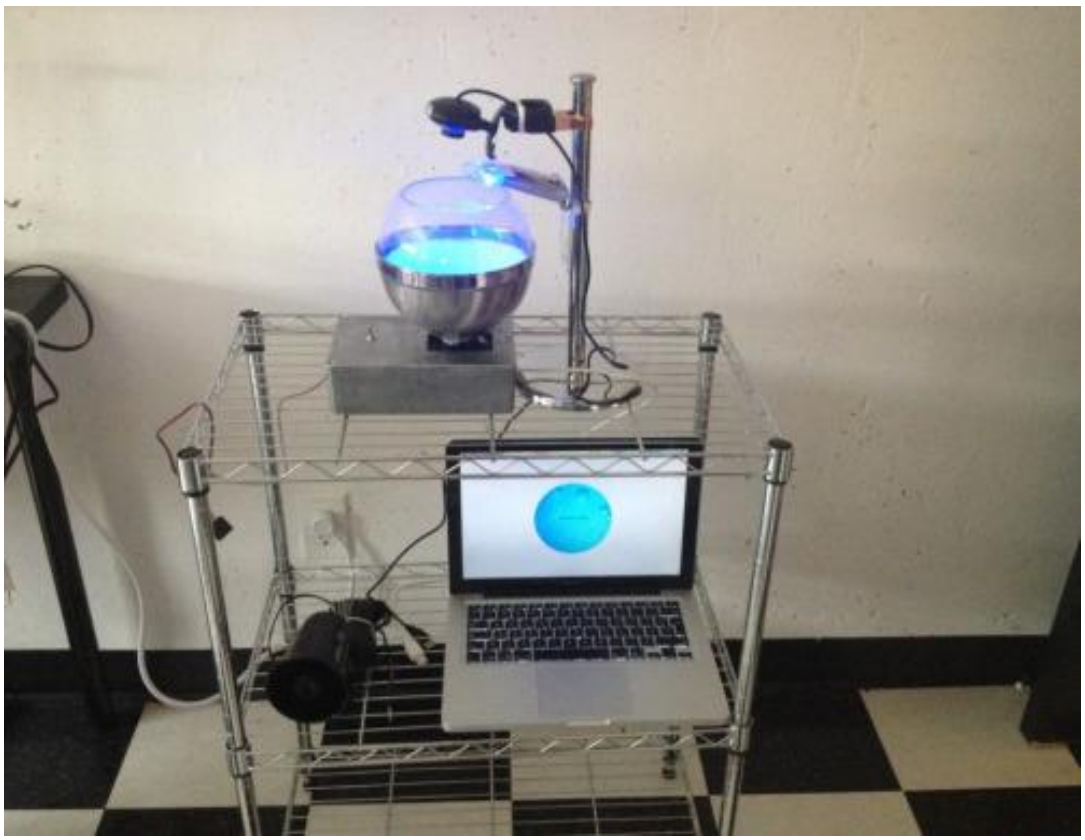

Figure 18 - Installation set up for pulse sensor, arduino and servo motor, and computer

Further Research

During the installation several areas of improvement arose. Because we couldn't see the pulse sensor output number in the installation view it was difficult to tell if the arduino pulse sensor was in accurate ranges. During testing

with the arduino pulse sensor would occasionally spike to above 200, which are pulse rates not humanly possible. To amend for this, it would be useful to also have the arduino pulse sensor's data available to ensure that it was accurately picking up heart rate.

The servo motor used for spinning the water also had limitations. Throughout the servo motor was quite loud, and especially so if the heart rate was high. The sound of the servo motor at these times impeded the user's ability to hear the water sounds made with processing. As a result most users did not even notice that the installation was making water sounds that coincided with the speed of the water.

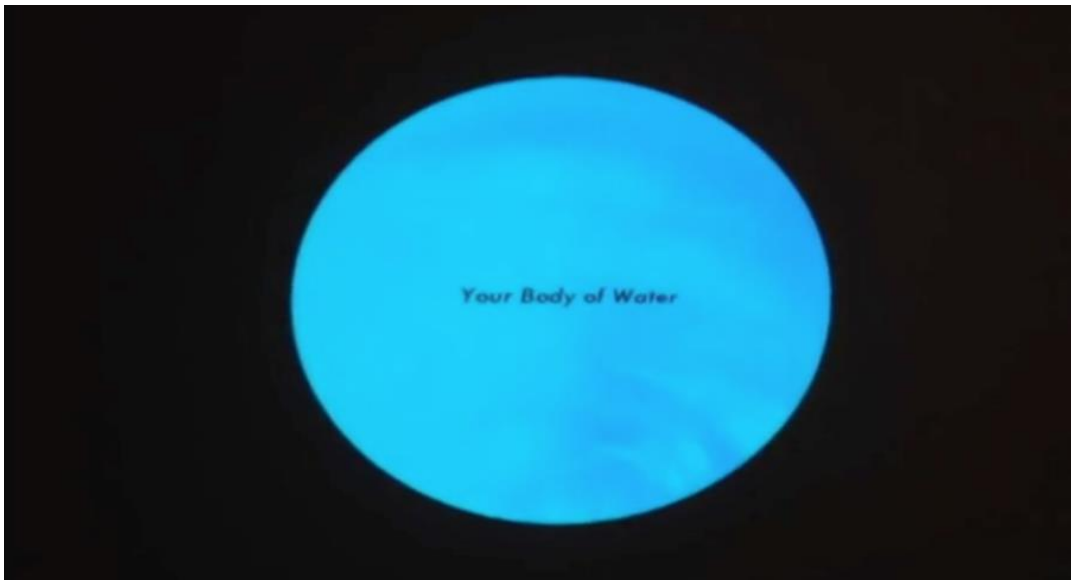

Figure 19 - Installation view of Your Body of Water

Video: https://vimeo.com/111663292

4.2.2 Prototype Two

The first prototype of the project was useful for determining how the pulse sensor data could guide the movements of the water. To amend for some of the issues raised in the first prototype, for the second prototype the project was moved entirely digital. This also gave users a greater sense of control as their heartbeat changed more aspects of the installation. In this version the water had three aspects: the speed of the spinning water, the size of the water circle, and the volume of the sound of the water's waves. All three aspects increased and decreased depending on the heart rate of the user.

Similar to the first prototype, this version used the arduino pulse sensor but instead of using processing the visuals were coded using HTML, JavaScript and Node.js . To make my project, I made water .gifs files that showed water moving at different speeds and sizes. Certain beats per minute from the arduino pulse sensor triggered .gif files of different sizes and speeds as well as the sound of waves at different volumes.

Conclusions and Further Research

As mentioned in the previous prototype, One issue I came across with this project was the inaccuracy of the pulse sensor. At times there were strong data spikes and a user's heart rate would suddenly go to 200 (an impossible heart rate). Having the pulse rate number on the installation helped as it let us know when this was occurring and when the installation went back to normal (see Figure 20).

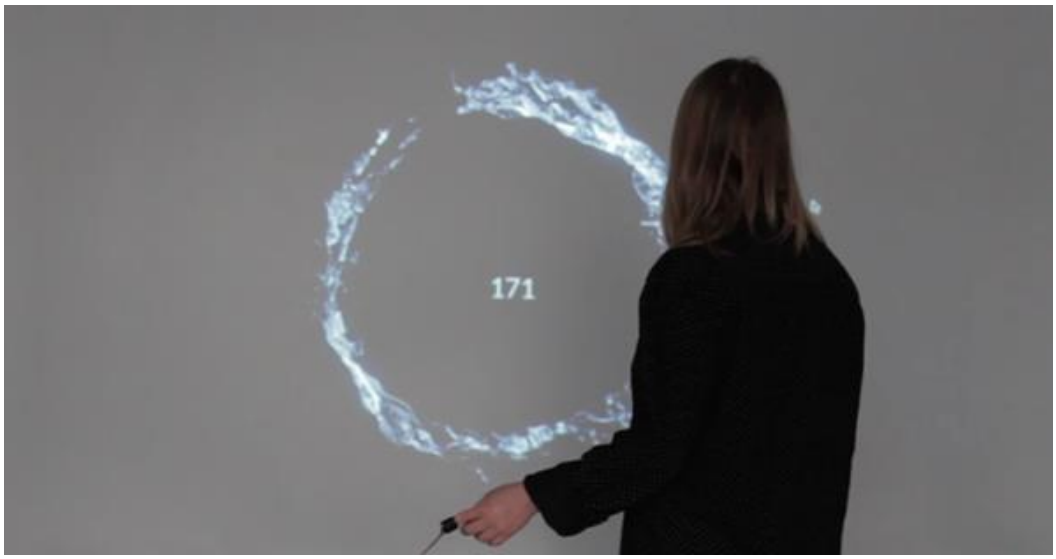

Figure 20 - Projected visualization of Your Body of Water

For the next version of this project, I used a smoothing tool in order to avoid these spikes in the data. I also explored other options for getting heart rate. One problem with these two prototype is that the pulse sensor cord at times got in the way of participants looking at the installation, as it kept users toggled to the computer. For further iterations I will be exploring wireless options for gathering heart rate for more accurate heart rate and so that the participants can move around and not be toggled to the computer.

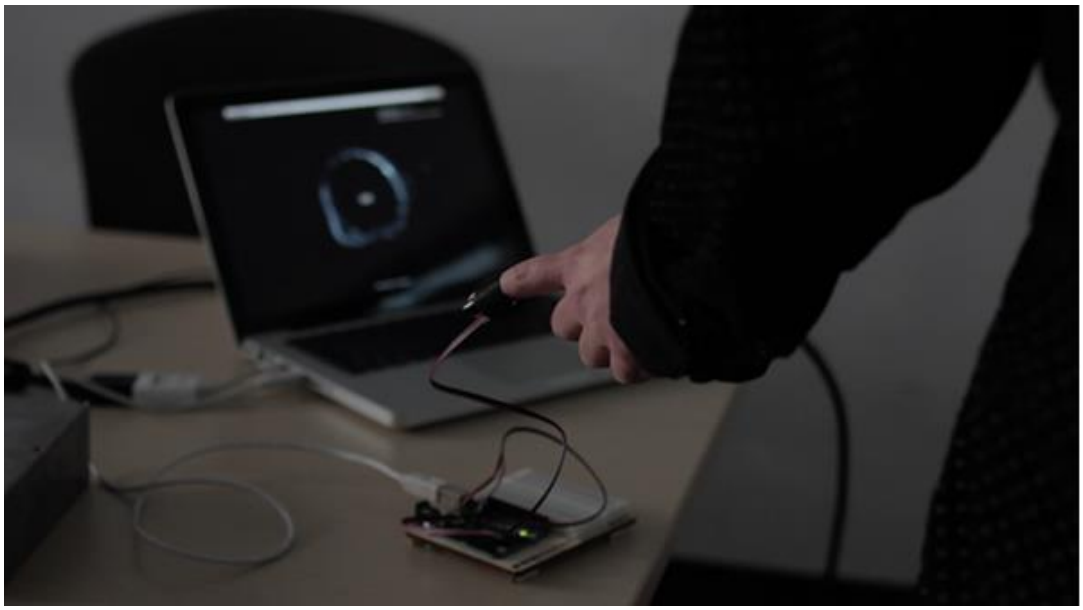

Figure 21 - Arduino pulse sensor and screen image of Your Body of Water

4.2.3 Reflection Using Somaesthetic Appreciation Design

To reflect on these two prototypes, I employed tenents of experience that are testable by comparing them to somaesthetic appreciation design characteristics. To reiterate: these characteristics include subtleness in how they encourage bodily inquiry, making space by shutting out the outer world and encouraging inward focus, intimate correspondence in how the feedback follows the rhythms of the body, and articulation in how the design help participants understand, learn and become more aware of their bodies and lived experience.

With these first two prototypes the system critics noticed several barriers to reaching a successful somaesthetic design. The characteristic of subtleness was not met as, rather than gently increasing and decreasing, the water visuals jumped instantly from one level to the next. The characteristic of making space was met to a certain extent. Getting hooked up to the pulse sensor and looking at the work did

create temporal space for self reflection; at the same time it was mentioned in certain critiques that the water sounds were a bit distracting. The characteristic of intimate correspondence was repeatedly not met because of sensor issues. When someone is feeling calm but spikes in the arduino pulse sensor data said otherwise this created a disconnect between the work and the participant and they could not create an affective loop. In terms of articulation, wearing a pulse sensor made users focus on their heart specifically, rather than how their body as a whole was feeling, and so users were confused by how the water could connect to their heart, when in fact it was meant to encourage reflection on how they are feeling as a whole.

Several aspects were rethought in order to improve the next iteration of this somaesthetic design. Primarily, I determined that transitions in the water needed to be more graceful and subtle. Second, the sensor used needed to be rethought both for intimate correspondence and for articulation of what is being shown.

Video: https://vimeo.com/120626834

4.2.4 Third Prototype

Figure 22 - Your Body of Water third prototype plan

For the third prototype of *Your Body of Water* several design changes were made. The most significant ones were how the water was visualized and the type of sensor used for heart rate. For this iteration, the data capture and visualization reframed the work so that it was presented as a visualization of one's entire body rather than heart rate alone. In the following sections I cover research into water, sensors, data capture and informative art.

3.3.4.1 The Water

It was important to think about the aesthetics of the display quite thoroughly since the display is meant to help participants become more aware of and reflect on their emotional and felt state. Water was chosen as the aesthetic theme for this project because of its relaxing and pleasing properties, and certain

types of water were chosen based on previous research in the areas of architecture and planning. In the paper “Landscape mirror: the attractiveness of reflecting water,” Nasar et al (2004) examine how people respond to different water properties and in particular to its reflective surface. To examine this they showed participants similar scenes but each with one small change. In the various images one had a pond with reflective water, one had a pond made out of transparent glass, and one had a pond with a reflective mirror. In all of the images the pond looked realistic but individuals still rated the actual water as more attractive. Secondly, the surfaces that showed reflection were also rated as more attractive. This suggested to me that I should use reflective water in order to achieve better aesthetics within the interaction.

In another study by the same team the researchers examined how humans respond to different types of water flow (Nasar 2003). The team analyzed responses to five kinds of water - still, flowing, falling, jet and combination. In terms of preference, the thirty participants favoured jet and combination. Unsurprisingly the participants found the still water to be the most calming, and found the moving water to be most exciting. Interestingly, falling and flowing water (as in a stream or directional water) received the most unfavourable scores of all the water types. This suggested I should not use directional water within my prototypes.

This research changed how I thought the water should be presented. Originally, as can be seen in the first two prototypes, I had assumed from the state

of the art literature review that a circular formation would be the best way to simulate the water for somaesthetic design. Though this might have worked for Khut's abstract visualizations, when water was replaced it became a circular directional stream which Nasar et al found to be neither attractive nor calming.

In terms of somaesthetic design, another issue was articulation. For this project I wanted participants to reflect on how their entire body felt. To call a project *Your Body of Water* and then only have one directional flow didn't connect. Though the mandala shape might have worked for literal interpretations of the heart, the same form did not seem to work when reflecting on one's felt bodily experience. To correct for this, in this current iteration I used a literal body of water -- an ocean -- to visualize the sensor data, hoping it would succeed in getting participants to reflect on their body as a whole.

4.2.4.2 Artwork Display - Informative Art Display

For the third physical prototype I was heavily influenced by informative art. Informative art is a genre developed out of slow technology where data is turned into abstract art on digital displays and aims to provident moments of reflection (Udsen et al 2005; Skog et al 2003). Informative art is an extension of information visualization but with a focus on aesthetics -- a type of "amplified work of art" (Redstrom et al 2000; 103) where the data is aestheticized. Just as one would put paintings, posters and other traditional art objects on their wall, informative art lives in the same space. Importantly, the works do not aim to

present important or urgent information since the visualization isn't meant to be read, so much as interpreted. Also, in informative art the visualization of the data isn't meant to be exact, but rather to give users a feel of what is going on and what is therefore suitable for somaesthetic design (Holmquist et al 2003). For example, one project called Miro had abstract visualizations that measured and represented the stress of an office environment (Boeher et al 2005). Though the visualization was never decoded how the researcher's thought it would be, Miro did act as a trigger for interpretation and encouraged reflection among employees on the emotional climate of the office.

Informative art also lies somewhere between the app projects (such as Affective Health by Stahl) and the installation art projects in gallery settings. Informative art can be installed in various environments outside of the gallery space -- such as in the home, in waiting rooms, in office building entrances--and can therefore bring this aestheticized data to make somaesthetic self-reflective space within everyday life. The importance of the wall display (when compared to an app) is the passivity involved in walking by a display. You do not need to actively remember to click an app, or be pestered by notifications. Instead, walking by the work gently reminds you to make space within your day for bodily reflection.

Figure 23 - Informative art examples (Skog et al 2003)

4.2.4.3 Sound

For this iteration of the project I decided to remove water sounds and instead focus on the visuals. From his own practice, interactive artist David Rokeby (1995) has found that users gain a greater sense of control when he restricts the variables or interactions available to them. For example, by having a limited amount of possible interactions, it is more likely that the user will know what action the artwork is reflecting as well as what actions will have their desired result. When there are several variables, users become less clear of what the work is responding to. To narrow this focus I have decided to just use visual representations of interactive water.

4.2.4.4 Sensors

During the first two prototypes one of the major barriers to somaesthetic design was the lack of intimate correspondence because of sensor inaccuracies. Also, in terms of articulation, once participants had put on a heart rate sensor they

immediately connected everything visualized with their heart rate rather than reflecting on how their body felt as a whole. To correct for these two issues I decided to explore wireless computer vision heart rate sensors for the third prototype. By using the camera as a sensor there will hopefully be less spikes in the data, and participants will be less likely to connect visuals to heart rate alone.

Kinect V2

The Kinect V2 is a 3D camera released to developers in early 2014 that can pick up heart rate using Infra-Red sensors (Kinect for Windows Team 2015). For measuring heart rate a user stands in view of the camera, clicks to begin, and must stay still for 30 seconds while the program does the heart rate reading (Goins 2015). Though the heart rate was accurate to my felt pulse (counting beats with a few fingers on my neck), the heart rate capture was significantly limited by the fact that users had to stay still, and that the program needed 30 seconds to capture data. Unfortunately, having to go through the step of standing still for calculation alters this from a passive sensor to an active interaction that requires active participation. As was noted in the earlier prototypes, having a focus on the sensor or active participation for readings meant that participants saw the work as a reflection of heart rate rather than how their body was feeling as whole.

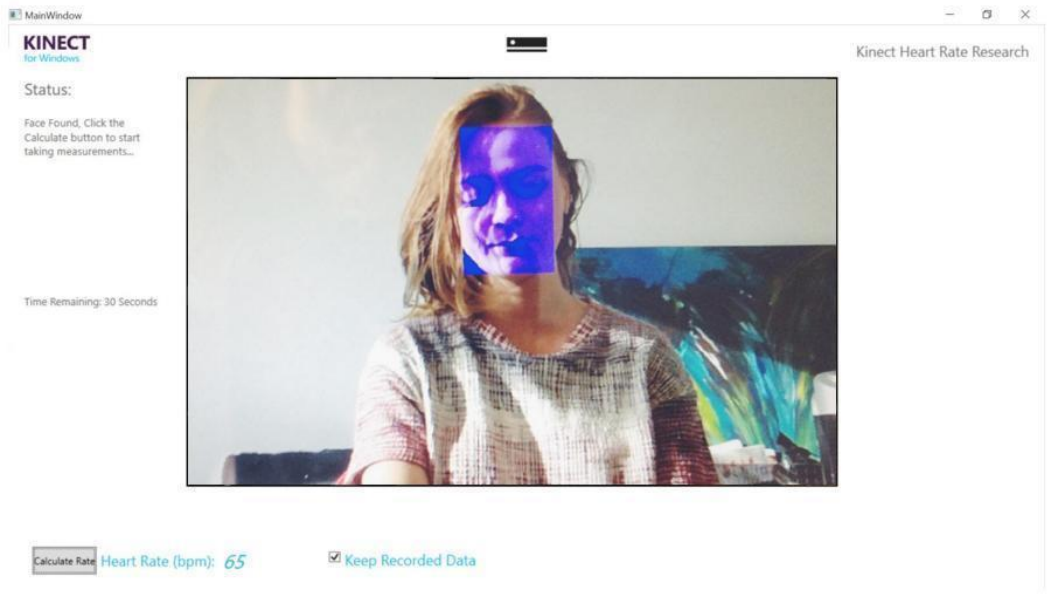

Figure 24 - Heart rate capture with the Kinect V2

Intel RealSense Camera

The Intel RealSense Camera for developers was released in October 2015 and uses camera vision to detect heart rate through minute colour changes in your blood vessels (Bamber 2015). Unlike the Kinect V2, the Intel RealSense has a smaller range (up to 1.5 meters) and focuses on upper body tracking, and in particular for heart rate it focuses on our eyes. When blood pumps through the veins in our eyes there are small colour changes that only the camera can pick up on. This technique is a very effective way of capturing heart rate because it means that you can be facing sideways or partially covering your face, and as long as the camera can see some of your eye it can pick up your heart rate.

Figure 25 -The IntelReal Sense Camera capturing heart rate while moving, while turned to the side, and with face partially covered

While doing preliminary testing and experimentation with the Intel RealSense I noticed that the heart rate calculations matched up with my own felt pulse (counting beats with a few fingers on my neck). Also the ability to capture heart rate data during movement means that the sensor can be passive.

The only limitations I have come across with the sensor is that because it captures heart rate through small colour changes the lighting conditions are very important. If the room is lit from above this can cause shadows over the eyes, which will impede the camera's ability to get a reading. Fortunately, because the artwork is screen based a user's face will be lit up by the brightness of the monitor.

As a result of the initial testing sessions with the Kinect V2 and the Intel RealSense camera, the Intel RealSense was chosen as the sensor for this thesis project because it successfully and accurately read heart rate data passively.

4.2.4.5 Data Capture

Since I am using wireless sensors for my thesis (i.e. the use of Intel RealSense camera to pick up wireless heart rate), it is important to think about how passive sensors can be used in an ethical way for reflection, and how I can avoid creating tools for surveillance and control. In the essay "Defining the Sensor Society", Andrejevic and Burdon (2015) discuss some of the implications of passive sensors, ones that can pick up on our actions without us knowing that they are there. The result of this increasing "passivity of interactivity" (19) is more forms of control through the monitoring of individuals. Since this project is about reflecting on how one is feeling in real time I decided that the project should not store the data.

An individual's heart rate is personal information that should not be stored without permission, and this will played a strong role in how my display was designed. Primarily, the display was designed to only present "live" information. This means that it only responded to a user in real time and did not keep or store heart rate data for the future. Secondly, though facial recognition is used in order to determine heart rate, the ambient display did not identify or store an individual's facial data. By designing the display to only respond in real time, and to not store or keep user's data, this ensured that the display was used for an aesthetic experience by individuals rather than as a source of surveillance through passive data collection on heart rate.

4.2.4.6 Pulling It Together

For the third prototype for system critique I used the Microsoft Surface Pro 3, which is a 2-in-1 computer and tablet. This allowed for the prototypes to be easily displayed as informative art for the critique sessions. On top of the display sat the Intel RealSense camera. For the water visualizations I used the program Unity, which connected easily with the Intel RealSense software development kit. As someone heart rate increased the choppiness and speed of the water increased. As a participant's heart rate lowered the water became calmer and the speed decreased.

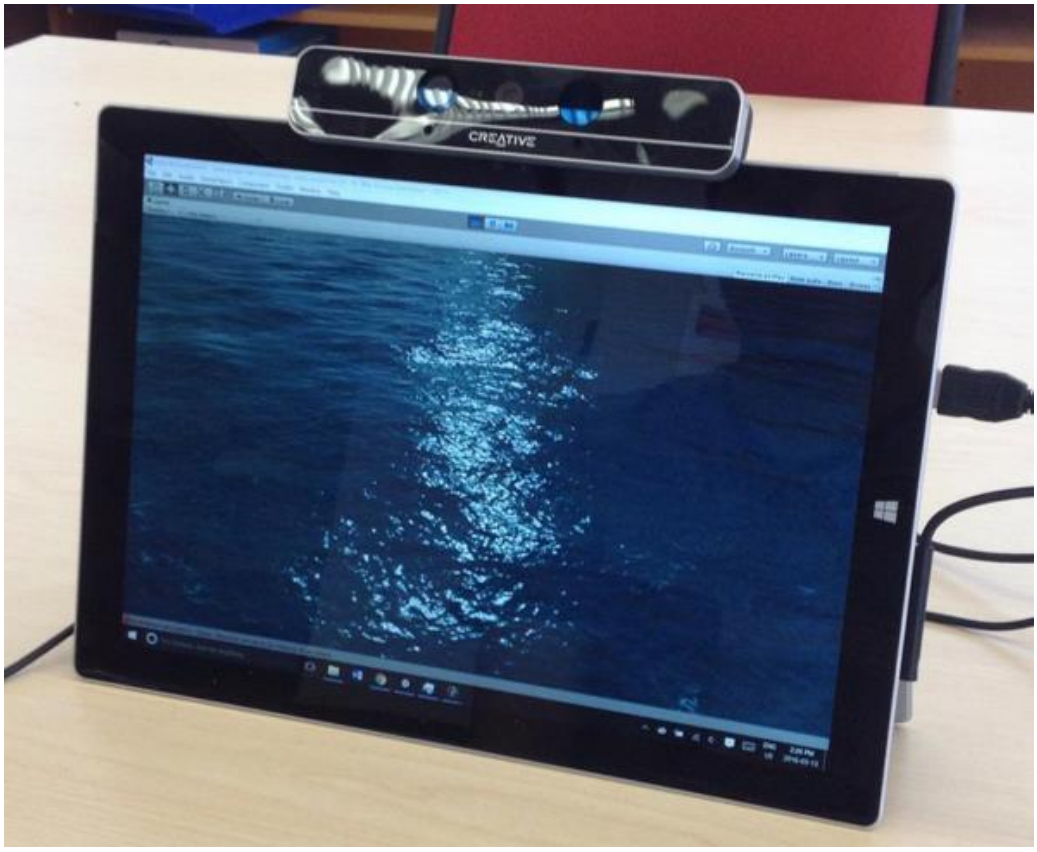

Figure 26 - Setup of the work during critique with system critics

4.2.5 System Critiques for Prototype Three

As mentioned in section three, for the evaluation of these interactive artworks I used the evaluation technique of "system critics" (Hook 2003, pp 248), which involved critique sessions with designers and interaction designers in the Digital Futures graduate program who could evaluate the system using their background knowledge. For the third prototype I conducted 10 system critique sessions with individuals. In these sessions the system critic was given as much time as needed to test out the system. The sessions were rather informal and the critic could sit, stand, or try any experimental interactions with the work (one individual even did push ups in front of it!). Once they felt they had a good understanding of the system these individuals were then asked to critique the works based on somaesthetic appreciation design characteristics. During these sessions I took notes of their critiques.

4.2.5.1 Subtle Guidance

Subtle guidance is the design's ability to subtly direct a participant's attention inward. To do so the speed of the interaction has to occur slowly (in contrast to an on or off switch which changes dramatically). During the system critique sessions participants noted that the interaction was subtle, but at times too subtle. Participants stated that at times they decided to explore the work by jumping up and down, doing pushups, or thinking about uncomfortable thoughts, and at these times expected the water to be really stormy, but instead only noticed

subtle changes in the water. This also connects to the work's intimate correspondence, but in particular several participants noted that the visualization changes in the water were too subtle. To correct for this, future iterations will have more dramatic transformations in the water depending on heart rate values.

Another issue was that when participants first stood in front of the display they noted that the water would be a bit jittery, and not as smooth as real water. This jitteriness went away within a few seconds, but it reduced the subtlety of the changes in the water when someone first stood in front of it. To correct for this, the changes in the water need to be smoothed out more.

4.2.5.2 Making Space

Making space is the design's ability to create both temporal and physical space within a participant's day for self reflection. Every system critic involved said this characteristic was met. Some said the soothing imagery acted as a reminder to relax and reflect, and some mentioned that by simply having an object like this in one's home they would be more encouraged to reflect on how they were feeling. Seven systems critics mentioned locations either within the home, or in offices, where it would be useful to place an object like this to encourage reflection. Significantly, two participants compared the somaesthetic display to an emotional mirror. Just as one might check their hair in their mirror on the way out, these participants recommended that the display could be used for a moment of

self reflection before you leave your home for the day, or after you return from work.

Other participants noted that location was important but for other reasons. The critiques occurred in a common area and at times someone would walk past that would take the participant's focus off of the display. Another interesting critique was that though in previous iterations a few participants noted that sound was distracting, several of the participants in this round of critiques suggested that sound should be included noting that it would enhance their ability to focus on the water rather than getting distracted by other things going on in the environment (i.e., within the room around them). It was suggested that sound would help people get more immersed in the work and therefore help to make space for reflection. At the same time, having a display that is constantly making sound could become a nuisance. As a result, for further iterations I will explore using sound that can be toggled on or off depending on preference and the environment the display is within.

A few participants stated that the time needed to understand the system, or the user-unfriendliness, acted as a way make temporal space within the interaction. These participants stated that at first the interactions were too subtle to notice, but as they learned the system they were able to notice more of the changes. Still, as is evident from the critique on subtle guidance, the work needs to be less subtle for most of the system critics.

4.2.5.3 Intimate Correspondence

Intimate correspondence is how closely the interaction follows how the participant is feeling and what they are experiencing. This is where the accuracy of the sensors and how the responding visualizations aesthetically represent the data become important. In the critique sessions the characteristic of intimate correspondence was only met to a certain extent. As mentioned in the critique of subtle guidance, the visualization changes were thought to be too subtle. A few participants explored how they could raise their heart rate, but the changes in the water did not seem to reflect the extent to which their heart rate was elevated, for example during push ups. At the same time those who were able to notice the subtle changes said that how the project was framed or explained mattered to a great extent. For example, one participant said that they made the connection to stress level rather than heart rate, but when it's framed as a heart rate sensor you immediately try to connect it to heart rate. This suggests that framing the device as a reflection of how their body is feeling could encourage participants to experience somaesthetic reflection, as their body as a whole would be the focus rather than heart rate.

4.2.5.4 Articulation

Somaesthetic articulation means to create responses that support bodily reflection. It gives participants a way to articulate how they are feeling, as well as a way to make sense of their experience. All participants found the choice of

water to be an effective visual for thinking about how how they were feeling. The water was described as soothing and an apt metaphor for states of feeling. People understood how water moves, and the concept of it getting stormier as heart rate went up was a connection that made sense to the system critics. The issues in articulation were mostly the result of problems with intimate correspondence. As mentioned previously, several system critics stated that the water didn't become stormy enough when they expected it to, and as a result the water did not give them a way to reflect on that experience. From the system critiques it was suggested that solving for the issues in intimate correspondence (and in particular the level of change in the water) would also improve the characteristics of somaesthetic articulation. Overall, it was suggested that the water was aesthetically pleasing but needed more dramatic differences in state.

4.2.5.5 Summary

Using somaesthetic design appreciation characteristics in system critiques was an effective way of finding problematic areas in the interaction as well as for discussions on how the display could be improved. The main issues that impeded somaesthetic reflection included the subtlety of the water, an inability to read when the system was picking up a participant, and some jitteriness in the water simulation. The system critics also suggested that the location of the work and how it was presented mattered to a great extent, and it was suggested that this would change how the work would be interpreted. The systems critics also

suggested that including sound would help to make space for reflection, but because of previous critic session responses and considerations for location, it seems that being able to toggle sound on and off would be the best approach moving forward.

In the discussions on location, the comparison between the display to a mirror suggests that the project was successful to a certain extent. The aim of the somaesthetic display was to encourage bodily reflection, and when the system critics compared it to a mirror it demonstrated how they saw it as a tool for contemplation. In the essay "Transforming Mirrors," David Rokeby (1995) describes and defines interactive artworks as devices that act as a mirror by reflecting our own actions. When this reflection matches our intent and is recognizably a result of our actions, then the work provides us with "a self-image, a sense of self" (1). The idea being that mirrors help us to understand and "check-in" with ourselves.

This also highlights the main issue that was brought up with the work--the problems in intimate correspondence. Initially while designing for the characteristic of subtle guidance I aimed to make the changes as subtle as possible. The critique sessions revealed that as a result the work was too subtle, and that the water needed to change more dramatically with heart rate. In order to provide a more accurate self-image, the water needs to respond more dramatically when heart rate goes up. As mentioned in the previous research on the affective loop and evocative balance, the visualization needs to respond and give

participants a sense of how the interaction is changing, while also leaving room for subjective interpretation. When their heart rate is high, and the water is not reflective of that, the loop breaks.

The other major issue was understanding when a participant is being "read" by the wireless camera. Participants found it difficult to recognize when the camera was reading them and when they went out of range. As a result, system critics suggested using an on/off visualization in the water so that participants could immediately recognize when they were being read by the sensor. One suggestion that I thought would be really effective was changing the environment lighting from night to day when a participant was in range.

Finally, participants suggested several locations that they thought would be useful environments to have moments of reflection. These included waiting rooms, lobbies, and when you enter or exit your home. Testing the work in these locations, as well as the including the changes in lighting and wave subtlety, will form the areas for future research.

5.0 Future Research

5.1 Summary

The system critic evaluation using somaesthetic appreciation design characteristics was useful for identifying many of the problematic areas within an interaction, as well as how to correct for them. During the system critiques it was suggested that the display would be suitable for environments such as waiting rooms or in the home. To further this line of inquiry, I will be using *in situ* evaluation with somaesthetic appreciation design characteristics, which is useful for exploring how participants use the device in daily life and within their current habits. *In situ* evaluation involves putting the device in a location and seeing how participants respond to it.

Further research would also test the improvements made to the display based on the system critiques. Elements suggested during the system critique sessions that need to be tested include changing lighting from night to day when the sensor picks up a participant, creating more dramatic changes in the water as heart rate goes up, exploring the effectiveness of sound that toggles on and off, and whether these changes improve the display as a somaesthetic design project.

5.2 Improvements to be Implemented

5.2.1 To know when the display is reading an individual

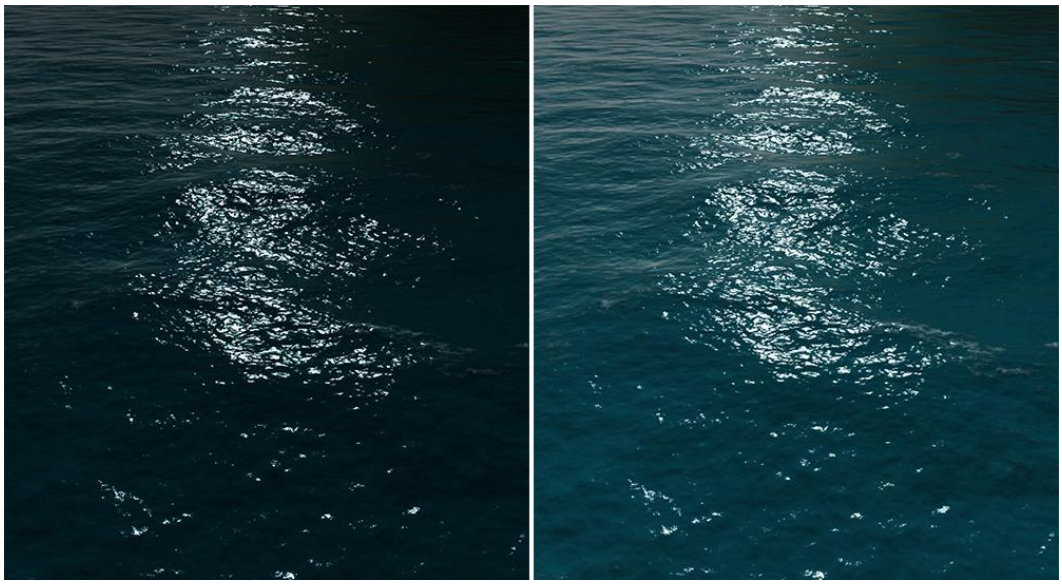

Figure 27 - Alternating the lighting from night to day when someone's face is picked up by the sensor

As mentioned during the system critiques, participants had a difficult time knowing when the sensor was able to read their heart rate. Not only were they not sure when the device began reading their heart rate, but they also weren't clear on when they had moved outside of the sensor's range. This was an issue in terms of error prevention as well as somaesthetic intimate correspondence. The systems critics stated that they needed a way of knowing that they were being read by the system, as well as an immediate way of knowing that they weren't just watching a video of water. It was suggested that the system needed to give them an on or off signal of recognition.

One suggested solution that was particularly fitting was the idea of having the lighting transform from night to day when the system began sensing a participant with facial tracking. This dramatic lighting change would be a very clear signal to participants that the water was responding to them, and also that they are in sensing range. The transformation from night to day is also a visual mapping that makes sense when we think of other interactive technologies, such as the "sleep mode" available on many devices and the dimming of computer screens after a period of not being used. Secondly, by using the facial tracking capabilities, not only would the work be responding to their heart rate but also to their movements, which will hopefully encourage somaesthetic reflection on how participants are feeling as a whole rather than heart rate alone.

5.2.2 Intimate correspondence with the water

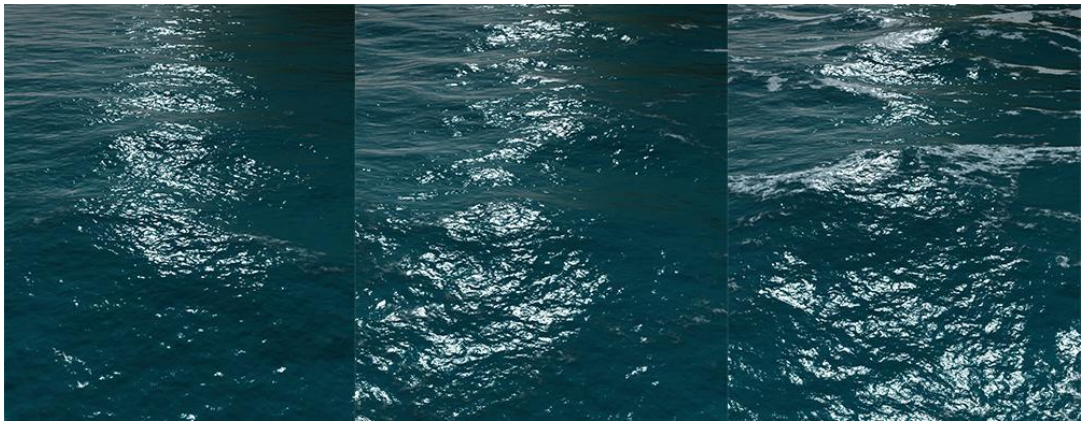

Figure 28 - More dramatic changes in the water as the heart rate increases

Another major issue with intimate correspondence was that the water animations were thought to be too subtle, and did not change as dramatically as participants expected and wanted them to. As a result, future iterations of the

project will test more dramatic differences in the characteristics of the water including wave speed, wave height, choppiness of the water and the amount of foam. The goal of these more dramatic changes in the water will be to more accurately reflect raising levels of heart rate. By reflecting a participant's raised heart rate with stormier water this will hopefully improve the display's ability to encourage affective loops and evocative balance. In order for somaesthetic intimate correspondence to be effective the display needs to give participants a way of understanding and visualizing what they are feeling, and this can only occur when the visuals and their feelings are in sync.

5.2.3 Adding water sounds

Throughout the system critic sessions I've received conflicting responses on the use of water sounds. During the first two prototypes that included sound a few participants found the sounds to be distracting. During the third prototype without sound many participants suggested that it should be included as a way to make space and help participants focus on the display. Another issue is that many of the locations may not be suitable spots to have constant water sounds -- such as in one's home or in office waiting rooms. One possible solution is to have the water audio work in the same was as the night to day lighting changes. The water sounds could come on only when the system senses that someone is in front of the display. Also, having the ability to toggle sound on or off on top of this would allow for subjective preference depending on whether the participant found the sounds useful for somaesthetic reflection.

5.3 Next Steps - *in situ* Evaluation

5.3.1 What is *in situ* Evaluation?

Though the system critic evaluation was an excellent way of discovering problems and possibilities with the display, the next step involves exploring how it will be used. Traditional user testing techniques tend to be insufficient for evaluating how a technology will affect people in less predictable scenarios, such as the variety provided by everyday life (Consolvo et al 2007). To test how technologies can be used within daily life, the best way to do so is to actually put the device in the environment. This is called *in situ* evaluation and has been shown to be very useful for the evaluation of ubiquitous technologies. The process for *in situ* evaluation involves a pre-study interview and a post-study interview, as well as a way to monitor how participants are using it. As was demonstrated in the system critic sessions, many of the participants already had ideas about locations where the display could be valuable. Because of the time and resources needed for an *in situ* evaluation this testing will occur outside of the scope of this thesis (Consolvo et al. 2004).

5.3.2 First Location - Praxis Holistic Health

One suggestion that was brought up several times in the system critic sessions, was the value this somaesthetic display could have in lobbies or waiting rooms to give participants a few moments of self reflection. To further explore

this area of inquiry I will be doing research with Praxis Holistic Health, a Toronto wellness clinic led by psychiatrist Dr. Henry Moller. For this in situ evaluation the somaesthetic display will be placed in the waiting area of the clinic and volunteers will be asked to fill out two questionnaires based on their experience.

Dr. Moller and his clinic Praxis Holistic Health are particularly suitable partners for this project. The clinic provides stress reduction therapies through a variety of meditation tools and virtual environments (Moller et al 2015). Over the past few years the Praxis research team has explored how technology can aid in meditation therapies through systems such as the BrainLight meditation chair, which incorporates massage with a guided meditation soundtrack, and developing virtual reality meditation walks using tools such as the Oculus Rift. Dr Moller and his team are continuously exploring new ways to bring meditation to their clients, and as a result have a clientele that are interested in new media meditation and reflection.

To evaluate the somaesthetic display clients who volunteer for the study will be asked to fill out a questionnaire when they enter the clinic on their experience with devices for meditation and reflection, and then will be asked to do a post-session questionnaire after their appointment before leaving the office. This *in situ* evaluation will help to evaluate whether the somaesthetic display could be useful in waiting areas or lobbies for moments of self reflection.

5.3.3 Second Location - Home Environment

Another location that came up often in the system critic sessions was the home environment. For in situ evaluation in the home, volunteers will be asked to have the display within their home for 2-3 days. The *in situ* deployments will begin and end with a 10-20 minute interview, participants will complete pre- and post-session questionnaires, and photos will be taken of the display's location at the beginning and at the end of the project to find out where participants found the display to be more useful.

One particularly effective technique for in situ evaluations is the use of a self-reporting log or diary (Consolvo et al 2007). These self-reporting logs can give important details about a participant's context or feelings throughout the day in relation to the display. A self-reporting log is important for gathering those subjective aspects which are important to good somaesthetic design. Also, because it doesn't rely on imagining a situation (such as is done in most *ex situ* HCI research), the responses tend to be more useful. In the same vein, having post-session questionnaires after actually using the device for 2-3 days would give the participants a more informed way of describing whether the display caused them to reflect more on their bodily perception, whether their habits changed or remained the same (making room for reflection) (Klasnja et al 2011), as well as where they would want the device to be placed in their home (Consolvo et al. 2004).

Overall, the system critique sessions using somaesthetic design appreciation characteristics were an incredibly useful evaluation technique for discovering problematic areas of the interaction as well as areas for further research. Though the plans for *in situ* testing lies outside of the current scope of this thesis, the system critique sessions provided an excellent first step of evaluating and improving upon the interactive prototypes.

6.0 Conclusions

This thesis started as a way of exploring some of the countertrends within interactive art and human computer interaction that use self trackers and biometric devices for embodiment rather than quantitative data. The aim was to explore how these devices, and particularly those that use heart rate, could be used to help us get more in touch with our bodies and our own subjective felt experience.

When I started this thesis project I began with two research question:

a) Rather than using biometric devices for quantitative data, how can somaesthetic design be used to visualize aesthetic heart rate biofeedback in order to help us reflect on our lived experience and feel more embodied?
b) How can somaesthetic design appreciation characteristics be used to evaluate interactive devices?

To address the first research question, after doing a thorough review of the current state of the art of heart rate biofeedback artworks, somaesthetics and somaesthetic design were used for imaging new ways of visualizing the biofeedback data. Whereas many of the previous interactive heart rate artworks utilized literal visual mappings to represent heart rate, such as the use of bright red colours as heart rate increased, the somaesthetic designs presented ways of visualizing this data with calming colours and soothing lighting to encourage bodily reflection. After researching calming visualizations, water was used for this thesis as a way of visualizing heart rate, and as a way of reflecting on how one's body feels as a whole.

The influence of somaesthetic design was found to be particularly effective. During the system critique sessions every participant stated that the water was an effective way of visualizing the biofeedback data for self reflection. The water provided soothing imagery and many participants stated that by simply having the display within their home they would be reminded to relax and reflect on how they are feeling. The water visualizations, and the presentation as an informative art display, were seen as useful tools for creating space within one's day for somaesthetic reflection. Overall, somaesthetics and the somaesthetic design characteristics of subtle guidance, making space, intimate correspondence, and articulation were useful guiding principles during the research through design process.

This thesis demonstrates the effectiveness of using somaesthetic appreciation design characteristics both for the design process of research through design, but also in terms of evaluation with system critics. As mentioned previously, *in situ* evaluation is currently one of the most effective ways of evaluating ubiquitous technologies, but it is also a time and resource-intensive process that involves individual interviews and longer periods of user testing. In contrast, the evaluation with system critics was a timely and resource-effective way of identifying many of the problematic areas with the interaction as well as figuring out ways to correct for these issues.

Though many important aspects of the interaction were addressed in the state of the art literature review--such as the importance of real-time feedback and

accurate sensors--a system critique using the somaesthetic appreciation design characteristics provided a framework for improving the interactions for embodiment. Somaesthetic appreciation design characteristics allowed many of the problematic areas to be addressed before more intensive *in situ* testing, which lies outside of the scope of this thesis and will take place over the Summer of 2016. To a great extent, this thesis demonstrates the effectiveness of somaesthetic appreciation design as a tool for designing for embodiment, as well as for evaluation of the resulting designs with system critiques.

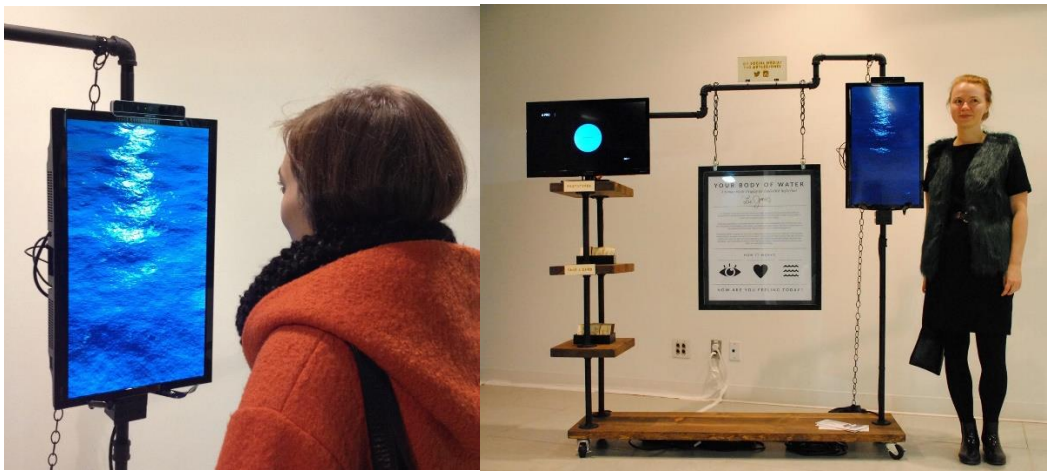

Figure 29 - Thesis Exhibition Installation

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Appendix A: Criteria for System Critique

This project was designed using somaesthetics. Somaesthetics is an interdisciplinary field with roots in philosophy, and developed by Richard Shusterman, that combines soma (the living body) with aesthetics (our sensory perception and appreciation). The main premise of somaesthetics is that we can train our body to become more aware of itself. Somaesthetics explores how we can improve and cultivate our senses through a better understanding of our sensory appreciation (aesthesis). In your critique of this work please evaluate the work using the following somaesthetic design appreciation characteristics:

1. **Subtle Guidance**

Subtle guidance is a characteristic that focuses on how a somaesthetic design should direct a participant's attention inward (Hook et al 2016). This is one of the most difficult parts to designing a somaesthetic experience, because balance needs to be found between a noticeable feeling and a distraction, which can be a very grey area. The participant's attention needs to be subtly guided, but not grabbed. The design aims to keep interest and focus. A major part of this has to do with the speed of the interaction. Instead of just turning an element on or off, it's better to slowly increase and decrease certain elements.

2. **Making Space**

An important part of somaesthetics is the idea that you need to actively create space within your day for reflection (Hook et al 2016). This space is both physical and temporal. The characteristic of making space means to create an environment where you can feel calm and reflective, as well as maintaining focus for a specified time period within one's day.

3. **Intimate Correspondence**

Intimate correspondence is how closely the feedback and interaction follows how the participant is feeling and what they are experiencing (Hook et al 2016). This is where the accuracy of the sensors can be important. For example if you have a sensor with errors or your system has delays, and the input and visuals do not correspond to how the user is feeling, then you will have a disconnect and the participant will not have a somaesthetic experience. This idea of intimate correspondence is very similar to the affective loop. You need to feel at one with the system and that it is responding to you as you are responding to it.

4. Articulation

Articulating the somaesthetic experience means creating visuals or responses that support reflection (Hook et al 2016). This can be through verbalization or discussions afterwards, but also in the feedback of the system. The system needs to help participants make sense of what they are experiencing. Similar to intimate correspondence, manners in which input is visualized needs to have the evocative balance where it allows participants to make their own meaning, but also has some visual mappings that make sense.