Let the Heart Break:
Creating a Safe Space for Grieving

by

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Abstract

As wearable sensing technologies increasingly become part of everyday life, this thesis examines how jewelry and wearable design practices can use physiological data, particularly heart rate, to engage with grief and heartbreak. These emotions are approached as embodied, temporal, and non-linear states rather than conditions to be repaired, optimized, or resolved. In a contemporary context characterized by acceleration, efficiency, and continuous productivity, emotions are often expected to remain stable, hidden, or quickly regulated and suppressed. In response, this research argues for a repositioning of physiological data within emotional and wearable design, emphasizing its potential to support emotional presence rather than correction.

Drawing from somaesthetic design theory and affective computing frameworks related to emotional visualization and physiological feedback, this research develops a design-oriented framework for engaging with grief and heartbreak through wearable artifacts. Rather than treating physiological data as information to be interpreted or adjusted, the project explores how bodily signals such as heart rate can be translated into open-ended, non-instrumental interactions that allow emotions to be sensed, held, and experienced. Using a Research-through-Design methodology, the project involves the iterative making of wearable devices, reflective documentation of the design process, and the synthesis of insights across material, interaction, and experiential dimensions. The resulting framework offers guidance for designing biofeedback systems that prioritize emotional expression and release over optimization, attending to the relationship between the body, the wearable artifact, and emotional experience.

The importance of this research lies in its aim to provide a safe space for those experiencing grief, through this thesis and its accompanying wearable works, allowing emotions to be released and grief to exist without being forced toward resolution or repair.

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Chapter 1: Introduction

I first became aware that 'grief grows out of the body' during my first heartbreak as an adult. At the time, I didn't yet have the language to explain what I was experiencing; I only remember my hands turning cold, my chest tightening, my breath shortening, and my face feeling as if something heavy was sitting on top of it. I did not want to be seen by anyone. In public, I would instinctively pull my hair forward, use a scarf to cover my face, or look for corners where I could hide. I once assumed these gestures were merely personal habits, but as I began this research, I realized they were bodily expressions of grief — a form of embodied emotional response rather than conscious decisions.

This understanding aligns with research on *emotional body maps*, which conceptualize emotions as things that are felt throughout the body and spread out in space, instead of just internal mental states. Emotional body maps are visual representations derived from self-reported bodily sensations, indicating where different emotions are felt as increased or decreased activity across the body. In their study, Nummenmaa and colleagues asked participants to mark spots on standard body outlines where they felt sensations while experiencing or recalling different emotions. These markings were combined into heat maps that show consistent patterns of body activation and deactivation linked to specific emotions.

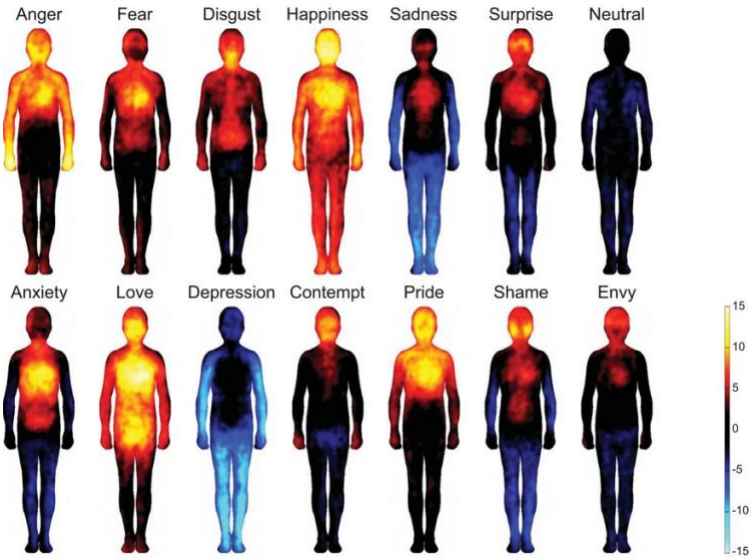

Figure 1. Bodily maps of emotions illustrating the spatial distribution of self-reported bodily sensations across different emotional states. Warmer colors indicate increased activation, while cooler colors indicate decreased activation. Adapted from *Nummenmaa* et al. (2014).

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As shown in Figure 1, different emotions are linked to specific bodily distributions. For instance, emotions such as anger and happiness tend to be associated with widespread bodily activation, while grief is characterized by heightened sensation in the chest and head regions alongside reduced activation in the limbs. This pattern suggests a bodily experience of heaviness, constriction, and withdrawal. As Nummenmaa et al. note, "emotions are not confined to the mind; they spread throughout the body, altering temperature, posture, and perception" (Nummenmaa et al., 2014). This framework is central to my work, as it provides both scientific and conceptual support for understanding grief as something that is *felt through the body* rather than merely processed cognitively. My project builds on this idea by translating internal, often invisible bodily sensations into external, wearable forms that respond to physiological and emotional states.

A few years ago, in 2023, I experienced a more intense form of grief following the death of my grandmother. This loss occurred during a period when my daily life had already been shaped by prolonged emotional strain, making me more acutely aware that grief is not merely a psychological state, but a real and ongoing bodily experience. Although I had not yet heard of Takotsubo Syndrome at the time and cannot relate my experience to any medical diagnosis, the physical responses were unmistakable: a loss of appetite, difficulty breathing, and a persistent tightening in my chest, as if my body were slowly sinking.

Later, I came to understand Takotsubo Syndrome, often referred to as "Broken Heart Syndrome." It is a stress-induced cardiac condition triggered by intense emotional or physical stress, characterized by a temporary weakening of the heart muscle. Clinically, its symptoms resemble those of a heart attack, including chest pain and shortness of breath, yet it typically occurs without coronary artery blockage. First identified in Japan in the 1990s, the syndrome takes its name from a traditional octopus trap (*takotsubo*), as the shape of the left ventricle during an episode resembles this vessel. Although Takotsubo Syndrome is generally considered reversible, there is currently no direct or specific treatment for the condition; clinical care relies primarily on supportive treatment and the alleviation of triggering stressors. This aspect is particularly significant in medical research, as it highlights that emotional trauma is not always something that can be quickly "fixed," but rather a bodily state that must be understood, endured,

and accompanied. In this research, Takotsubo Syndrome is not referenced as a medical diagnosis, but as a conceptual and physiological framework that emphasizes the close relationship between emotional trauma and bodily response.

It was during this same period that I began frequently wearing masks and hats. In 2023, as the COVID-19 pandemic was gradually coming to an end, people in public spaces had largely begun to stop wearing masks. For me, however, the mask did not lose its significance. On the contrary, it provided a very immediate sense of safety. I tended to choose larger masks and pair them with hats, allowing them to cover more of my face and even part of my visual field. This form of covering made me feel slightly protected in public environments, as if it created a small space where I could pause and breathe.

For me, wearing a mask and a hat was not motivated by public health concerns, but functioned more as a form of self-protection. They allowed me to remain present in public spaces while my emotional state was still fragile and reduced the likelihood of being approached or disturbed by others. The sensation of being partially covered created a small distance between myself and my surroundings, making it easier for me to remain quietly within my own state. This deliberate choice of concealment blurred the boundary between protection and withdrawal and led me to realize that bodily coverings do more than alter appearance—they subtly reshape the relationship between the body and public space. This experience later developed into an important thread within my wearable design practice, in which bodily coverings are no longer treated merely as tools for hiding or defense, but as embodied interfaces capable of responding to emotion and holding vulnerability.

Looking back on this period, I began to recognize that wearing a mask was only one of many small acts of concealment I relied on. I became acutely aware of small acts of concealment: covering my face with my hands, curling my shoulders inward, pressing my body against a wall, or using objects as temporary shields. These movements were not deliberate decisions, but bodily responses that emerged when grief felt overwhelming.

It was only later, through research, that I began to understand how closely these gestures mirror historical mourning practices. For instance, in Victorian Britain, the mourning veil functioned as a material strategy that granted privacy, dignity, and protection to the bereaved in public space (Jalland, 1996). Similar forms of bodily covering appear elsewhere. In traditional

Chinese mourning practices, loose white garments and head coverings signaled grief while also creating social distance and reducing direct visibility. In ancient Greek and Roman funerary customs, women often veiled their faces during mourning as a gesture of withdrawal and restraint. In Japan, formal mourning attire (*mofuku*) employs subdued color, material, and silhouette to regulate emotional expression in public settings. Although rooted in distinct cultural traditions, these practices share a common structure: bodily covering operates to manage vulnerability, control visibility, and preserve dignity during periods of loss.

As I came to realize that these acts of concealment were not accidental, but recurring forms of mourning across different cultures and historical contexts, I began to rethink these experiences themselves. They were not meant to be seen, nor were they deliberate symbolic gestures. Instead, they emerged naturally when the body felt vulnerable and were enacted through proximity to the body.

My interest in wearable technology gradually took shape through this process. Whether covering the face, curling the body inward, or creating a small zone of retreat within public space, these actions were not symbolic performances directed toward an external audience. Rather, they were carried out through contact, closeness, and movement between the body and objects. *Unlike static or distanced objects, wearables remain in continuous interaction with the body and shape how one enters and perceives public space.* Because these experiences were inseparable from the body itself, wearable forms emerged as a particularly fitting medium through which to explore them.

In this project, I develop a series of wearable artifacts that explore grief as an embodied and ongoing condition rather than a state to be corrected or resolved. These wearables respond to bodily gestures, proximity, and physiological signals, and function as protective or responsive structures rather than tools for monitoring or optimization. Wearable technology, in this sense, was not established as a solution from the outset, but gradually emerged through repeated reflection on bodily experience and the need for safety, retreat, and gentleness during moments of emotional vulnerability.

Contemporary wearable technologies often emphasize efficiency, health monitoring, or productivity, while paying little attention to the subtle and fragile emotional needs that arise during grief. Research in affective computing has historically focused on detecting, classifying,

and modeling emotions (Picard, 1997), prioritizing recognition and control over lived experience. While this work has been foundational, it rarely addresses how emotions are felt, endured, and carried through the body over time.

It is within this gap that my project takes shape. Rather than attempting to repair or optimize emotional states through technology, this research is guided by a set of concerns that emerge from my own lived experience and design practice.

Figure 2. First prototype——*Breathing heart* device

My first prototype: *Breathing heart* (Figure 2) emerged directly from these questions. It took the form of a heart-shaped device that used heart rate as input and light as output. When the heart rate rose above 100 BPM, the device glowed red, flickered, and transitioned into a box-breathing light rhythm intended to support calm breathing. I initially hoped that visualizing physiological data in this way would help soothe emotional distress. However, when I tested the device during moments of real grief, the red flashing light produced the opposite effect. Rather than offering comfort, it made me feel exposed, tense, and subtly reprimanded, as if my emotional state were being publicly flagged as something abnormal or in need of correction. This reaction resonates with critical scholarship on emotion-tracking and self-monitoring

technologies. Researchers have noted that many affective and biometric devices position emotions as data to be monitored, evaluated, and regulated, often reinforcing feelings of surveillance and moral pressure rather than care (Lupton, 2016). Within such systems, emotional deviation is implicitly framed as a problem to be fixed. In moments of grief, this logic can be especially harmful, as it transforms emotional pain into a visible signal of failure or lack of control. Through this experience, I came to understand that people who are grieving do not always want their emotions illuminated or made legible. Sometimes, what they long for instead is a soft, private refuge where emotion can exist without judgment or demand for improvement.

Figure 3. Second prototype——*Rigid Shell*

This realization shifted my second prototype: *Rigid shell* (Figure 3) toward concealment. Drawing on existing research in anthropology, performance studies, and fashion theory that examines masks, veiling, and facial coverage, I created a series of wearable masks to investigate how different forms of concealment shape emotional experience. Scholars working on masking practices have shown that covering the face is not merely a form of disguise, but a way of

regulating visibility, vulnerability, and social interaction in public space. Informed by this body of work, I explored concealment as a relational and bodily strategy rather than a purely visual one. Using plaster and lightweight materials, I tested masks with varying degrees of transparency, weight, and breathability. Wearing semi-transparent or partially covered masks produced a palpable sense of withdrawal and temporary relief from social gaze, allowing emotional tension to soften. In contrast, fully opaque or heavy masks often resulted in pressure, anxiety, and restricted breathing. These experiments revealed that the grieving body does not simply need concealment; it requires concealment that is soft, breathable, and non-oppressive forms that protect without introducing additional bodily strain.

These insights guided the development of my third prototype (Figure 3): a feathered headpiece and a mourning veil headpiece constructed from metal wire, fabric and soft feathers. The feathered headpiece design draws from observations of birds, many of which wrap their wings around their young as a gesture of protection. The mourning veil headpiece, by contrast, draws on historical mourning practices in which willing functions as a means of regulating visibility, vulnerability, and social interaction. Rather than fully concealing the face, the veil introduces a semi-transparent boundary that softens visual exposure while allowing the wearer to remain present in public space. In this way, it creates a controlled distance between the body and its surroundings, supporting a sense of privacy and emotional protection without complete withdrawal. Translating this behavior into a wearable system, the headpiece is currently being developed to incorporate a heart rate sensor embedded within an ear-mounted component.

The sensor is intended to read the wearer's pulse through direct contact with the skin near the ear, allowing heart rate data to be monitored continuously without requiring the wearer's hands or focused attention. When the heart rate rises above a predetermined threshold, the system is designed to trigger a slow, inward closing motion of the feathered wings.

This movement is conceived as gradual and restrained, avoiding any sense of alarm or urgency. As the wings close, they form an intimate enclosure around the wearer's face, creating a sense of being held. This effect emerges from the softness and movement of the feathers, which create a gentle, shifting boundary rather than a fixed or rigid surface. As the feathers move in response to the body and surrounding air, they produce a subtle sensation of being surrounded rather than confined. This form of enclosure reduces visual exposure and softens the wearer's

relationship to the surrounding environment, allowing a sense of protection to emerge without introducing pressure or restriction. At the same time, the gesture is designed to communicate vulnerability outwardly, offering a quiet, non-verbal signal to others: *I am grieving. Please give me space.*

This research treats grief as an embodied condition rather than a purely psychological state. This position aligns with work in affective science, phenomenology, and somaesthetic design, which emphasizes that emotions are lived through bodily sensation, posture, and physiology rather than located solely in cognition. Framing grief as embodied challenges clinical models that reduce emotion to internal mental states, and instead foregrounds the body as a primary site of emotional experience.

Methodologically, this project adopts a research-through-design approach, drawing on traditions that understand design practice as a mode of knowledge production. Rather than beginning with fixed hypotheses, knowledge in this project emerged through iterative cycles of making, wearing, and reflecting. I tracked this process through design journals, photographic documentation, bodily reflection notes recorded after wearing each prototype, and comparative analysis between iterations. Shifts in design direction were informed not only by technical performance, but by how each prototype felt when worn during moments of emotional vulnerability, documented through reflective notes, photographs, and iterative testing records.

Through this practice-based process, knowledge emerged gradually across the three prototypes, revealing intricate relationships between emotion, bodily sensation, material softness, movement, and concealment. Rather than producing a single optimized solution, this research generates situated insights into how wearable devices might support the grieving body by offering moments of shelter, retreat, and gentle accompaniment in everyday life.

Project Overview

This project explores how emotions live in the body and how physical responses shape the experience of grief. Research shows that emotions are not just thoughts in the head. They appear through physical changes like heart rate, breathing, and posture (Nummenmaa et al., 2014; Kreibig, 2010). These facts made me rethink how design and technology treat grief. Instead of seeing body reactions as simple side effects, this project views them as important experiences that design can support directly. I argue that grief is a physical condition that involves pulling away and seeking protection. Wearable design can help people in grief by creating private, safe spaces. The goal is not to monitor or fix the emotion, but to offer a gentle place to feel it safely.

Studies on Takotsubo Syndrome, also called "Broken Heart Syndrome," show the deep link between stress and the body. This condition temporarily reduces heart function during intense stress, often feeling like a heart attack even without blocked arteries (Templin et al., 2015; Pelliccia et al., 2020). I use this syndrome as a reference to show how emotional pain triggers real body protection. This perspective changed how I use heart rate in my designs. In my prototypes, heart rate is treated as a simple indicator of emotional strain rather than a medical or diagnostic metric. The threshold of 100 beats per minute was not derived from a controlled experimental study, but instead emerged through self-testing during moments of emotional fluctuation. Through repeated wearing and observation, I noticed that increases toward or above this range were often accompanied by changes in breathing, muscular tension, and a heightened sense of bodily awareness.

Within this project, 100 BPM therefore functions as an approximate and situational threshold. It is a design decision grounded in embodied observation rather than generalized physiological measurement. It marks a point at which the body begins to feel unsettled or strained and is used to trigger responses that offer shelter and support rather than correction. These observations are based on informal, first-person noticing in everyday public settings such as transit, classrooms, and shared spaces, as well as reflection on my own behaviors during periods of grief. Rather than constituting a formal observational study, they function as situated and experiential insights that informed the design process.

This approach aligns with practice-based research methods, in which knowledge emerges through making, wearing, and reflecting.

I also looked at the quiet ways people protect themselves while grieving. People often cover their faces, curl inward, or avoid eye contact in public. Research suggests these are healthy ways of coping. The Dual Process Model describes grieving as a natural move between focusing on the loss and trying to return to daily life (Stroebe & Schut, 1999). This helped me see that hiding and pulling away are smart strategies, not failures.

History also shows that hiding can be a form of support. In Victorian times, mourning veils and special clothing gave people privacy and dignity in public (Jalland, 1996). These practices created a rhythm that allowed people to move between being seen and staying hidden. They did not end grief, but they provided structured moments of protection.

In the field of affective computing, most work focuses on recognizing and tracking emotions (Picard, 1997). Some critics argue this feels too much like surveillance or constant self-discipline (Lupton, 2016). My project tries something different. I use body signals to create non-intrusive responses that a person can use on their own terms.

Somatic design provides the methodological foundation for this work, positioning the lived experience of the body as a primary site of knowledge (Höök, 2018). Within this framework, I adopt a first-person, practice-based approach in which I function as the primary participant. Rather than aiming for generalizable data, this approach focuses on situated, embodied insight, allowing subtle bodily sensations and emotional responses to inform the design process.

The prototypes were developed through iterative cycles of making, wearing, and reflection. This process involved attending closely to changes in bodily states, including shifts in heart rate, breathing patterns, muscular tension, and spatial awareness. These observations were documented through reflective notes and informed subsequent design decisions.

While the use of the self as the sole participant limits the generalizability of the findings, it enables a depth of embodied understanding that would be difficult to access through external observation alone. This approach is consistent with practice-based and soma design methodologies, where knowledge emerges through direct bodily engagement rather than detached measurement.

In this context, breathing is considered alongside heart rate as part of a broader set of interconnected physiological responses associated with emotional states. Research in emotion

physiology indicates that grief and stress are often accompanied by changes in respiratory rhythm, including shallower or irregular breathing patterns (Kreibig, 2010). Attending to these changes supports a more holistic understanding of how emotional experience unfolds through the body.

These areas of research create a path from understanding how grief feels to recognizing that hiding is a way to find support. This matches new work in human–computer interaction that treats grief as a life experience rather than a problem to be solved (Massimi & Charise, 2009; Wallace et al., 2020). This path led to a series of wearable prototypes titled *Let the Heart Break*. These devices use heart rate as input and movement to offer concealment. They aim to support breathing and emotional holding during difficult moments of grief.

Research Questions

The primary research question guiding this project is:

How can wearable design based on body signals create a safe space for grieving?

To address this, the project is further guided by two sub-questions:

1. How can heart rate data become a supportive physical gesture rather than a form of surveillance?
2. How can movement and softness help a person feel emotionally safe during grief?

Together, these questions frame grief as an embodied experience that can be supported through careful and sensitive design.

Chapter 2: Literature & Contextual Review

Recent research in the fields of emotion physiology and embodied cognition demonstrates that emotions are not merely abstract psychological states but are deeply rooted bodily phenomena. They manifest through measurable physical changes such as decreases in peripheral temperature, fluctuations in heart rate, muscle tension, and shifts in autonomic activity (Nummenmaa et al., 2014; Kreibig, 2010). Clinical studies on Takotsubo Syndrome further reveal that intense grief can induce transient cardiac dysfunction resembling acute myocardial infarction, which is understood as a "protective physiological response" triggered by overwhelming emotional stress (Templin et al., 2015). These findings emphasize that grief is fundamentally an embodied experience rather than solely a psychological one.

Despite the advancing scientific understanding of how emotions influence and inhabit the body, contemporary society offers limited space for experiencing grief. The pace of public life, societal norms of professionalism, and everyday social expectations often necessitate that individual "return to normal" swiftly, neglecting the ongoing physiological and emotional impact of grief. For those required to re-engage in work, academic, or public environments shortly after experiencing loss, emotions do not simply dissipate; instead, they persist as embodied responses, such as withdrawal, concealment, tightness in the chest, or a heightened desire for privacy. This tension—being compelled to remain present while one's emotional state remains unresolved—is seldom recognized within existing emotional support systems or technologies.

The importance of this research resides in addressing this conceptual and practical gap. This project explores how body-centered design can provide grieving individuals with a subtle, private, and activatable "emotional refuge" within public contexts. Unlike traditional emotional wearables that focus on monitoring, classification, or correction, this work draws upon emotion physiology, historical practices of concealment, and soma design methodologies to position the body as the primary locus of emotional knowledge. It advocates for the use of technology as a companion and extension of the body's natural protective mechanisms, rather than as a supervisory or disciplinary instrument.

Building upon this theoretical foundation, the practical objective of the thesis is to develop a wearable "emotional shelter device" that offers a tangible sense of protection when heart rate increases or emotional distress intensifies—whether the user is in an office, on public transit, in a

classroom, or any situation requiring continued social presence. When activated, the device softly illuminates, encloses, or folds inward, providing the wearer with a visceral sense of being protected while also communicating a subtle, non-verbal social cue: “I am grieving; please give me space.” This signal is neither a plea for help nor a rejection but a gentle, embodied method of establishing boundaries.

Ultimately, this thesis aims to create a portable micro-sanctuary for individuals navigating public life while still processing grief. By translating physiological signals into protective, nuanced gestures rather than alarming outputs, the project seeks to expand the potential of emotional technology—offering a socially meaningful and emotionally sensitive form of support for individuals who are grieving yet must continue to live, work, and be visible.

Wearable technology—broadly defined as digital systems integrated into clothing, accessories, or bodily adornments—has emerged as a prominent area of research within health tracking, affective computing, and emotion-support interventions (Peake et al., 2018; McDuff, 2021). Many contemporary emotional wearables incorporate physiological sensors, commonly measuring heart rate, skin temperature, or galvanic skin response, to infer emotional arousal and deliver real-time feedback aimed at facilitating self-regulation (Picard, 2016). These systems seek to supplement traditional therapeutic practices by providing continuous, everyday emotional support outside clinical environments, addressing what Lupton (2016) describes as “the temporal and spatial gaps” inherent in conventional mental health care.

Nonetheless, scholars have identified several persistent limitations within existing emotional wearable technologies. Sensor accuracy is often compromised by motion artifacts or inconsistent skin contact (Hernandez et al., 2014); interaction models frequently reduce complex emotional experiences to simplified metrics that fail to capture nuance (Balestrini et al., 2021); and many wearable devices neglect aesthetic and cultural considerations, resulting in low social acceptance in public settings (Rapp et al., 2019). Ruckenstein and Schüll (2017) further contend that mainstream wearables tend to impose a logic of surveillance or emotional correction rather than supporting the lived, embodied experience of emotion, thereby making them uncomfortable or undesirable for daily use.

In response to these challenges, this project investigates how heart-rate–based feedback can be embedded into jewelry-like wearable forms, particularly those positioned near the face or

head, to function not only as sensing systems but also as protective emotional tools. While changes in breathing are considered as part of the broader embodied experience of grief, heart rate remains the primary physiological input informing the design of the prototypes. Jewelry has historically served as an intimate and culturally meaningful extension of the body—carrying symbolic, ritualistic, and expressive significance—and its placement near the face or head is closely associated with emotional expression, visibility, and social identity (Tarlo, 2016; Miller, 2010). Unlike wristbands or smartwatches, which often prioritize utility over affective experience, jewelry forms can support what Kwon and Lee (2020) describe as "emotionally resonant wearable interactions," integrating seamlessly into personal appearance and social communication.

By leveraging the symbolic, aesthetic, and spatial qualities inherent in jewelry, this project aims to develop wearables that do more than display emotional data; instead, they offer a gentle, socially legible "emotional shelter" for individuals navigating grief in public contexts. Rather than emphasizing diagnostic precision, the design emphasizes embodied experience, privacy, and the cultural significance of concealment—dimensions often overlooked in mainstream wearable design. Through this approach, the project endeavors to demonstrate how wearable technology can transition from mere emotion monitoring to providing gentle, supportive spaces that acknowledge emotional vulnerability while remaining socially acceptable and aesthetically integrated.

This literature review explores four principal areas that situate the project within the domains of medical research, affective sensing, wearable design, and embodied emotional experience. The initial section examines studies related to Takotsubo Syndrome, which serve as a foundational reference for understanding how intense emotional states can elicit measurable physiological responses within the autonomic nervous system. Empirical research indicates that episodes of acute grief or emotional shock may induce transient cardiac dysfunctions, which are interpreted as protective physiological responses to extreme affective stimuli (Templin et al., 2015). These findings underscore the intrinsic connection between emotional experiences and bodily processes, providing vital groundwork for conceptualizing grief as an embodied phenomenon.

The second section assesses current applications of wearable technology in the context of emotional regulation and mental health support, including stress-monitoring devices, affective computing tools, and wearables integrated with mindfulness-based or cognitive-behavioral interventions (McDuff et al., 2019; Sanches et al., 2019). While physiological feedback mechanisms have demonstrated potential in fostering emotional awareness and self-regulation, existing research also identifies notable limitations. These include issues related to data accuracy, oversimplified emotion classification models, restricted modes of user interaction, aesthetic and cultural incongruence with daily wear, and concerns about users experiencing emotional surveillance or behavioral pressures in public environments (Lupton, 2016; Ruckenstein & Schüll, 2017). Such critiques reveal important gaps in current affective wearable design and emphasize the necessity for alternative approaches that prioritize cultural sensitivity, subtlety, and embodied emotional care.

The third section centers on wearable fashion and facial ornamentation as culturally and emotionally significant interfaces. Research spanning design, fashion theory, and emotional sociology demonstrates that facial adornments such as veils, masks, and forehead ornaments serve not merely decorative functions but also facilitate privacy management, identity expression, and the regulation of emotional visibility (Harper, 2020; Ahmed, 2014; Jalland, 1996). For example, historically, the mourning veil provided mourners with a socially sanctioned boundary that concealed signs of grief and mitigated the emotional burden of public exposure. These practices illustrate that facial adornments often act as subtle mechanisms of emotional protection, enabling individuals to regulate their visibility and navigate vulnerability within social contexts. These cultural insights position facial jewelry and mask-like structures as particularly suited for exploring themes of emotional concealment and embodied grief.

The final section reviews methodologies involving emotion recognition and physiological feedback, with particular emphasis on the rationale for selecting heart rate as the primary input signal. Heart rate is widely acknowledged as one of the most stable, accessible, and socially acceptable indicators of autonomic arousal, reliably reflecting emotional states such as grief, stress, and affective fluctuations (Kreibig, 2010). Compared to more invasive sensing techniques, heart-rate monitoring can be discreetly embedded within jewelry-like wearables, avoiding associations with clinical or surveillance contexts, thus enhancing cultural and aesthetic compatibility with facial accessories. Furthermore, grief often manifests through cyclical

autonomic patterns—brief elevations, reductions, and subsequent re-elevations in heart rate—providing a meaningful physiological basis for designing responsive, non-intrusive emotional feedback systems. By translating heart-rate fluctuations into subtle movements or lighting cues rather than alarming signals, this project aims to develop an "emotional sheltering interface" that offers the wearer a momentary refuge in public settings while subtly communicating a non-verbal message: "I am grieving; please give me space."

Literature Review

2.1 Takotsubo Syndrome: Medical Background and Emotional-Physical Interplay

Takotsubo Syndrome, commonly referred to as "broken heart syndrome," offers a compelling medical and physiological perspective for understanding grief as a somatic event rather than solely a psychological experience. First identified in Japan in the early 1990s, this condition characterizes an acute stress-induced dysfunction of the left ventricle, which assumes a ballooned shape reminiscent of the Japanese takotsubo octopus trap (Templin et al., 2015). Clinically, episodes of Takotsubo mimic myocardial infarction: patients present with chest pain, shortness of breath, electrocardiogram abnormalities, and elevated cardiac biomarkers; however, coronary angiography typically reveals no arterial blockage (Templin et al., 2015). This contrast underscores a significant point: in Takotsubo, the destabilization of the heart is not caused by vascular damage but by an overwhelming emotional event.

Extensive case analyses reinforce this correlation. Ghadri et al. (2018), utilizing data from an international registry, report that over 80% of cases occur shortly following an acute emotional shock, such as bereavement, relationship breakup, unexpected humiliation, fear, or intense interpersonal conflict. Physiological stressors—including surgery, infection, or physical trauma—are much less common triggers. Consequently, the phrase "dying of a broken heart" reflects an epidemiologically supported pattern rather than poetic exaggeration. Templin et al. (2015) emphasize that Takotsubo transforms the metaphor of emotional heartbreak into a visible and measurable phenomenon through cardiac imaging and biomarkers.

The underlying mechanism has been described as a neuro-cardiac cascade. Pelliccia et al. (2020) detail how sudden emotional distress triggers a surge of catecholamines, particularly adrenaline and noradrenaline, exerting toxic effects on myocardial cells and causing regional "stunning" of the ventricle. In other words, during episodes of intense emotional overwhelm, the heart temporarily loses its contractile coherence—not due to failure, but as a response to extreme autonomic imbalance induced by emotion.

Wittstein (2021) suggests that this transient dysfunction may be better understood as a protective physiological shutdown. Rather than interpreting the reduced ventricular motion as collapse, Wittstein posits that the heart may be "stepping back" to reduce metabolic demand during overwhelming emotional stress. This perspective reframes emotional breakdown not as

bodily destruction by emotion, but as an adaptive attempt—through drastic measures to shield itself.

This extreme example aligns with broader research in emotion physiology. Kreibig (2010) documents how grief consistently provokes a cluster of autonomic changes: decreased heart-rate variability, slower and shallower breathing, reduced muscle tone, and peripheral vasoconstriction. Nummenmaa et al. (2014), through large-scale body-mapping experiments, demonstrate that participants across cultures report remarkably similar somatic sensations during grief, including chest pressure, throat tightness, limb cooling, and a tendency to adopt a folded or inward posture. As they note, "emotions are represented in the body through highly consistent sensation patterns" (Nummenmaa et al., 2014). Thus, grief is not only experienced emotionally—it manifests physiologically, shaping posture, temperature, respiration, and movement.

Collectively, these studies paint a coherent picture: intense grief and emotional upheaval can temporarily impair cardiac function, alter heartbeat rhythm and variability, reshape breathing patterns, invoke postural contraction, and promote withdrawal. Templin and Ghadri elucidate the immediate cardiac effects; Pelliccia explains the neuroendocrine mechanism by which emotional events influence cardiac motion; Wittstein interprets this withdrawal as a protective response; and Kreibig and Nummenmaa reveal that similar bodily patterns—contraction, cooling, inwardness—are observable throughout different systems.

For the purposes of my thesis, the significance of Takotsubo Syndrome extends beyond its medical implications. Instead, it functions as a conceptual and empirical framework illustrating why grief often manifests as a desire to conceal, retreat, or shield oneself from external observation. The syndrome exemplifies how emotional overwhelm induces not only psychological distress but also measurable physiological withdrawal—a collapsing inwardness that echoes instinctive gestures such as covering the face, lowering the head, or seeking shelter. Accordingly, the literature surrounding Takotsubo syndrome helps clarify why a wearable device designed for grief should not aim to "correct" emotion but to support the body's natural tendencies toward protection. By demonstrating how grief disrupts and reconstructs the body from within, this research advocates for the development of wearable emotional-shelter devices that work in harmony with the body's protective instincts rather than opposing them.

2.2 Five level of Grief: From Linear Stages to Embodied Processes

The concept of the five stages of grief was first introduced by Elisabeth Kübler Ross and later clarified and refined in her collaborative work with David Kessler. These five states include denial, anger, bargaining, depression, and acceptance (Kübler Ross & Kessler, 2005). Although this framework has been widely disseminated in both psychological literature and popular culture, it is frequently misunderstood as a linear temporal sequence, suggesting that individuals progress through each stage in order and eventually reach emotional resolution or recovery. Kübler Ross and Kessler (2005) explicitly caution against this interpretation, emphasizing that grief does not unfold in a fixed order and that individuals may move back and forth between these states repeatedly. Rather than functioning as a developmental timeline, the five states of grief are more accurately understood as recurring emotional and bodily responses that may arise at different moments following a significant loss. Grief is not a process that can be completed or resolved but an ongoing experience that continuously interacts with the body. This interpretation aligns closely with contemporary research in emotion physiology and embodied cognition, which emphasizes that emotions are not confined to mental or cognitive domains but are expressed through physiological processes such as heart rate fluctuations, respiratory rhythm, muscular tension, bodily posture, and facial expression (Kreibig, 2010; Nummenmaa et al., 2014).

When grief is approached as an embodied experience, the five states can be reinterpreted as five levels of emotional intensity rather than sequential stages. Each level does not represent emotional progress or regression but reflects the degree of emotional load carried by the body at a given moment. In this research, heart rate is used as a reference indicator of momentary physiological arousal rather than as a diagnostic tool for determining psychological stages. In healthy adults, resting heart rate typically ranges between sixty and eighty beats per minute, a range commonly used as a baseline in psychophysiological studies of emotion.

Denial often emerges when emotional impact has not yet fully entered the body. Kübler Ross (2005) describes denial as a protective mechanism that allows individuals to survive overwhelming loss without being immediately consumed by emotional intensity. At this level, heart rate tends to remain close to resting levels, generally between sixty and 75 beats per minute. Bodily responses may include cool extremities and shallow breathing, while facial expression is often reduced, with limited movement in the eyes and mouth. This state does not

indicate an absence of emotion but rather reflects the body's temporary regulation of emotional exposure.

Anger represents a heightened level of emotional arousal within grief. Kübler Ross and Kessler (2005) describe anger as a stage that provides temporary structure amid emotional chaos, allowing individuals to feel connected to the world again. Physiologically, anger is associated with increased activation of the sympathetic nervous system, resulting in elevated heart rate that often exceeds 85 beats per minute and may approach or surpass 100 beats per minute in some individuals. The body exhibits muscular tension, raised shoulders, and jaw clenching, while breathing becomes more forceful. Facial expressions commonly include furrowed brows and narrowed gaze, signaling outward expression under sustained bodily pressure.

Bargaining is frequently described as a cognitive state, yet it also manifests as a distinct embodied condition. In this level, heart rate typically fluctuates rather than stabilizes, often oscillating between 75 and 90 beats per minute. This variability reflects the oscillation between hope and distress characteristic of bargaining. Breathing patterns may become irregular, with frequent pauses or short inhalations. The body remains alert but unable to relax, and facial expressions often shift subtly, reflecting anxiety, guilt, or persistent rumination. This level illustrates the body's attempt to regain control through mental negotiation while remaining physiologically unsettled.

Depression, within the grief framework, is not indicative of pathology but constitutes a natural and necessary response to loss. Kübler Ross (2005) emphasizes that this state involves a deeper inward turning rather than emotional dysfunction. Heart rate in this level often returns toward resting range or slightly below, typically between 60 and 70 beats per minute, accompanied by reduced heart rate variability. Bodily posture becomes collapsed, with lowered head position and rounded shoulders. Facial movement diminishes, gaze lowers, and social engagement decreases markedly. This state reflects the point at which grief is fully embodied and emotionally internalized.

Acceptance does not imply emotional resolution or approval of loss but rather recognition of its permanence. Kübler Ross and Kessler (2005) clarify that acceptance involves learning to live alongside grief rather than overcoming it. Physiologically, acceptance is often associated with greater autonomic stability. Heart rate tends to stabilize within the individual's resting

range, commonly between 65 and 75 beats per minute. Breathing becomes more regular, muscular tension decreases, and facial expression softens, allowing for cautious openness and renewed engagement with others.

By reframing the five states of grief as embodied levels of emotional intensity, this model moves away from a linear temporal structure and toward a dynamic system of emotional regulation. Rather than asking which stage an individual occupies, this perspective focuses on how much emotional load the body is carrying in the present moment and what form of protection or support it requires. Within the context of this research, this interpretation provides a critical theoretical foundation for subsequent design decisions. By correlating grief states with heart rate tendencies, bodily posture, and facial expression, the five levels are translated into a graded logic of bodily response. This framework supports the development of a multi-level wearable enclosure system that responds to physiological signals without assuming emotional progression or recovery. The five levels do not constitute a therapeutic pathway but instead form an embodied structure that allows grief to recur, be sensed, and be physically held.

2.3 Wearable Technology and Emotional Support

2.3.1 What is Wearable Tech ?

Wearable technology is generally defined as a category of digital devices specifically designed to be worn directly on the body, integrating sensing, processing, and feedback mechanisms into every day, embodied experiences. Unlike handheld or external devices, the defining characteristic of wearables is their constant proximity to the skin and their ability to merge with bodily rhythms and personal routines. As Eysenbach (2019) notes, "wearable technology is a group of objects that, because they are close to the body, interact frequently, and access personal information, tend to become part of you" (p. 72). This close positioning ensures that wearables are not merely tools but extensions of the body itself.

Research within the field of human–computer interaction further emphasizes the embodied nature of wearable technologies. Dunne and Raby (2013) describe wearable artifacts as “micro-environments of perception,” shaped by emotional states, posture, movement, and material textures. Rodgers and Black (2017) argue that wearability is not solely a technical feature but a relational aspect that arises from the interaction between skin contact, bodily movement, sensory

experience, and the cultural meanings associated with body adornment. Consequently, wearable objects function on multiple levels—technical, material, social, and symbolic.

From a technical perspective, wearable devices typically integrate miniaturized sensors, low-power microprocessors, soft or flexible materials, and wireless communication modules (McCann & Bryson, 2014). These components enable wearables to continuously monitor physiological indicators such as heart rate, respiration patterns, or temperature fluctuations, translating this data into visual, tactile, or kinetic feedback. As a result, wearables operate through ongoing interactions driven by movement, breathing, and contact, rather than discrete user commands. This research embraces a more seamless approach to wearable interaction. Instead of relying on manual commands or notifications, the prototypes developed here respond continuously to the body's internal state—specifically heart rate, hand-to-face proximity, and muscle tension. In this model, interaction is not a conscious instruction, but an ongoing process enacted through the simple act of wearing, moving, and breathing. By integrating sensing and feedback directly into the physical space between the device and the wearer, these wearables function as embodied interfaces. They do not just react; they evolve alongside the wearer's emotional landscape, particularly through the unpredictable waves of grief.

Additionally, wearables are increasingly recognized as social and emotional interfaces. Harper (2020) emphasizes that wearable objects "mediate how the body is perceived within social space," offering a means to negotiate visibility, privacy, vulnerability, and identity. This perspective broadens the understanding of wearable technology beyond utilitarian health or fitness functions, situating it within the realm of culturally meaningful body adornment—objects capable of expressing, concealing, or protecting emotional states.

In summary, wearable technology transcends a purely technological category to embody an intimate, embodied, and socially embedded form of interface that blurs the boundary between the body and the device. This conceptual foundation is vital for the present thesis, which investigates how wearable artifacts might respond to grief with gentleness rather than surveillance, fostering spaces of temporary retreat, emotional shielding, and embodied communication for individuals experiencing grief.

2.3.2 Wearable Technology in Emotional Support

Advancements in affective computing and physiological sensing have positioned wearable devices as significant tools for emotional regulation and mental health support. The foundational theoretical basis for this body of work originates from Picard's seminal research, which posits that emotions are expressed through measurable autonomic nervous system responses—including heart rate variability (HRV), electrodermal activity (EDA), and respiratory rhythm—and that these physiological signals can be sensed, visualized, and fed back to users to enhance emotional awareness and self-regulation (Picard, 1997). Building upon this framework, McDuff et al. (2019) demonstrated that providing users with real-time HRV and heart rate feedback during stress-inducing tasks enables individuals to recognize rising stress more promptly and adopt more effective self-regulatory strategies. Collectively, these studies established the principle of "making the body legible" as a central tenet in affective wearable design.

Current applications of wearable systems often prioritize stress detection as their primary function. Devices such as the Empatica E4, Fitbit Sense, and Garmin's Stress Score monitor autonomic signals to estimate levels of emotional arousal. Research by Hernandez et al. (2014) and Healey & Picard (2005) indicates that signals such as EDA, HRV, and PPG can detect subtle physiological changes preceding conscious stress perception, effectively transforming wearables into "pre-conscious sensing tools" capable of revealing bodily processes previously hidden from awareness.

Beyond detection, an increasing number of systems incorporate guided emotional regulation strategies, particularly through mindfulness-based or respiratory modulation techniques. When irregular or rapid breathing is identified, some systems respond with light cues, haptic rhythms, or auditory signals to assist users in adopting slower, deeper breathing patterns. Moraveji et al. (2011) found that rhythmic biofeedback can significantly reduce sympathetic nervous system activation during anxiety-provoking tasks, while Hõrak et al. (2022) demonstrated that wearable breathing guides can stabilize users' emotional states within minutes. Through these approaches, wearables evolve from diagnostic tools into continuous companions that facilitate ongoing emotional rhythm regulation throughout daily life.

Additional research integrates principles from cognitive-behavioral therapy (CBT) into wearable technologies. Sanches et al. (2019) describe devices capable of detecting physiological

signs of emotional escalation and prompting users to become aware of maladaptive thoughts or behavioral patterns. By embedding CBT-informed cues within everyday contexts, such systems extend clinical therapeutic strategies into micro-moments of lived experience, fostering what the authors refer to as an "embodied reflective process."

However, when considering these technological approaches within the context of grief, their limitations become readily apparent. Grief differs fundamentally from stress or anxiety in both temporal structure and bodily expression. Psychological and sociological grief research emphasizes that grief is not a state to be regulated or resolved, but a prolonged and non-linear process characterized by oscillation between emotional, cognitive, and somatic conditions (Stroebe and Schut, 1999; Neimeyer, 2016). Bodily withdrawal, emotional numbness, exhaustion, and sudden surges of affect are not signs of dysfunction but integral components of grieving.

Existing technological interventions that explicitly engage grief further illuminate this mismatch. One category includes AI based memorial and digital afterlife systems, often referred to as griefbots. These systems attempt to simulate or preserve interactions with the deceased through chat interfaces or generated personalities. Scholars such as Öhman and Floridi (2018) argue that such technologies risk reinforcing denial and bargaining by sustaining the illusion of continued presence, potentially delaying emotional integration. Rather than supporting embodied mourning, these systems often redirect grief toward prolonged interaction and emotional attachment, raising ethical and psychological concerns.

A second category involves physiological monitoring applied to bereavement related stress. Some studies adapt stress sensing wearables to detect heightened arousal or depressive symptoms following loss. However, scholars including Lupton (2016) and Ruckenstein and Schüll (2017) caution that framing grief through metrics of deviation and recovery positions mourners within regimes of surveillance and correction. In such systems, emotional fluctuation is implicitly treated as a problem to be fixed, reinforcing social pressures to return quickly to productivity and emotional stability.

A third category includes artistic, and research based interactive installations that use biofeedback to express grief, such as heartbeat driven visualizations or responsive environments. While these works effectively externalize emotional experience, they are often situated within

exhibition or laboratory contexts and remain primarily representational. Their capacity to accompany grief in everyday public life remains limited, as they rarely address issues of wearability, concealment, or sustained bodily presence.

These critiques collectively expose a critical gap in current wearable technology. Existing systems are fundamentally engineered for stress and anxiety regulation, emphasizing stabilization and reducing heightened states of physiological arousal. They do not adequately accommodate grief, a condition that often requires withdrawal, protection, and the allowance for emotional rhythms to unfold without urgency. Historically, grief has been supported through cultural rituals, garments, and socially recognized periods of withdrawal that provided material and spatial structures for mourning. As these practices have diminished or become incompatible with contemporary daily life, grief increasingly unfolds without tangible support, particularly in public and professional environments.

Within this context, technology holds a unique potential not to replace cultural mourning practices, but to complement what they once provided. Unlike static rituals tied to specific places or times, wearable technology can function as a portable and privately activated form of emotional shelter. It allows grief to be carried into everyday life without demanding explanation, visibility, or resolution. Rather than accelerating recovery or enforcing emotional normalization, such technologies can create temporary spaces of retreat, protection, and pacing, supporting the body as it navigates vulnerability in public settings.

Accordingly, this research advocates for an alternative paradigm in emotional wearable design. Rather than relying on alerts, corrective feedback, or performance optimization, the project explores how movement, spatial enclosure, and bodily proximity can respond to physiological signals in ways that affirm vulnerability rather than discipline it. While the current prototypes employ rigid and mechanical materials such as metal to articulate structure and motion, softness in this project is primarily investigated at the experiential level through movement quality, pacing, and degrees of enclosure. Slow inward motion, partial coverage, and adjustable proximity to the face produce a sense of being held without pressure or constraint. Material softness remains an active direction for future exploration, with subsequent iterations intended to investigate lighter, more flexible, and breathable materials that further align physical sensation with emotional shelter.

Through this reframing, wearable technology is repositioned not as a tool for emotional correction, but as a compassionate companion capable of offering privacy

2.3.3 Limitations and Critiques — and why these limitations matter specifically for grief

Despite the increasing sophistication of affective wearables, scholars consistently identify limitations in their core assumptions, technical logic, and social implications. When these systems are examined through the lens of grief rather than stress or anxiety, these limitations become more pronounced. Many existing devices follow what Lupton describes as a regulatory paradigm, where emotional arousal is framed as a deviation from a desired baseline and therefore requires correction or normalization (Lupton, 2016). This model can support short term stress management. It becomes problematic when applied to grief, which is not a malfunction but a meaningful emotional and bodily response to loss. Medical research on Takotsubo Syndrome and broader emotion physiology demonstrates that grief related bodily responses such as chest tightness, irregular breathing, and heart rate fluctuation often function as protective mechanisms rather than pathological signals (Wittstein, 2021). When wearables interpret these signals as errors to be fixed, they risk denying the embodied logic of grief and compressing a complex process into a problem to be solved.

A second critique concerns the oversimplification of emotional classification within affective wearable systems. Many devices reduce physiological patterns to single labels such as stress or negative mood. Barrett's constructivist theory of emotion emphasizes that physiological signals do not map cleanly onto discrete emotional categories, because emotions are shaped by context, memory, and meaning rather than bodily signals alone (Barrett, 2017). In grief, emotional states often coexist and shift rapidly, including grief, anger, numbness, longing, and exhaustion. When grief is misread as stress or anxiety, the feedback provided by a device can feel confusing or invalidating rather than supportive.

This project responds to that challenge by avoiding emotion classification altogether. Instead of assigning emotional labels or prompting regulation, the wearable translates physiological change into non-verbal, material gestures such as gradual enclosure or spatial withdrawal. These responses do not claim to identify what the user feels. They acknowledge that something is happening in the body and offer protection without interpretation.

A third critique, especially relevant to grief, relates to emotional surveillance. Ruckenstein and Schüll describe how continuous monitoring can create a feeling of being observed by data, devices, or oneself (Ruckenstein and Schüll, 2017). For grieving individuals, who often face social pressure to appear functional and composed, this form of monitoring can intensify self-awareness and emotional restraint. In this context, controlled exposure refers to the ability to regulate how much of one's emotional state becomes visible to others in public space. Many current wearables undermine this control by making emotional arousal legible through screens, vibrations, or alerts. Rather than supporting privacy, they risk turning grief into a visible performance.

This concern also extends to the visual and cultural language of most affective wearables. Devices shaped like fitness trackers or medical tools often signal monitoring, optimization, or diagnosis. As Lupton notes, such aesthetics can reinforce a sense of surveillance and stigma (Lupton, 2016). For people who are grieving, whose embodied needs often include retreat, softness, and reduced visibility, these signals can be intrusive. Historical mourning practices offer a contrasting model. The Victorian mourning veil, for example, provided a socially recognized way to reduce facial exposure while remaining present in public (Jalland, 1996). The veil did not hide grief completely. It softened visibility and created distance between the grieving body and the social gaze.

The wearable proposed in this research addresses this issue through form and behavior rather than notification or display. The design centers on a headpiece that responds to physiological signals, with heart rate functioning as the primary trigger for its movement. Rather than announcing emotional state through data, the feathered headpiece expresses change through subtle shifts in enclosure and proximity around the face. It responds slowly and quietly to physiological change by altering spatial proximity around the face. The movement is subtle and inward rather than outward. It reduces exposure instead of producing spectacle. In this way, the device offers emotional shelter rather than attracting attention.

Taken together, these critiques reveal a central gap in affective wearable design. Existing systems are optimized for emotional regulation and performance. Grief requires a different orientation. It requires time, protection, and permission to withdraw without disappearance. Technical intervention in grief is not valuable because it can fix emotion. It becomes meaningful

when it helps sustain the body in public life while honoring vulnerability. By drawing on material gestures, slow movement, and partial concealment, this research proposes an alternative role for technology. Wearables can act as companions that hold space rather than correct behavior. They can complement cultural practices of mourning by offering a contemporary, embodied form of retreat that remains flexible, personal, and non-verbal.

2.4 Wearable Fashion and Facial Ornamentation as Cultural and Emotional Interfaces

Wearable fashion, particularly facial ornamentation, has long served as a meaningful interface through which individuals navigate emotional visibility, social expectations, and personal vulnerability. Because the face is the most expressive and most scrutinized site of emotional display, objects placed on or around the face play a distinctive role in shaping how emotions are communicated, concealed, or socially managed. Research across the fields of design studies, fashion theory, and emotional sociology consistently demonstrates that facial adornments such as veils, masks, forehead ornaments, and facial jewelry function not merely as decorative objects but as active mediators of privacy, identity, and affective experience (Harper, 2020; Ahmed, 2014). These works illustrate that adornment is intrinsically linked to emotional life and that materials positioned around the face influence how individuals inhabit and negotiate social environments.

Historical mourning practices provide some of the clearest examples of facial ornamentation acting as an emotional interface. Jalland's study of Victorian mourning culture (1996) reveals that the mourning veil did more than signify grief; it established a socially sanctioned boundary that protected mourners from intrusive gazes, unwelcome inquiries, and the emotional labor involved in maintaining composure publicly. The veil softened the visibility of tears, facial swelling, or exhaustion, allowing grief to progress at a pace aligned with the mourner's internal experience rather than societal expectations. In this context, the veil functioned as both a psychological buffer and a physical means of regulating exposure to external perceptions. Ahmed (2014) describes such coverings as "affective boundaries," objects that mediate the distance between the grieving body and the social sphere, enabling individuals to occupy public space while preserving emotional privacy. These cultural forms demonstrate how facial adornments have historically served as subtle mechanisms of emotional protection.

Contemporary cross-cultural research further underscores that facial adornments enable individuals to control the extent to which their emotional states are visible to others. Harper (2020) contends that adornment around the face creates a dynamic field of "managed visibility," where partial coverage, selective opacity, and layered materials allow wearers to modulate their presence. This modulation extends beyond aesthetic identity; it functions to manage vulnerability, recover from emotional strain, or mitigate social pressure. These practices closely align with Goffman's concept of appearance management, wherein individuals employ aesthetic strategies to navigate the emotional demands and expectations of public life. When applied to grief, these insights highlight the emotional labor involved in maintaining a composed or functional appearance amidst internal turbulence.

Within the domains of interaction design and human–computer interaction scholarship, facial adornment is increasingly recognized as a site of affective communication and embodied meaning. Devendorf and Rosner (2017) argue that wearable devices can become "soft interfaces," transmitting emotional cues or boundaries without the need for verbal communication. This perspective positions facial ornaments as capable of performing gentle negotiations of intimacy, distance, and interpersonal sensitivity—qualities that resonate profoundly with the experience of grieving. For individuals experiencing loss, there is often a tension between the desire to engage with daily responsibilities and the need to protect one's emotional vulnerability. An interface that caresses, shields, or partially obscures the face can provide a sense of refuge without necessitating withdrawal from social engagement.

These cultural and theoretical perspectives directly inform the present thesis, which explores grief as an embodied condition that necessitates subtle forms of protection rather than correction or suppression. Existing emotional technologies often emphasize stabilization, productivity, or behavioral normalization; however, these goals do not align with the nuanced temporal nature of grief, which unfolds gradually, unevenly, and with profound bodily effects. Facial adornment offers an alternative design approach—one that emphasizes concealment, softness, and controlled visibility as meaningful emotional gestures. It invites a redefinition of emotional wearables from diagnostic tools into aesthetic and embodied companions that acknowledge vulnerability rather than seek to eliminate it.

The wearable prototypes developed in this research draw upon this lineage of facial interfaces. Semi-transparent masks, lightweight textile structures, and a feathered headpiece that gradually encloses the face in response to elevated heart rate reflect the cultural logic of the veil. Their purpose is not to completely conceal the wearer but to provide temporary refuge and gentle protection. These materials reshape the ways in which the body communicates grief, creating a zone where the wearer can breathe, withdraw marginally, and regulate exposure to others. By incorporating movement and physiological responsiveness, these designs extend historical practices into contemporary emotional contexts, transforming face-based adornment into a responsive emotional sanctuary.

From this perspective, wearable fashion and facial ornamentation provide essential theoretical insights for this thesis. They reveal grief as a condition that requires boundaries, softness, and modulated visibility, and demonstrate that the face has long been a critical site where individuals negotiate the tension between emotional expression and emotional safety. Understanding these cultural precedents enables this research to reconceptualize emotional wearables not as tools for optimization but as gentle companions supporting the grieving body and communicating its needs within the social environment.

2.5 Emotion Recognition and Physiological Feedback: Rationale for Using Heart Rate as Primary Input

Research in affective computing and physiological sensing lays the groundwork for really understanding how emotions show up in how our bodies behave. Picard's key work, "Affective Computing" (1997), was the first to point out that emotions match up with measurable autonomic responses, like changes in heart rate (HR), heart rate variability (HRV), skin conductance (EDA), and breathing patterns. These bodily changes often happen before we even consciously realize we're feeling something, making the body an early hint of emotional shifts. Building on this, McDuff et al. (2019) showed that real-time physiological feedback can help users become more aware of their emotional arousal and support better self-regulation during stressful situations. Overall, these studies show that making internal bodily states visible can boost how well people understand and reflect on their emotions.

Kreibig's (2010) meta-analysis of autonomic response patterns across different emotions gives especially clear insights into grief that are relevant here. She points out that grief usually

involves lower HRV, less blood flow in the periphery, shallower breathing, heaviness in muscles, and occasional rises in heart rate. Importantly, these changes don't happen suddenly but develop slowly over hours or days. This timing matches the experience of grief, which often involves swinging between numbness, heaviness, and sudden emotional spikes. These findings help explain why quick emotional correction tools—great for anxiety—might not work well for grief, which calls for understanding and patience rather than suppression.

This idea is backed up by Nummenmaa et al.'s (2014) "bodily maps of emotion," which show that grief tends to be felt in the chest, throat, and limbs, with sensations of cooling, tightness, and less movement. Their research suggests that emotions are "universally represented in the body," meaning feelings influence posture, body temperature, and internal rhythms in ways that we might not be totally aware of. For designers creating wearable tech, this highlights how important it is to consider the sensory, spatial, and timing aspects of emotional experiences.

In this context, heart rate stands out as a good physiological signal for grief-focused wearables. Heart rate is widely accepted, non-invasive, easy to monitor, and can be discreetly embedded into everyday items like jewelry or accessories without making them seem clinical or like surveillance tools (Kreibig, 2010). Compared to EDA or EMG, which might need gels, electrodes, or bulky hardware—heart rate sensors fit better with the look and feel of decorative wearables discussed earlier in Section 2.3.

Changes in heart rate resonate both symbolically and physically with what people experience during grief. For example, research on Takotsubo Syndrome shows that intense emotional events like losing a loved one can cause sudden autonomic surges that temporarily impair the heart (Templin et al., 2015; Ghadri et al., 2018). While this project isn't about medical diagnosis, it highlights how emotional shock is closely linked to heart rhythms. Pelliccia et al. (2020) also show that these heart responses are often more about the body's protective shutdown rather than pure pathology, meaning spikes in heart rate during overwhelming emotions might be the body's way of coping, retreating, or conserving energy.

This view lines up with critiques from Lupton (2016) and Ruckenstein & Schüll (2017), who argue that many physiological sensing techs tends to see emotional arousal as something to fix. Devices that send alerts or give warnings often aim to regulate anxiety but can end up pathologizing grief—something that's natural and necessary. For someone grieving in public or

at work, this kind of corrective feedback might make them feel more exposed, inadequate, or under pressure to “look okay.”

My thesis offers a different approach. Instead of treating high heart rate as a problem that needs fixing, it sees these changes as meaningful signs of vulnerability. By turning them into subtle sensory cues—like a soft pulse of light, a change in color, or a gentle inward movement of a wearable—the device acts as an “emotional shelter.” These gestures give the wearer a kind of temporary refuge and send a quiet, non-verbal message: “I’m grieving; please give me space.” It shifts physiological feedback from a way of monitoring to a form of support and care.

In this view, heart-rate interactions move from just tracking to being a gentle, caring gesture, respecting the body’s rhythms and vulnerabilities linked to grief. This approach provides a conceptual foundation for developing wearables that respond softly to emotional stress, offer a brief mental pause, and validate grief as a natural, embodied emotional state—not something abnormal to be fixed.

Contextual Review

3.1 Encoded Communication and Protective Wearables: Farahi's Can the Subaltern Speak?

Behnaz Farahi's Can the Subaltern Speak? provides a critical reference for this research by demonstrating how wearable interfaces can function as systems of coded communication, protection, and resistance. Her project draws directly from Gayatri Chakravorty Spivak's foundational question in Can the Subaltern Speak? (1988), which interrogates whether marginalized subjects can meaningfully express their experiences within dominant structures that routinely overwrite, distort, or silence them. Farahi translates this theoretical concern into the domain of wearable technology, asking how bodies might communicate outside regimes of surveillance, visibility, and control.

Farahi's work is informed by Bandari masks historically worn by women in southern Iran. These masks operated in a dual capacity. On one hand, they were instruments of patriarchal regulation. On the other, they functioned as shields against the colonial gaze. Farahi reinterprets this history through two AI enabled masks that communicate via eyelash blinking. The blinking sequences resemble Morse code and transform a gesture often associated with flirtation or objectification into a private channel of communication. Through this transformation, blinking becomes a tool for evading surveillance rather than inviting attention.

The project also references broader practices of encoded bodily communication. These include prisoners blinking messages such as "TORTURE" during televised appearances, women using hand gestures to signal domestic abuse during COVID lockdowns, and artificial intelligence systems that develop internal shorthand languages when not constrained by human grammar. Together, these examples demonstrate a shared logic. When verbal expression becomes unsafe or socially restricted, meaning shifts into subtle bodily gestures that resist easy detection.

This logic resonates strongly with the conceptual concerns of my research. This project is grounded in a practice-based self-study that reflects my own experience of grief while continuing to participate in everyday public routines such as commuting, working, and social interaction. Rather than claiming to represent a broad population, I treat my own embodied experience as a situated point of inquiry. Within this context, grief often remains physically present while social norms require emotional composure. As a result, grief is managed through small bodily actions

rather than explicit expression. These actions include lowering the head, covering the face, wearing sunglasses, pulling hair forward, or seeking spatial withdrawal.

Such gestures function in ways that parallel the Bandari masks discussed in Farahi's work. They regulate visibility. They create distance. They offer temporary protection. Historical precedents such as Victorian mourning veils further demonstrate how concealment has long served as a culturally sanctioned means of managing grief in public space by establishing boundaries around emotional exposure (Jalland, 1996). Across these examples, concealment does not indicate weakness. Instead, it operates as a strategic method for maintaining dignity and emotional safety.

Spivak's framework helps clarify why these indirect expressions matter. People experiencing grief often lack socially acceptable spaces to express its duration, intensity, or unpredictability. Their voices are not erased through direct censorship but through expectations of productivity, emotional resilience, and rapid recovery. In such conditions, the body becomes a site of indirect communication. Changes in heart rate, breathing, posture, and muscle tension act as signals that verbal language cannot easily convey. These signals do not demand interpretation. They simply state a limit.

Farahi's masks demonstrate how wearable interfaces can amplify such bodily signals while also protecting the wearer. This insight directly informs my own design approach. Rather than creating a device that diagnoses, labels, or corrects emotional states, this research explores how a wearable interface might support people experiencing grief by offering protection and spatial retreat. The feathered headpiece developed in this project responds to physiological change through gradual movement and enclosure. Its purpose is not to display grief but to soften exposure. The device forms a boundary around the face during moments of emotional overload, creating a small zone of privacy while remaining wearable in public settings.

Through this comparison, Farahi's work clarifies how wearable technology can operate beyond function or decoration. It can become a tool for negotiating visibility, vulnerability, and agency. In this thesis, wearable design is positioned not as a solution to grief, but as a means of allowing grief to exist without forced articulation, correction, or performance.

3.2 Biofeedback Art and the Emotional Externalization of the Heartbeat

Biofeedback art has long explored how emotional states manifest through the body, seeking to make subtle internal changes perceptible through light, sound, or movement. Foundational work in affective computing argues that emotions are expressed through measurable physiological signals such as heart rate, skin conductance, and breathing patterns (Picard, 1997). Kreibig (2010) further demonstrates that distinct emotional states are associated with characteristic patterns in heart rate and heart rate variability. Large scale body mapping studies by Nummenmaa et al. (2014) reinforce this understanding, showing that grief is commonly associated with sensations of chest pressure, shallow breathing, and altered cardiac rhythm. Together, these studies indicate that heart rate is not only a measurable physiological signal but also a shared, embodied form of emotional expression.

Within the context of grief, this insight becomes particularly significant. People experiencing grief often cannot articulate their emotional state verbally in public settings. In such moments, physiological responses such as changes in heart rate function as involuntary bodily signals. In this research, heart rate is understood as a form of nonverbal emotional information that emerges without conscious effort. Wearable devices can sense these changes and respond without requiring the wearer to speak, perform, or explicitly disclose their emotional state.

A well-known example within biofeedback art is Rafael Lozano Hemmer's *Pulse Room* (2006). The installation consists of hundreds of hanging light bulbs that flicker in synchrony with participants' heartbeats when they hold a sensor. Lozano Hemmer describes the work as an attempt to "amplify individual life rhythms and turn them into a shared language in public space" (Lozano Hemmer, 2006). Here, emotional states such as tension or calm are communicated directly through cardiac rhythm, without verbal narration or visual representation of the body. Heart rate becomes a quiet, non-performative channel of expression. This logic is relevant to grief, where individuals may wish to remain socially unobtrusive while still having their internal state acknowledged.

Lozano Hemmer's *Pulse Index* (2010) extends this approach by emphasizing heart rate as a temporal emotional trace. The work collects fingerprints and pulse waveforms from participants and projects them as a continuously evolving collective portrait. Rather than presenting a static emotional snapshot, the installation foregrounds fluctuation over time. This temporal quality is

especially relevant to grief, which does not progress linearly but unfolds through recurring physiological shifts. Small increases and decreases in heart rate mark moments of emotional intensity, release, or withdrawal.

In contrast to these large-scale public installations, Jung In Jung's *A Tangible Heartbeat* (2018) offers a markedly intimate model of biofeedback interaction. The work translates heart rate into gentle tactile feedback that remains close to the body. Jung argues that tactile biofeedback enables users to reconnect emotion to bodily sensation, supporting reflection without visual exposure (Jung, 2018). This approach prioritizes privacy, softness, and inward attention rather than outward display. Emotional information is not broadcast into space but contained within the body device relationship.

This distinction is central to the design logic of my project. While my prototype takes the form of a feathered headpiece with motorized movement, its interaction strategy is deliberately restrained. The device does not visualize heart rate through light, sound, or numerical display. Instead, physiological change triggers a slow, gradual closing motion that reduces facial exposure. The movement functions as a protective gesture rather than a signal meant to attract attention. When the wings close, they create a partial visual boundary around the face, limiting outward visibility rather than increasing it.

From this perspective, the headpiece should not be understood as a spectacle but as a wearable shelter. Its purpose is not to communicate information to an audience but to regulate the wearer's relationship to public space. Comparable practices already exist in everyday life, such as wearing sunglasses, lowering one's head, or pulling clothing closer to the body during moments of emotional vulnerability. The headpiece extends these familiar gestures through responsive material movement.

Psychophysiological research further supports this design choice. Kreibig (2010) and Nummenmaa et al. (2014) emphasize that heart rate reflects emotional depth, rhythm, and transition rather than simple arousal. During grief, fluctuations in heart rate indicate ongoing bodily processing rather than a state that requires correction. Using heart rate as an input is therefore not a technical convenience but a conceptual alignment with grief as a dynamic, embodied process.

Unlike large scale biofeedback installations, this project intentionally limits visibility. Heart rate is not externalized for others to read. It remains embedded within the device and expressed through subtle material response. The resulting interaction is low intensity in effect rather than low visibility in form. The headpiece may be noticeable as an object, but its behavior prioritizes enclosure, slowness, and withdrawal over display.

Taken together, these biofeedback artworks and emotion studies demonstrate that heart rate functions as a shared but quiet emotional language. It can be sensed and translated into movement without demanding verbal explanation or emotional performance. This makes it particularly suited for grief, where individuals often continue daily routines while carrying unresolved emotional weight. By responding to heart rate through protective movement rather than display, this project reframes biofeedback not as emotional revelation but as emotional shelter.

Chapter 3: Approach

Practice-Based Approach

This thesis adopts a practice-based research approach that understands knowledge as something generated through the act of making, rather than through theory alone. I position myself as the initial and primary participant in this research, adopting a first-person, practice-based approach grounded in somatic design. This methodological choice is intentional, allowing direct access to subtle bodily and emotional responses that are central to examining grief, vulnerability, and the need for protection.

Rather than aiming for generalizable findings, this approach prioritizes situated and embodied insight, generated through iterative processes of making, wearing, and reflection. While the use of the self as the sole participant limits the generalizability of the results, it enables a depth of experiential understanding that would be difficult to access through external observation alone.

In this research, making is not treated as a secondary activity used to illustrate pre-existing ideas, but as a primary mode of inquiry through which understanding develops. Design research has increasingly recognized that certain forms of knowledge are experiential, situated, and difficult to access through language alone (Wilde, Vallgårda & Tomico, 2017). Practice-based research responds to this limitation by positioning material engagement as a way of thinking, sensing, and reflecting through the body.

A key theoretical foundation for this approach comes from Dr. Nithikul Nimkulrat's research on embodied material practice. Nimkulrat's work emphasizes that materials are not passive tools used to execute predefined concepts, but active participants in the research process (Nimkulrat, 2012). Through sustained bodily engagement with materials, such as shaping, adjusting, repeating, and resisting, makers develop forms of understanding that emerge only through physical interaction. In this view, cognition unfolds through touch, pressure, movement, and sensory feedback, rather than existing solely as abstract reasoning.

Nimkulrat argues that much of the knowledge generated through making is tacit and embodied. Makers often know how something feels, fits, or functions before they can explain it verbally. This knowledge resides in bodily memory, muscle movement, and sensory awareness

rather than in explicit description (Nimkulrat, 2016). As a result, making becomes a legitimate research method for exploring experiences that are difficult to articulate, including emotional and affective states. This perspective is particularly relevant to research on grief. Grief often manifests through bodily sensations such as heaviness, tension, withdrawal, altered breathing, and changes in posture. These experiences are frequently felt before they can be named or explained. Approaching grief through embodied material practice allows the research to engage with these sensations directly, without forcing them into verbal or representational frameworks. In this thesis, making is used to access grief as a bodily condition rather than as a purely psychological or narrative one.

This embodied approach aligns closely with soma design research, which foregrounds bodily sensation as a site of knowledge. Höök, Jónsson, and Ståhl (2021) describe soma design as a practice that tunes designers into subtle bodily experiences that often remain beneath conscious awareness. Through material interaction, designers become attentive to weight, softness, warmth, resistance, and rhythm. These sensory qualities shape emotional experience and inform design decisions at a somatic level. Rather than designing for the body as an object to be optimized, soma design treats the body as a sensing, feeling subject.

Colombetti's work on affect further supports this orientation. She describes emotions as embodied orientations toward the world, shaped through posture, movement, and bodily readiness rather than isolated mental states (Colombetti, 2017). From this perspective, emotions such as grief or vulnerability are not located solely in cognition but are distributed across the body's sensory and motor systems. Understanding these emotional states therefore requires engagement with how the body moves, contracts, withdraws, or seeks support.

Phenomenological research on affect also highlights that grief alters bodily tone and perception in ways that often remain unspoken. Fuchs (2018) shows that grief can change muscular tension, breathing patterns, spatial orientation, and thermal sensation. These bodily shifts are often experienced as atmospheres or moods rather than as discrete feelings that can be easily named. Practice-based making allows these subtle changes to be explored through material form, where bodily response becomes a source of insight rather than an object of measurement.

Within this research process, prototypes function not simply as outcomes, but as thinking tools. Wensveen and Löwgren (2020) describe such artifacts as devices that enable reflection

through use, rather than through explanation. In this project, making and wearing prototypes becomes a form of first-person inquiry. Through repeated cycles of fabrication, adjustment, and bodily testing, design decisions emerge in response to how the body feels when interacting with the object. These decisions are informed by sensations of enclosure, pressure, warmth, movement, and emotional comfort. This approach follows Höök's argument that soma-based prototyping generates experiential knowledge that cannot be accessed through interviews or observation alone (Höök et al., 2021). By engaging directly with materials and bodily response, the research remains grounded in lived experience. Reflection occurs during making, not after it. Each modification becomes a response to felt experience rather than to abstract criteria.

Rooted in my background in metalsmithing and jewelry design, this practice-based method treats material engagement as both technical and perceptual. Metals, soft structures, and wearable forms are explored not only for their structural properties but for how they interact with the body emotionally. Through this process, making becomes a way to think with the body. It allows grief to be approached as something sensed, carried, and negotiated physically.

In this thesis, practice-based research is therefore not used to illustrate theory, but to generate it. By drawing on Nimkulrat's embodied material practice, soma design, and phenomenological accounts of affect, the project establishes making and wearing as central research methods. This framework enables an investigation of grief that remains attentive to bodily experience, material response, and emotional nuance. Rather than seeking to explain grief from a distance, the research engages with it through proximity, contact, and embodied interaction.

Methodology: Research through Design (RtD)

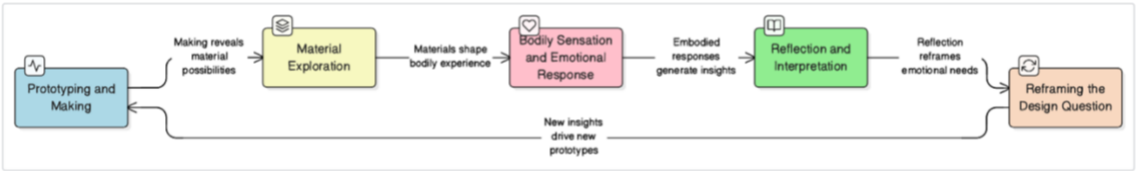

Figure 4. Research-through-Design Cycle Used in the Development of Wearable Prototype

Research through Design offers a valuable methodological framework (figure 4) that aligns well with the embodied and emotionally focused nature of this project. In recent scholarship, Gaver and Bowers (2022) argue that design artifacts act as research instruments capable of

revealing experiential and emotional qualities that traditional analytical methods cannot access. Stappers and Giaccardi (2017) similarly emphasize that prototypes materialize hypotheses and allow insights to emerge through situated interaction. These perspectives echo the role of making within this project, where wearable forms serve not only as aesthetic or functional objects but as vehicles through which emotional, sensory, and physiological questions can surface.

This approach aligns particularly well with my thesis, which explores how grief is experienced physically and how wearable objects might support emotional safety, protection, and self-soothing. In soma design research, Höök et al. (2018) describe how design inquiry must begin with attending to deeply felt, bodily sensations, allowing designers to understand emotional states through lived experience rather than verbal description alone. Schiphorst (2020) further argues that embodied design practices reveal tacit knowledge that is inaccessible through cognitive self-report, a point that directly supports the need to study grief through bodily engagement.

Through Research through Design, the winged headpiece become more than just aesthetic or functional objects; they serve as research tools that facilitate the emergence of material, emotional, and physiological questions during their creation and use. This resonates with Giaccardi and Karana's (2022) assertion that materials influence meaning and emotional interpretation, demonstrating that textures, temperatures, and bodily movements actively shape the user's emotional experience. Each iteration of the headpiece provides an opportunity to examine how varying degrees of facial enclosure influence feelings of retreat, vulnerability, or protection

Therefore, Research through Design emphasizes making as a primary mode of inquiry, allowing the project to explore grief not only as a psychological state but as an embodied experience that can be shaped, supported, and communicated through material and wearable forms. This aligns with recent work by Loke and Robertson (2021), who demonstrate that embodied prototyping enables designers to detect micro shifts in emotional tone through real-time bodily engagement. Their findings support the methodological foundation of this project, where emotional understanding emerges through the iterative act of crafting, wearing, sensing, and reflecting.

Methodology

Prototyping and material exploration

Prototyping and material exploration serve as the primary methods through which this research advances knowledge. Over three iterative stages, the prototypes developed from a basic system of light-based physiological feedback into wearable emotional interfaces capable of creating a temporary sense of safety through subtle movements generated by the wearable in close proximity to the body, where engagement emerges through passive contact and sensory experience rather than deliberate action. In affective interaction research, Höök (2018) notes that iterative, soma-based exploration helps designers' sense subtle bodily shifts that cannot be accessed through purely cognitive evaluation, supporting the need for iterative prototyping in emotionally sensitive contexts.

In the first stage, I started with a heart-shaped LED module connected to a heart rate sensor that visualized physiological arousal in real time. When my heart rate exceeded 100 BPM during testing, which I achieved through light physical activity such as walking, climbing stairs, or recalling emotionally intense situations, the LEDs flashed red before transitioning into a box-breathing rhythm intended to guide respiration, the device emitted a brief red warning light for three seconds before transitioning into a box breathing rhythm. If the heart rate remained below this threshold, the device displayed a steady green glow. During this phase, I conducted systematic experiments varying brightness, flicker frequency, and color transitions to explore whether specific light patterns could convey emotional meaning. Research on color-emotion associations supports these interpretations: red illumination is commonly linked with tension, urgency, or emotional heaviness, while softer rhythmic light patterns support calm and regulation (Jin et al., 2021; Elliott & Maier, 2014). These explorations aligned with theoretical frameworks such as the color emotion wheel, emphasizing light as a fundamental medium for emotional expression.

To better understand how light behaves when filtered through different tactile surfaces, I tested various diffusion materials including semi-translucent textiles, wool yarn, beads, felted wool, translucent plastics, and silicone. The aim was to evaluate whether these surfaces could produce a soft, non-intrusive glow with sufficient emotional nuance. The results indicated that the body interprets each material symbolically, consistent with material experience research

showing that texture, translucency, and surface temperature shape emotional interpretation and bodily response (Giaccardi & Karana, 2015). Semi-translucent textures softened the light, making it resemble an internal emotional pulse, while rigid transparent shells produced a harsher illumination that reduced subtlety. This stage yielded an important insight: grief is not effectively represented through harsh or mechanical light patterns; it requires gentle, breathing-like illumination. Additionally, the prototype raised ethical considerations, as red warning lights could potentially amplify stress or shame, making the wearer feel monitored or corrected during private moments of grief. This concern echoes broader critiques of biofeedback systems that may unintentionally impose corrective emotional norms (McDuff & Czerwinski, 2018).

In the second stage, the feedback system was expanded into wearable masks created through plaster casting. These masks examined how various levels of facial concealment influence emotional experience. Research on facial occlusion suggests that partial concealment can generate feelings of safety and reduced social exposure, while full concealment may evoke claustrophobia or distress (Krekula et al., 2022). The core physiological logic remained consistent: elevated heart rate activated red light and box breathing, while calmer states activated green light. Material choices included plaster, PLA, TPU, medical bandages, lightweight fibers, and metal armatures. The coolness, hardness, and weight of plaster created a physically intense and sometimes oppressive feeling of concealment. Different coverage levels such as half face, eye area, or upper face elicited distinct emotional responses. Through self-testing, I found that partial masking provided a sense of retreat and temporary invisibility, whereas full masks often induced discomfort or claustrophobia. Limitations of this form became evident, including weight, rigidity, low comfort, and a lack of dynamic responsiveness, indicating a need to explore forms capable of expressing emotion through movement rather than fixed structures. This aligns with findings in wearable affective interface design showing that movement-based expression fosters relational and emotional interpretation more effectively than static forms (Gonzalez et al., 2020).

Consequently, in the third stage, a feather-based headpiece was introduced to incorporate heart rate sensing with mechanical motion. When the wearer's heart rate exceeded certain level range, the feathered wings gently closed inward, symbolizing protection and creating a temporary emotional refuge. This design draws on research showing that slow, soft movements are perceived as calming and supportive, while rapid movements may be interpreted as startling

or threatening (Fattal et al., 2022). Material investigations shifted toward lightweight, meaningful materials such as feathers, flexible wire, soft supports, and comfortable headbands. Feathers, with their associations of embrace, nesting, and gentle cover, provided a calming and less intrusive form of contact compared to rigid materials. As the wings moved gradually toward the face, I perceived this tactile gesture as protective through my own bodily experience. This motion also conveyed a social signal indicating the wearer was grieving and needed time and space. Extensive testing refined the movement's speed, angle, and extent to ensure comfort without causing pressure or discomfort. This prototype transformed the device from a static physiological indicator into a dynamic structure capable of holding and expressing emotional experiences, echoing the idea that wearables can serve as expressive companions rather than monitoring tools (Rapp & Tirabeni, 2021).

Collectively, these three stages outline an evolving process from visualizing physiological signals to creating wearable emotional interfaces and ultimately developing action-oriented protective forms. Every material experiment whether related to light diffusion, the weight and temperature of plaster, the softness of feathers, or the pacing of mechanical motion contributed to deepening the understanding of new relationships between the body and emotion. Through these iterative processes, abstract experiences such as grief, vulnerability, retreat, and the need for protection became tangible and materially embodied. This approach reflects recent findings that iterative material engagement enables designers to surface tacit emotional knowledge that would otherwise remain unarticulated (Loke & Robertson, 2021).

Self-testing and embodied reflection

Self-testing and embodied reflection are important components of this research because understanding the emotional and physiological experiences at the core of this project requires direct engagement with the prototypes. As Höök (2018) argues, designers access emotional meaning "through lived, bodily engagement rather than detached analysis," and Loke and Robertson (2021) similarly emphasize that first-person methods are essential for accessing tacit and somatic forms of knowledge. Since the work addresses themes such as grief, vulnerability, the need for protection, and bodily responses to emotional stress, it is helpful for the designer to serve as the initial user and observe how the body responds in real-life situations involving

stress, grief, or calm. Through repeated testing sessions, I evaluated not only the technical functionality of each prototype but also the sensory and emotional responses that emerged during use. Each prototype was worn repeatedly over multiple sessions ranging from several minutes to over one hour, across a period of several weeks. All sessions were recorded in a design log that included timestamps, contextual notes, bodily sensations, emotional responses, photographs, videos, and sensor data. This approach helped to deepen the understanding of how each design interacts with the body as a lived and feeling experience, rather than simply as a neutral testing surface.

During *Breathing heart* testing, I paid close attention to how different light patterns influenced my emotional state. Research shows that red light increases physiological arousal and tension (Knez & Niedenthal, 2008), which helps explain why, when my heart rate naturally increased above 100 beats per minute during everyday situations such as walking, time pressure, or emotionally charged moments, and a red warning light appeared, it prompted a complex emotional reaction. The light indicated physiological arousal but also evoked feelings of exposure and self-criticism, especially during moments of grief when emotional privacy can feel delicate. Conversely, the box breathing rhythm provided brief moments of grounding, aligning with findings that paced breathing effectively downregulates sympathetic activation (Khazan, 2019). These experiences highlighted that emotional feedback should not be purely functional; it needs to be gentle, non-intrusive, and respectful of the user's inner state. The red-light response also raised an ethical consideration, as it has the potential to heighten stress rather than assist with emotional regulation.

Self-testing with Prototype 2 offered insight into how the body responds when the face is partially or fully concealed. Testing was conducted over approximately two weeks. With individual sessions lasted between twenty minutes and one hour. These sessions took place both in private studio settings and in semi-public environments such as walking outdoors or sitting in shared indoor spaces. During each session, I attended to physical comfort, breath restriction, thermal sensation, emotional safety, perceived social exposure, and bodily tension. Reflections were recorded immediately after wearing through written notes and visual documentation. Research on facial occlusion indicate that concealment shifts perceptions of safety, social exposure, and vulnerability (Carbon & Serrano, 2022). Wearing plaster-based masks allowed me to explore how factors like weight, temperature, rigidity, and tactile pressure influence emotional

experience. Partial concealment created a sense of retreat and temporary invisibility, whereas full concealment often resulted in discomfort or claustrophobia, reflecting research showing that excessive occlusion can intensify psychological distress (Krekula et al., 2022). These embodied reactions demonstrated that grief involves a balance between privacy and openness. Masks that are too heavy or restrictive may not foster a sense of emotional safety. My reflections at this stage emphasize the importance of materials that are soft, breathable, and considerate of the psychological effects of face concealment or exposure during vulnerable moments.

Prototype 3 extended this investigation by introducing movement as a primary mode of emotional expression. Prior research indicates that slow, continuous movement is commonly perceived as calming and supportive, while abrupt motion may be experienced as threatening (Fattal et al., 2022). Gentle tactile engagement has similarly been shown to support parasympathetic calming responses (Cascio et al., 2019). Following the completion of a functional winged headpiece prototype, I conducted first-person self-testing sessions to examine how gradual inward wing movement influenced bodily sensation and emotional response. Earlier cardboard-based iterations were worn to test scale, enclosure, and movement range before final material fabrication. Wearing the feathered headpiece revealed that slow inward movement around the face generated a sense of protection that had been absent in earlier prototypes. The tactile presence of feathers was experienced as lightweight, warm, and non-intrusive, contributing to feelings of comfort and care. Embodied reflection demonstrated that the emotional meaning of the device was strongly shaped by the quality of motion. Slow, restrained movement felt respectful and supportive, whereas faster movement produced tension and discomfort. Repeated trials enabled refinement of movement speed, angle, and closing range to support emotional grounding without introducing pressure or visual obstruction. In addition to its internal effects, the closing wings functioned as a subtle social cue, communicating a need for space without verbal explanation and establishing both internal emotional boundaries and interpersonal distance.

Throughout the study, all self-testing sessions were documented through written reflections, photographs, videos, and sensor recordings. This aligns with Schön's (1983) concept of "reflection-in-action," in which understanding develops through iterative engagement with a material situation. These materials created an ongoing reflective cycle in which bodily sensations, emotional responses, and material qualities were continually compared and

interpreted. This process revealed aspects of grief and stress that cannot be fully grasped through quantitative data alone. It also demonstrated how different textures, temperatures, and movements can either soothe or intensify emotional experiences. Through embodied reflection, the prototypes served as tools guiding the development process, with the body acting as an active source of insight and understanding.

Chapter 4: Prototype

Chapter Overview

A structured diagram showing the progression from hypothesis to research question and prototype development. It illustrates how physiological data, emotional responses, and material experimentation inform three stages of wearable design exploration.

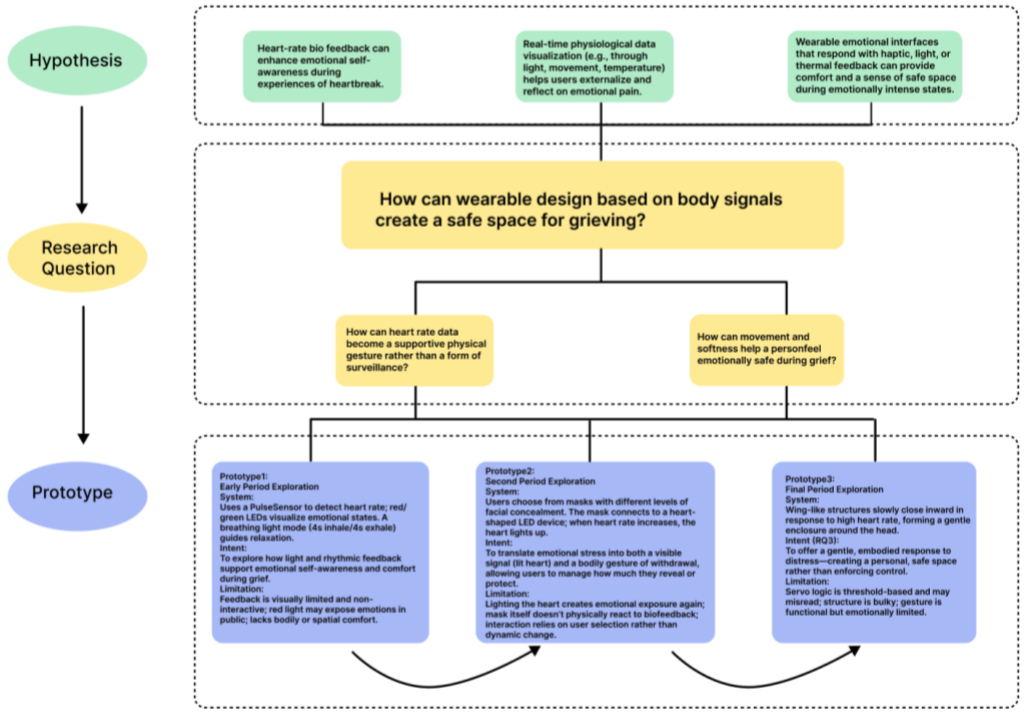

Figure 5. Research-through-Design Structure Connecting Hypothesis, Research Questions, and Iterative Prototypes.

This chapter walks through how the research was put together and shows how the methods introduced in the previous chapter—Research through Design (RtD), embodied reflection, material-led inquiry, and biofeedback-based experimentation—were applied in the development of three major prototypes. The use of Research through Design (RtD) in this project is grounded in its capacity to generate knowledge through iterative making, testing, and reflection. Rather than aiming to produce generalizable or statistically validated findings, this approach prioritizes situated, embodied insight that emerges through direct engagement with materials, prototypes, and lived experience. Within this framework, I position myself as the primary participant, adopting a first-person methodology informed by soma design practices (Höök, 2018). This

decision enables close attention to subtle physiological and emotional responses that are difficult to access through external observation alone. At the same time, this approach introduces important limitations. The findings are inherently subjective and cannot be generalized beyond the specific conditions of this study. Instead, they should be understood as exploratory and indicative, offering insight into how wearable systems might be designed to support emotional experience.

From an ethical perspective, the use of self-testing avoids risks associated with involving external participants in emotionally sensitive contexts such as grief. However, it also requires careful reflection on the boundaries of personal experience and its role in informing design knowledge. As such, this research does not claim universal applicability, but contributes a situated, practice-based understanding of how bodily signals, materials, and movement can be configured to create a sense of emotional safety.

While the earlier literature review mapped out the conceptual foundations of the project, including how grief manifests physically, how affective computing makes invisible emotional states perceivable, how biofeedback supports emotional self-awareness, and how wearable objects communicate feelings without words, this chapter moves from theory into situated practice. Following Zimmerman et al. (2007, 2010) and Gaver (2012), each act of making is treated not only as a technical step but as a knowledge-producing activity that surfaces new questions, tensions, and possibilities.

Across the research process, each prototype is guided by the central research questions established earlier and connected to the theoretical issues identified in the preceding chapters. Rather than addressing all design challenges at once, the investigation is structured into interconnected lines of inquiry that examine the role of physiological signals in expressing emotional states, the use of partial facial concealment as a means of protection and withdrawal, and the capacity of gentle, device-driven movements—such as the inward closing motion of the feathered headpiece—to function as non-verbal forms of emotional communication. These prototypes are not treated as incremental steps toward a singular final artifact, but as situated experiments that test hypotheses, expose limitations, and redirect the next phase of inquiry.

The chapter is therefore organized around three prototype stages (1 and 2 completed), each involving multiple rounds of refinement in both materials and conceptual framing. For each

prototype, the discussion begins with the research question that anchors its development, then outlines the theoretical ideas the iteration aimed to probe—such as embodied emotional cues, symbolic acts of concealment, or how movement-based responses can influence one's felt experience. The chapter then examines how design decisions concerning materials, fabrication processes, sensor integration, and interactive behaviours shaped the evolution of the prototypes from simple physiological visualizations into expressive, protective, and emotionally meaningful wearable interfaces.

Prototype 1: Breathing heart——Light-Based Biofeedback Exploration

Breathing heart marks the transition from theoretical inquiry to material exploration. It focuses on how heart rate can be translated into light-based feedback to support emotional awareness and provide a sense of grounding during grief. Rather than re-establishing the broader theoretical framework, this phase centers on testing how physiological signals might be externalized through form, color, and rhythm.

Figure 6. *Breathing heart:* heart-shaped LED module with integrated heart rate sensing.

Breathing heart takes the form of a sculpted, heart-shaped LED module connected to a heart rate sensor (Figure 6).

Figure 7. Material exploration and shaping process using air-dry stone clay.

The outer shell was constructed using air-dry stone clay, a material selected through iterative testing (Figure 7). Early experiments with wire frameworks, cardboard, and other lightweight materials proved insufficient in structural stability or aesthetic coherence. These materials either failed to securely hold the LED strip and sensor or did not provide a smooth and symbolically appropriate surface. As a small, installation-like object intended to be held, the "heart" needed to feel tactile and grounded, allowing it to be cradled in the hands and brought close to the body. Stone clay offered the most suitable balance. When moist, it allowed for precise shaping and adjustment of complex curves. Once dried, it provided enough strength to protect the electronics while remaining relatively lightweight. Its matte surface diffused the LED light, producing a softer and more muted glow compared to rigid or glossy materials, which often felt harsh or clinical. The material therefore contributed not only to structural performance but also to the emotional tone of the interaction.

Figure 8. Light behavior sequence: red alert, transition to breathing rhythm, and steady green state.

Using Arduino, the system detected heart rate in real time and translated it into two light behaviors. When my heart rate exceeded 100 BPM during testing, the LEDs flashed red for three seconds before transitioning into a box-breathing light pattern designed to guide respiration and support a gradual return to a calmer state. When the heart rate remained stable, the device emitted a continuous, soft green glow (Figure 8). In this configuration, light functioned both as a representation of internal physiological change and as a patterned prompt intended to support breathing.

Testing focused on how variations in brightness, rhythm, and color influenced emotional perception. Brighter and more intense light created a sense of exposure, as if internal states were being revealed or emphasized. Dimmer and slower light felt more inward and contemplative. Rapid flashing increased tension and agitation, while slower pulsating rhythms were perceived as calmer and more supportive. These observations are consistent with prior work on rhythmic visual stimuli and emotional response (Larsen et al., 2009; Kaya & Epps, 2004), but here they are explored specifically in relation to grief.

Figure 9. Transparent fabric with beats

Material experiments further examined how light behaves when diffused through different surfaces. Semi-translucent fabrics, wool yarn, felt, silicone, and clear plastics were tested. Soft, fibrous materials diffused the light and produced a sensation similar to an internal pulse, while rigid transparent materials made the light appear more mechanical and medicalized (Figure 9). These findings align with somaesthetic approaches that emphasize how material qualities such as softness and texture shape embodied experience (Höök, 2018).

Through self-testing, it became clear that biofeedback is not neutral. When elevated heart rate triggered red flashing light, the response often produced feelings of tension, exposure, and subtle judgment. Rather than offering comfort, the feedback risked framing emotional intensity as something to be corrected. This reflects critiques of biofeedback systems that reinforce self-monitoring and emotional regulation as normative goals (Ruckenstein & Schüll, 2017).

In this prototype, breathing was intentionally incorporated through a box-breathing light pattern as a way to connect visual feedback with physiological regulation. However, testing revealed important limitations. The pacing of the light was difficult to follow consistently, particularly during moments of emotional distress, when attention and bodily control were already compromised. Synchronizing breathing with an external visual cue introduced a sense of effort and misalignment, rather than ease.

This limitation suggests that not all physiological interventions translate effectively into embodied design contexts. As a result, breathing was not carried forward as a primary interaction mechanism in later prototypes. Instead, the design direction shifted toward more passive forms of support that do not require active user participation.

Breathing heart also revealed broader limitations. As an external object, it lacked the intimacy of wearable systems positioned close to the body. Its threshold-based logic simplified the fluctuating nature of grief, and light alone could not provide tactile qualities such as weight or containment. These findings prompted a shift toward exploring facial interfaces and protective structures in the next stage of the research.

Prototype 2：Rigid shell——Exploring Emotional Withdrawal Through Mask-Based Wearables

Rigid shell builds directly on the limitations identified in *Breathing heart* and shifts the focus from light-based expression to the face as a site of emotional exposure. Rather than using light to externalize internal states, this phase explores how different forms of facial concealment can create psychological distance and support emotional withdrawal during grief. To investigate this, I developed a series of masks using a range of materials, coverage levels, and tactile qualities. Each mask was paired with the same heart-rate feedback system used in *Breathing heart*, allowing me to examine how facial interfaces interact with physiological signals in emotionally intense situations.

Figure 10. Rigid shell in SPARK

The process began with a plaster bandage cast taken directly from my face to ensure an accurate fit. This shifted the mask from an external object to a body interface that sits in direct contact with the skin. However, wearing the initial plaster cast immediately revealed significant discomfort. The weight, hardness, and cold surface pressing against the cheeks and forehead created a strong sense of physical burden. These sensations were not neutral. They intensified feelings of compression and restriction, echoing the inward, suffocating qualities often associated with grief. This made it clear that materiality plays an active role in shaping emotional experience, rather than simply serving as structural support. From this initial form, I developed multiple variations with different levels of coverage, including fully enclosed masks, half-face masks, upper and lower facial coverings, a cheek-wrapping form, and minimal frames around the eyes. I also created a lightweight openwork mask using silver wire and beads, introducing breathability and structural delicacy (Figure 10). These variations allowed me to explore how

different boundaries of concealment affect perception: whether the face is blocked, filtered, or subtly reframed, and whether the wearer feels protected or further exposed.

Figure 11. 3D printing version for Rigid shell

As the forms developed, I expanded into digital fabrication to explore more precise and repeatable structures. I first created a plaster mold on a mannequin head to establish overall dimensions, then translated the form into a digital model in Rhino, which was used for 3D printing. The surface pattern was informed by historical mourning veils from early twentieth-century Western contexts, which used lace and netting to partially obscure the face while maintaining visibility (Figure 11). Rather than fully concealing identity, these veils functioned as filters that softened facial features and regulated emotional exposure in public space. In this project, this reference is used not for stylistic reproduction, but as a material strategy for negotiating visibility, presence, and emotional restraint.

Material testing during fabrication revealed further constraints. PLA produced clean results but felt rigid and uncomfortable against curved facial surfaces. TPU offered flexibility but presented significant technical challenges during printing, including support removal and surface damage. Adjustments to print orientation and post-processing were required to balance structural integrity with comfort.

To introduce softness and breathability, I experimented with fabric manipulation techniques inspired by shibori. Instead of using it as a dyeing method, I adapted its principles of binding and compression to create raised textile forms that hold air and volume. These structures introduced a soft buffer between the face and the external environment, reinforcing the idea of emotional separation without complete enclosure. Similarly, the wire structures underwent multiple iterations. Thick wire provided stability but lacked delicacy, while thin wire failed structurally. The final solution combined multiple thin wires twisted together into a lightweight, net-like framework that balanced strength and fragility.

Despite these variations, all masks retained the heart-rate feedback system from *Breathing heart*. A sensor clipped to the ear transmitted data to a small heart-shaped module worn adjacent to the mask. When my heart rate exceeded 100 BPM, the module flashed red and transitioned into a box-breathing light pattern. When stable, it emitted a soft green glow. Although separating the light from the face reduced direct exposure, the feedback remained perceptually intrusive. The breathing-based light pattern required attention and introduced a sense of obligation, while the red light continued to evoke feelings of being observed or flagged.

Self-testing highlighted how different forms of concealment shape emotional experience. Partial masks created a sense of psychological retreat, allowing a temporary withdrawal from social expectations without inducing discomfort. In contrast, fully enclosed masks often intensified bodily strain, producing heat buildup, pressure, and occasional claustrophobic sensations. These findings suggest that the protective function of concealment is highly sensitive to degree and material. Too much enclosure can become oppressive, while too little fails to provide sufficient emotional buffering.

The silver wire and beaded mask introduced a different form of interaction. Its openness allowed light and air to pass through, shifting the function of the mask from concealment to modulation. Rather than hiding the face, it softened the experience of being seen. The tactile qualities of cool metal and smooth beads reduced the heaviness associated with plaster, demonstrating that spatial structure alone can create a perceptual filter without full opacity.

Overall, *Rigid shell* demonstrates that material qualities such as weight, temperature, rigidity, and elasticity significantly shape emotional experience during grief. Within a facial

interface, physiological feedback becomes intertwined with touch, proximity, and bodily withdrawal, rather than functioning as purely visual information.

At the same time, several limitations emerged. Plaster-based structures are not suitable for long-term wear due to their weight and lack of breathability. More importantly, these masks remain static and cannot adapt to changes in emotional intensity. This points to a key requirement for the next phase of the research: a protective system must be capable of movement, allowing it to respond dynamically to shifts in the body.

These insights led to the development of Prototype 3, which explores how soft materials, feather structures, and controlled movement can create a responsive form of emotional protection that adjusts with changes in heart rate.

Prototype 3: Moving veil and Folding wings——Movement Based Protective Headpieces

Prototype 3 continues the exploration of emotional protection by shifting from static forms of concealment toward responsive movement. Grief is not an on and off condition. While *Rigid shell* examined how fixed facial coverings mediate visibility and withdrawal, this phase investigates how changing spatial boundaries around the body can provide adaptive forms of protection during fluctuating emotional states.

This change comes from earlier tests and personal observations. Grief is a state that surfaces, grows, and fades within the body. It is not a problem that needs a quick fix. This perspective is helpful for daily life. Many people must work or travel in public after a loss. In these moments, they cannot always show their feelings, but the feelings stay in the body. Prototype 3 creates a middle space. It helps the wearer stay part of society while keeping a safe distance for their emotions.

Prototype 3 includes two designs called *Moving veil* and *Folding wings*. Both use a five-level system to measure the intensity of grief. This system uses heart rate as a guide. It divides grief into five ranges. These ranges determine how the device moves. These levels are not labels for emotions. They simply describe how much emotional weight the body is carrying.

***Moving veil*: Vertical Movement Headpiece**

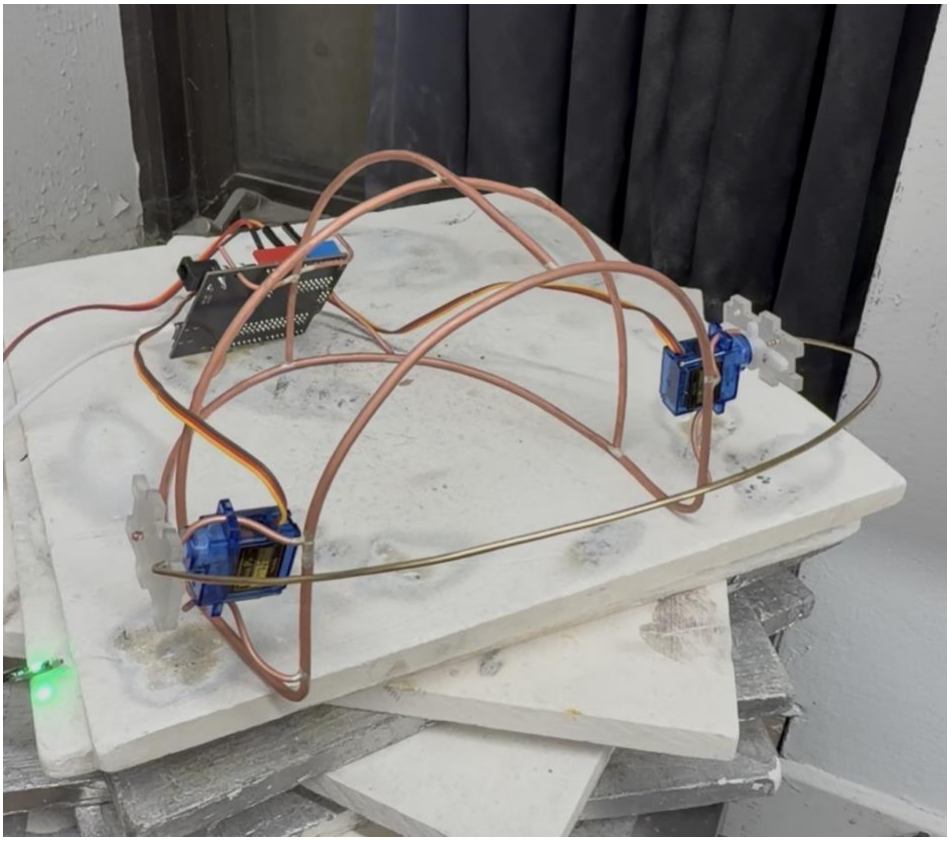

Figure 12. Copper wire structure of *Moving veil*

Moving veil uses slow vertical movement to show different levels of grief. The device has an arched wire frame above the head. A small motor moves a clear part of the frame up or down. It does not touch the face directly. Instead, it changes the space around the head. This creates a feeling of being shielded from the world.

This design is inspired by the history of mourning veils. In the past, these veils were not just for hiding. they were social signals. A person wearing a veil stayed in public, but the veil showed they needed space. It created a visual distance and told others not to interrupt. Prototype 3A turns this history into a modern tool. A sensor reads the heart rate and matches it to five levels. Each level moves the frame to a different height.

At the level corresponding to acceptance, as described in the grief framework proposed by Kübler-Ross and later expanded by Kessler, the heart rate is around 60 to 75 beats per minute.

This is close to a resting state. The emotional load is manageable, so the frame stays lifted. The device does not interfere much with the space.

Denial happens when the heart rate is between 75 and 85 beats per minute. The body feels pressure even if the mind has not noticed it yet. The device moves a very small amount as a first sign of protection.

Bargaining shows a heart rate of 85 to 95 beats per minute. This level involves internal back and forth thoughts. The structure contracts slightly but gently.

Anger raises the heart rate to 95 or 110 beats per minute. This is a high energy state. The device reacts clearly by lowering the frame to set a strong boundary.

Depression is different. The heart rate is between 70 and 85 beats per minute, but it does not change much. The body feels low on energy. The device moves into its strongest protective shape to hold and contain the wearer.

During testing, the slow downward movement changed how I stood. I lifted my head less and looked down more. My interaction with the world became softer. I did not have to leave the room. I could stay present without explaining my feelings. The device showed that protection does not always mean hiding the face. Changing the space around the face is enough to create a buffer.

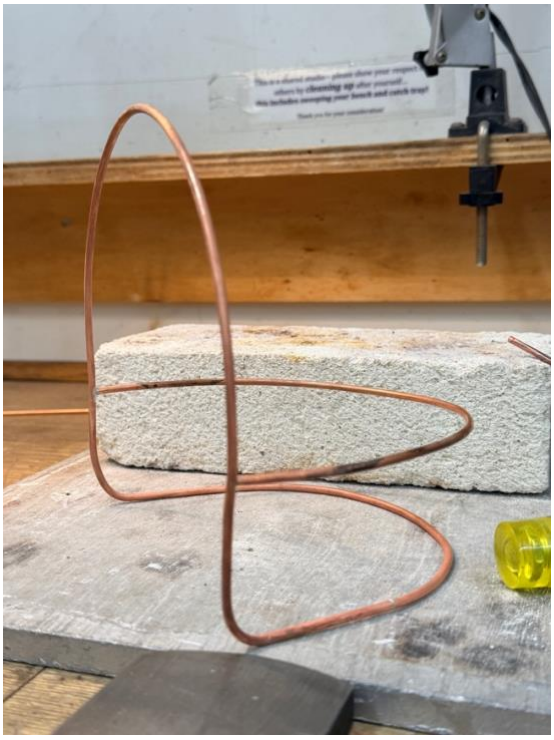

Figure 13. Initial copper wire structure of *Moving veil*

During the construction process, the structural framework of *Moving veil* was developed through iterative bending and adjustment of metal wire (see Figure 13). The initial form was created using a single continuous copper wire, shaped into an arched structure to establish the primary spatial boundary around the head. This early configuration was used to determine the overall proportions of the device and its spatial relationship to the body.

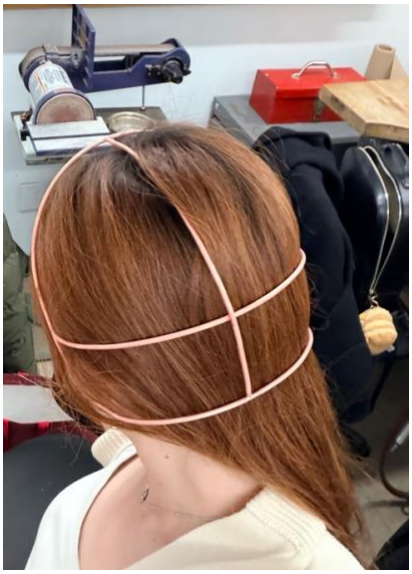

Figure 14. *Moving veil* structure worn on the body

As the design progressed, additional horizontal and vertical wire elements were introduced, transforming the structure from a simple outline into a more defined three-dimensional framework. When worn on the body (Figure 14), the structure forms an open enclosure around the head without making direct contact with the face. The curvature and positioning of each wire segment were carefully adjusted to follow the contours of the head, ensuring stability while maintaining a breathable and unobstructed spatial relationship between the device and the wearer.

This wire-based construction serves both structural and spatial functions. The rigidity of the metal provides necessary support for the overall form and potential movement mechanisms, while the open framework avoids full concealment. Instead of covering the head, it establishes a visible yet non-enclosed boundary that mediates the relationship between the wearer and the surrounding environment.

In the veil component, I aimed to recreate a sense of lightness, partial visibility, and subtle mystery through material and structure. To achieve this, I worked with lightweight fabrics and incorporated hand-formed volumetric structures inspired by *shibori*. Shibori is a traditional Japanese textile technique that involves binding, folding, or compressing fabric to create textured patterns and three-dimensional effects (Wada, Rice, & Barton, 2002). In this project, rather than using it as a dyeing method, I adapted shibori as a spatial construction strategy. By gathering and

shaping the fabric, I created small, raised protrusions across the surface, allowing the textile to hold volume and depth. These structures prevent the fabric from collapsing onto the face and instead establish a breathable and buffered interface between the body and the environment (Figure 15).

Figure 15. Shibori fabric

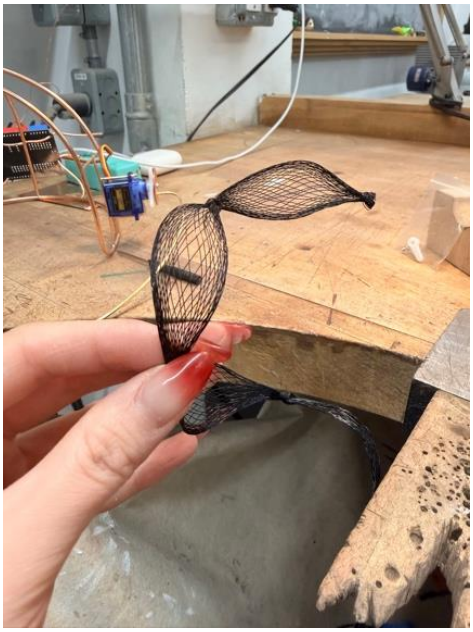

Figure 16. Metal mesh

To further support this spatial separation, I used curved brass wire to define the overall contour of the veil (Figure 16). The curvature of the wire frame naturally lifts the fabric away from the face, maintaining a consistent gap between the material and the skin. In addition, I employed extremely fine metal wires, which were woven and twisted into a mesh-like three-dimensional structure This lightweight framework provides both flexibility and stability, enabling the veil to maintain its form while remaining responsive and delicate.

Figure 17. Victorian mourning hat with layered fabric and feather elements, illustrating historical approaches to concealment and emotional signaling.

https://rebeccashedd.com/2021/09/10/the-writers-guide-to-1890s-womens-fashion/

Feather elements were also introduced into the design. This decision was informed by references to Victorian mourning attire, where veils were often constructed from layered lightweight fabrics and occasionally incorporated feathers to mediate between concealment and visibility. In these historical contexts, the veil functioned not only as a covering but also as a social signal of grief (Figure 17), allowing individuals to communicate emotional states and maintain distance within public space (BillionGraves, n.d.). Drawing from this reference, the integration of feathers in this prototype contributes to a soft, diffused boundary that balances exposure and protection.

***Folding wings*: Wing Based Headpiece**

Figure 18. Copper wire structure of *Folding wings*

Folding wings uses the same logic but moves sideways. It has two wing structures on the sides of the head. These wings open and close horizontally.

In human behavior, moving inward is a sign of protection. People naturally lower their heads or pull in their shoulders when they feel vulnerable. These are not acts for an audience. They are real responses to pressure. *Folding wings* turns this body language into a mechanical movement.

This device also uses heart rate to control the wings. When the heart rate is low, the wings stay open. As the heart rate goes up, the wings move inward. At high intensity, the wings close further to provide strong spatial protection. The speed of the movement is very important. Fast movement causes tension. Slow and steady motion feels safe. Because of this, the wings move at a pace that matches breathing or a gradual heart rate change. The device acts like a companion that responds to the body.

The five-level system shows that grief is a bodily experience. It is gradual and it comes in waves. These levels are not steps to finish. They are measures of emotional weight. Both prototypes follow one core rule. As emotional intensity rises, protection increases. As the body becomes stable, the space opens again. This allows a person to be in public without justifying their feelings. The devices make grief visible in a way that is not exposed.

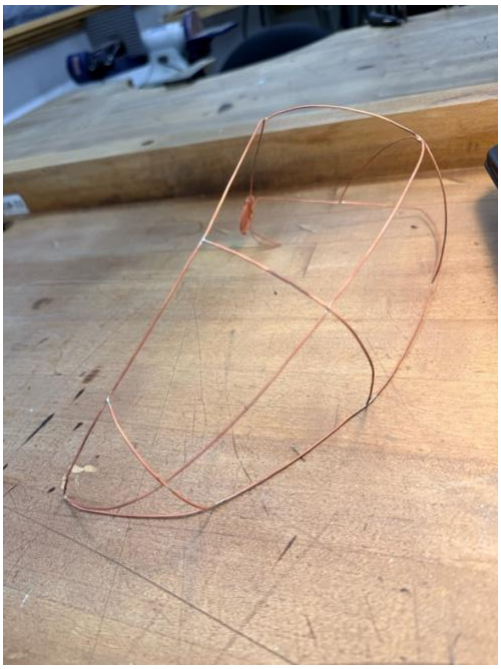

Figure 19. Copper wire wing structure of *Folding wings*

The wing structure of *Folding wings* is primarily constructed using copper wire with a diameter of approximately 1 mm (see Figure 19). Through multiple iterations, this material was found to provide an effective balance between flexibility and structural strength. However, due to the relatively large span of the wings and the additional weight introduced by the attached feathers, the connection points became a critical aspect of the design.

Figure 20. Hammered copper plate used as a connection and reinforcement element for the wing structure.

In early experiments, lightweight materials such as plastic and acrylic were tested as connection components. While these materials were easy to fabricate, they proved insufficient under load, as they tended to deform and failed to provide stable support. Through further testing, I replaced these components with a hammered copper plate and soldered the wire structure directly onto it (see Figure 20). This approach significantly improved structural stability. The textured surface of the hammered copper also enhanced load distribution, resulting in a more secure connection.

The positioning of the connection point was also iteratively refined. Initially, the joint was placed at the top of the wing structure, but this caused the wings to tilt inward under gravity, leading to instability. After testing, the connection point was relocated toward the middle of the wing, slightly below its center. This adjustment allowed for a more balanced distribution of force, improving both stability and the smoothness of movement.

After completing the soldering and polishing of the structure, a layer of black nylon stocking was stretched over the metal framework. This layer provided a continuous surface that allowed feathers to adhere more securely, while also visually softening the presence of the metal structure.

For the feather application, approximately eight different types of feathers were selected, varying in size, density, and texture. The feathers were applied in layers to gradually build volume and depth across the surface. Some feathers were used in their original form, while others were manually trimmed to refine their edges, creating a softer and more cohesive “fluffy” appearance. This process not only enhanced the volumetric quality of the piece but also contributed to a richer sense of movement when the structure is in motion.

Figure 21. Rebecca Horn, Cockatoo Mask (1973)

https://agora.ifa.de/en/work/cockatoo-mask-from-the-movie-performances-ii-148045

The development of *Folding wings* is also informed by the work of Rebecca Horn, particularly her *Cockatoo Mask* (Figure 21). In this piece, feathers are integrated into a wearable structure that opens and closes in response to bodily movement, establishing a dynamic relationship between concealment and exposure. Horn’s work demonstrates how the body can be extended and reconfigured through material systems, creating tension between protection and expression. This approach is reflected in Prototype 3B, where the wing structures similarly function as extensions of the body, translating internal emotional states into spatial gestures that are perceptible without being overtly exposed.

Chapter 5: Results and Reflection

This chapter presents the outcomes of the wearable prototypes through on-body testing and reflective observation. Rather than repeating the design and fabrication process, the focus here is on how the devices perform when worn, and how structure, material, and movement collectively shape emotional experience.

The results are documented through photographs and reflective notes, capturing both the physical behavior of the devices and the sensations that emerge through bodily interaction.

5.1 Moving veil: Vertical Spatial Modulation

Through self-testing of *Moving veil*, I observed that vertical movement can subtly influence bodily posture and perception. As the structure gradually moved downward, it naturally guided my head to lower. The veil reduced outward visual engagement while also making it more difficult for others to clearly ready facial expression.

When worn, the structure did not fully obstruct vision. Instead, it altered the spatial relationship between the face and the surrounding environment. This created a state of partial withdrawal, allowing me to remain present while shifting into a more inward mode of perception.

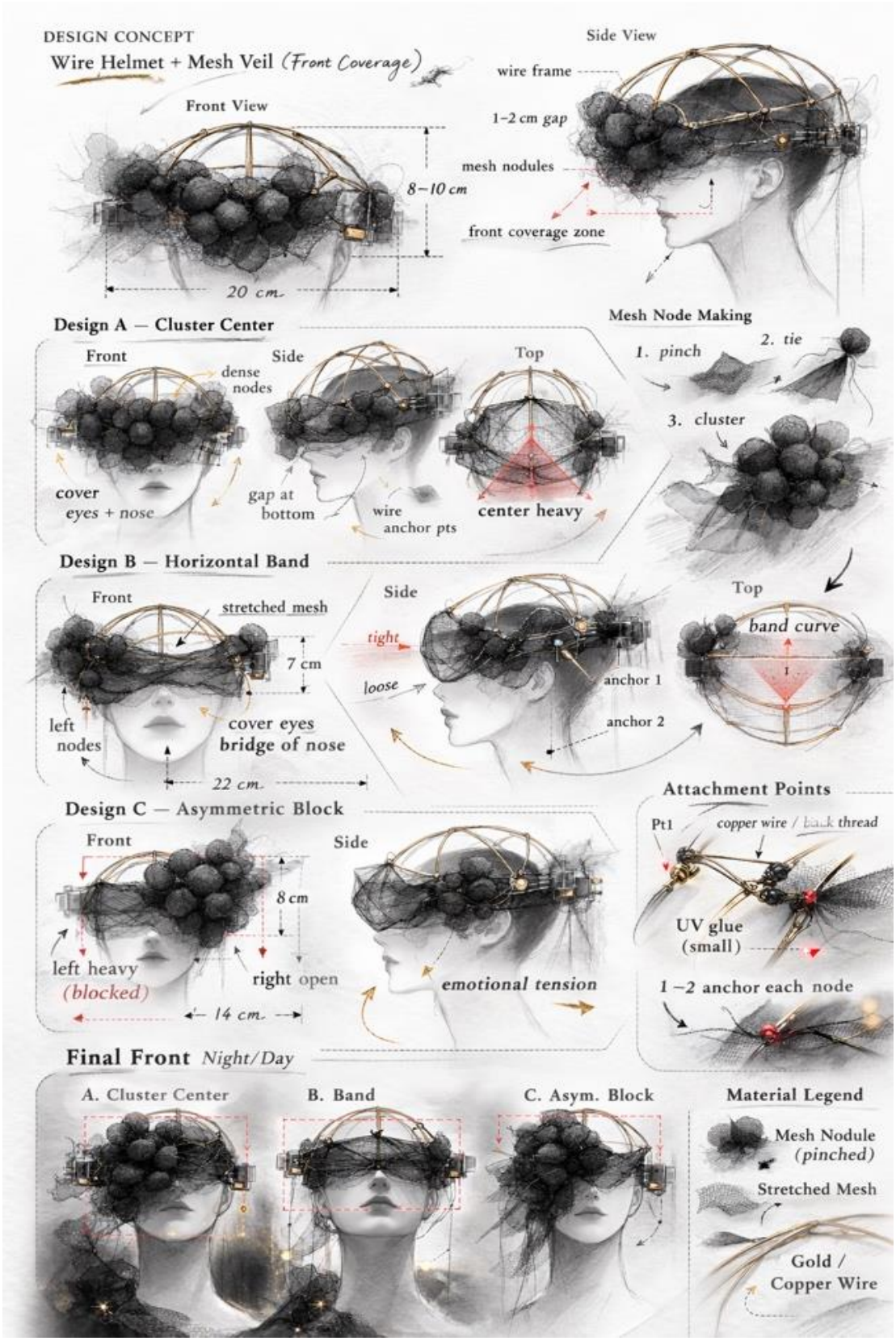

Figure 22. *Moving veil* design sketches

Figure 23. *Folding wing* design sketches

Figure 24. Broken visual effect of veil

In an earlier version of the design, I experimented with adding shibori-based bubble textures on both sides of the veil to connect the central translucent fabric. These elements were intended to express a sense of fragmentation associated with heartbreak. I also introduced irregular burnt and cut patterns into layered fabric to create a broken visual effect (Figure 23). However, the result appeared visually chaotic, and the copper wire structure became overly prominent (Figure 25). Additionally, the motors struggled to lift the front veil due to insufficient torque.

Figure 25. Open version

Figure 26. Close version

In response, I replaced the original motors (SG90) with MS90 motors, which are slightly larger but capable of supporting greater weight. I also restructured the veil by attaching the copper wire framework to the lower edge and layering a netted fabric over a softer, filament-like veil. This adjustment improved both visual coherence and structural stability. Extending the veil upward and securing it to the head structure also provided additional support for the motors (Figure 26).

Figure 27. Final version of *Moving Veil*

This suggests that subtle spatial modulation can influence perception without requiring full concealment, allowing emotional withdrawal to occur in a gradual and non-disruptive way.

5.2 Folding wing: Lateral Enclosure and Wing Movement

When I am wearing *Folding wing*, the inward movement of the wings created a sense of enclosure. This experience closely resembled natural protective gestures of the body during moments of vulnerability. As the wings closed, the space around the head became more contained, but without producing pressure or restriction. Instead, it felt as though the head was being gently held.

Structural stability played a critical role in shaping this experience. After reinforcement, the wings were able to support the weight of the layered feathers while maintaining smooth and controlled movement. This allowed the enclosure to feel continuous and stable, strengthening the sense of protection.

Figure 28. Final version of *Folding wing*

The addition of feathers further transformed the perception of the structure. The layered feather surface softened the presence of the metal framework, creating a more diffused boundary. Compared to rigid forms of concealment, this approach resulted in a softer and more permeable spatial condition (Figure 27).

This indicates that protection in this context is not produced through rigid boundaries, but through soft and adaptive spatial conditions that respond to the body.

5.3 Movement and Temporal Experience

Across both prototypes, movement emerged as a key factor influencing experience. The speed and rhythm of motion directly affected how the devices were perceived. Slow and continuous movement was experienced as stable and supportive, allowing the body to gradually adapt to changes. In contrast, fast or abrupt movement disrupted this rhythm and introduced tension.

Unlike the earlier light-based feedback, movement did not require focused attention. It operated at the periphery of awareness, allowing me to remain engaged with my surroundings while still sensing the presence of the device. These observations suggest that temporal qualities, such as speed and continuity, are central to how emotional support is perceived in wearable systems.

5.4 Spatial Protection

The results suggest that protection is not achieved through concealment alone, but through spatial modulation. In *Moving veil*, protection emerged through subtle vertical shifts that influenced posture and visual orientation. In *Folding wing*, lateral movement created a more defined spatial boundary around the head.

These spatial adjustments allowed emotional states to be held rather than displayed. It became possible to remain in public space while maintaining a degree of separation from external attention.

This points to a shift from concealment toward spatial mediation, where protection is achieved through adjusting proximity rather than removing visibility entirely.

5.5 Material Experience

Material qualities also played an important role in shaping the results. A contrast emerged between the rigid metal structure and the softness of feathers and fabric. The metal provided structural support and enabled movement, while the feathers introduced lightness and softness, preventing the device from feeling harsh or restrictive. The layered combination of feathers and fabric increased the thickness of the spatial boundary, making it feel more diffused and less abrupt.

This combination allowed the device to maintain a strong presence without overwhelming the body.

This suggests that material softness and permeability play a crucial role in shaping emotional comfort and bodily acceptance.

5.6 Exhibition Documentation and Defense reflection

The project was presented as a small installation that brings together the wearable pieces, design process, and moving image in the same space. It shows not only the final outcomes, but also how the work was developed.

The two headpieces were placed on white plinths in the center of the space, each mounted on a mannequin head. The plinths were set at slightly different heights, allowing viewers to approach the pieces from different angles, while also highlighting their relationship as part of the same system.

On the left side, a large poster introduced the project title *Let the Heart Break* along with its overall concept. Behind the pieces, two display boards presented sketches, structural explorations, and different stages of the design process. This made the development of the work more visible, so the pieces could be understood not only as final objects, but as part of an ongoing process.

On the right side, a monitor showed photos footage of the pieces being worn. This helped communicate aspects that are difficult to capture through static display, especially how the pieces move and interact with the body.

The layout encouraged viewers to move around the installation, observe the work from different perspectives, and shift between reading the process materials and watching the video. This allowed the work to be experienced both as physical objects and in relation to the body.

During the exhibition, many viewers were drawn to the material and structure of the pieces, especially the feathers and their overall scale. Some described a sense of enclosure or protection, while others focused on how the pieces change over time. These responses suggest that the work is not only understood visually, but also through imagined bodily experience.

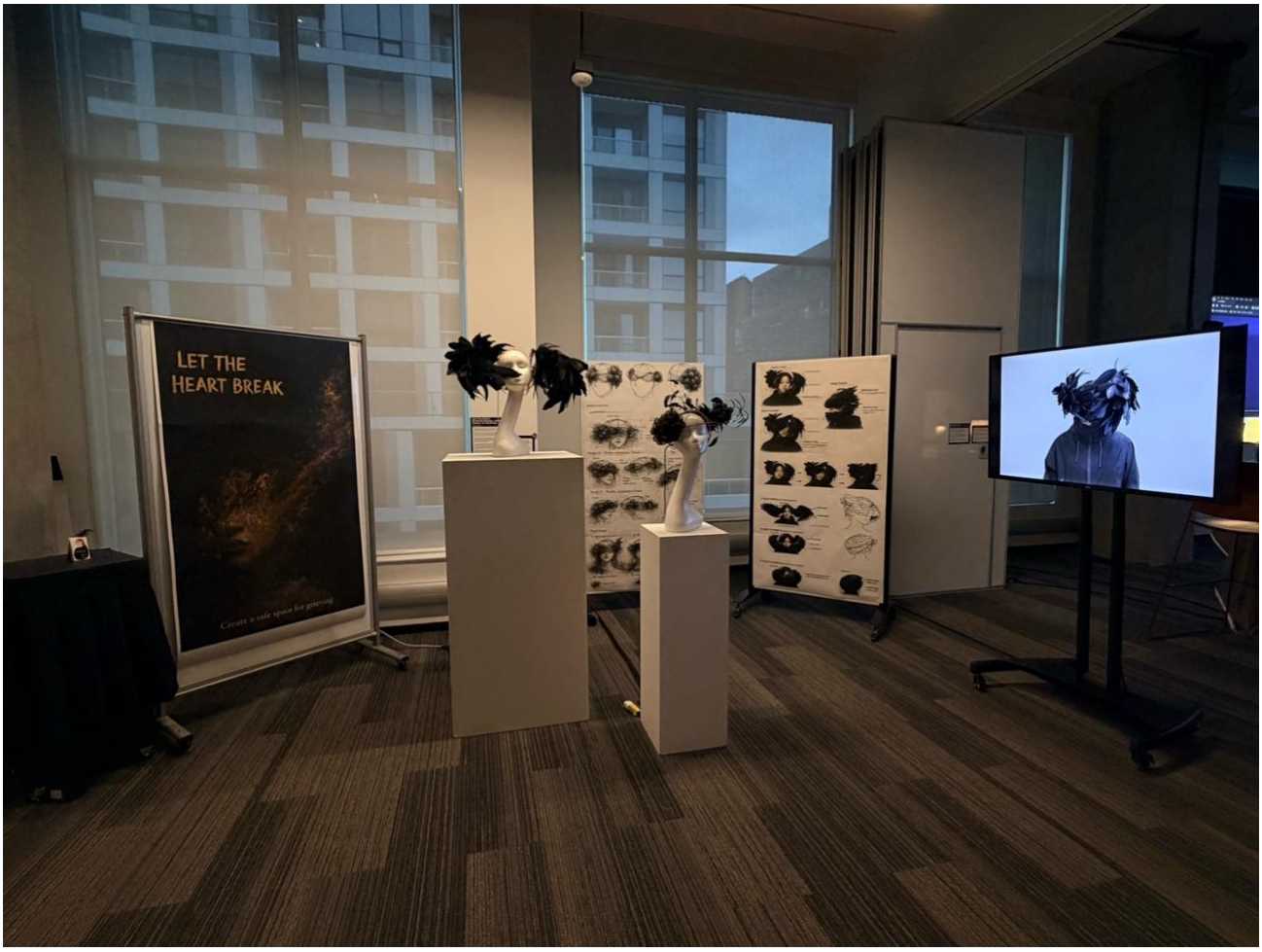

Figure 29. Exhibition view

Figure 30. Installation details

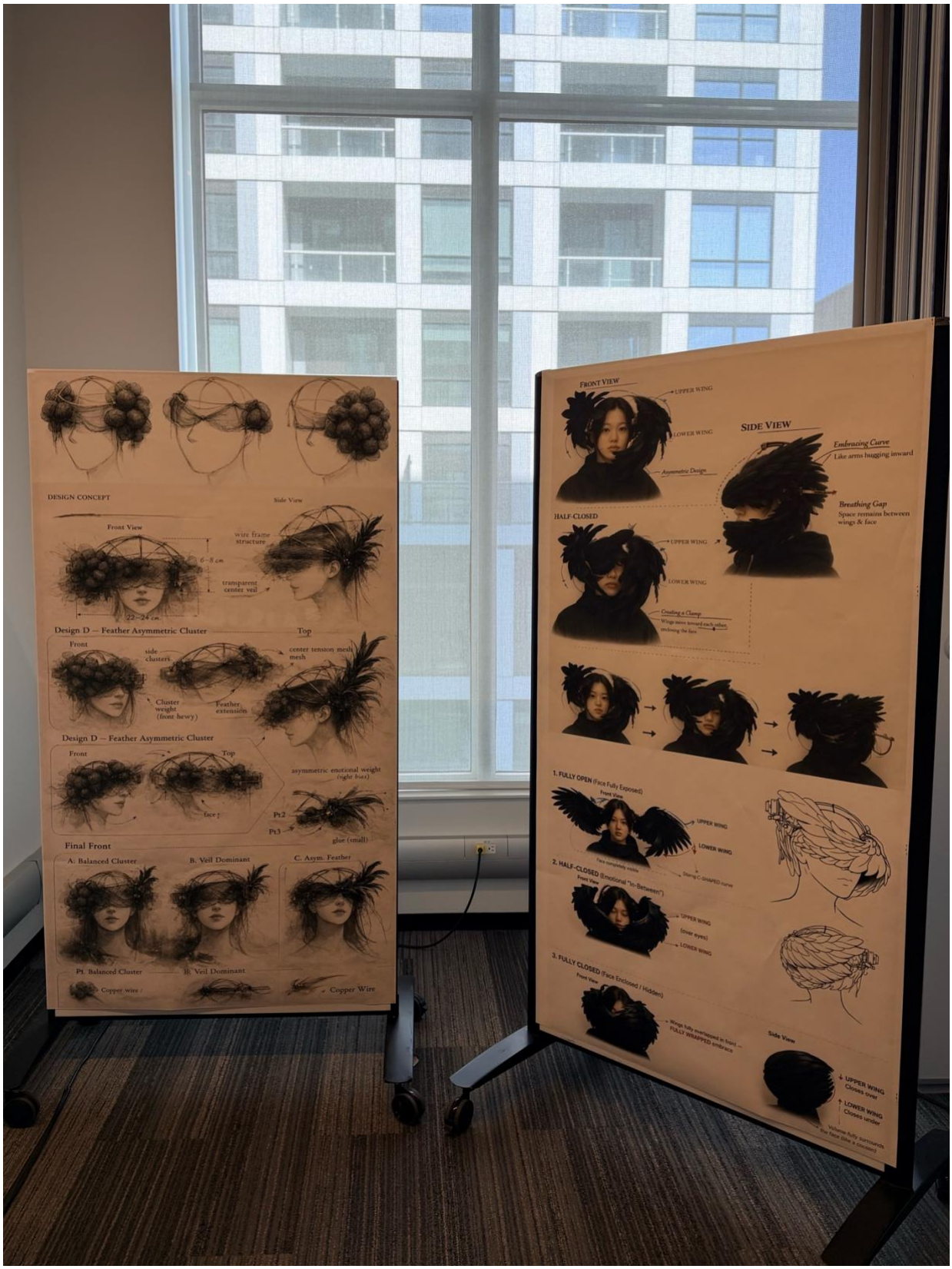

Figure 31. Installation details

Figure 32. Business cards

Following the defense, the committee identified two main areas for revision: reflection and limitations. The feedback highlighted several themes that emerged during the discussion, particularly around the complexities and tensions within the design. Some of these points were not fully addressed at the time, but they revealed important aspects of how the work operates and how it can be understood.

Rather than treating these tensions as problems, they are considered here as part of working with grief as a multifaceted and sometimes contradictory experience. This section reflects on those discussions and uses them to further clarify the position of the project. The reflection is organized into five key points that respond directly to the questions raised during the defense.

5.6.1 Protection and Spectacle

This project engages with a tension between protection and visibility. The wearable pieces are not intended to hide the body completely, but to create a boundary between the wearer and the surrounding environment. This boundary allows the wearer to step back into a more internal space and to hold their emotional state without being fully exposed to others.

In this context, protection is not about disappearing. Instead, it is about creating a distance. The wearer remains present in a public space but is no longer fully open to it. This distance provides a kind of buffer that supports emotional experience, making it possible to stay within one's own state while still being in a shared environment.

At the same time, the pieces are visually noticeable. Their form, structure, and movement make them present and perceptible to others. This visibility is not treated as a contradiction, but as part of the design intention. When seen, the pieces communicate something without requiring explanation. They suggest that the wearer is in a certain emotional condition and may need space rather than interaction.

Being visible in this way does not mean being exposed. It allows for a controlled presence, where the wearer can be perceived without needing to engage. This creates a subtle shift in how others relate to the body, opening the possibility for recognition without intrusion.

Rather than resolving the tension between protection and visibility, the project holds both at the same time. Grief is not a single state, but a complex experience that includes both withdrawal and the need to be understood. The work reflects this condition by allowing the body to remain present while still maintaining a sense of boundary.

5.6.2 Engagement with Histories and Cultures of Mourning

This project does not aim to represent mourning practices across all cultures, but instead works with selected references that can be translated into design. In particular, it draws on Western mourning traditions such as the mourning veil, which regulates visibility and shapes how the body is perceived in public space. These references are closely connected to the body, material, and wearable form. The veil is not only symbolic, but also spatial. It creates a layer between the face and the outside world, changing both how the body is seen and how it relates to

others. This aligns with the focus of the project, which is to translate emotional states into a form of spatial boundary around the body.

During the defense, one question that came up was why, as a Chinese designer, I did not work more directly with East Asian mourning traditions. This led me to reflect more carefully on how mourning is expressed differently across cultures.

In many East Asian contexts, grief is not primarily expressed through wearable forms, but through rituals, behaviors, and social practices. In Chinese culture, for example, mourning often involves practices such as keeping vigil, burning incense, and performing acts of remembrance over a period of time. These practices are structured around duration, repetition, and collective participation, rather than physical forms worn on the body. There are also differences within these practices. In some southern regions of China, mourning rituals can be more elaborate and extended, sometimes lasting several days and involving symbolic objects such as paper offerings. In northern regions, practices are often more simplified and centered around family-based remembrance. There are also differences between urban and rural contexts. In cities, mourning is often condensed due to space and time constraints, while in rural areas it tends to be more visible, collective, and socially embedded.

These forms of mourning are not fully explored in this project, which means the cultural scope of the work remains selective. Rather than proposing a universal model of grief, the project focuses on specific practices that can be translated into material and spatial design. Expanding this perspective to include a wider range of cultural expressions would be an important direction for future work.

5.6.3 Role of Fashion in the Mourning Process

Fashion in mourning is not only about appearance, but also about how emotional and social states are communicated. Mourning garments often function as non-verbal signals, allowing others to recognize that someone is going through a change without the need for explanation. At the same time, mourning is often associated with a fixed visual expectation. It is commonly linked to dark colors, heaviness, and a subdued atmosphere. This creates a stereotype that grief must always be expressed through a visibly low or withdrawn appearance. While this

has historical grounding, it can also limit how emotional experience is understood and expressed through the body.

This project does not aim to reproduce that singular image of mourning. Instead, it considers how grief can be expressed without requiring the body to appear diminished or subdued. Even in a state of emotional difficulty, what one wears does not have to visually reinforce that condition in a literal way. It can still carry form, structure, and a sense of aesthetic presence. In this sense, fashion becomes a way of holding emotion rather than simply reflecting it. From a design perspective, fashion is also not inherently directed toward a general audience. Many artists, fashion designers, and jewelry designers work with a more specific or selective audience, creating forms that are not meant to be universally understood. These works often operate through their own visual language, which may only resonate with certain viewers.

This project aligns with that approach. It is not intended as a universal solution, but as a way of exploring how wearable design can communicate emotional states and create boundaries in public space. The pieces function less as decorative objects and more as a form of expression that shapes how the body is perceived and approached.

My background in jewelry design also informs this approach. Jewelry and wearable objects often carry symbolic meaning and operate at an intimate scale. This influences how the pieces are designed to stay close to the body while still engaging with a broader social environment. Through this, fashion is understood not as decoration, but as a medium that can express emotional conditions, establish boundaries, and reshape the relationship between the individual and others.

5.6.4 Limitations in Testing

This project suggests that the pieces could be used in everyday situations, especially in moments when someone might need a bit of distance or emotional space. At the same time, it's important to say clearly that this has not been tested in real-life settings. Most of the testing so far has been based on self-wearing and short interactions, rather than long-term use or observation in daily environments. Because of this, the project does not make claims about how the pieces would work across different people or social situations.

The intention here is not to prove that the design works in a functional or measurable way. Instead, the prototypes are used to explore how wearable forms might respond to emotional states and create a sense of boundary around the body. More structured testing would be needed to understand how this could translate into everyday use. This could include longer periods of wear, working with different users, and observing how the pieces are experienced in real social contexts.

5.6.5 Limitations of Heart Rate and Its Relation to Grief

In this project, heart rate is used as a way to register changes in the body. At the same time, it is important to acknowledge that heart rate does not directly correspond to specific emotions, and it cannot be used to define or measure the stages of grief in a precise way.

Heart rate can change for many reasons, such as movement, environment, or general physical condition. Because of this, it does not clearly indicate whether someone is feeling sadness, anger, or calm. The connection made in this project between heart rate and different emotional states should therefore be understood as a loose and conceptual mapping, rather than a scientific one. There are also limitations in the sensor itself. The heart rate sensor used in this project can be affected by movement, inconsistent contact with the skin, or external noise. This means the readings are not always stable, especially outside controlled conditions.

Rather than treating heart rate as a source of accurate emotional data, it is used here as a trigger. It introduces variation into the system and allows the wearable to respond in a dynamic way. The goal is not to represent emotion correctly, but to create a relationship between the body and the form. Future work could explore other types of bodily signals, or combine multiple inputs, to build a more nuanced understanding of how emotion is carried through the body.

5.7 Summary

The results of Prototype 3 demonstrate that emotional support can be achieved through spatial and material strategies rather than direct visual feedback. Instead of emphasizing expression or regulation, the devices create a condition in which emotion can exist.

This shift repositions wearable technology from a tool for displaying emotion to a structure that accompanies it, providing support without requiring exposure. This reflects a broader shift in wearable design, where technology moves from representing emotion to quietly supporting its presence.

Chapter 6: Conclusion and Future work

6.1 Conclusion

Grief does not unfold in a linear way. It lingers, recedes, and returns, often without warning. It does not follow schedules, nor does it respond to urgency. Yet in everyday life, emotions are often expected to be manageable, interpretable, and quickly resolved. Within such conditions, emotions like grief, those that resist simplification—rarely have space to remain.

This research begins from that tension.

Through the process of making and wearing, I gradually realized that the body does not necessarily need to clearly express its emotional state. Instead, what becomes essential in moments of grief is a condition, one in which emotion can exist without being exposed, interpreted, or corrected.

The project initially explored heart-rate-driven light feedback, attempting to translate internal bodily states into visible signals. However, through testing, this direct form of visualization often produced a sense of being watched rather than being supported. Emotion was not held but highlighted. This realization led to a shift in direction: the design moved away from asking how emotion can be expressed, toward asking how space can be created for emotion to remain.

In the later prototypes, heart rate was no longer used to display emotional states. Instead, it became a trigger for spatial transformation around the body. The data itself was not presented but translated into subtle movements, openings and closures around the face, shifts in distance, and the formation of soft boundaries. Through this transformation, heart rate moves from being a readable signal to becoming a supportive physical gesture. It does not ask to be understood or interpreted, but quietly reorganizes the relationship between the body and its surrounding space.

In doing so, this research responds directly to its initial inquiry: wearable design based on body signals does not need to visualize emotion to create a sense of safety. Rather, when physiological data is translated into spatial and material responses instead of visible output, it becomes less a form of surveillance and more a condition of support. At the same time, movement and softness emerge as essential in shaping emotional safety. Slow, continuous

motion aligns with bodily rhythms, while soft materials—feathers, fabric, and layered surfaces—form boundaries that are present yet permeable. Together, they create a condition in which the body can withdraw slightly without fully disappearing from the world.

Through these practices, the project suggests that creating a safe space for grieving does not require a fixed or enclosed environment. Instead, it can take the form of a wearable condition, one that moves with the body, requires no explanation, and allows emotion to unfold at its own pace.

Rather than designing systems that detect, measure, or optimize emotion, this work proposes a quieter approach. Design does not need to define emotion but can instead create the conditions for it to exist. In this sense, wearable devices shift from being tools of expression to structures that generate protective relationships around the body.

This project is not about making grief visible, but about making room for it.

6.2 Future work

Grief does not resolve within the timeframe of a project. It continues, shifts, and returns, often beyond what can be observed or fully understood. In this sense, the work presented here remains partial, less a conclusion than a point of entry.

One possible direction for future work is to move beyond a self-as-sole-participant approach. This project is grounded in first-person, embodied experience, allowing for close attention to subtle changes in perception. However, grief does not manifest in the same way across different bodies. Expanding the work to include multiple participants may reveal how spatial boundaries, movement, and material softness are perceived differently, and how the notion of a “safe space” is negotiated across varied emotional and social contexts. In doing so, the project may shift from an individual experience toward a more relational understanding of emotional support.

Another direction concerns the role of body signals themselves. While heart rate has been used as a primary input, the research suggests that its value does not lie in its accuracy or visibility, but in how it is translated. Future work may explore more subtle or indirect forms of sensing, or even question whether explicit sensing is necessary at all. Instead of relying on

measurable data, wearable systems might respond to posture, proximity, or other forms of embodied interaction that do not require interpretation, allowing support to emerge without being defined.

Material and structural development also remain open for further exploration. The current combination of metal, fabric, and feathers establishes a balance between rigidity and softness, yet future iterations may investigate lighter, more adaptable materials that better accommodate long-term wear. Similarly, refining the movement mechanisms—making them slower, quieter, and less perceptible, could further integrate the device into the rhythms of the body, reducing the sense of technological intervention.

Context is another dimension that has only begun to be explored. This project primarily considers individual experience, but future work may situate these wearable forms within shared or public environments. How might others perceive the shifting spatial boundaries around the body? At what point does protection become visible, and how does that visibility affect social interaction? These questions suggest that the "safe space" created by the device is not only personal, but also relational.

Finally, there is potential to further develop the temporal dimension of the work. The importance of slow, continuous movement suggests a different understanding of interaction, one that unfolds over time rather than responding instantly. Future designs might move away from direct triggers and instead evolve gradually, reflecting the ongoing and uneven nature of emotional experience.

If this project begins with the question of how a wearable device can create a safe space for grieving, future work may continue by asking how such a space can remain like how it adapts, shifts, and endures alongside the body over time.

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