Designing an Extimate Wearable

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Abstract

This project explores the concept of "extimacy" in wearable technology, focusing on the externalization of internal emotions. The research involved a review of current literature on emotional communication and extimacy, followed by the development and evaluation of a prototype using the Creative Technology design process. The target demographic of this product being those with issues identifying and expressing their emotions. Ethical considerations and user research were leading in making informed design decisions. The result is a concept, and rudimentary prototype, of a necklace capable of showcasing emotions through colour, coloured patterns, and images. To enhance user agency, emotions are based on manual input instead of relying on biometric data. Despite some limitations, the findings demonstrate the potential of wearable technologies to enhance emotional communication and embody extimacy. Future work should strive to overcome the limitations and further refine the design to better align with user needs.

Acknowledgements

Contents

Introduction

In recent decades, the relationships between technologies and human bodies have become increasingly "intimate" [1]. Technological advancements are present on the body, in the form of watches that track various physiological metrics such as steps taken, heart rate, and sleeping patterns. The development of internal technologies, cochlear implants or pacemakers for instance, further exemplifies the intensity of this dynamic. These extimate technologies can aid in sustaining life or improving its quality. They are both intimate and external, both embedded and foreign [1]. Among the simpler yet evocative examples of this integration are mood rings, which can be found in souvenir shops worldwide. These rings, which vary in colour in response to the temperature that the liquid crystals inside are exposed to, claim to be able to reflect the wearer's emotional state. Despite being rudimentary and often dismissed based on their gimmicky appeal, the concept of mood rings is an example of externalising internal data, a central principle present in extimate technologies. These fun accessories were what inspired the project.

While many types of tracked physiological data can be relayed to users, externalising the most intimate form of data, emotions, has proven to be a challenge. Although the presence and intensity of emotions can be measured, categorizing them as positive or negative is difficult, as they are deeply personal. Thus, they largely rely on being self-reported [2]. The aim is to develop a wearable that effectively showcases the wearer's emotional state, inspired by the mood ring. However, instead of relying on data such as temperature, the input will be manual, allowing for user agency. The intention is that this wearable will not be used as a feedback tool for the user but as a form of communication towards their environment. This could be of use to those with emotional communication issues (ECI). There are numerous reasons why individuals may experience difficulties in communicating their emotions. This research focuses on people who struggle with sharing their emotions, such as those affected by physical disabilities like facial paralysis, a speech disorder, or various neurological disorders. The target demographic includes those who solely have communication difficulties, as well as those unable to properly identify and categorise their emotions, a personality construct known as alexithymia.

This research project strives to understand how wearable computing can embody the concept of intimacy and extimacy. Furthermore, it investigates what design aspects are most important to facilitate proper extimacy of emotions using technology and how users can take agency over their intimate relationship with technology. Conducting comprehensive research

and user research and testing is required to discern answers to the questions posed. This project consists of nine chapters, each addressing a component of this research, with this introduction serving as the first chapter. The second chapter presents an overview of the performed background research, including a comprehensive review of current research on the topic of extimacy in wearables, emotional communication and its barriers, and state-of-the-art research. The third chapter outlines the methods and techniques employed in this project, providing an understanding of the research process. The fourth chapter is dedicated to the step of ideation, ensuring design questions are formulated and set up to be answered, resulting in a selected prototype. In the fifth chapter, this prototype is specified further, including user analysis, goal setting, data encoding and preliminary requirements. The sixth chapter describes the process of realization, showcasing the developed prototype. In the seventh chapter, the prototype is evaluated by a user study and checking the preliminary requirements. The eighth chapter involves a discussion on the gained insights and the limitations found within this project, and a conclusion on the research questions. Lastly, the ninth chapter explores future work.

Background Research
Building a Theoretical Foundation

Within this chapter, the researcher aims to establish a theoretical groundwork upon which the project can be developed. Three components make up this chapter. First, an examination of the definition of intimacy and extimacy as found in current research will be conducted. This literature review will allow for a definition of extimacy to be created for use within this project. Second, the chapter will explore ECI to further identify and define the user and their challenges. Third, state-of-the-art research provides an overview of currently existing technologies, informing the project's direction and allowing the researcher a foundation to build upon.

2.1   Intimacy and Extimacy in Technology

To design an efficient wearable that embodies the concept of extimacy within technology, having a clear definition of extimacy is vital. The following presents a comprehensive literature review of how extimacy and intimacy are defined within the literature in the context of technology. Lastly, an overview of the application of extimacy on technologies will be provided.

2.1.1 Defining Intimacy

Intimacy within technology spans multiple dimensions. The most visible and tangible dimension is the human body. Each person's physical body, both its exterior and interior, holds a profound sense of intimacy and privacy. Lettow [3] claims the body to be a central dimension of agency, the means of communication with the world. As technologies permeate this dimension and become incorporated into the body, they become directed towards the self. Zwart [1] argues that this process will culminate in colonising the human body. The dimension of intimacy within the body relates to the key moral principles of autonomy and consent, which are vital to this project.

The second dimension of intimacy manifests in the form of personal data that technology can monitor. Lupton [4] describes a group of individuals who monitor and track their data, creating extensive databases. The type of data they track varies wildly: from the trackers' physical location and movements in space; to physical metrics such as body weight, heart rate, mood, sleep patterns, intimate relationships, and fertility cycles; and less

physical yet still intimate data such as financial information and energy use. In the eyes of these trackers, no data is too private to track. Although the existence of this data is not an inherent risk, technologies ease the tracking and misuse of such data. Royakkers et al. [5] discuss moral boundaries as the digitisation of human lives affects every aspect of their lives, referring to this as the concept of the intimate technological revolution. Not only is data more easily tracked, but it can also be more easily shared. Not everyone is interested in sharing their intimate data. Hartmann et al. [6] discuss this in the context of sharing emotions, stating that people do not necessarily want to share these openly with others. They regard the right to decide with whom and to what extent we want to share our feelings to be that of emotional privacy.

2.1.2 Defining Extimacy

There is a division between two types of definitions for the concept of extimacy; one in which the relationship between humans and technology is at the forefront, and one in which it is not. The first set of definitions focuses on the act of sharing intimacy. In their research, Gervasoni et al. [7] describe extimacy as the natural tendency of a person to want to reveal specific parts of their intimacies to others, interpreting it as the exposure of one's intimacy in social environments; either through speech, image, or writing. They claim that exposing one's intimate thoughts or opinions facilitates personal emancipation. Furthermore, they believe it fosters a sense of community and sociality as dialogues are formed around intimate topics such as physical acceptance, sexuality, and other personal beliefs [7]. The social environments conducive to extimacy are not necessarily physical. Lupton [4] describes how online sharing can lead to feelings of community, social engagement, intimacy and support in the same manner. Royakkers et al. [5] point out that technologies such as the smartphone facilitate this process. As they nurture the interconnectedness between our physical and virtual lives, the distinctions between physical and online social environments blur.

Whereas the first type of definition focuses on the sharing of intimate data, the second set focuses on the relationship between humans and intimate technology, which through that process becomes an extimate technology. Aydin [8] and Zwart [1] define extimacy in the same manner, exemplifying the concept by stating that technologies that are incorporated within the human body cannot be simply externalized, as they are becoming something that is both a part of the human body and not. In their belief, it is embodying these clashing concepts at

once that characterize extimacy: intimate and external, familiar and strange, disruptive and lifesaving, common and artificial.

2.1.3 Characteristics of Extimate Technologies

Two varieties of technologies have been described as extimate within the literature: either situated outside or other inside of the body. An extensive portion of the first set is the type of technology that can collect intimate personal data on the user and their environment. In the opinion of Gervasoni et al. [7], these technologies consist of any device that can capture extimacy. Zwart [1] describes them as something that is not organic; yet small, communicative, elegant, carefully designed, and containing a miniature, chip-sized computer. Often, this technology exists in the form of a wearable. Segura Anaya et al. [9] list various types of technologies embedded within wearable devices, such as lifelog technology, RDIF technology, and augmented reality technology. Royakkers et al. [5] broaden the scope by including many other Internet-of-Things technologies and artefacts capable of tracking biometrics. Baker [10] carved a section within the area of wearables that includes computing artefacts applying the data they have monitored to direct user behaviours, either implicitly or explicitly. This form of technology, often referred to as pervasive technology, consists of products that aspire to improve the lives of their users. Often, this type of technology is in use in the medical sector. Baker states that the commercial sector has been adopting this technology, using it to guide and improve numerous aspects of user behaviours by providing them with data about the self.

By clustering many such pervasive products together with several other extimate technologies capable of tracking intimate data, a smart home can be created that fits the needs of the user. Aydin [8] describes the use of such a smart home specified for the use of the elderly. They describe a smart home as consisting of different devices, which collect data. This data is then related, interpreted, and evaluated. The smart home's brain, a central decision-making platform, processes and analyses the data after which it sends feedback to the user or actuators. By employing prediction algorithms and deep learning, behavioural and physiological patterns of the occupants can be created. These can lead to the development of models for the home environment. This process has the potential to take on easy daily chores and tasks, such as making coffee or opening the curtains, assuming a role close to an extra brain for its user, extending beyond their body.

Not all external technologies are required to track data to be labelled as extimate. When an artefact integrates so seamlessly into a human's life that it becomes ubiquitous and nearly imperceivable as external, it is also extimate. It is simply incorporated as an extension of the self. Lettow [3] exemplifies this by describing the relationship between mobility canes and people with visual impairments who use them. They argue that to its user, the cane is no longer an object. Rather than being perceived as an item, its point has become a sensual zone. It has become their sight. They state that if an artefact becomes a part of a human's body for such a purpose, the item is integrated to transform the bodily agency of the individual.

The second category of extimate technologies is those indeed integrated into the intimacy of the body. An advanced example is technologies implanted to regenerate living tissue. De Kanter et al. [11] exemplify the process of extimacy for human-integrated technologies by describing a type of implant that adjusts and communicates with the body. Although the implants start as technological artefacts, they become living tissues; one with this body, that is both object and subject, when they enter the intimacy of the human body. De Kanter et al. attribute this entanglement to the smartness of the technology, its integration within a living system, and the likeness it holds to the human body. Other instances of integrated extimate technology utilize self-sensor data (SSD). Baker [10] describes this type of data as a means or end in a technological system; a mere means of communication between body and device in the case of myoelectrically controlled prosthetic limbs. In this scenario, the data is not of importance or intellectually meaningful to its user, utilising the technology as naturally as their own, natural, electrical impulses. This scenario illustrates the unobtrusiveness of such extimate technologies.

2.1.4 Conclusion

The main findings of this review are that two categories within intimacy lead down two distinct paths within extimacy, as can be seen in Figure 1. The aspect of intimacy that focuses on the privacy of the human body as a tangible dimension is directed towards the component of extimacy focusing on integrating technology within the human body. The part of intimacy
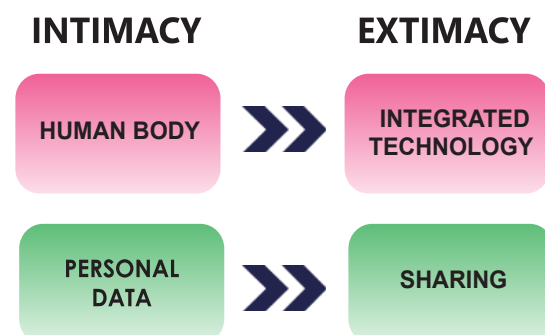

Figure 1 The Defining Process of Intimacy to Extimacy

that focuses on personal data directs into the element of sharing personal data when considering extimacy. Furthermore, aspects of extimate technologies are that they are either internal or, when external, they either track biometric data or are an expanded part of the human body without being considered internal. A pattern found in the literature reviewed is that extimacy is closely tied to two relationships: the one between the human body and technology and tracking and sharing personal data with a social environment. In addition, a gap was identified in the literature when searching for the effect extimacy has on users and their objects, and whether they form personal attachments. The literature further exemplified the lack of a set definition for both intimacy and extimacy within technology. Defining this could aid in clarifying when something is or is not extimate. In the scope of this project, the following definition of extimacy will be utilized:

Extimacy is defined by the concept of an artefact that is an almost imperceivable extension of the human body, that can share their user's intimate data with their environment.

2.2   Alexithymia and Emotional Communication Issues

Emotional intelligence is often described as a set of skills that allow people the ability to understand, use, and manage their emotions in positive ways [12]. The level of skill is not stagnant as it can be improved upon through reflection and practice. Regrettably, there are many for whom this skill does not come as effortlessly. Within the scope of this project, we focus on problems with two skills that lie within the topic of emotional intelligence: emotional awareness and emotional communication. Although emotional communication exists in explicit and nonverbal forms, this research aims to ease emotional communication for those who struggle with communicating their feeling explicitly.

Simply put, good communication leads to better relationships and bad communication leads to worsening relationships [13]. It would be ideal if one could tell with an objective glance how another is feeling, as people often do not rely on accurate and compatible perceptions. Instead, they frequently carry their communication conclusions from earlier experiences into the current situation [13]. Improper attention to, or incapability to understand, the visual cues the other gives off can lead to a situation which has been called conflicting communication. In this situation, mutual communication cannot be successful, as the message undergoes some alterations during the transfer process from one individual to the other. Common

characteristics of such a situation are misunderstandings, getting angry with the other person without listening to them, and insisting on one's point of view [13]. As these problems increase, relationship satisfaction decreases, validating the point that communication skills are a crucial factor in the health of a relationship [13]. A healthy relationship can profoundly impact and improve an individual's well-being. Barden et al. [14] assert that interpersonal connections are pivotal for mental and emotional health. Whether positive or negative, intimate relationships are central to shaping an individual's well-being throughout their life. Consequently, adverse aspects of intimate relationships, such as heightened conflict and breakups, can generate stress and erode overall well-being [14].

The product being developed intends to be an aid in improving emotional awareness and emotional communication through self-reflection and practice. Additionally, by visibly displaying emotions during interactions, it seeks to enhance communication within relationships, ultimately leading to stronger relationships and increased well-being for both individuals. The upcoming subchapter aims to identify and explore two kinds of emotional communication problems, examining the factors that make it difficult for people to express and understand emotions effectively. By understanding these issues, the subchapter hopes to offer insights into improving emotional communication and enhancing relationships.

2.2.1 Alexithymia and Emotional Communication Issues

The first step in communicating emotions is knowing your emotions [15]. Emotional awareness is not something that people should assume others are capable of on the same level, and in the same manner, as themselves. A personality construct that restricts emotional awareness, is alexithymia. Silvertant [16] characterises alexithymia as the inability to identify and describe emotions in the self. Several attributes define it. The following attributes are related to the cognitive dimension of alexithymia, characterized by difficulties in identifying, verbalizing, and analysing emotions [16].

1.　　　Difficulty in identifying feelings.

2.　　　Difficulty distinguishing between feelings and the bodily sensations of emotional arousal.

3.　　　Difficulty describing feelings to other people.

4.　　　Difficulty identifying facial expressions.

5.　　　Difficulty identifying and/or remembering faces.

Next to the cognitive dimension, alexithymia contains an affective dimension reflecting emotional arousal and imagination. The following attributes characterize it [16]:

6.   Constricted imaginal processes, as evidenced by a scarcity of fantasies.

7.   A stimulus-bound, externally oriented cognitive style.

While not classified as a disorder, alexithymia has been linked to various mental health conditions including PTSD, eating disorders, depression, and substance abuse [16], [17]. The causes of this personality construct are not clear, yet some studies suggest it may result from genetics, brain injury, or environmental factors. The degree of alexithymia can worsen or lessen over time, influenced by co-occurring mental health disorders and environmental influences. While it is reported that up to 13% of the population experiences clinically relevant alexithymia, over 30% of a population of prisoners in China reported experiencing the attributes [17]. As alexithymia is not a disorder, there are no current recommendations or prescriptions for the construct. However, if it co-occurs with another condition, treatment for those issues can be sought to avoid worsening symptoms or complications [17].

Alexithymia occurs in people with autism spectrum disorder (ASD) more often than in those who do not. In a study performed by Oakley et al. [18], it was found that autistic individuals reported significantly higher alexithymia than comparison, with 47.3% of autistic females and 21.0% of autistic males meeting cut-off for clinically relevant alexithymia. Emotional communication and regulation issues, as well as social communication deficits [19], are known symptoms of ASD. Often, individuals with ASD deviate in their social-emotional processing. One reason for this is the difficulty people with ASD often have in identifying affect from facial expressions [19]. A further challenge to emotional communication for people with ASD is emotion regulation, a complex and multifaceted construct that involves physiological, behavioural, and cognitive processes, which allow an individual to monitor, evaluate, and modify emotional reactions to accomplish one's goals [20]. The limited communication resulting from this challenge affects not only the individual but their environment as well.

Studies into the communication barrier between children with ASD and their parents show that these communication difficulties can impact parent well-being throughout their lifespan [21]. These parents may struggle in differentiating between whether a child can't or won't respond to a request, often resulting in frustration and emotional drain. These situations and feelings hinder the facilitation of better relationships between parent and

child. Oakley et al. [18] believe that psychological therapies targeting emotional awareness may improve social communication and anxiety symptoms in autism, potentially conferring long-term benefits. Salomone et al. [21] found interventions targeting communication skills effective in reducing child emotional and behavioural problems as well. In addition, it has been found that the interventions, aiding children with ASD in their communication, have shown increased parental satisfaction and reduced psychological distress [21].

Current research underlines the diverse range of social-cognitive abilities in individuals, ranging from typical development to varying degrees of autism spectrum traits, with classic autism being the most severe [22]. Relatives of individuals with ASD often exhibit milder but similar traits to their family member(s) with ASD, known as the broader autism phenotype. Even individuals with high autism traits but no formal diagnosis may encounter socio-emotional and cognitive challenges associated with ASD.

The advancement of new and innovative emotion regulation technologies has resulted in great potential for use within support strategies [23]. Monitoring emotional states with technology can help reduce stress and improve emotion regulation, potentially preventing challenging behaviours. Carers of people with ASD agreed that technology that aims to support individuals in expressing their emotions or recording patterns in their behaviours would be more beneficial than the current method of recording their emotions on paper [23]. Most wearable technologies designed to be used by those with ASD, still focus on treating autistic traits as deficits instead of supporting sensory regulation, emotion regulation, executive function, or communication, reflecting outdated views of autism. A study by Gillies-Walker et al. [23] investigated the thoughts of adults with ASD on these technologies. They stressed the importance of not limiting a device to one IQ level, as ASD affects people in a plethora of manners. This highlights the importance of adaptive designs. Furthermore, participants agreed that technology should promote independence, rather than try to 'mask' or 'fix' autism.

Real-time emotion regulation technology via physiological signals has also been proposed as a method of emotion regulation. However, participants of the study were divided on utilizing biometric tracking in emotion regulation technologies, raising both positive aspects and ethical concerns [23]. Additionally, a study by Dijkhuis et al. [20], in which the heart rate and heart rate variability (HRV) of both people with and without

ASD were measured during a public speaking task, found that data related to stress, such as HRV, presents differently in people with ASD. The results of the study suggested a mismatch between arousal regulation and emotional awareness, which may be related to problems in social adaptation in people with ASD.

2.2.2 *The Role of Physical Disabilities in Emotional Communication*

The ability to move is vital to using the face or body to convey the way one is feeling. Facial expressions communicate emotions, which Horstmann [24] describes as multi-componential phenomena that comprise feelings, intentions, and wishes. These movements, which can be overt or subtle, play a critical role in how people communicate, make decisions, show empathy, and establish relationships [25]. Seven basic facial expressions have been identified, common among most cultures: happiness, sadness, fear, disgust, anger, contempt, and surprise [26]. Numerous physical factors can be a barrier to the communication of emotions. This section will focus on one specific area of physical disabilities, restricted movement, highlighting how physical limitations can hinder expressions and gestures that aid in conveying the emotions a person wants to show.

The Facial Paralysis Institute [27] underlines the frequent co-occurrence between facial paralysis and emotional paralysis, linked to depression, anxiety, and heightened stress; highlighting the impact that restricted expression has on well-being. The Institute describes situations where patients who cannot make facial expressions isolate themselves due to embarrassment or shame of their condition. Facial paralysis can have many causes. Common types are Bell's palsy, synkinesis, congenital facial paralysis, Ramsay Hunt syndrome, and Moebius syndrome [27].

Cerebral Palsy (CP), referring to a range of disabilities which severely impact movement, can also be a negative factor towards an individual's ability to convey emotions using their face [28]. Individuals with CP have damage to the part of the brain that controls muscle tone. This brain abnormality does not worsen over time, although symptoms can change. This condition begins early in life, with damage beginning during pregnancy, birth, or before age 5. Facial motor impairments are common among individuals with CP [29], which can result in uncontrolled facial expressions or drooling. This does not facilitate accurate and voluntary facial expressions meant to convey emotions. Previously, it has been mentioned that certain interventions that bring greater attention to emotions can positively

influence emotional communication. This has been reaffirmed in this different area of study by Belmonte-Darraz et al. [30], who state that greater attention to emotional knowledge in children with CP could improve adjustment in social and behavioural functioning.

2.2.3 Conclusion

This subchapter highlights the importance of effective communication of emotions in establishing and maintaining healthy relationships. As relationships are pivotal to individual well-being, it is vital to aim to limit the barriers to this communication. Two significant barriers have been identified as alexithymia, often occurring in individuals with ASD, and physical disabilities. Insights from this subchapter influenced the design decisions and approaches taken in this project.

It was mentioned that interventions and therapies targeting emotional awareness may improve social communication and anxiety symptoms in people with ASD, and social and behavioural function in children with CP, potentially conferring long-term benefits. The researcher proposes that using the extimate wearable could be one of these psychological therapies, as reflecting and practising mindfulness to find the emotion the user is feeling could aid in setting many practice moments throughout the day. Additionally, it was mentioned that carers of people with ASD believed that technological interventions aimed at emotional awareness would be more beneficial than recording on paper, supporting the addition of the optional feature of tracking emotions to find patterns in behaviour or affect (4.4). Another finding that influenced the project, was the notion of ensuring the device did not limit use to one IQ level, allowing more people to use the device (4.4). Lastly, findings regarding the deviancy of physical changes in emotions between people with ASD and those who are neurotypical, reinforce the researcher's caution against relying on biometric tracking to interpret and output emotions, given its potential limitations in practical application.

2.3 State-of-the-Art Research

This subchapter outlines the artefacts related to the project currently on the market. These will be researched to find inspiration and to gain awareness of what already exists to avoid inventing the wheel twice. After a description, their qualities will be ranked concerning the fit to the project. First, smart rings will be discussed, as mood rings are the main source of inspiration and can be viewed as the starting point for the design process of the final prod-

uct. Afterwards, artefacts capable of extimating emotions will be explored.

2.3.1 Smart rings

Most smart rings are created as an alternative to a smartwatch. Their functions are mostly the same, except for their lack of a tangible output screen. Instead, these products focus on tracking a plethora of biometric signals. The purpose of most smart rings is to integrate into the lifestyle of the user, the continuous feedback providing valuable health insights and promoting a holistic approach to their wellbeing. The RingConn Smart Ring [31], for instance, can track many bio signals focusing on sleep, activity, stress, and heart health. The Oura Ring [32], expands upon these functions with early illness detection, recovery, heart health, and women's health. Detecting stress would appear to be most relevant to this project, as it is most closely related to emotions. However, although these rings can track heightened emotions, they cannot categorize them as positive or negative.

Other smart rings narrow their target demographic. For instance, the Ultrahuman Ring [33] focuses on its use in its user's fitness journey. Next to some features mentioned before, it analyses the data to find connections between stimuli such as light exposure, food, and exercise and the circadian rhythm of the body. The focus on physical well-being can also be found in the use of a movement index and its relation to heart health. Although it tracks many of the same metrics as many other rings, the Evie Ring [34] targets women. The difference is that the data is compared and analysed by keeping in mind the menstrual cycle and the hormonal fluctuations experienced by most women as these can largely impact body temperature, heart rate and other physiological data.

Many companies market their smart rings to be supplemental to health care. If one wants to manage their sleep, one could use the Go2sleep ring [35]. In contrast to other smart rings, this product is only worn during sleep when it tracks blood oxygen levels, heart rate and the different sleep stages. As it performs continuous monitoring throughout the night, it can provide extensive reports on sleep conditions in the morning. An interesting feature of this product is that it utilizes subjective measurements, in the form of electronic sleep diaries and questionnaires, in addition to the objective data tracked to provide a complete view of the quality of sleep received. In contrast, the Happy Ring [36] is supposed to always be worn, claiming better outcomes through continuous data. This ring utilizes generative AI in addition to biometric sensors, delivering personalized insights to improve patient health.

The Happy Ring can be utilized in a myriad of applications: from monitoring patients during clinical trials to treating at-home patients, and was created to bridge that gap. Since it was made for this purpose, the smart ring has a focus on ease of use for the wearer and the medical practitioner in charge of patient care. According to its website, the Happy Ring can track over twenty different bio signals; from heart health, to sleep quality, cognitive performance, and stress; to scratching, seizures, and geolocation.

Where the previous rings mainly focused on physical health, the Nuanic smart ring [37] focuses on tracking mental health; claiming that it can detect, prevent, and treat mental disorders by monitoring a person's stress long term. This is achieved through measuring the electrodermal activity of the wearer, which reportedly has a high accuracy in classifying stress levels [38]. The company asserts that the measurement signal has been validated by two independent studies. However, they also state the product is meant for use in research institutes and R&D labs for studying the reactions of the autonomic nervous system, not for everyday use by the public [37].

By delving into the market of smart rings, options were found for use when creating a wearable. It was discovered that smart rings can track data that can be analysed in a variety of manners, from finding patterns solely in physical health to focusing on mental health. Although this could be very useful if the project relied on biometric input, the researcher decided to rely on self-reported manual input instead, to support the agency of the user, which will be discussed in section 4.1.

2.3.2 Artefacts Extimating Emotions

A prime example of extimacy can be found in social media platforms, from Facebook to TikTok, where users can and do share remarkably private details about themselves and the people close to them. Users can share their intimate thoughts, feelings, and opinions with an audience of their choosing, from friends and family to the entire world. This relies on the extimacy of sharing and extending personal data. One way in which people can share their emotions is by adjusting an emotionally expressive avatar, such as a Bitmoji.

Bitmoji is an application that allows the user to create a cartoon version of themselves. Then, they can send this figure in several positions through messages, as can be seen in Figure 2. The positions match emotional categories such as happy, sad, and angry. To many, this

avatar feels very personal. In an interview [40], Bitmoji founder and CEO Jacob Blackstock stated: "*Social media doesn't allow people much of a presence. It's just a collection of some information and photos and stuff, but mock up a Bitmoji avatar in your image, and all of a sudden, you exist. [⊠] People form this intense bond with their avatars. It really becomes an extension of themselves.*" [40]. It is this extension that highlights the strong relationship between the physical body and its virtual counterpart.
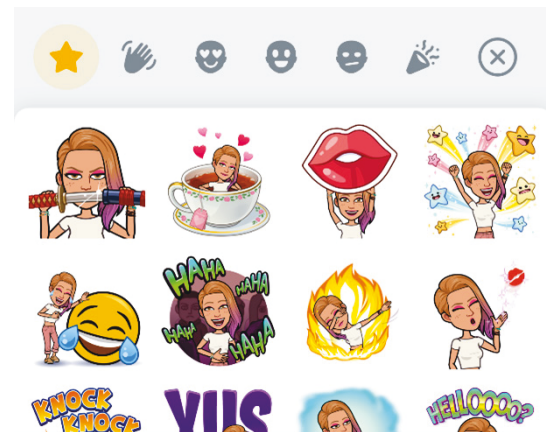

Figure 2 A Screenshot of the Bitmoji Application [39]

Next to being an extension of the self, the Bitmoji aids in the extimate characteristic of sharing intimate information with others. Iovine [41] believes that Bitmoji may provide information to difficult conversations more readily. Hess [40] claims that Bitmoji can foster emotional disclosures and accelerate bonding, to the extent of suggesting it can encode real love with its virtual expression, avoiding the difficulty of expressing true excitement, affection, or vulnerability in physical proximity. Aligned with that, Iovine [41] adds: "*You may more readily send a Bitmoji of flies coming out of your empty wallet than write in words, "I'm too broke right now." You may more readily send a chipper Bitmoji holding an "I hate myself" mug rather than write out a self-loathing comment. The personalization of Bitmojis enriches the experience: it's not a generic avatar's wallet that is empty, it's yours*".

Another example of an application that aids in emotional communication, is the range of augmentative and alternative communication (AAC) apps and devices that allow people who are nonverbal to communicate more easily. An example of this is the iPad application ElineSpeaks [42]. The product was created as an alternative to other AAC devices that are often expensive and not flexible in use. The user can select an image that corresponds to a word, or use text-to-speech, to talk without having to use their mouth. On the companies' website, the creators define their target demographic as those who have or have suffered from a stroke or aphasia, a brain injury, ALS or MS, autism, a spinal cord injury, Down syndrome or learning difficulties.

A distinction exists between the previously mentioned artefacts and the project, as the

project is a physical object. An example of a physical object that aims to express emotions through colour, is the mood sweater designed by Kristin Neidlinger's studio Sensoree [43], depicted in Figure 3. The sweater has a large collar which changes colour based on the wearers' excitement level by measuring skin conductivity. The goal of this product is similar to this project: to create an artefact for individuals who are unable to communicate their mood, giving them the opportunity to show others how they're feeling. "*This concept holds exciting promise for the future,*

Figure 3 Sensoree's GER Mood Sweater [43]

as wearable clothing could be adapted for the personal healthcare arena," stated Neidlinger [43]. "*For those who struggle to communicate their emotional state – in Alzheimer's disease for instance – a person may easily become aggressive and agitated, often without warning and for no apparent reason.*"

There are many types of emotional communication artefacts. What can be taken from those explored during this state-of-the-art research, is that there is not yet an object that relies on manual input and visually showcases emotions. This research has indicated that often virtual artefacts rely on the characteristic of extimacy which focuses on sharing emotions, whereas the physical artefact more frequently relies on integrating technology. The goal is to be able to combine both to realise a truly extimate wearable.

2.4 Conclusion

With this extensive chapter, a theoretical foundation has been laid upon which the project can be built. The definition of extimacy was set, the concept of an artefact that is an almost imperceivable extension of the human body, that can share their user's intimate data with their environment, and its relation to intimacy in technology was outlined. The target demographic was researched, with the main barriers to emotional communication found to be the inability to identify and the incapability to express emotions. Research into state-of-the-art aided the researcher in narrowing down the type of wearable and finding similar technologies. This allowed reflection on ethical considerations, which will be expanded upon later in section 4.1.

Methods and Techniques:
The Design Process for Creative Technology

The following chapter describes the methods and techniques employed during this research project. This research is part of the BSc Creative Technology, which utilizes a specific model during the design process [44] the diagram of which can be found in Figure 4. This model consists of four phases: Ideation, Specification, Realisation, and Evaluation. As this model is a combination of divergence and convergence models as well as spiral models, the process will be iterative, going back and forth between steps, creating context and providing feedback to aid the specification and realisation of a final product prototype.
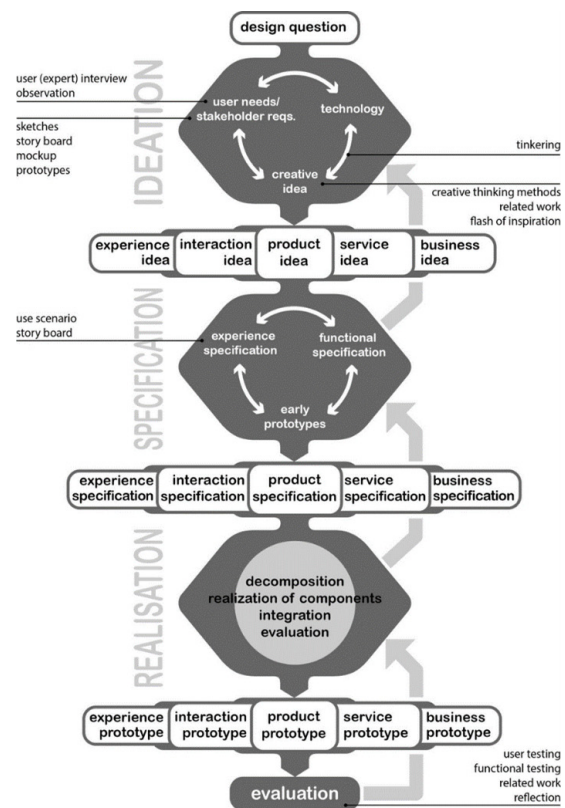

Figure 4 The Creative Technology Design Cycle [44]

3.1 Ideation Phase

A creative technology project starts with a design question in the form of a product idea, client order, creative inspiration, or specific technology. When approaching a design question from a technology, many kinds of applications will be thought the goal is to identify new applications for both existing and new technologies [44]. Following this, activities will take place with the goal of finding a spark of inspiration for a product, service, interaction, experience, or business. Examples are brainstorming, looking for related works, and hoping for a flash of inspiration. Once one or a list of ideas has been found, the process moves to the next phase.

Within this project, the inspiration for the product idea was mostly found in a flash of inspiration. Ethical considerations influenced many design decisions. Ethical reflection will be included in this phase. Furthermore, related work, as found in Chapter 2.5; user needs and stakeholder requirements; as well as sketches are part of the Ideation phase of the project. This phase will be expanded upon in Chapter Four.

3.2 Specification Phase

This phase allows further exploration of the design space. Several lo-fi prototypes give way for a short evaluation. The use of a feedback loop allows for further refinement of specifications on the user experience and functional requirements [44]. Specific to the creative technology design process is the interplay between technology and user experience. Within this project, this phase is applied by specifying the functionalities using the MoSCoW method and further defining the user need by actualizing a user study in the form of a survey. Adjustments may be necessary to ensure the product embodies the values of the project. This phase is expanded upon in Chapter Five.

3.2.1 Survey

A survey was the first method employed in the user research within this project. The survey served to address multiple goals. The most vital objective was to find preferences on design decisions and ethical aspects regarding the product. Multiple dilemmas were faced where there was no one perfect solution. By asking others for their standpoint on these dilemmas, the decisions made could be more informed and grounded. These dilemmas included whether the emotions extimated should be tracked for a daily or weekly report and how the emotions should be visualised. A choice had to be made between displaying only colours with lights or using a programmable LCD screen which provided an opportunity for displaying not only colours but also patterns and emoticons. This could grant much more personalized options and capture small nuances in emotion.

Next to informing design decisions, questions were asked regarding the respondents' emotional awareness. The goal of this was to find how someone with their specific emotional awareness characteristic would use this product. This was achieved using reflecting and scaled questions. The respondents were asked whether they would see themselves or someone else using the product. For this survey, questions from the Toronto Alexithymia Scale (TAS) [45] and Interpersonal Communication Competence Scale (ICCS) [46] were used. Lastly, the survey served as a way for the participants of the prototype testing to be found, as the respondents were asked whether they would be interested in participating in such a session. This will be expanded upon in the evaluation phase. The survey can be found in Appendix B

3.3 Realisation Phase

Now that the specifications have been clearly defined, the product can be realized. This phase consists of the composition of the start specification, realisation of the components, integration of the components and evaluation [44]. In case of wrong decisions, backtracking is an option as this phase is formed as a Waterfall or V-Model. The creation of a well-designed, fully formed, functioning, and good-looking product does not lie within the scope of this project. Within this project, this phase will exist in the creation of a lo-fi, yet functioning, prototype and an accompanying smartphone application which will serve as the input method. This will be further expanded upon in Chapter Six.

3.4 Evaluation Phase

The last phase of this process is the evaluation phase, which can include several aspects, such as functional testing, user testing and validating whether the ideation phases' original requirements are present [44]. Furthermore, related work can aid in positioning the result in the context of existing work. It is stated that reflection is the basis for both academic and personal progress. The reflection process can make implicit decisions explicit and attempt to reconsider one's implicit standards. Within this project, this phase will be embodied by a user study and the MoSCoW method. The user study will be in the form of a prototype testing session on the prototype, which consists of an application for input and a colour-changing physical component. This will be further expanded upon in Chapter Seven.

Ideation

When presented with the description of the topic of this Graduation Project, to create something which is extimate, the researcher immediately thought of a smart mood ring. It can be said that this initial concept came from a flash of inspiration. However, although this concept was decided upon rapidly, the development of a final prototype was not instant and required a process of ideation. Research into intimacy and extimacy, as well as state-of-the-art, played a role in the decision to move away from a ring, as its size would mostly facilitate an intimate technology, not one that is extimate. Deliberations emphasised the importance of user agency within this project. Consequently, including sensors capable of tracking biometric functions that aid in finding the wearer's emotion was not deemed appropriate. These deliberations will be discussed in section 4.1. Afterwards, the process of ideation on the design of the prototype will be outlined. Within this process, some questions came to mind which the researcher could not answer. Because of this, certain design choices were informed by a survey. Lastly, the final design of the preferred concept will be presented.

4.1 Ethical Considerations: Ethical Dilemmas and a Code of Ethics

During a technological design project, it is important to be aware of ethical issues that may arise. During the design process, some ethical dilemmas came forward. An ethical dilemma exists when there is a conflict between two moral principles, as will be discussed in section 4.1.3. The researcher decided upon an outcome in both dilemmas to continue the project. A code of ethics has been established which will be the basis upon which the decisions are made and be the model for behaviour regarding this project. Before this, the relevant stakeholders regarding this project are identified and analysed.

4.1.1 Stakeholder Identification and Analysis

The first stakeholder that can be identified is the user of the product. This stakeholder can be described as someone who has an interest in one or both purposes of the product: easing communication with their environment and practising identifying their emotions. This stakeholder has trouble in emotional communication and believes this product might help them with that. The interest of the stakeholder lies in a reliable product that is accessible to them.

The second stakeholder is the environment of the user. This stakeholder refers to the

users' close friends, family, and care providers. Their goal in providing someone with or supporting someone in using the product can be interest in their well-being, ease of communication between the stakeholders, or a combination of both. The interest of this stakeholder lies in a reliable product that provides obvious feedback on the user's state of mind.

The third stakeholder is the researcher. As the creator of the product, the moral responsibility of all faults and negative outcomes falls upon them. Their goal is to help people communicate their emotions and to do so in an ethical manner, with the ability to stand by their code of ethics, which can be found in the next section.The interest of this stakeholder lies in the creation of an ethically produced, by which is meant a product of which all ethical risks have been thoroughly evaluated and weighed.

The fourth stakeholder is the producers of the product. Their goal is to provide for themselves and their families. Meanwhile, their interest lies in fair wages and labour practices, allowing them to work in an enjoyable and safe environment.

The fifth stakeholder is the natural environment, whose interest lies in supporting a healthy web of ecosystems. To support this stakeholder, it is vital to ensure that the production process is eco-friendly and sustainable, including but not limited to limiting the amount of non-recyclable and non-recycled materials to fabricate the product. Furthermore, unnecessary CO_2. The goal is to have a positive impact on the natural world.

The fifth stakeholder is the public at large. Their interest lies in maintaining a safe society with high well-being. This will be managed by supporting all stakeholders and ensuring a safe product that has low potential for harm. By adding to the well-being of all other stakeholders, the well-being of the public at large is expected to increase.

4.1.2 Code of Ethics

The following contains the moral principles which are held at the centre of this project. By explicitly naming these, they can more easily be thought of at every stage of the design process: from Ideation to Realization.

Integrity and Honesty

Integrity and honesty are interlinked and therefore will be linked as a set of one key moral principle. The IEEE [47] holds honesty and integrity high within its Code of Ethics. They

state that the profession of engineering must be conducted in an honest, faithful, and truthful manner. This includes but is not limited to, that facts may not be manipulated and that agreements must be upheld. Naturally, this will apply to this project as well. Within the scope of this project, integrity, and honesty form, together with the next key moral principle, the basis of professional ethics of the code of ethics. This moral principle defines that communication should be clear and lies should not be told to any stakeholder. Honesty and integrity are made visible by designing a product that is transparent and honest in its workings and goals, and by clearly stating reasoning for all design choices.

Social Responsibility

Van de Poel and Royakkers [48] mention multiple moral principles often present in Codes of Conduct that relate to social responsibility. These are also mentioned in the International Council of Design's Code of Conduct [49], who calls this concept the professional responsibility to society. The Code of Conduct states:

"Designers have the responsibility to seek a more rational production and consumption model, using their skills and position to utilise technology and innovation for the long-term good and for the well-being of all living things" [49, p. 9]

Social responsibility is a subject the researcher feels strongly about and strives to embody in the final product. The three principles that will be key in this project are sustainability, inclusivity, and accessibility. As related to the first principle, the product created for this project must be created sustainably and fairly for the environment and those who make the product. The project should set the goal to limit the inclusion of non-recyclable materials and make the product durable to avoid unnecessary replacements. Furthermore, the product should be inclusive in its use. It should be able to be used by anyone, even those with colour blindness or physical disabilities limiting movement. Lastly, the product should be accessible. Anyone should be able to use a product, no matter the size of their wallet. This could be done by having multiple types of the product, differing in price.

Reliability

This moral principle refers to both the product, which should work reliably and without frustrating errors, and the communication between users and the researcher. Maintaining fast, honest, and reliable customer service is vital in sustaining a positive relationship and attract-

ing new users. Furthermore, this means that the user can rely on the company to treat them, and their data, with respect. Within the project, this can be seen in the creation of a durable design that is easy to maintain and repair. The product should be reliable both in hardware, as well as software. By keeping the software up to date, data privacy and public safety can be maintained as network devices which are not secure can be used in DDoS attacks.

Agency

Mentioned as the outcome of the ethical dilemma of knowledge against privacy in section 4.1.3, agency in this context refers to ensuring that the user has complete control while interacting with the wearable device. Within the scope of the project, user agency has been defined as an independent decision to pursue a certain action.

Empathy

The use of empathy within designing technology is vital as technologies have the power to shape how we interact with others. Preferably, this would be done in an empathic manner. Empathy has been described in many ways but within the scope of this research the definition of Bollen [50] has been implemented. She describes empathy as the balance between proximism and distantism.

Design for empathy: a framework for reflection

Readiness	Does the technology obscure or highlight **the status of another as a subject**?
Development	Does it contribute to a **safe and constructive learning environment and culture** to develop and refine empathy?
Skills	What **skills** are **required** to successfully empathise using the technology?
Norms	Could this technology **change societal expectations/norms** on empathy?
Equality	Does the technology **relieve or introduce an asymmetry/imbalance** between users?
Equity	How are the **challenges and opportunities** for empathy with this technology **distributed** among the population?
Interconnectivity	How does it relate to **existing human tendencies** towards proximism and distantism like similarity bias **on a larger scale**?

Figure 5 The framework, Design for Empathy: a Framework for Reflection [50]

In order to realize an empathic product, a framework has been utilized. The framework, Design for Empathy: a Framework for Reflection [50], was applied to the concept of the product in a workshop session with the designer of the framework. The framework is showcased in Figure 5.

4.1.3 Ethical Dilemmas

Knowledge & Privacy

This first dilemma appeared at the very beginning of the ideation phase of the project. Within this dilemma, knowledge is defined as having a large amount of data on the user of the de-

vice, whereas privacy is not having any data on the wearer. Similar products, which measure emotion and output this to either the environment or as digital data, require a plethora of sensors in order to track physiological data. An example of such a product is the previously mentioned mood sweater designed by Kristin Neidlinger's studio Sensoree [43]. Considering the dilemma between knowledge and privacy, this product would be an example of a knowledge-based artefact. The user has no control over what is being shown and has no privacy in their excitement level. The researcher believed privacy should play a larger role when considering sharing something as intimate as one's emotions with their environment.

In contrast to full knowledge, allowing a user complete privacy would equal to not tracking emotions at all. This is, of course, not the intention of creating an extimate wearable device. By using this device, the wearer must allow themselves to give up a part of their privacy. For this reason, a balance had to be found between allowing the user privacy of their state of mind and providing the product with more accurate data on their emotions, without any user control.

The researcher believes that a balance has been found by relying on user input, tipping the scale from knowledge to privacy. This enables the user with the ability to share their emotions by selecting them manually. Although full knowledge of the stress and excitement levels is not present, knowledge still exists in the form of the colours being emitted at that moment informing the environment of the users' feelings. Additionally, tracking, and by extension knowledge, will be implemented further within the product in the shape of an optional daily or weekly report. This would give the user and their environment information on the emotions felt and for how long they were felt. By identifying patterns, the user could use this knowledge to recognize how situations influence their emotions. In summation, the outcome of this ethical dilemma emphasizes user agency.

Honesty & Consent

The next dilemma follows from the previous: as the input is self-reported, the user can lie. The dilemma exists between encouraging honesty and encouraging autonomy and consent in the emotions that are shared. Being honest would give the user and their environment the most accurate data on their emotions and allow the environment of the user to interact with the user in the most suitable manner, easing communication. However, the researcher believes that autonomy of choice is vital in the use of this extimate wearable device: if the

user wants to lie about their emotions, they should feel free to do so: just because one is sad, doesn't mean they need to show this to everyone. By allowing the user the choice between extimating the emotion of their choice, when extimating one that can be perceived as negative they can choose whether they consent to sharing the accurate emotion or keeping it to themselves. The researcher is of the opinion that the user is entitled to not be open about their emotions, as those who share their emotions more readily and conventionally often also have a choice in whether they share their emotions.

4.1.4 Markkula Center for Applied Ethics: Ethics in Tech Practice: A toolkit

This toolkit, designed by the Markkula Center for Applied Ethics, consists of tools which represent concrete ways of implementing ethical reflection, deliberation, and judgment into tech industry engineering and design workflows [51]. When implemented and used correctly, the toolkit can aid in the process of developing ethical practices that are well-integrated, explicit, regularized, and operationalized. The toolkit consists of seven tools, of which two will be used in this project:

1.   Ethical Risk Sweeping

2.   Ethical Pre-Mortem or Post-Mortems

3.   Expanding the Ethical Circle

4.   Case-Based Analysis

5.   Remembering the Ethical Benefits of Creative Work

6.   Think About the Terrible People/misuse

7.   Closing the Loop: Ethical Feedback and Iteration

Ethical Risk Sweeping

Ethical risks are choices that may cause significant harm to persons or other entities with a moral status or are likely to spark acute moral controversy for other reasons [51]. It is vital to understand the moral risks within a project so they can be reduced, eliminated, or mitigated. If failures appear when a project neglects this step within its design/production process, it is ethical negligence. Risks that continue to be classified as significant must be subjected to a monitoring and mitigation strategy. The goal of this tool is to identify ethical risks within the project.

Ethical risks are hard to identify when we: do not share the moral perspective of other

stakeholders, fail to anticipate the likely causal interactions that will lead to harm, consider only material/economic causes of harm, fail to draw distinction between conventional and moral norms, misclassify ethical risks as legal, economic, cultural, or PR risks, lack explicit, regularized practices of looking for them, or when the ethical risks are subtle, complex, or significant only in aggregate [51]. By having regularly scheduled ethical risk-sweeping exercises, assuming that risks will be missed and assessing them on priority and probability, challenges can be mitigated. It is vital that this process is repeated regularly. Even when no vulnerabilities are found, it will not have been a wasted effort.

Within the scope of this project, the ethical risk with the highest priority is privacy issues. This risk extends to two layers: data security and the privacy of the intimacy of the user. The first can be managed by ensuring secure storage of data and limiting the amount of intimate data to be gathered. For example, not linking the data on the emotions to any demographic information by not gathering this demographic data in the first place. The second part of this risk is more difficult to manage, as the use of the device is inherently breaching the privacy of the user. Ensuring that the data is all entered voluntarily is how this project aims to mitigate this issue.

Case-Based Analysis

In this tool, a similar moral case is analysed. The goal of this is to transfer ethical knowledge and skill across cases so that it is not necessary to be 'starting from zero' every time an ethical situation is analysed [51]. This toolkit consists of four steps.

1. Identify Similar or 'Paradigm' Cases Mirroring the Present Case

The purpose of this step is to identify cases ethically relevant to this one, similar to this situation. Two cases were identified. In the case of introducing a new device that affected the public, the introduction of the first iPhone will be explored. For the case of using a device to communicate, communication applications for people who are nonverbal will be investigated.

2. Identify Relevant Parallels Between/Differences Among All the Cases

In this step, the similarities between the cases and this project will be outlined. The case of the introduction of iPhones relates to the project because even though the user is the one in use of the product, the environment of the user and therefore the public at large is also greatly affected by the use of the product. A major difference is the public mood and culture surrounding technology. As compared to nearly two decades ago, (wearable) technology

plays a much larger role in everyday life. People are much more accepting of technology in their daily lives.

The second case is relevant as it closely relates to user agency, a value central to this project. Furthermore, as it can also be used to state emotions more clearly, it can be viewed as quite a similar product goal. It was thought to be interesting whether this type of product presented any kind of ethical risks.

3. Evaluate Choices Made and Outcomes of the Paradigm Cases

Both products, communication apps and the iPhone, were released to the public. As the iPhone paved the way for many different types of smartphones, repercussions came about in the short and the long term. Examples are smartphone addiction and reliance upon smartphones. Most of these came about because the relationship between user and device came out to exist in a manner very different from what Steve Jobs envisioned [52]. He thought the iPhone would be a device to help their user with only a small number of activities: listening to music, listening to music, placing calls, and generating directions. He didn't think he would radically change the rhythm of users' daily lives. Now, years later, many smartphones come with features allowing the user to use their phone more safely by tracking the time spent on the device and on which app. Restrictions can also be placed on the device and applications.

For AAC devices, there were quite some issues that came up in introducing them. A few examples are dealing with family/staff wants versus the person who uses AAC (PWUAAC) needs, ensuring freedom of speech for the user, and assuming that there can be a one-device-fits-all solution for all [53]. Furthermore, research found that ethical issues arise when the PWUAAC and their environment are not involved in the design process and when there is a lack of a thorough evaluation process, including other professionals [53]. In this case, the agency is highly supported as it is stated that people using AAC needs trump all others' wants. To clarify the ethical responsibility, a Webinar given on ethics and AAC by Tripp et al. [53] cited some codes of ethics. They highlighted the importance of a few principles: that individuals shall honour their responsibility to hold paramount the welfare of persons they serve, and their responsibility to the public when advocating for the unmet communication and swallowing needs of the target demographic. Furthermore, occupational therapy personnel shall promote equity, inclusion, and objectivity and hold paramount the welfare of persons served professionally. Tripp et al. [53] highlighted the need for challenging

expectations for individuals with exceptionalities to develop the highest possible learning outcomes and quality of life potential in ways that respect their dignity, culture, language, and background.

4. Use Analogical Reasoning to Identify Parallel Risks, Opportunities, Solutions, Risk Mitigation Strategies

There are many things that these cases can teach about this project. One thing is that it is important to be realistic and not too positive about the impact a product can have on the public. Not imagining worst-case scenarios, such as Steve Jobs might not have done, can have far-reaching and long-lasting consequences. The second case might be the closest to this project as it also describes the issues that come with introducing a communication device specifically for those who have issues communicating. It is vital to keep the principles brought up in mind and look at the issues that have arisen as many will probably be similar in this project. As a result of being aware of the existence of these issues, they can be avoided or be made clear, together with a possible solution, to the user and their environment.

4.2 Process of Ideation on Wearable

Before landing on a necklace, other accessories were considered. A visualization of this process can be found in Figure 6 below. As the product was based upon a mood ring, an extimate ring was the first product idea. Although there are some benefits in the use of a ring as they can be worn most of the time, in the end, it was decided that it was too small to be visible to the environment. Then, a bracelet and smartwatch application were considered as options. Their visibility is much higher than a ring, and a smartwatch application was thought to be a more affordable and sustainable alternative to the creation and purchase of a one-use product. However, visibility would still be an issue for talking, as the environment would have to look at someone's wrist while they are talking to their face. Next to this, the layering of clothing could unintentionally hide the wearable.

Finally, the researcher decided on the use of a necklace. This type of wearable has many benefits. First, the visibility of a necklace is high when talking to someone's face. Next to this, a necklace adds to the accessibility of the product as there is a higher chance of the user being in possession of a neck than a wrist. Furthermore, a necklace can be layered easily on top of clothing. However, some vital considerations are keeping the product accessible

to all gender expressions and affordable. To support this decision, the survey consults the participants on their preferred type of wearable in the case of this project.
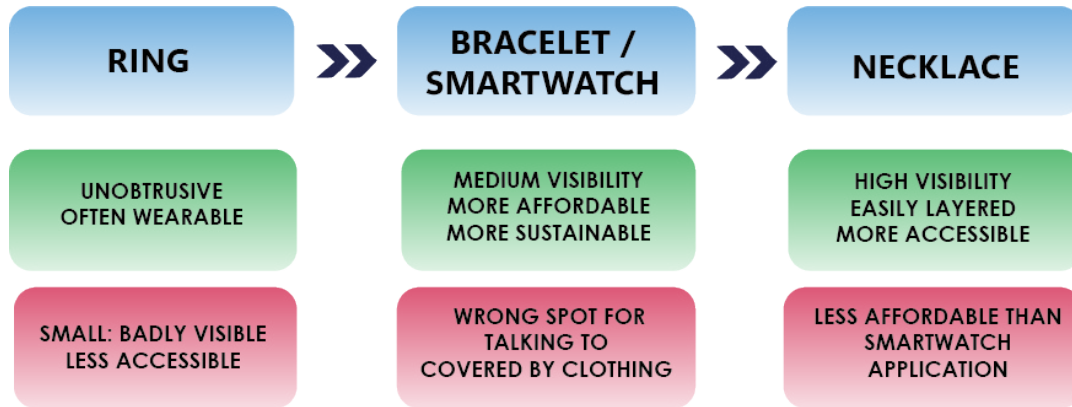

Figure 6 The framework, Design for Empathy: a Framework for Reflection [50]

4.2.1 Concept 1

The first concept, which can be seen in Figure 7, can be described as a tube of light on a metal choker. The tube of light can change colours based on user input through an accompanying smartphone application, as there is no proper space to position buttons on this device. This device would require RGB lights, a chargeable battery, and utilize chips that could receive the input for new states. There are some pros and cons to this concept, as can be seen in Table 1.

Figure 7 Sketch of Concept 1

+	−
Modern and sleek design	Does not fit all necks
Would not dangle when moving around	The metal might be uncomfortable
Weight distributed around the neck	Difficult to layer on shirts with high necklines

Table 1 Pros and Cons of Concept 1

4.2.2 Concept 2

The second concept, which can be seen in Figure 8, is a pendant necklace. It consists of a chain necklace, which should be nickel-free, durable, and not easily able to tarnish. The chain

necklace allows for changes of length, making it easier to layer and more accessible. The chain holds a pendant, in which lights slowly change colour in a gradient. The movement makes it so that the pendant catches the eye more easily. The pendant could be removed from the chain, allowing for placement in other places of the body. This device would require RGB lights, a chargeable battery, and utilize chips that could receive the input for new states. There are some pros and cons to this concept, as listed in Table 2.

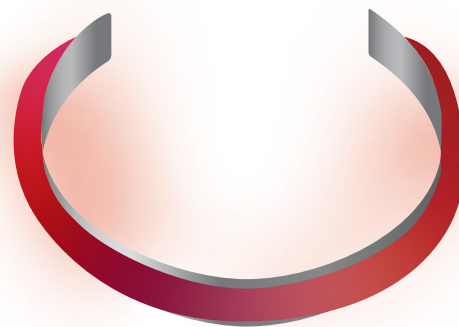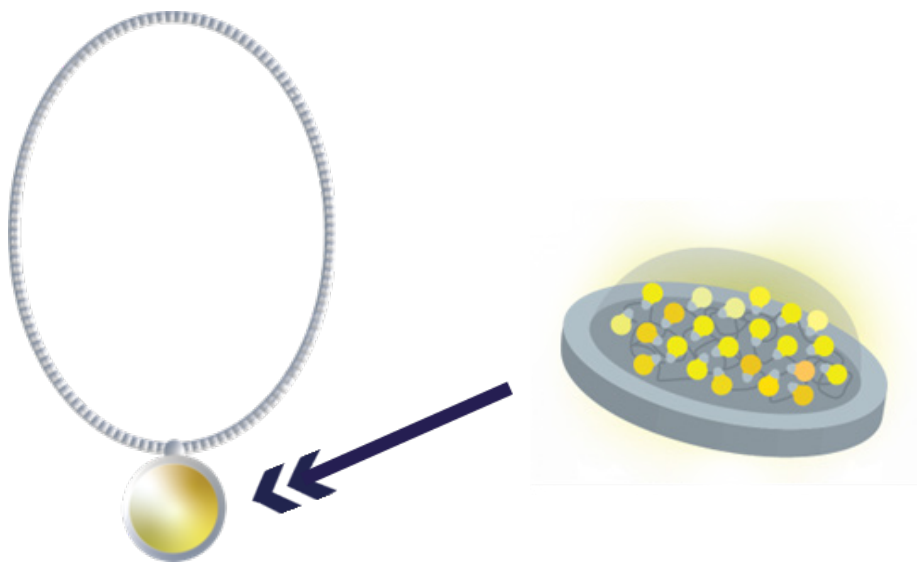*Figure 8 Sketch of Concept 2*

+	−
Easy to layer	Dangles when moving around
Height can be adjusted easing accommodation for all bodies	Does not allow for subtle differences in emotions
Comfortable around the neck	The pendant might be a little heavy
Colours allow for quick recognition of emotion	

Table 2 Pros and Cons of Concept 2

4.2.3 Concept 3

There are little changes between the second and third concepts. The one change is the use of a small LCD screen in place of RGB lights. The concept can be seen in Figure 9. This would allow for displaying coloured patterns and pixelated images next to colours. Some considerations can be seen in Table 3

Figure 9 Sketch of Concept 3

+	−
Easy to layer	Dangles when moving around
Height can be adjusted easing accommodation for all bodies	It requires more effort and time to input the emotion
Comfortable around the neck	It is more difficult to program
Allows for more distinction between emotions	The pendant might be a little heavy, especially when using a big battery
Allows for more personalization	Too many options might be overwhelming
Showcases emotions in a more nuanced manner	An LCD screen would require more energy than RGB lights, meaning that there has to be a bigger or more effective battery, or the product has to be charged more often

Table 3 Pros and Cons of Concept 3

4.2.4 A Consideration Between Concepts

The first concept has been rejected by the creator based on not supporting the moral principle of accessibility: its size and being a choker would make it uncomfortable to wear for many types of bodies. A choice must be made between the second and third sketches. This will rely on the results of the user study, where participants are asked whether they prefer the use of colours, patterns, and images such as emoticons (Appendix A).

In the eyes of the researcher, there is no one perfect decision regarding the choice between displaying colour or a pattern/image. There are benefits and drawbacks to each. On

one side, colour makes it easier to see at one glance what the person is feeling, or even by just having the product at the corner of your eye. However, displaying only colour doesn't allow for more specific and less distinctive emotions to be seen. On the other hand, the LCD, which could display both patterns and images, allows for more distinction within and multiple emotions simultaneously. Next to this, it will support accessibility to people with colour blindness. However, intricate images and patterns are not as obvious to the environment. This would lessen the impact of the use of communication but allow for more specific emotions to be shared.

A solution could be to use the third concept but give the user a choice between three modes: colour, pattern, and image. This would support user agency and accessibility, vital moral principles within the code of ethics. Furthermore, it allows for customization towards situations. Although some might prefer or are only capable of identifying core emotions, others might be more interested in sharing vaguer, and more complicated and connected feelings. A drawback to this solution could be that the many options can make the user feel overwhelmed.

4.3 Informing Design Choices with a Survey

As mentioned in Chapter Three, one of the chosen methods within this research project is user research in the form of a survey. The first half of this survey intends to inform design choices that the researcher was split on, such as how emotions should be shown and whether tracking should be done. In total, there were 28 responses. However, as one person did not give consent, there were 27 participants. Interestingly, most design choices resulted in diverse outcomes, with one exception. Within this subchapter, the responses to this part of the survey will be outlined. Furthermore, the survey's impact on the design choices will be discussed.

Surprisingly, most participants (52%) were of the opinion that the device should be a bracelet, as can be seen in Figure 10. Only 30% thought the device should be a necklace, with 19% believing it should be a smartwatch application. Although the researcher decided on a necklace for visibility and accessibility reasons, further work could be the creation of a bracelet version of the device. This, and other further work, will be expanded upon in Chapter Nine.
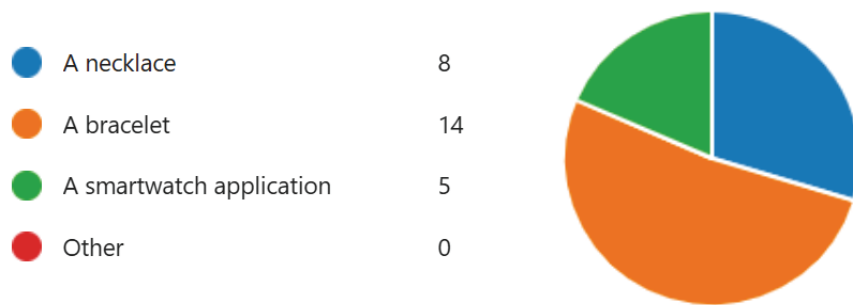
Figure 10 Answers on the Question: What Should the Wearable be?

Another design decision that had no singular outcome, was how emotion should be visualized. The results were nearly split evenly between the three options: colours only, coloured patterns and images. This can be seen in Figure 11. Because of this, it was decided to create three different "modes" that allow the user to show emotions how they want to. A benefit of this is that it allows for more distinctive and more basic emotions to be shown and that multiple IQ levels will be able to use the device, as participants in a study performed by Gillies-Walker et al. [23] mentioned should be a consideration during the design process.
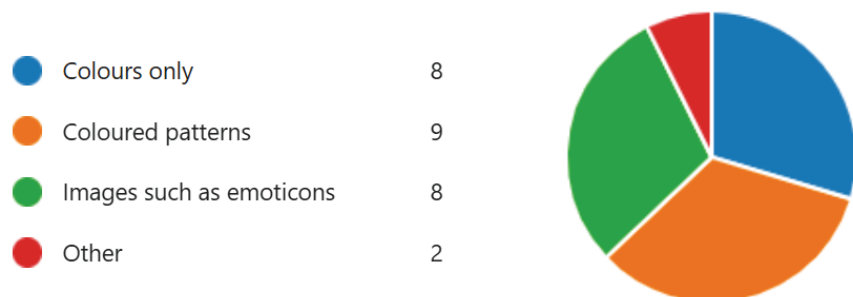

Figure 11 Answers on the Question: How Should Emotions be Visualized?

A feature that the researcher deemed controversial, as it would allow for less privacy and possibly lead to the user being less carefree in expression, is tracking the emotions the user puts in. The data collected would be compiled into daily and/or weekly reports. Surprisingly, 93% of respondents believed this should be a feature of the device, with the others unsure about it, as can be seen in Figure 12. Many believed it would be an excellent addition to the product. They stated that it could help with identifying patterns, triggers, and changes in behaviour. Furthermore, it could aid in self-reflection for the user and give them certain insights into their emotions. However, many users noted that they felt the feature should be optional, allowing the user to opt-out at any time.

Other considerations were mentioned. Several respondents expressed privacy concerns regarding the collection and storage of such intimate data. Next to this, a respondent

indicated that they thought that tracking emotions could lead to both avoidant and obsessive behaviour in users. As nearly all respondents indicated that the feature should be an option for this device, it was decided to include it. However, the considerations given were kept in mind during further specification of the product.
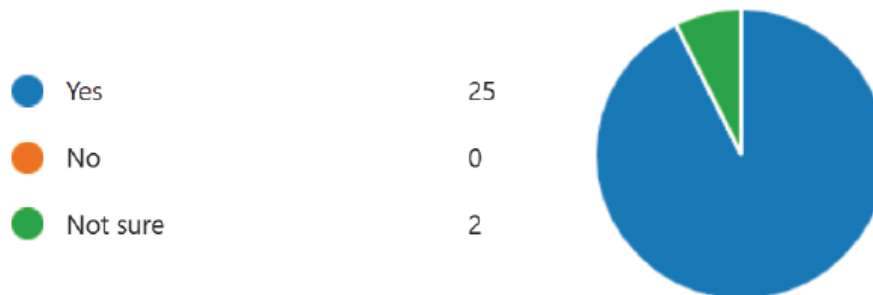

Figure 12 Answers on the Question: Should Emotions be Tracked?

Lastly, respondents were asked whether the user should be able to assign colours to different emotions or if the colours assigned to emotions should be the same across all devices. There was a difference in opinion on this topic. Although 59% of respondents believed that users should not be able to choose a colour for an emotion, the rest disagreed or were unsure. This has been visualized in Figure 13. Reasoning for their answer was asked. Those who thought colours should be preassigned believed that inconsistency could lead to miscommunication. Many stated that by making the emotion the same colour, it would make it more uniform for the environment. This would make the feelings of the user clear and make sure they don't need to explain their emotions anyway. Those who believed the user should assign the colours themselves stated that this would allow the user more nuance within their feelings. One stated:

"I want the option to change the colour. Maybe I am a little angry and want light red or very angry and want a deep red."

Additionally, respondents believed that the choice of colour could aid in a more authentic and intentional expression for the user. Another argument presented was that, given the device is created for those with ECI, it is vital for them to connect their emotions to the colour they believe corresponds. This will ease confusion for the user. One respondent replied that there should not be colour in use at all, since the relationship between colours and emotion is different for many people. To find whether there these associations would indeed not be similar to those of others, the respondents were asked which colour they associated with some emotions.
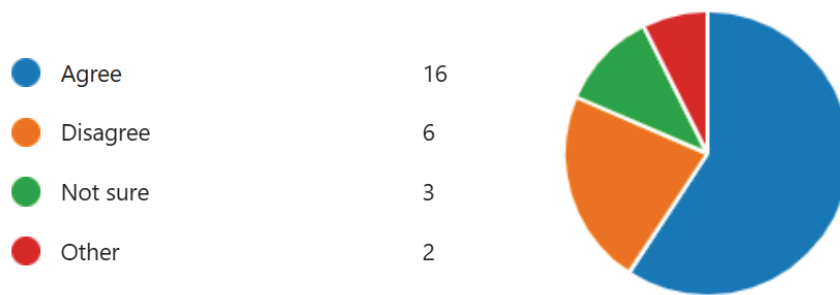
● Agree	16
● Disagree	6
● Not sure	3
● Other	2

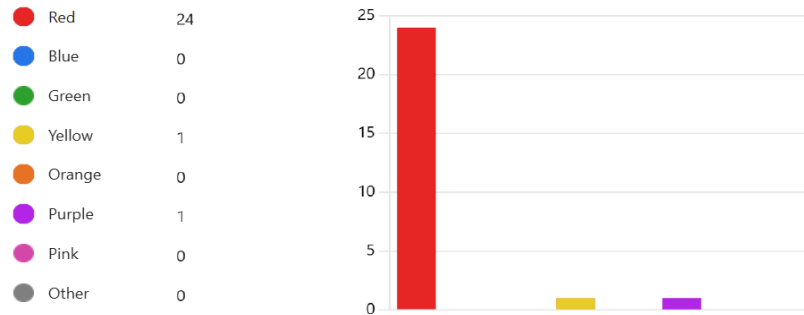*Figure 13 Answers on the Question: Should the Colours for Emotions be Pre-assigned?*

As can be seen in Figure 14, which visualizes what colour the participants associate with anger, sadness, happiness, stressed, and relaxed in a bar chart, the participants mostly agreed on the most basic emotions, anger sadness and happiness. The researcher hypothesized that for the more complicated emotions, there would be more of a spread in colours. Although this was partly true for the feeling of stress, the association was mostly split between two colours. For the other more complicated emotion, this was not true at all with a large preference for green.

From these results, it could be found that most respondents agree on the same colours for their emotions. This supports the preference of the researcher to allow the user to assign colours to emotion as it is likely that the colour is that which most agree on. Of course, if the colour assigned does fall out of the standard, miscommunication can happen. However, as this project strives to embody user agency in all aspects, it was decided to give the user control. Furthermore, the researcher strives to have the device be as accessible as possible. In that spirit, being able to assign colour could be a positive to users with colour vision deficiency as they can choose shades they can differentiate more easily.

4.4 Argumentation of the Preferred Concept

To come to the final concept of the prototype, several aspects had to be carefully considered. First, ethical considerations were reflected upon concerning the project. These helped in realising that agency and accessibility to facilitate extimacy should be what drives the design choices made in this project. Agency, interpreted as giving the user as much choice as possible when using or not using the device, was at the forefront when deciding to not include biometric tracking, incorporate multiple modes of communication, allow change in the colours associated with emotions, and integrate the optional feature of tracking the input. Accessibility was leading when choosing the type of wearable, as a necklace was deemed to be most accessible, and led to disregarding the first concept. Furthermore, the input of the app

Please add the colour you associate with: **ANGER**

🔴 Red	24	
🔵 Blue	0	
🟢 Green	0	
🟡 Yellow	1	
🟠 Orange	0	
🟣 Purple	1	
🟣 Pink	0	
⚫ Other	0	

Please add the colour you associate with: **HAPPINESS**

🔴 Red	0	
🔵 Blue	0	
🟢 Green	3	
🟡 Yellow	17	
🟠 Orange	4	
🟣 Purple	1	
🟣 Pink	1	
⚫ Other	0	

Please add the colour you associate with: **SADNESS**

🔴 Red	0	
🔵 Blue	23	
🟢 Green	0	
🟡 Yellow	1	
🟠 Orange	0	
🟣 Purple	1	
🟣 Pink	0	
⚫ Other	1	

Please add the colour you associate with: **STRESSED**

🔴 Red	1	
🔵 Blue	0	
🟢 Green	1	
🟡 Yellow	2	
🟠 Orange	15	
🟣 Purple	7	
🟣 Pink	0	
⚫ Other	0	

Please add the colour you associate with: **RELAXED**

🔴 Red	0	
🔵 Blue	2	
🟢 Green	14	
🟡 Yellow	1	
🟠 Orange	3	
🟣 Purple	2	
🟣 Pink	2	
⚫ Other	2	
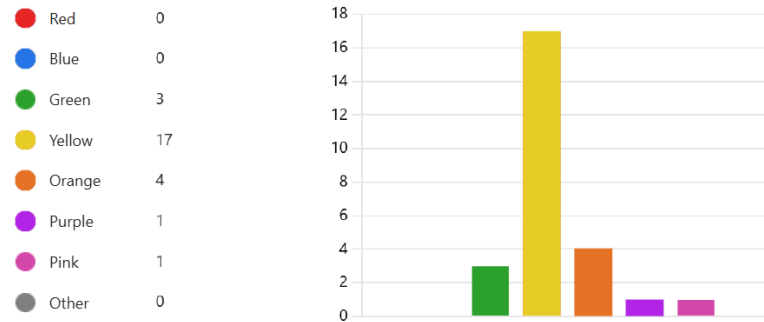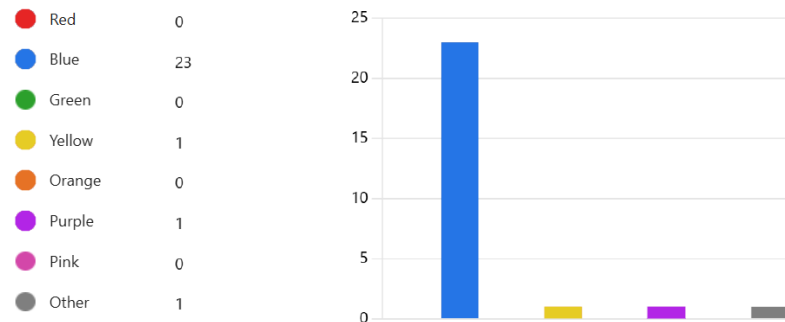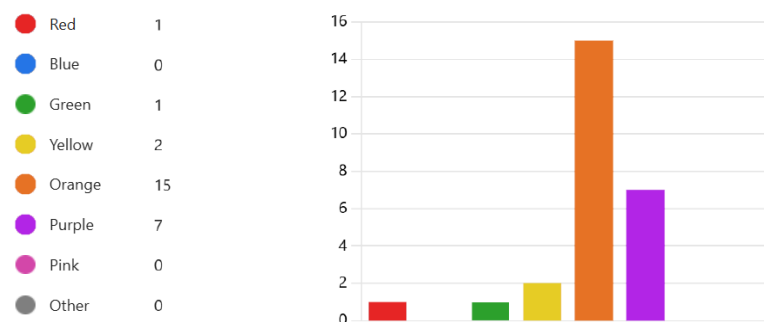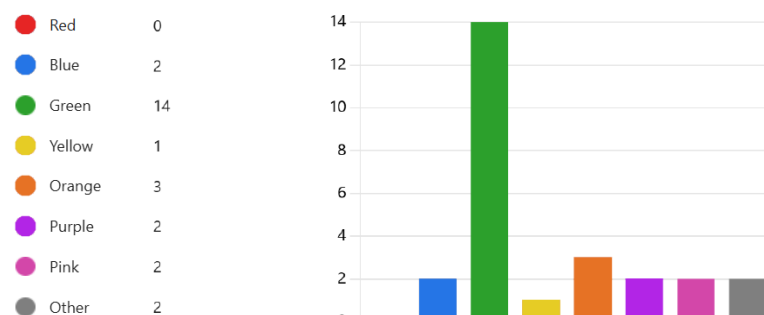
Figure 14 Results of Survey: Colour Associated with Emotions

should be as accessible as possible. Therefore, the researcher aimed to include voice command functionalities to accommodate individuals with visual impairments or movement issues. To allow incorporation of the design choices made by the researcher, as informed by the survey and influenced by ethical considerations, the third concept was chosen as the final sketch of the prototype.

Specification

This chapter further specifies the development of the prototype. First, a comprehensive user analysis is outlined using insights gained from a survey. Then, the product's goals, process of data encoding and preliminary requirements for the prototype are delved into. These steps facilitate the creation of a more specific list of specifications for the prototype.

5.1   Insights from a Survey on User Need

As outlined in section 2.3, this research strives to ease emotional communication for those who struggle with communicating their feeling explicitly. Since ECI can stem from a plethora of mental or physical origins, the target user can fall in the range of alexithymia severity. If one has an issue in identifying their emotions, it is difficult to share how they are feeling. The target demographic can be described as the following:

> *The target demographic consists of individuals who have issues with communicating their emotions to their environment, are interested in a device that could aid them regarding this issue and are willing to breach their privacy by sharing their emotions more explicitly.*

To prove or disprove a need for the device, a user study was performed in the form of a survey. In the second part of this survey, respondents were asked questions from the TAS [45], ICCS [46] and some additional questions created by the researcher. The goal was to identify whether the population of respondents included some who had symptoms of alexithymia or other ECI. The researcher hypothesised that, as studies have shown that 13% of the population has alexithymia [17], the researcher expected that at least 13% of respondents would indicate any form of ECI. A full overview of answers can be found in Appendix C.

Some insights were gained from the answers to this section of the survey. Most respondents indicated they had little or no difficulty identifying emotions, except an average of 6 respondents who expressed a non-negligible amount of difficulty with this. When looking at the participants' ability to describe their feelings, an increase in difficulty was reported with more participants agreeing. One statement, people tell me to describe my feelings more, was an outlier as many respondents disagreed with that. Considering the section on externally oriented thinking, there were strong 'agree' responses for thinking in such a manner, with only two participants not (strongly) agreeing with the statements that being in touch with emotions is essential and that they could feel close to someone even in moments of silence. The

responses to the other statements were more distributed. In general, participants responded they could disclose and express themselves, although some outliers were identified. One surprise was that there was no clear pattern in responding to the statement of whether they had difficulty in finding the right words for expressing emotions. There were many more who responded agree than other statements might have suggested. The section identifying barriers to communication signalled that many had obstacles in conveying their emotions. However, many disagree that these barriers have a negative effect on their well-being. Additionally, respondents reported fewer issues in communicating their emotions, both verbal and non-verbal, to those who they are close to than to those with whom they are not.

Finally, respondents were asked two questions related to the product: if they would benefit from using the device and whether someone they know would benefit from this device. Interestingly, only 2 (7%) respondents thought they would benefit from using the device. 14 (52%) respondents thought they would not benefit from the use of the device. The others were unsure. The respondents were asked to explain their reasoning. These varied wildly. Those who said they would use the device indicated that they believed that it would give clarity into what was going on inside them if they were not feeling good. Another stated that it could be valuable for everyone to have more insight into their emotions. Many were unsure if they would benefit from the device. Although one respondent indicated that they might have difficulty deciding which emotion they want to put on the device, they agreed with others, who expressed no issue in identifying emotions, that tracking the emotions would be fun and act as a positive affirmation. The identification of possible patterns was seen as an additional advantage.

Those who responded they would not benefit from this device had numerous reasons. Some expressed no interest in using the device as they did not need it. They claimed that they felt no need to further reflect on emotions or had no issues communicating their emotions in the first place. One respondent noted that they would rather talk about their emotions themselves and were presently capable of the ability to choose when to share emotions. Others did not feel the need to talk about their emotions at all. Additionally, one respondent expressed that if people could not see how they were feeling, it was because they were purposefully hiding their emotions. One respondent believed that they would get stuck thinking about their emotions, feeling it might become an emotional competition.

Some participants were unsure about the product itself, pointing out aspects of the product as considerations to why they might not use it. Some respondents stated that they would neglect or forget to properly log their emotions. They believed that that would mean that the device would have little effect on them. Next to this, one respondent expressed that the tracking of emotions would be useful for them but that they would not always like to share the emotions that they would input. There were a few who thought the design of the product would not facilitate enough nuance in emotions. Another was not as positive about the concept, thinking it could be a superficial approach to the complexity of emotions.

Notably, nearly half of respondents (48%) did think that someone they know would benefit from the device. 26% of respondents were unsure, with the other 26% not knowing anyone who would use the device. Again, respondents were asked to expand on their answer. Those who were positive recognized individuals in their environment with mental or physical disabilities, as part of the target demographic. They stated these individuals either had issues in expressing or identifying emotions and believed the device could help them with these communication barriers. Others thought to benefit from the device were people without (obvious) disabilities, who the respondents believed suffered from a type of ECI. Some respondents could identify someone from the target demographic in their environment yet were unsure whether they would be open to using the device or were interested in showing their emotions. Those who did not know anyone who would benefit from the device expressed that did not mean no one would benefit from the device.

What can be inferred from the answers gathered from this section of the survey, is that a need for the product has been identified. Although many responded in ways not indicating any type of ECI, some participants responded in a manner corresponding to a non-negligible amount of ECI. Identifying this in themselves might be more difficult, as most did not believe or were unsure whether the device would benefit them. The respondents could more easily see the need for the product in others.

5.2   Goals of the Product

The product is designed to serve two primary purposes for the user. Firstly, it aims to ease communication between the user and their environment. The second goal is to give the user practice identifying their emotions, enhancing their emotional awareness. While the product

can be used by those who are aware of their emotions but require assistance in expressing them, it is also beneficial to those who struggle with identifying their emotions, known as alexithymia. For users with alexithymia, the device may prove to be a successful aid in practising the recognition of their feelings. As there is an optional feature of tracking the manual input and receiving a report on emotions, an optional and additional goal of using the device is to find patterns in emotions. This information can be used to implement lifestyle changes to enhance overall well-being.

5.3   Data Encoding

During the Ideation phase, it was determined that users would be granted full freedom to assign any colour, pattern, or image to represent their emotions. This is to support user agency. Initially, some examples will be available to guide the user, although they can choose to leave them as set if preferred. For the colour mode, the assignment of colours to a few basic emotions was based on the survey results, primarily serving as an easter egg for this research. The assigned colours can be found in Table 4.

EMOTION	COLOUR
Angry	Red
Sad	Blue
Happy	Yellow
Stressed	Orange
Relaxed	Green

Table 4 Encoding Colours and Emotions

5.4   Preliminary Requirements for the Prototype

To set preliminary requirements, the MoSCoW Prioritization method was utilized [54]. This acronym represents four categories of prioritization for the creation of a product or, as relevant in this case, a prototype: Must-have, Should-have, Could-have, and Will-not-have. During the creation of the prototype, the prioritization will be considered. During the evaluation phase, the following list will be considered to find whether vital components are present:

Must-have

-       The ability to change colours
-       Be able to process user input
-       Be easy to use
-       Work via a smartphone application

Should-have

-       Three modes of expression
-       Function using voice commands
-       Have an option to gather input for a daily and/or weekly report

Could-have

-       The colour neutralizes after a set amount of time
-       Be a functional wearable
-       Be comfortable to wear and use

Will-not-have

-       Biometric tracking
-       Data security issues
-       Sound output

Realization

This chapter delineates the process of creating the prototype, addressing both the construction of the physical and the development of the virtual prototype. Certain design choices will be justified and discussed. As stated in section 4.4, the selected concept was a necklace with an LCD screen capable of displaying colour, coloured patterns, and images. Ideally, this concept would have been fully realized. However, it was determined early in the project that constructing the complete concept would be unfeasible given the timeframe and go beyond the scope of the project. Therefore, the focus shifted towards the creation of a prototype capable of performing the most basic tasks and preliminary requirements as listed in section 5.4, not considering appearance or practical usability. Additionally, as prototype testing would be performed on the mode of input, a smartphone application, this was prioritized. It was vital that this aspect of the project would be able to be integrated into the users' lives to strengthen extimacy.

6.1 Physical Realization of the Prototype

The initial design of the prototype included an LCD screen. However, due to technical difficulties, this approach was abandoned and replaced by employing an RGB LED light. As a result, the prototype was limited to merely one of three communication modes. Figure 15 provides a schematic representation of the physical realization of the prototype, consisting of an Arduino, breadboard, 10k Ω resistors, and several jumper wires. Figure 16 showcases the completed prototype. Various sources were consulted to complete this aspect of the prototype, aiding in the coding and setting up of the components [55], [56].
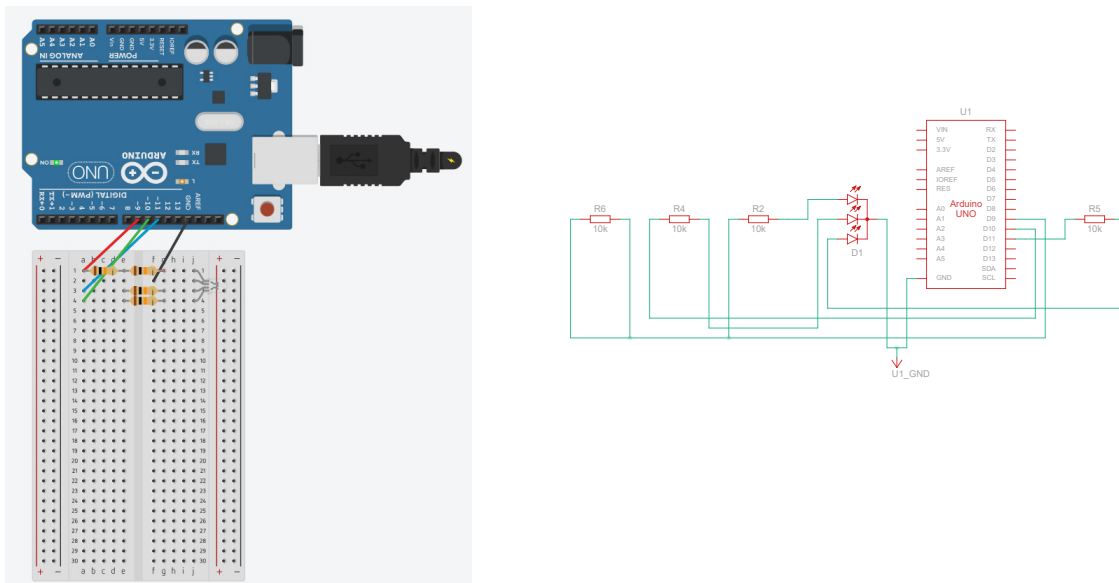

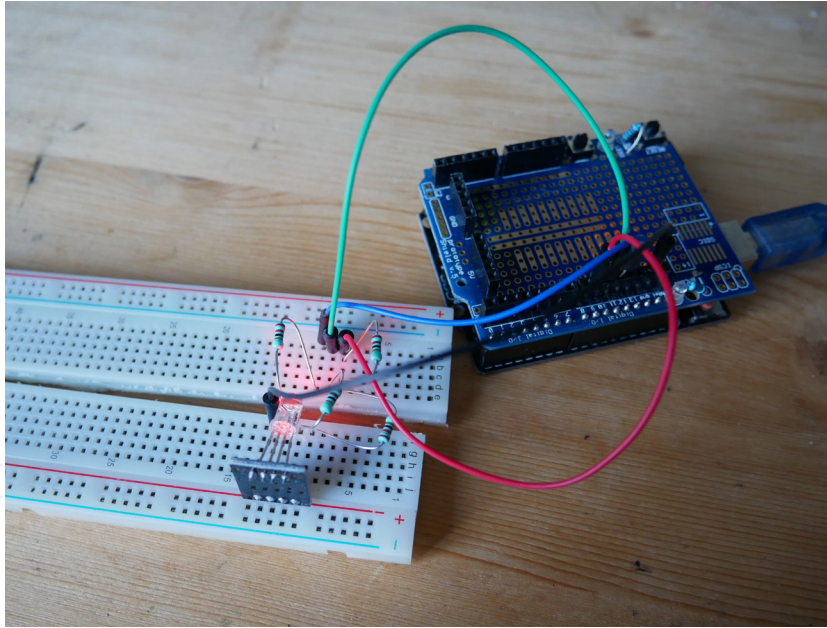*Figure 15 Overview Physical Realization*

Figure 16 Physical Prototype

6.2 Virtual Realization of Accompanying Smartphone Application

As indicated above, ensuring that the application would function as easily as possible, allowing for natural use and integration into the body, was vital to this project. Inspiration for the design of the application was taken from other mock-ups, gathered in Figure 17. These inspired the rounded design and other design aspects can be seen in the mood board and then you can recognize them in the final prototype that you can see in Figure 18. The prototype was developed using Figma.

The application interface begins with a login page. When logged in, there are three different screens which can be navigated to using the navigation bar on the bottom of the screen. The first page is the emotion tracker. This feature is optional. When turned off, the user doesn't see anything on the screen. When turned on, the interface includes patterns of the input over time and an additional navigation bar. The buttons lead to a calendar for seeing input per day, a notes section, and a trends section where patterns over an extended period can be found. The settings page offers basic options. On the home page, the user can navigate between the three communication modes, indicated with C, P, and I. When the colours, patterns, or images are pressed, the wearable would change colour and screen pop-ups. Within this screen, a button navigates to an overlay where emotion and colour can be edited. Of course, new emotions can be added as well. Figure 19 below shows the paths which can be taken when pressing certain parts of the screen.
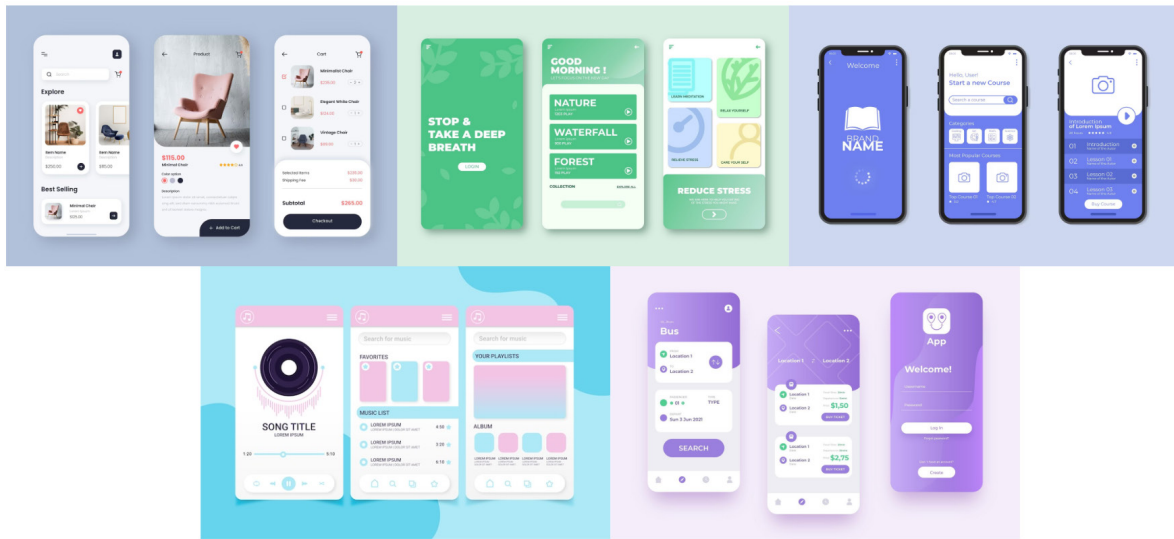
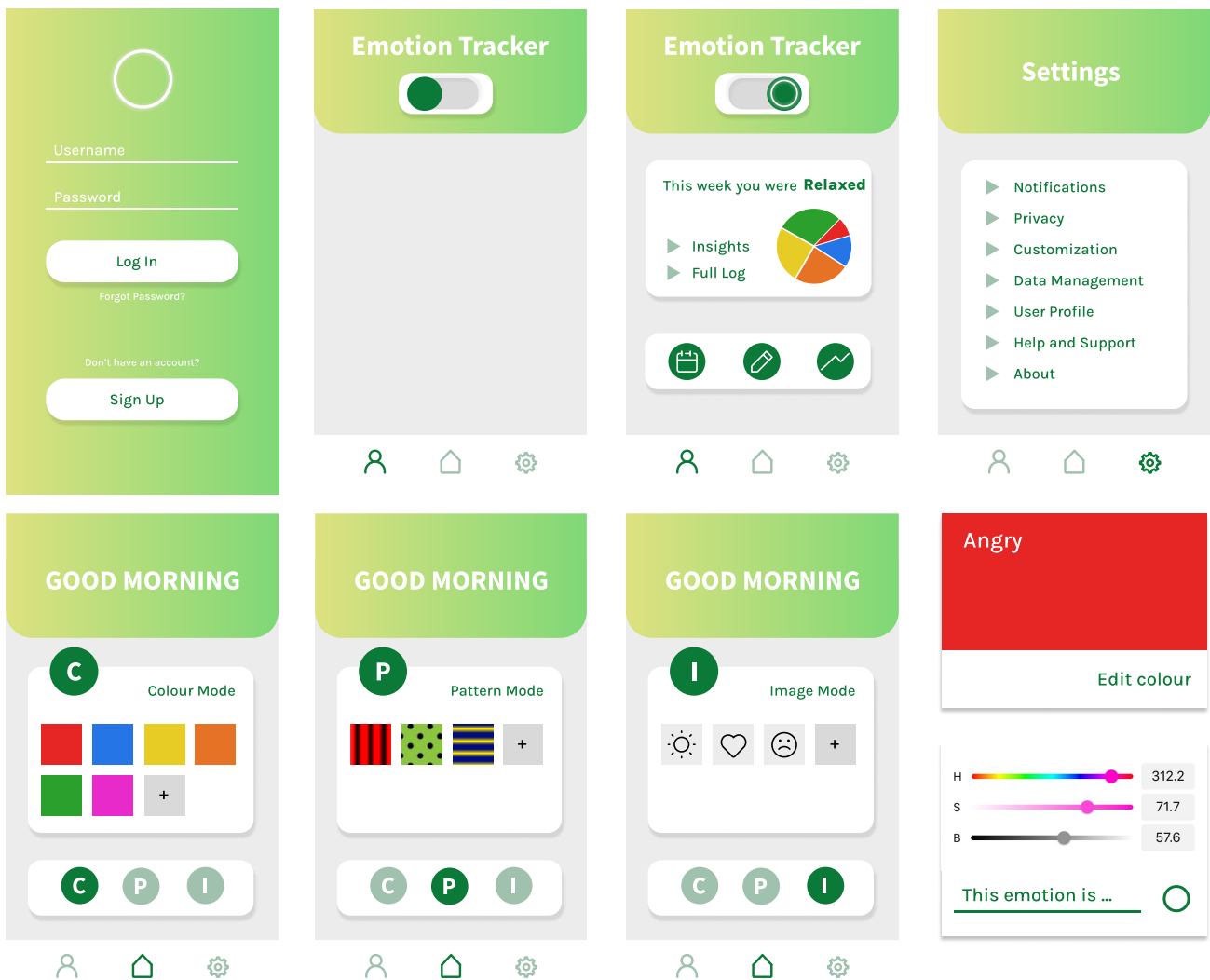*Figure 17 Inspiration for the Design of the Application*

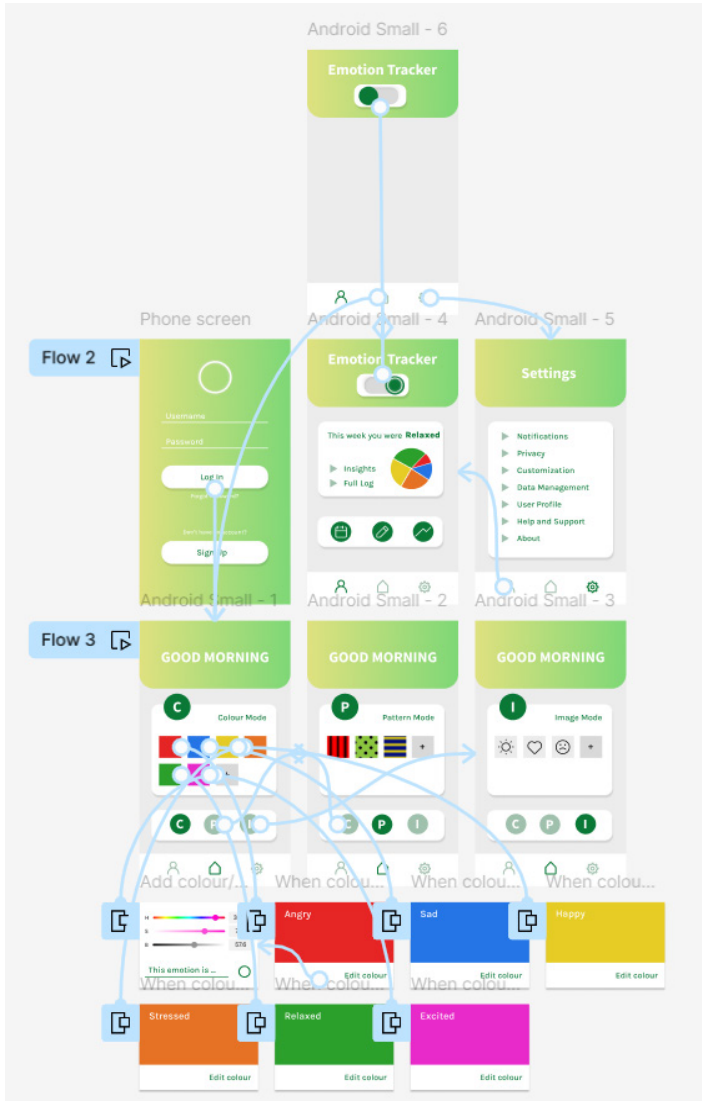*Figure 18 Prototype of the Application*

Figure 19 Flow of the Prototype

Evaluation

This chapter outlines the steps taken to evaluate the functionality and effectiveness of the developed prototype. The initial step involved user testing to assess the usability and ease of use of the virtual input management component, a smartphone application. The following step utilized the MoSCoW method [54] to evaluate both the physical and virtual components.

7.1 User Testing

Two user testing sessions were performed on the prototype of the application, testing its usability. It was vital to the researcher that this application was easy to use. The outline of these sessions was the following:

1.   The ethical protocol was followed, requiring consent before participants were allowed to partake in the user study.

2.   Participants were given access to the prototype of the app. They could navigate to other pages by clicking certain buttons. Audible feedback was given when a button clicked would change the colour of the wearable. During this step, participants were asked to think out loud.

3.   Four tasks were given to the participants:

• Can you add a colour?

• Can you change the colour of the necklace?

• Can you turn off the emotion tracker?

• What do the buttons in the emotion tracker lead to?

4.   Participants were asked to voice any questions, comments, and additional concerns.

The first participant experienced some initial confusion at the start of the session and encountered some difficulty navigating the app, clicking around for some time. They took some time before clicking a colour to change the wearable. The participant was unclear about what the letters P, C, and I, which correlate to the communication modes, referred to. This participant provided additional feedback on and recommendations for the design of the app, such as reordering the settings. Next to this, the participant stated they believed it would be interesting to choose an emotion and then choose a communication mode whenever the input should change. Furthermore, this participant suggested that a guided tour of the app would be appropriate when opening it for the first time. The participant questioned the choice

of these specific colours and emotions, suggesting an additional list of emotions for users to choose from, as they were unsure whether they could generate these themselves. Despite some initial challenges, when asked to perform the tasks after being given an appropriate amount of time navigating the application, the participant had no trouble with them. The only mistake was assuming that the pencil would lead to an edit section instead of a notes section. Their final feedback was to make it clear which emotion has been chosen and to make it clearer how this emotion can be selected. Although many suggestions were made, the participant was very positive and enthusiastic about the prototype's design.

The second participant had less trouble with navigating the app. Immediately, this participant understood aspects of the app such as what the letters C, P, and I stood for. The participant noted that they liked the image mode the best. They did not like the pattern mode and did not understand why, when, or how someone would use it. Although they liked the colour mode, the participant believed that the image mode would be clearest in communication. The participant would have liked to have seen more preselected images and wondered how more would be added. They proposed the ability to draw them in the app. The participant could perform all tasks but had the same problem with thinking that the notes section meant an edit button. This participant was positive about the prototype's design as well.

7.2 MoSCoW Evaluation

Section 5.4 listed the preliminary requirements of the prototype. In this section, an evaluation will take place on what aspects are present and in what form. For the must-have requirements, the prototype includes the ability to change colours, is user-friendly, as found in the user study, and has the smartphone application prototype function as the input mode. However, the colour change of the physical prototype is not yet linked to the input given in the virtual prototype. Currently, this feature is manual. In the should-have category, the option to gather input for a daily and/or weekly report is present in the prototype of the application but only one of three modes of expression is currently possible: the colour mode. Furthermore, the prototype does not yet function using voice commands, as the virtual prototype is not yet a functional application. For the could-have category, no requirements were met as the device is not a functional, comfortable wearable. Neither does the colour neutralize after a set amount of time. Finally, the requirements of the will-not-have section were met. There is no sound

output and biometric tracking is not included in the design. As there is currently no data stored, there are no data security issues. What can be gathered from this evaluation is that while some essential and highly prioritized requirements were met, others were not, largely due to the prototype's rudimentary nature and the technical difficulties faced using an LCD screen.

7.3 Conclusion

The physical prototype, while meeting some essential requirements, remains basic and is yet unfunctional as a wearable. It cannot be worn as a necklace and does not resemble the concept sketch. However, emotions can be estimated using colours, indicating that the skeleton of the product is present. Future development could lead to a comfortable and fully functional product, including all the features imagined. The smartphone application was found to be natural in use with potential for improvement. For instance, changing the colour of the application depending on the emotion that is being externalised, could provide clarity on what the last mode of expression was without looking at the necklace. Both participants of the user study struggled with correctly identifying the pencil button as the notes instead of the edit button. instead of notes. A change in the icon should resolve this issue. An additional feature is to incorporate a guided app tour when logging in for the first time. During this tour, the purpose of each mode can be clarified to lessen confusion about use cases. These adjustments could aid in improving the app's usability, making it even more of an extension of the human body, and positively impacting the potential for the extimacy of the product.

Discussion and Conclusion

Regarding the user research, several insights were gained on the project. It was gathered that the respondents were interested in the product but saw more need for the device in their environment than themselves. This suggests that people perceive themselves as better communicators than might be the reality. Some respondents raised specific concerns regarding the project. One mentioned that sharing emotions with complete strangers may not be wanted, although they saw the point in using the device to communicate with their close environment. Other participants shared that they believed that the use of the device should be done under supervision. Otherwise, the user might not know what they are feeling at that moment themselves and they might become too conditioned and focused on the wearable. Additionally, one participant thought the device might prove useful in tracking issues such as monthly cycles for women, helping in disrupting patterns which may need to be addressed. However, the researcher is cautious about tracking data specific to women, as data regarding fertility could be misused.

Several limitations to the project were identified. The primary limitation is that user research and studies were not specifically performed using the target demographic, mainly due to time and resource restraints and the target demographic's vulnerability raising ethical concerns. Another limitation was the absence of a functional wearable prototype during user testing. It had been decided early in the project that this would not be feasible, but it could have given additional depth to the results of the prototype testing sessions. Lastly, a limitation might have been the language used during the survey. This was quite formal and academic and was mentioned as a barrier to some. After two participants had given feedback regarding this, the language was simplified, and extra clarification was given regarding the project.

To conclude this thesis report, the research questions posed in the introduction will be answered. Wearable computing can embody the concept of intimacy and extimacy by becoming a natural part, or extension, of a body and by tracking and/or sharing intimate data. Furthermore, the user can be given agency over their intimate relationship with technology by providing them with as many choices and options as possible and not tracking biometric data, thus allowing the user to mould the technology to their needs and wishes. Finally, key design aspects to extimating emotions include multiple communication modes, ensuring high visibility to the environment and making the wearable technology as natural in use as possible to facilitate a proper extension of the human body.

Future Work

Limitations mentioned in Chapter Eight have indicated the existence of possible future work. Expanding the research by focusing on user research and studies specifically targeting individuals with ECI, rather than the general population, is recommended. It is essential to consider a diverse spectrum of ECI, from physical and mental disabilities to alexithymia. Additionally, developing a physical and usable wearable could present a promising project. User studies could then be performed using the physical wearable, which could yield valuable insights and more realistic feedback. It is proposed that in addition to further usability testing, field studies and focus groups be incorporated.

Various additional features or designs were considered alongside the prototype developed in this project. For instance, the optional feature to link the wearable to others. Then, if the user is feeling a specific emotion, the person they are linked with could receive a notification. This could, for example, be useful in a clinical setting or when there is one caretaker for multiple users. The caretaker could then receive a notification when they are needed. Another option could be to link a wearable to friends, seeing how they feel when they choose to share this. Next to this component, future work could be done on the optional feature of tracking the data input and, especially, how this should be analysed. The data input must be analysed in a significant manner, giving reports that the user has a use for. The last notion identified relating to the actual product is the design of different types of wearables and technologies. In user research, interest in a bracelet was found to be high. A smartwatch app could be developed in addition to this, as this would be the most affordable and environmentally friendly option.

Furthermore, some interesting questions and topics which could be examined further and more closely were identified during this project. These have been categorised according to topic. Regarding intimacy and extimacy in technology, an interesting area is the user's reliance on extimate technology. This dependency raises possible complications when the technology is malfunctioning or breaks, leaving the user vulnerable. Additionally, the concept of ownership over these technologies could merit examination. Another significant are for future research, is the possible relationship that exists between affordance and extimacy, mindfulness and extimacy, and imperceivability and extimacy (a subtle presence that only becomes noticeable when you focus on it). These interconnected topics promise to enrich our understanding of user interactions with technology, offering valuable insights for future advancements within this field.

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During the preparation of this work the author used ChatGPT as a brainstorming tool and to receive feedback on writing style. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.

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Appendix A

Information Letter and Consent Form for Extimating Emotions: Designing a Wearable

Author: Marloes Collewijn
Last edited: 24/05/2024

INFORMATION REGARDING PROJECT

Sharing emotions with one's environment is not always easy. This is especially true for those suffering from emotional communication issues, which can come in many forms. In the scope of this project, extimacy is defined as the concept of an artefact that is an almost imperceivable extension of the human body, that can share their user's intimate data with their environment.

This project aims to design an extimate wearable capable of sharing the users' emotions with their environment. Vitally, this is done without any type of tracking, relying on user input. This is to promote agency for the user. The goal of this user study is to inform design choices and test use cases.

INFORMATION REGARDING THE SURVEY

This survey will consist of x-y questions, with an estimated answering time of 15-20 minutes. It consists of mostly scaled questions.

Some questions rely on self-reflection. As a result, a possible risk is mental discomfort. If this occurs, you are welcome to contact the researcher at m.a.collewijn@student.utwente.nl or her supervisor m.honauer@utwente.nl.

At any moment, you may stop the survey for any or no reason. When unwanted, answers do not have to be submitted after being filled in.

At the end of this survey, you will be asked to leave your email address if you are interested in taking part in more in-depth interviews and/or prototype testing or if you would like to receive the final thesis by email. This is voluntary. The list of email addresses gathered will be kept utterly confidential and deleted after they have fulfilled their purpose of being used for interest in the interviews and/or the final thesis.

Data will be kept anonymous and used quantitively. Quotes may be used unattributed in the thesis or thesis presentation. Collected data will be deleted within a year after the thesis has been published (before September 2025). The retention period will last from submitting the data, until September 2025.

This research project has been reviewed by the Ethics Committee Information and Computer Science.

For any additional questions, issues, concerns, or comments regarding the research or data collection, or anything related to this, you are welcome to email the researcher at m.a.collewijn@student.utwente.nl or her supervisor m.honauer@utwente.nl .

If you want to file a complaint regarding this survey, please contact the Ethics Committee Computer and Information Science at the University of Twente https://www.utwente.nl/en/eemcs/research/ ethics/. They can be contacted via email at ethicscommittee-cis@utwente.nl

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INFORMATION REGARDING THE INTERVIEW SESSION

This session will take 20-30 minutes. It consists of a semi-structured interview and prototype testing.

Some questions rely on self-reflection. If you are sensitive to the topic of emotional awareness, a possible risk is mental discomfort. If this occurs, you are welcome to contact the researcher at m.a.collewijn@student.utwente.nl or her supervisor m.honauer@utwente.nl.

This research project has been reviewed by the Ethics Committee Information and Computer Science.

At any moment, you may stop the session for any or no reason. Answers may be subtracted at any time.

At the end of this interview, you will be asked to leave your email address if you are interested if you would like to receive the final thesis by email. This is voluntary. The list of email addresses gathered will be kept utterly confidential and deleted after they have fulfilled their purpose.

Data will be kept anonymous and used qualitatively. Quotes may be used unattributed in the thesis or thesis presentation. Collected data will be deleted within a year after the thesis has been published (before September 2025). The retention period will last from submitting the data, until September 2025

For any additional questions, issues, concerns, or comments regarding the research or data collection, or anything related to this, you are welcome to email the researcher at m.a.collewijn@student.utwente.nl or her supervisor m.honauer@utwente.nl .

If you want to file a complaint regarding this interview session, please contact the Ethics Committee Computer and Information Science at the University of Twente https://www.utwente.nl/en/eemcs/research/ethics/. They can be contacted via email at ethicscommittee-cis@utwente.nl

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Consent Form for Extimating Emotions:
Designing a Wearable
YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated 24/05/2024, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	O	O
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	O	O
I understand that taking part in the study involves completing a survey questionnaire as a participant.	O	O
Risks associated with participating in the study		
I understand that taking part in the study involves the following risk: mental discomfort.	O	O
I am informed on steps to take when the risk presents.	O	O
Use of the information in the study		
I understand that the information I provide will be used for academic publications, in the form of a thesis report and a thesis presentation	O	O
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	O	O
I agree that my information can be quoted in research outputs	O	O
Survey only:		
Future use		
I give the researchers permission to keep my contact information and to contact me for future research projects.	O	O

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Signatures

_____   _____   _____
Participant name [printed]   Signature   Date

I have accurately read out the information sheet to the potential participant and, to the best
of my ability, ensured that the participant understands to what they are freely consenting.

_____   _____   _____
Researcher name [printed]   Signature   Date

Study contact details for further information:
Marloes Collewijn
m.a.collewijn@student.utwente.nl

Michaela Honauer (supervisor)
m.honauer@utwente.nl

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant, or wish to obtain
information, ask questions, or discuss any concerns about this study with someone other than
the researcher(s), please contact the Secretary of the Ethics Committee Information &
Computer Science: ethicscommittee-CIS@utwente.nl

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Appendix B

Survey on Designing an Extimate Wearable

Hi! Would you mind taking 10-15 minutes to complete this form? Thank you!

℀

* Required

Information & Consent

Please read the following meticulously before providing consent

Sharing emotions with one's environment is not always easy. This is especially true for those suffering from emotional communication issues, which can come in many forms. In the scope of this project, **extimacy is defined as the concept of an artefact that is an almost imperceivable extension of the human body, that can share their user's intimate data with their environment.**

This project aims to design an extimate wearable capable of sharing the users' emotions with their environment. Vitally, this is done without any type of tracking of biometric data, relying on user input. This is to promote agency for the user. What this looks like tangibly, is a product, such as a bracelet or necklace, that can change colour based upon what the user wants. If the user wants others to know they are feeling happy, they can press a button to change the colour of the product to the appropriate feeling. The goal of this user study is to inform design choices and (dis)prove a need for the product.

This survey will consist of 18 questions, with an estimated answering time of 10-15 minutes. It mostly consists of scaled questions.

Some questions rely on self-reflection. As a result, a possible risk is mental discomfort. If this occurs, you are welcome to contact the researcher at m.a.collewijn@student.utwente.nl or her supervisor m.honauer@utwente.nl.

At any moment, you may stop the survey for any or no reason. When unwanted, answers do not have to be submitted after being filled in.

At the end of this survey, you will be asked to leave your email address if you are interested in taking part in more in-depth interviews and/or prototype testing or if you would like to receive the final thesis by email. This is voluntary. The list of email addresses gathered will be kept utterly confidential and deleted after they have fulfilled their purpose of being used for interest in the interviews and/or the final thesis.

Data will be kept anonymous and used quantitively. Quotes may be used unattributed in the thesis or thesis presentation. Collected data will be deleted within a year after the thesis has been published (before September 2025). The retention period will last from submitting the data, until September 2025.

This research project has been reviewed by the Ethics Committee Information and Computer Science.

For any additional questions, issues, concerns, or comments regarding the research or data collection, or anything related to this, you are welcome to email the researcher at m.a.collewijn@student.utwente.nl or her supervisor at m.honauer@utwente.nl .

If you want to file a complaint regarding this survey, please contact the Ethics Committee Computer and Information Science at the University of Twente https://www.utwente.nl/en/eemcs/research/ ethics/. They can be contacted via email at ethicscommittee-cis@utwente.nl

I am 16 or older and capable of giving consent *

◯ Yes

◯ No

I have read and understood the study information. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. I understand that taking part in the study involves completing a survey questionnaire as a participant. *

◯ Yes

◯ No

I understand that taking part in the study involves the following risk: mental discomfort. I am informed on steps to take when the risk presents *

◯ Yes

◯ No

I understand that the information I provide will be used for academic publications, in the form of a thesis report and a thesis presentation. I understand that personal information collected about me that can identify me, will not be shared beyond the study team. I agree that my information can be quoted in research outputs *

◯ Yes

◯ No

Informing Design Choices

Extimacy is defined as the concept of an artefact that is an almost imperceivable extension of the human body, that can share their user's intimate data with their environment.

The wearable should be... *

◯   A necklace

◯   A bracelet

◯   A smartwatch application

◯   Other

The wearable should visualize emotions using... *

◯   Colours only

◯   Coloured patterns

◯   Images such as emoticons

◯   Other

If the wearable would make your emotions visible through colours, the output of the wearable should be the same for every user. E.g. if the user wants to extimate anger, it would be red. They would not be able to choose a different colour to show that emotion. *

◯   Agree

◯   Disagree

◯   Not sure

Please explain why (not). *

[   ]

Please add the colour you associate with: **ANGER** *

○ Red

○ Blue

○ Green

○ Yellow

○ Orange

○ Purple

○ Pink

○ Other

Please add the colour you associate with: **SADNESS** *

○ Red

○ Blue

○ Green

○ Yellow

○ Orange

○ Purple

○ Pink

○ Other

Please add the colour you associate with: **HAPPINESS** *

○ Red

○ Blue

○ Green

○ Yellow

○ Orange

○ Purple

○ Pink

○ Other

Please add the colour you associate with: **STRESSED** *

◯ Red

◯ Blue

◯ Green

◯ Yellow

◯ Orange

◯ Purple

◯ Pink

◯ Other

Please add the colour you associate with: **RELAXED** *

◯ Red

◯ Blue

◯ Green

◯ Yellow

◯ Orange

◯ Purple

◯ Pink

◯ Other

An option is to track the emotions that the user puts in. The data can be stored, analysed , and compiled into a daily or weekly report. This report could help the user in finding patterns within their emotions and improve their well-being. Should this be a feature of the device? *

◯ Yes

◯ No

◯ Not sure

Please explain why (not). *

[   ]

Emotional Awareness and Communication

Please rate the following statements based on how much you agree with them *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
I am often confused about what emotion I am feeling	◯	◯	◯	◯	◯
I am often puzzled by sensations in my body.	◯	◯	◯	◯	◯
I am able to describe my feelings easily.	◯	◯	◯	◯	◯
I prefer to analyze problems rather than just describe them.	◯	◯	◯	◯	◯
I prefer to just let things happen rather than to understand why they turned out that way.	◯	◯	◯	◯	◯
Other people know what I am thinking	◯	◯	◯	◯	◯
I express myself well verbally	◯	◯	◯	◯	◯
I have the ability to easily communicate my emotions to people I am close to **without** talking to them	◯	◯	◯	◯	◯
I can feel close to someone, even in moments of silence.	◯	◯	◯	◯	◯
People tell me to describe my feelings more.	◯	◯	◯	◯	◯

Please rate the following statements based on how much you agree with them *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Being in touch with emotions is essential.	◯	◯	◯	◯	◯
Looking for hidden meanings in movies or plays distracts from my enjoyment.	◯	◯	◯	◯	◯
I often don't know why I am angry.	◯	◯	◯	◯	◯
It's difficult to find the right words to express myself	◯	◯	◯	◯	◯
There are no obstacles for me to share my emotions	◯	◯	◯	◯	◯
People who don't know me can tell how I am feeling **without** talking to them	◯	◯	◯	◯	◯
I reveal how I feel to others	◯	◯	◯	◯	◯
I find it hard to describe how I feel about people.	◯	◯	◯	◯	◯
I have feelings that I can't quite identify.	◯	◯	◯	◯	◯
When I am upset, I don't know if I am sad, frightened, or angry.	◯	◯	◯	◯	◯

Please rate the following statements based on how much you agree with them *

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The obstacles I face in communicating my emotions do not affect my emotional well-being	○	○	○	○	○
The people I am close to can tell when I'm happy or sad	○	○	○	○	○
I have the ability to easily communicate my emotions to people I am close to **when** talking to them	○	○	○	○	○
I allow the people I am close to to see who I really am	○	○	○	○	○
I prefer talking to people about their daily activities rather than their feelings.	○	○	○	○	○
It is difficult for me to find the right words for my feelings	○	○	○	○	○
I don't know what's going on inside me.	○	○	○	○	○
People who don't know me can tell how I am feeling **when** talking to them	○	○	○	○	○
I find examination of my feelings useful in solving personal problems.	○	○	○	○	○
It is difficult for me to reveal my innermost feelings, even to close friends.	○	○	○	○	○

I would benefit from using this wearable device *

○ Yes

○ No

○ Not sure

Please explain why (not) *

[   ]

Someone I know would benefit from using this device *

◯ Yes

◯ No

◯ Not sure

Please explain why (not) *

[   ]

Do you have any additional questions or remarks regarding the contents of the survey?

[   ]

Interest in receiving thesis **or** partaking in an interview/prototype testing session

OPTIONAL I give the researcher permission to keep my contact information in order to be able to contact me for future research projects or to receive the thesis by mail. *

◯ Yes

◯ No

Please fill in your email address

[   ]

I am interested in...

☐ partaking in an interview/prototype testing session

☐ receiving the thesis by mail

Microsoft Forms

Appendix C
Overview of Results of the Survey

The wearable should be...

More Details   💡 Insights

🔵 A necklace	7
🟠 A bracelet	14
🟢 A smartwatch application	5
🔴 Other	0

If the wearable would make your emotions visible through colours, the output of the wearable should be the same for every user. E.g. if the user wants to extimate anger, it would be red. They would not be able to choose a different colour to show that emotion.

More Details   💡 Insights

🔵 Agree	15
🟠 Disagree	6
🟢 Not sure	3
🔴 Other	2

The wearable should visualize emotions using...

More Details   💡 Insights

🔵 Colours only	8
🟠 Coloured patterns	9
🟢 Images such as emoticons	7
🔴 Other	2

An option is to track the emotions that the user puts in. The data can be stored, analysed , and compiled into a daily or weekly report. This report could help the user in finding patterns within their emotions and improve their well-being. Should this be a feature of the device?

More Details   💡 Insights

🔵 Yes	25
🟠 No	0
🟢 Not sure	1

Please add the colour you associate with: **ANGER**
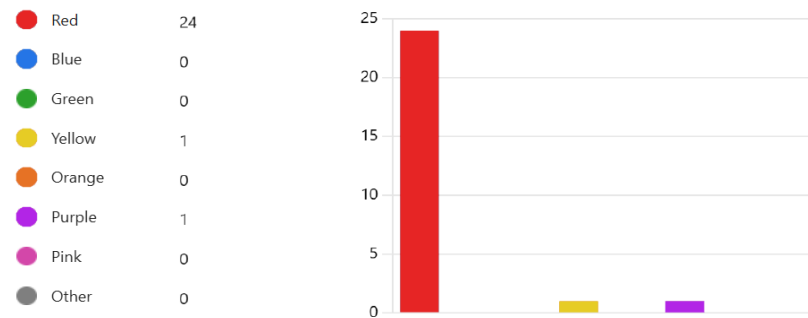
🔴 Red	24
🔵 Blue	0
🟢 Green	0
🟡 Yellow	1
🟠 Orange	0
🟣 Purple	1
🟣 Pink	0
⚫ Other	0

Please add the colour you associate with: **HAPPINESS**

🔴 Red	0
🔵 Blue	0
🟢 Green	3
🟡 Yellow	17
🟠 Orange	4
🟣 Purple	1
🟣 Pink	1
⚫ Other	0

Please add the colour you associate with: **SADNESS**

🔴 Red	0
🔵 Blue	23
🟢 Green	0
🟡 Yellow	1
🟠 Orange	0
🟣 Purple	1
🟣 Pink	0
⚫ Other	1

Please add the colour you associate with: **STRESSED**

🔴 Red	1
🔵 Blue	0
🟢 Green	1
🟡 Yellow	2
🟠 Orange	15
🟣 Purple	7
🟣 Pink	0
⚫ Other	0

Please add the colour you associate with: **RELAXED**

🔴 Red	0
🔵 Blue	2
🟢 Green	14
🟡 Yellow	1
🟠 Orange	3
🟣 Purple	2
🟣 Pink	2
⚫ Other	2
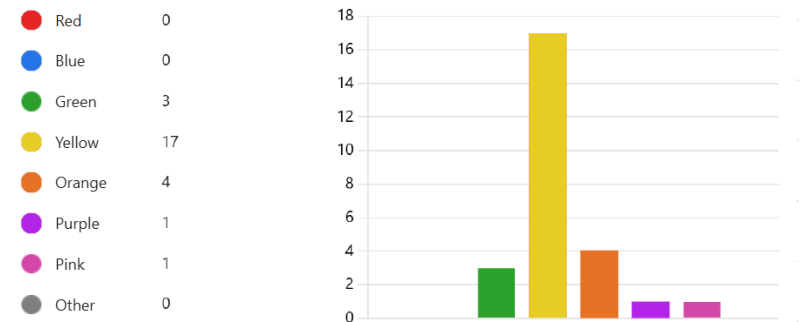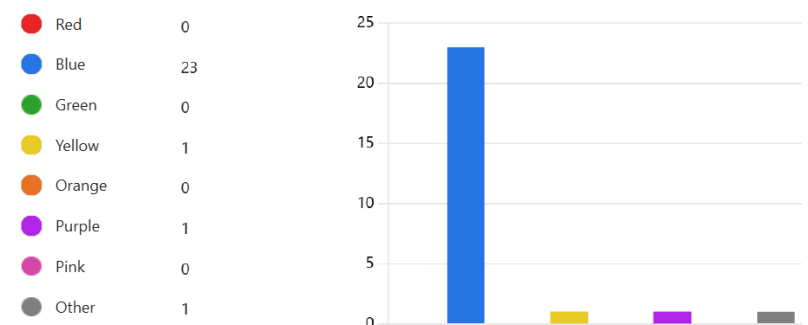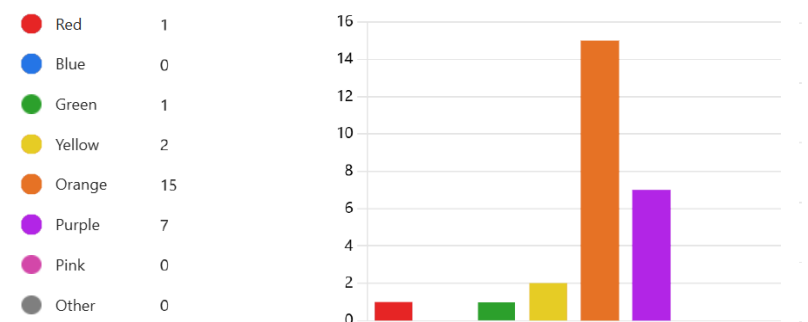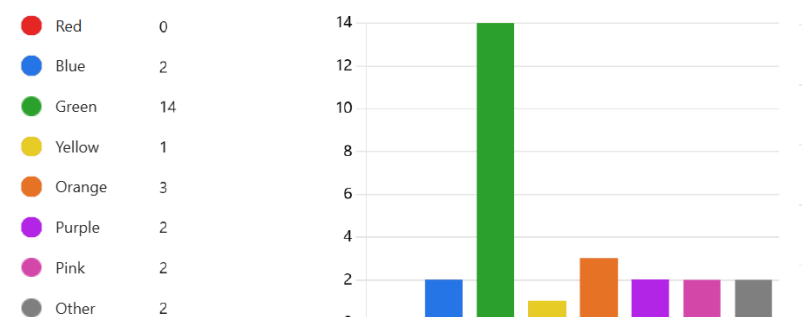
I would benefit from using this wearable device

More Details　　🔆 Insights

🔵	Yes	2
🟠	No	14
🟢	Not sure	10

Someone I know would benefit from using this device

More Details　　🔆 Insights

🔵	Yes	12
🟠	No	7
🟢	Not sure	7

Please rate the following statements based on how much you agree with them

More Details

🟥 Strongly Disagree　🟧 Disagree　⬜ Neutral　🔵 Agree　🟦 Strongly agree

- I am often confused about what emotion I am feeling
- I am often puzzled by sensations in my body.
- I am able to describe my feelings easily.
- I prefer to analyze problems rather than just describe them.
- I prefer to just let things happen rather than to understand why they turned out that way.
- Other people know what I am thinking
- I express myself well verbally
- I have the ability to easily communicate my emotions to people I am close to **without** talking to them
- I can feel close to someone, even in moments of silence.
- People tell me to describe my feelings more.

100%　　　　0%　　　　100%

Being in touch with emotions is essential.

Looking for hidden meanings in movies or plays distracts from my enjoyment.

I often don't know why I am angry.

It's difficult to find the right words to express myself

There are no obstacles for me to share my emotions

People who don't know me can tell how I am feeling **without** talking to them

I reveal how I feel to others

I find it hard to describe how I feel about people.

I have feelings that I can't quite identify.

When I am upset, I don't know if I am sad, frightened, or angry.

100%   0%   100%

■ Strongly disagree ■ Disagree ■ Neutral ■ Agree ■ Strongly agree

The obstacles I face in communicating my emotions do not affect my emotional well-being

The people I am close to can tell when I'm happy or sad

I have the ability to easily communicate my emotions to people I am close to **when** talking to them

I allow the people I am close to to see who I really am

I prefer talking to people about their daily activities rather than their feelings.

It is difficult for me to find the right words for my feelings

I don't know what's going on inside me.

People who don't know me can tell how I am feeling **when** talking to them

I find examination of my feelings useful in solving personal problems.

It is difficult for me to reveal my innermost feelings, even to close friends.

100%   0%   100%