Prototyping Emotions: A Modular Methodological Workshop Toolkit for Teaching Novice Interaction Designers the Creation of Low-Fidelity Single-Modal On-Body Affective Haptic Prototypes in Tandem Teams

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Declaration on Oath

I, **Vincent Clemens Coelestin Göke** , born on **25.03.1998** in **Marburg** , hereby declare on oath that I have written this thesis on my own and without external assistance, and have used no other source materials or aids than those listed. Furthermore, I hereby affirm that I have identified any text or content taken from the source materials used accordingly.

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Abstract

This thesis proposes the development and evaluation of a modular methodological toolkit designed to assist novice haptic designers in creating affective haptic feedback systems that can change a user's emotional state through the properties of human touch. Addressing the technical complexities and lack of accessible resources in affective haptic prototyping, the toolkit integrates theoretical frameworks such as the Circumplex Model of Affect (Russell, 1980; Posner et al., 2005) [43, 45], Emotion Typology from TU Delft [20], embodied metaphors (Bakker, 2012; Nardon and Hari, 2021) [5, 39], body mapping (Turmo Vidal et al., 2023; Cochrane et al. 2021, Nummenmaa et al., 2014) [15, 41, 56], and experience prototyping (Buchenau and Suri, 2000; Moussette, 2012) [11, 38]. This integration helps novice designers translate complex emotional concepts into tangible haptic prototypes, guided by principles from emotional design (Norman, 2004; Walter, 2011) [40, 59]. These frameworks simplify the translation of abstract emotional concepts into tangible haptic experiences, making the prototyping process more approachable for those without extensive technical backgrounds.

An educational workshop was conducted with six participants from diverse backgrounds in human-computer interaction and related fields of interaction design. The workshop included educative lecture elements and prototyping activities such as low-fidelity on-body prototyping in tandem team sessions, where participants alternated roles between designer and user. Throughout this workshop, participants engaged in iterative design processes, utilizing the toolkit to map emotional states to haptic stimuli and creating prototyping concepts for personalized affective haptic experiences. The chosen emotion was based on an object that the participants brought to the workshop with which they had a personal emotional connection when interacting with it.

The findings indicate that the toolkit enhanced participants' understanding of affective haptic design and prototyping. The use of embodied metaphors and body maps facilitated the communication and translation of complex emotions into haptic feedback, improving perceived collaboration and design outcomes. Participants reported that the toolkit reduced technical barriers, allowing them to focus on human-centered design aspects. However, challenges were identified, including technical limitations of the haptic hardware, a need for more diverse materials, and the subjectivity of emotional interpretation in the context of single-modal haptic user experiences.

This research contributes to the exploration and democratization of affective haptic technology by proposing accessible methodologies that empower novice interaction designers. The toolkit fosters emotional engagement and user-centered design practices, potentially influencing future developments in HCI, wearable technology, and affective computing. Recommendations for future work include expanding the toolkit to include a wider variety of haptic modalities, adjusting the adequate integration and preparation of the software of no-coding haptic hardware kits used, and conducting studies with more diverse participant groups to assess the toolkit's applicability across various contexts and cultures.

Keywords: Affective Haptics, Interaction Design, Prototyping, Methodological Toolkit, Educational Workshop

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1 Introduction

1.1 Background of Human-Computer Interaction(HCI) Methodologies

HCI has developed in distinct "waves," each of which has been characterized by changes in research priorities, technological advancements, and societal impacts. This evolution illustrates the importance of comprehending how methodologies have changed and why it is becoming important to make accessible research tools for the emerging research fields of Affective Haptics [18, 37, 47, 57].

The need for accessible and intuitive design methodologies for novice interaction designers in affective haptic design is highlighted by recent literature, including the affective haptic literature review by Vyas et al. (2023) [57], the overview of the history of haptic hardware systems by Seifi et al. (2019) [47], and an overview of recent advancements in the emerging field of affective haptic design provided Eid and Osman (2016) [18]. These resources underscore the importance of creating easy-to-understand, context-appropriate methodologies for ethical and effective affective haptic design.To foster responsible and effective AHSD, novice interaction designers and researchers need easy-to-understand, context-appropriate methodologies. These methodologies will ensure that affective haptic systems are ethically designed and reactive to users' emotional needs.

This thesis proposes the concept of a modular methodological toolkit for novice interaction designers, drawing on principles such as Haptipedia's design framework [47], exemplary toolkits like Haptic Bits Lab's low-cost haptic prototyping tools[1], and Moussette's 'Simple Haptics' design philosophy [37]. Thereby this research addresses the problem of inaccessible affective haptic design tools by proposing an approach to simplify emotional design and prototyping processes while maintaining flexibility for individual user contexts. The modular methodological toolkit of this thesis draws on these principles to adjust to the fact that single-modal haptic experiences are highly personal and context-dependent. The toolkit will provide novice interaction designers with a structured approach to acquiring and employing methodologies applicable to single-modal affective haptic design, including body maps, embodied metaphor elicitation, Emotion Typology, the complex model of affect, and Experience Prototyping principles. The application of these methodologies will be taught through a workshop and will also apply to the design processes of multi-modal systems that include affective haptic feedback. The toolkit will help them deal with technical challenges and use these methodologies to teach how to design affective haptic feedback or create affective haptic design systems that can be tested for emotional impact.

The following sections introduce the historical context of HCI's development, explore the relevance of Affective Haptics, and outline the need for accessible methodologies for novice interaction designers.

[1] https://lowingki.com/meet-the-haptic-bits-lab/

1.1.1 First Wave: Cognitive Science, Usability and Efficiency

Cognitive science and human factors engineering significantly created the first wave of HCI, which took place from the 1980s to the early 1990s. The primary focus during this period was optimizing the usability and efficiency of technological systems in controlled environments. Researchers applied meticulous scientific methods to study how users interacted with command-line interfaces and early graphical user interfaces (GUIs) [8, 9]. These efforts established foundational principles for beginner-friendly system design, prioritizing ease of learning, task efficiency, and error minimization [8, 12].

While the first wave improved usability, it was criticized for being too rigid and task-focused, neglecting the broader social contexts in which interactions occurred. As computers were introduced to everyday work life, there was a growing recognition that the usability of technological systems needed to extend beyond controlled, task-based environments and account for more dynamic social contexts. While the focus of the first wave was primarily on improving usability through controlled, cognitive studies, it became increasingly clear that more complex environments and social interactions required new research methodologies and technologies to become just to the broadened user group with new application contexts [8].

1.1.2 Second Wave: Context and Social Interaction

From 1992 to 2006, the second wave of HCI shifted its focus towards context and social interaction. During this period, technology spread into workplaces, homes, and communities, and researchers began investigating how systems could support collaborative work and group interaction. Technologies such as email systems and groupware emerged to support multiple users working together in shared environments, requiring new methodologies to enhance them with a scientific basis [6, 8, 9].

- **Situated Action** (Lucy Suchman, 1987) emphasizes that human actions are context-dependent and cannot be reliably predicted in isolation. Rather than following predetermined plans, human behavior evolves through dynamic interactions with the environment, suggesting that technology should accommodate this fluidity [29].
- **Distributed Cognition** (Ed Hutchins) extends the concept of cognition beyond the individual to include interactions with other people and objects in their environment, proposing that information is distributed across people, objects, and tools within an environment. This theory highlights the importance of designing systems that support collaborative work environments with shared knowledge [7, 25].
- **Activity Theory** (Vygotsky and Engeström) focuses on understanding human activities within social and cultural contexts. It argues that individuals use tools to achieve goals, which are shaped by the community they belong to. This framework emphasizes the importance of designing technology that aligns with users' practices and objectives [7, 9, 19, 58].

These frameworks helped expand HCI's focus from individual tasks to social systems, encouraging the design of more adaptive technologies that support complex human interactions. This wave also introduced Participatory Design, Co-design, Contextual Inquiry, and Experience Prototyping methodologies, which involve users directly in the design process, ensuring that the resulting systems fit within their real-world needs and practices [8, 9, 11, 44, 50]. Buchenau and Suri's (2000) concept of Experience Prototyping builds on this idea by allowing designers and users to engage directly with prototypes during the early prototyping process stage, enabling a more immersive exploration of how a design might feel in practice [11]. This methodological approach for the prototyping phase serves as a fundamental basis for this thesis research. The thesis contribution is in the form of an interactive affective haptic workshop structure concentrating on enhancing the prototyping process of affective haptics for novice interaction designers. As introduced by Raven and Flanders (1996), contextual inquiry provided a method for understanding how users engage with technology in their natural environments, uncovering insights into behavior and usage patterns that controlled studies could not reveal [44].

However, while participatory design was influential in structured work environments to consider work-related contexts, the second wave often struggled to accommodate the more spontaneous and personal uses of technology that emerged with the advent of mobile and ubiquitous computing [8, 13]. This limitation paved the way for the third wave, where individualization and emotional engagement became central. As Bødker (2015) argues, the third wave of HCI focuses on experience and meaning-making, but traditional methods often fall short when applied to non-work contexts and emergent technologies like Affective Haptics [8].

1.1.3 Third Wave: Individualization, Experience, and Emotionally Affective Technologies

The third wave of HCI, which emerged in the early 2000s, is characterized by a shift towards experiential and emotional dimensions of interaction (Bødker, 2006, 2015) [8, 9]. This shift has fostered the rise of Affective Computing and haptics, focusing on how technologies can be embedded in everyday personal contexts to enhance emotional engagement. It moves beyond functionality and usability to consider technology as profoundly intertwined with users' personal, social, and cultural identities [19]. These experiential, emotional, and aesthetic aspects of HCI consider how technology can support emotional well-being, personal expression, and social engagement in recognition that technology is more than just a tool for the workplace but also a medium that shapes and influences the human experience profoundly on an every-day basis [8, 21].

The third wave emphasizes individualism and personalization, recognizing that users have unique needs and emotional responses. This shift has led to the rise of Affective Computing—designing systems that recognize and respond to users' emotions, thereby fostering personalized user experiences that connect on a deeper emotional level. Affective Computing is the practice of developing systems that can recognize, interpret, and respond to users' emotional states. This approach goes beyond the usability focus of earlier technologies, prioritizing how technology can support personal well-being and emotional engagement. It also includes the research and development of Affective Haptics, which explores how tactile feedback can convey and invoke emotions, creating tailored and individualized UX.

The increasing use of affective haptic interfaces shows that computational processes are everywhere, not just limited to traditional desktop setups. Affective Haptics open up new possibilities for enhanced interaction in virtual and remote physical spaces, making use of the limited visual space available. Current haptic interfaces are mainly designed for desks and are unable to fully support widespread affective haptic communication. [18].

In the aforementioned context of healthcare, Affective Haptics can play a critical role, leveraging the sense of touch to convey emotional information. As technologies like virtual reality, wearable devices, and immersive interfaces become more prevalent [23, 24], haptics can offer an opportunity to engage users on a deeper emotional level through tactile feedback that resonates with their personal UXs, which shape their perceptual reality. The third wave's focus on embodied interaction and emotional engagement makes haptics an essential area of research, particularly in the context of Affective Computing. Still, it has yet to be explored and researched before it can be deployed within everyday technology with effective, personalized intent.

In this context, Affective Haptics emerged as a critical modality for enhancing emotional engagement. As wearable technologies, virtual reality (VR), and immersive interfaces became more prevalent, the potential for haptics to influence emotional states became clear, offering users a more personalized, immersive experience [18]. Wearable devices, in particular, are central to this development. González Ramírez et al. (2023) and Hickey et al. (2021) illustrate how wearable technologies, through biofeedback systems, are becoming essential tools for monitoring stress and emotional well-being, incorporating haptic feedback to regulate physiological and emotional responses in real-time [23, 24].

Bødker (2015) elaborates on the challenges and opportunities presented by the third wave, mainly focusing on "rest-of-life technologies" and the expansion of HCI beyond the workplace into every aspect of daily life. The third wave also brought about new methodological challenges, as traditional participatory design approaches were questioned for their applicability to emergent, non-work contexts. Bødker argues for a balance between the individual experience emphasized by the third wave and the shared, collaborative practices rooted in the second wave, proposing that HCI must embrace both to address the complexities of modern and future technology use [8].

To conclude the theoretical context, HCI has evolved significantly from its early focus on optimizing user efficiency through cognitive modeling and ergonomics to embracing emotional, social, and experiential dimensions in recent years. The third wave of HCI highlights the role of personalization and emotion, positioning Affective Haptics, among other things at the forefront of creating meaningful, emotionally affective UXs of the future. This shift also fostered the rise of Affective Computing, which designs systems capable of recognizing and responding to users' emotional states, with haptic feedback offering a potential role in facilitating tailored affective experiences.

Affective Computing As explored by Tian et al. (2022), Affective Computing is applied across various domains, from mental health and education to entertainment and human-robot interaction. The core idea is to enable computers and devices to process emotional data in a way that supports more personalized, adaptive, and human-like interactions. This capability enhances the UX by making it more intuitive, relatable, and responsive. It opens up new possibilities for designing real-time affective technological systems that can influence and support users' emotional well-being in impactful and meaningful ways [54].

1.2 The Role of Haptic Feedback

Haptics refers to the technology that simulates touch and allows users to experience tactile feedback through vibrations, pressure, or motion. It is divided into two main types: tactile feedback and kinesthetic feedback. Tactile feedback involves sensations felt on the skin, such as vibrations, temperature, and texture, while kinesthetic feedback provides information about movement and the forces felt through muscles and joints, offering a sense of weight and resistance [57]. These systems combine to create multi-dimensional interactions that can enhance user engagement. MacLean (2022) explores the role of haptics in promoting emotional regulation, particularly in wellness applications, where personalized haptic stimuli can help users manage stress and anxiety [34]. As haptic technology evolves, it is increasingly becoming a critical tool for designing affective interactions across wearables, VR, and immersive environments.

Affective Haptics refers to using tactile feedback to evoke or communicate emotions. The sense of touch is deeply connected to human emotions, making it a powerful tool for creating more immersive and emotionally engaging UX. Studies have shown that haptic feedback can convey a wide range of emotions, from comfort and relaxation to urgency and stress [14, 18, 28, 55].

The Circumplex Model of Affect (Russell, 1980) stems from cognitive sciences and describes emotions based on two variables on a two-dimensional diagram. This is used in affective haptic research and development to reduce the complexity of emotions on a 2D matrix [45]. Posner later argues that emotions are not singular but fluent and multiple emotions can be felt at the same time [43]. This theory provides a useful framework for haptic designers to map emotions and translate them into haptic feedback corresponding to specific emotional states. This model organizes emotions based on valence (pleasure-displeasure categorization of the emotion) on the X-axis and arousal (activation-deactivation level of the emotion described) on the Y-axis and designers can design tactile stimuli with a corresponding emotional response more easily. By mapping haptic stimuli to this model, designers can categorize haptic stimuli into emotional representations and, thus, could create tactile feedback that can evoke emotions like calmness, excitement, or anxiety [28, 43, 45].

Recent developments in haptic technology research, such as those looked at by Swindells et al. (2014), allow for guidelines and exploration of rapid prototyping and experimentation with vibrotactile effects, facilitating the creation of emotionally engaging feedback systems [52].

Despite its potential, designing affective haptic feedback presents unique challenges, particularly for novice interaction designers who may not have experience with the technical and emotional nuances of haptic technology, human touch perception, and their correlated emotional response. Haptics encompass an interdisciplinary approach involving biomechanics, psychology, neurophysiology, engineering, and computer science, focusing on the exploration of human touch and force feedback within the context of contemporary HCI [18]. The technical complexity of haptic devices, combined with the subjectivity of emotional experiences, makes it difficult to design functional and emotionally meaningful single-modal affective haptic systems.

1.3 Problem Statement: The Need for a Modular Methodological Toolkit for Novice Interaction Designers

As the field of HCI expands to incorporate more affective and empathetically reactive technologies [1, 3, 18, 57], there is a growing need for tools that enable designers — especially those new to haptic interaction design — to effectively integrate haptic feedback into their projects. Novice interaction designers often struggle with the challenges of mastering the technical aspects of haptic systems and translating abstract, subjective emotional concepts into tangible feedback. This is further complicated by the lack of accessible, beginner-friendly hardware toolkits and accessible methodological resources and guidelines that could facilitate these complex thought and design processes.

The complexity of current haptic toolkits - whether it be hardware, software or methodological toolkits -, which frequently require technical mastery over emotional design thinking, results in a lack of accessible resources for novice interaction designers (Vyas et al., 2023) [57]. Spinuzzi (2005) emphasizes the importance of participatory methods, suggesting that novice designers benefit from practical, user-centered tools that bridge advanced technology with accessible design approaches [51]. This toolkit aims to provide such a bridge, simplifying the prototyping of subjective single-modal affective haptic feedback through embodied design principles to teach affective haptic design to novice interaction designers.

While there are several toolkits for haptic design, many are geared toward haptic engineering, or computer science experts, and focus mainly on technical aspects such as actuator control and signal processing. novice interaction designers, especially those without a deep understanding of haptics, coding, or engineering principles, often struggle to translate abstract emotional concepts into concrete single-modal affective haptic feedback for user testing. In addition, existing resources usually lack support for iterative testing and emotional guidance, which are crucial for developing affective haptic feedback systems(AHFS) that achieve the intended emotional impact. To address this issue, the proposed toolkit will provide simplified methodological resources to guide designers through their design processes. It will offer materials to support ideation, prototyping, and user testing, integrating technical and emotional considerations effectively.

Recent innovations like the Haptic Bits Lab have demonstrated how accessible, low-cost haptic prototyping tools can enable rapid experimentation in haptic feedback design. By offering an intuitive and modular approach, projects such as these support novice interaction designers in exploring the possibilities of haptic technology without a requirement for extensive technical expertise[2]

To support novice interaction designers in creating single-modal(i.e. only haptic stimulus as interaction) affective haptic systems, concepts from Soma Design, embodied metaphor elici-

[2] `https://lowingki.com/meet-the-haptic-bits-lab/`

tation, Emotion Typology, the Circumplex Model of Affect and Experience Prototyping were introduced and combined in a workshop procedure to help simplify the approaching efforts for affective haptic feedback design processes.

To address these challenges, this thesis proposes a modular toolkit designed to guide novice interaction designers through the process of creating single-modal (i.e. only haptic stimulus as interaction) AHFS. Drawing on methodologies such as Soma Design [15, 56], embodied metaphor elicitation [5], and the Circumplex Model of Affect [43, 45], this toolkit simplifies the emotional design process by providing a novel approach for combining the theoretical frameworks. The Emotion Typology from TU Delft further aids in breaking down complex emotional states into their core components of valence and arousal, helping designers align their haptic designs with intended emotional responses [20]. By using these frameworks, novice interaction designers can develop a structured approach to translating abstract emotions into concrete, testable haptic feedback.

1.4 Research Questions and Hypothesis

The primary purpose of this thesis is to develop and test a comprehensive methodological toolkit designed to support novice interaction designers in creating affective haptic feedback. The toolkit leverages existing design methodologies including embodied metaphor elicitation, the Circumplex Model of Affect, and Experience Prototyping to provide novice designers with structured, accessible approaches to creating affective haptic systems. The methods in this toolkit were chosen to make single-modal affective haptic design more accessible by creating and combining beginner-friendly resources, guidelines, and methodologies that guide designers through their design process to integrate suitable approaches to affective haptic feedback into their projects. The core of the toolkit builds upon existing frameworks and tools, including the Circumplex Model of Affect (Russell, 1980) [45], embodied metaphors (Bakker et al., 2012) [5], body mapping (Turmo Vidal et al., 2023) [56], and Experience Prototyping (Buchenau and Suri, 2000) [11], adapting them to suit novice designers' needs. In order to gather feedback about the toolkit, an Affective Haptics workshop was conducted, focusing on the emotional dimensions of a personal object that participants brought and were tasked to translate it with a tandem partner into a haptic interaction. The toolkit seeks to enhance the quality and usefulness of single-modal haptic feedback to make them applicable for multi-modal affective haptic interfaces, enabling designers to create more empathetic and user-centered experiences.

This research is guided by the following key questions:

- **RQ1**: What is the impact of using embodied metaphors in combination with body maps on the design and communication process of affective haptic feedback for novice interaction designers?
- **RQ2**: How can Lo-Fi on-body Tandem prototyping sessions with haptic feedback be structured to elicit valuable insights into emotional responses from users?
- **RQ3**: What specific challenges do novice interaction designers encounter when integrating haptic feedback into Lo-Fi on-body prototype design concepts?

- **RQ4**: What tools and methodologies are needed to make on-body affective haptic prototyping accessible to novice interaction designers?

The specific objectives of this research are as follows:

- To facilitate the design and prototyping of emotionally affective haptic systems by providing a structured and accessible toolkit.
- To enhance the communication and understanding of emotional experiences through the use of embodied metaphors and body maps in the design process.
- To structure Lo-Fi on-body Tandem prototyping sessions that elicit valuable insights into emotional responses, thereby refining the design of haptic feedback.
- To identify and address the specific challenges faced by novice interaction designers in integrating haptic feedback into their prototypes.

Based on the research questions, the following hypotheses are proposed:

- **H1**: The use of embodied metaphors and body maps will significantly improve the ability of novice interaction designers to communicate and design affective haptic feedback.
- **H2**: Structured Lo-Fi on-body Tandem prototyping sessions will elicit valuable insights into users' emotional responses, enhancing the design process.
- **H3**: novice interaction designers will face specific challenges related to technical complexities and emotional translation when integrating haptic feedback into Lo-Fi prototypes.
- **H4**: The combination of beginner-friendly haptic hardware toolkits and structured design methodologies will make on-body affective haptic prototyping more accessible and reduce technical barriers for novice interaction designers.

1.5 Contribution of the Thesis

The significance of this thesis lies in its potential to make affective haptic design and research assessible by providing useful resources for novice interaction designers, making it easier to develop AHFS. As Frauenberger (2019) argues, the third wave of HCI emphasizes the entanglement of emotional, social, and cultural dimensions in technology design, making tools that support these aspects crucial for future developments in HCI [21]. The interpretation of a stimulus is highly dependent on context, and the interpretation can vary significantly based on the social, cultural, and environmental factors surrounding the interaction [18, 36]. This is especially true for haptic stimuli, as the meaning of touch has vastly different meanings depending on our cultural upbringing. Designing systems that can consistently communicate emotions across different contexts and cultures remains a major challenge in the field of Affective Haptics, particularly when considering the aforementioned cross-cultural differences in touch-based human communication. At present, there is no effective Affective Haptics repository available. The design of an effective Affective Haptics system relies on successful emotion induction. To address this, research and design of AHFS must be made accessible and a novel Affective Haptics database must be created to increase the availability of predictable haptic emotion stimuli. This database would store carefully chosen haptic patterns that elicit and/or display different emotions and can inform design decisions for future projects in affective haptic feedback design. Essentially, a database for successful emotion induction in Affective Haptics is still undiscovered [18].

By addressing these dimensions, the study contributes to the advancement of HCI by fostering more empathetic, user-centered affective haptic design practices. By enhancing the learning process of novice interaction designers to create single-modal emotionally affective haptic interactions, respecting the revised version of Engeström's "Learning by expanding(2015)" [19], the methodological approaches of the proposed modular toolkit also have the potential to improve the overall quality of haptic UXs across various applications, from wearable devices to immersive virtual environments.

To summarize, HCI branched from cognitive usability studies among other things into more experiential and emotion-centered designs. This transformation reflects the growing recognition that technology supports functional tasks and shapes emotional and social experiences. As the third wave of HCI emphasizes emotional engagement and personalization, Affective Haptics — using tactile feedback to evoke and communicate emotions — has emerged as a critical research area. However, despite its potential, affective haptic design is still a complex and novel field and remains inaccessible to many novice interaction designers due to its technical complexity and the lack of beginner-friendly methodological frameworks. To address this gap, this thesis proposes a modular toolkit that simplifies the design of affective haptic systems, drawing on key theories and tools from HCI's evolution. The goal is to make affective haptic design more accessible, particularly by offering beginner-friendly methods for prototyping, iteration, and testing which can be expanded into the realm of multi-modal feedback after learning the principles for single-modal haptic stimuli. By leveraging tools like emotion typologies, the Circumplex Model of Affect, body map sheets, embodied metaphor elicitation sheets, and no-coding haptic prototyping kits (i.e., Hapticlabs DevKit & Studio Software[3]), this thesis proposes a variety of methodological approaches with which designers will be equipped to explore affective haptic technologies without requiring deep technical expertise. By addressing current research gaps and providing accessible methodologies, this work contributes to the ongoing evolution of HCI, laying the groundwork for future innovations in affective haptic wearable technologies and beyond. The following section provides a detailed overview of related work, exploring the development of Affective Haptics and the design frameworks that inform the proposed toolkit.

[3] https://www.hapticlabs.io/

2 Related Work

This section reviews various studies, models, and design frameworks to support the developed methodological toolkit for guiding novice interaction designers in creating affective haptic feedback.

2.1 Emotional Design and User Experience

The importance of emotions in design has been extensively discussed by Norman (2004) in his seminal work *Emotional Design: Why We Love (or Hate) Everyday Things* [40]. Norman posits that successful products must appeal not only on a functional level but also engage users on visceral, behavioral, and reflective levels. He introduces the concept of emotional design, emphasizing that designers should consider the emotional responses their products evoke in users. This perspective is crucial in the context of affective haptic design, where the objective of the product device is to elicit specific emotional reactions in a user through tactile feedback. Researchers and developers of affective haptic design should therefore be very considerate of the ethical impact they have on the user's emotional state they design for.

Norman's framework categorizes emotional responses into three levels:

- **Visceral Level**: Relates to the initial impact of a design, its appearance, feel, and sound.
- **Behavioral Level**: Concerns the usability and function of the product.
- **Reflective Level**: Involves the user's personal satisfaction, memories, and the meanings attached to the product.

By understanding these levels, designers can create products that not only meet functional requirements but also resonate emotionally with users. In affective haptic design, this means developing tactile feedback that can induce emotional experiences aligned with the user's needs and contexts.

Norman's emphasis on user-centered design aligns with the goals of our proposed methodological toolkit. By integrating emotional considerations into the design process, novice designers can create more engaging and meaningful haptic interactions. This approach supports the need for tools and methodologies that facilitate the articulation, translation, and prototyping of emotional experiences, which are central to AHFS.

Furthermore, Norman's work highlights the subjective nature of emotional responses, reinforcing the importance of iterative design and user feedback.

2.2 Affective Haptics and Emotional Engagement

2.2.1 Affective Haptics

Vyas et al. (2023), who examined more than 110 papers from significant venues in HCI, Affective Computing, and haptics research, stated affective haptic system design(AHSD) has rapidly evolved over the past ten years. This analysis highlights not only the growing interdisciplinary nature of AHSD but also key advancements in understanding the relationship between touch and emotion, focusing on areas such as emotion regulation, body awareness, and bio-sensing [57]. While this literature overview highlights the potential of Affective Haptics, novice interaction designers still lack accessible tools that bridge the gap between these theoretical advancements and practical implementation. According to Vyas et al. (2023) and Eid and Al Osman (2016) [18], Affective Haptics will become a critical component of HCI by not only eliciting emotions but also enhancing the emotional depth of communication. Ju et al. (2021) and Schoeller (2023) have demonstrated that combining vibrotactile feedback with visual or auditory cues significantly enhances emotional communication, further supporting the role of multimodal interaction in Affective Haptics [28, 46]. Unlike unimodal cues, such as auditory or visual signals, multimodal haptic stimuli, including touch, evoke a stronger emotional response. According to Christensen (2015), emotional communication gains credibility and intensity when delivered through multiple sensory modalities, particularly in close proximity social contexts [14].

2.2.2 Emotional Framework for Affective Haptic Design

Central to the design of Affective Haptics is Russell's Circumplex Model of Affect, which organizes emotions along two axes: valence (positive-negative) and arousal (high-low) [45]. Building on Russell's work, Posner et al. (2005) expanded this framework, arguing that emotions should be viewed as fluid rather than discrete, meaning individuals can experience multiple emotions simultaneously. This nuance in emotional modeling is critical for haptic designers, who must account for the complexity and overlap of emotional experiences when crafting tactile feedback. The Posner theory of Russell's Circumplex Model of Affect enables haptic systems to produce stimuli that capture this emotional depth, particularly in immersive environments where haptic feedback can convey more than one emotional state at a time [43].

Incorporating the Circumplex Model of Affect into haptic design enables designers to categorize emotions effectively by valence and arousal. Research by Ju et al. (2021) have shown that vibrotactile feedback can serve as an effective medium for expressing a wide range of emotions. Their findings suggest that vibrotactile feedback offers universal cues for emotional recognition, with higher accuracy in emotions such as joy and anger [28].

This theoretical cognitive model is frequently used by the Affective Haptic Design community to better translate emotions into suitable haptic feedback, which informs the direction of the haptic design to elicit specific emotional reactions. Pinpointing an area and sorting the desired UX on the matrix makes it easier to identify the general direction of expected emotional impact and haptic design properties. As previously said, the actual interpretation of feedback remains highly personal and application context-dependent, yet this approach directs the design already in a certain direction.

Similarly, Tsetserukou et al. (2009) emphasized that combining haptic stimuli with visual cues significantly enhances emotional communication, reinforcing the role of multimodal interaction in Affective Haptics [55]. Schoeller (2023) also explored how haptic feedback can be aligned with specific emotional states, further highlighting how the sense of touch can facilitate emotional communication in immersive environments [46]. These studies demonstrate how Affective Haptics can enable deeper emotional engagement in digital interactions. While studies like Ju et al. (2021) and Schoeller (2023) explore the potential of vibrotactile feedback for emotional engagement, novice interaction designers require tools that facilitate rapid iteration for affective haptic feedback design.

Moussette (2012) presents a 'sketching' approach for simple haptics, enabling rapid prototyping and intuitive design iterations. This method significantly lowers the barrier for novice interaction designers, allowing them to quickly experiment with different tactile interactions without deep technical expertise [37]. Israr et al. (2014) further explore how haptic feedback can enrich narrative storytelling, demonstrating the potential of haptic stimuli to create emotionally engaging experiences, especially in entertainment or immersive environments like virtual reality and gaming [26].

Technological advancements like artificial intelligence (AI) and faster computing systems have broadened the potential for haptic design. Platforms like Haptipedia provide a comprehensive catalog of haptic technology and when it was developed, aiding designers in understanding, discovering, and selecting appropriate haptic hardware for their research efforts [47]. Further, Eid and Al Osman (2016) emphasize the role of haptic feedback in enhancing social communication, particularly for visually impaired users, showing how Affective Haptics can improve accessibility and inclusive design [18].

In line with Walter (2011), the role of emotional interaction in design is crucial for creating meaningful UXs. Affective Haptics, by leveraging the sense of touch, can offer a direct way to evoke and communicate emotions in digital environments. This supports the growing focus on emotional engagement in HCI [59].

My recent work and publication at the Eurohaptic Conference 2024 (Göke et al. (2024)) demonstrate how Affective Haptics could influence emotional states, particularly in fostering relaxation through real-time haptic feedback that slows down and becomes less frequent to lower the breath rate and thus inducing guided relaxation. Our ongoing research indicates how users can respond emotionally to presumably affective haptic feedback, and how this feedback can be fine-tuned through iterative design to achieve successful affective state changes with single-modal haptic interactions [22].

2.3 Emotion Typology and the Circumplex Model

To guide the emotional responses elicited through haptic feedback, the Emotion Typology from TU Delft offers a structured approach to understanding and categorizing emotions [20]. This typology was used to help participants elicit specific emotions and help non-native English speakers to express themselves better about emotional states. The Circumplex Model of Affect organizes emotions along two axes — valence (positive-negative) and arousal (high-low) — offering a framework for mapping emotional experiences to haptic feedback [43, 45]. As demonstrated by Ju et al. (2021) [28], this methodology was already used to map emotions to inform haptic feedback. In my workshop participants could use a combination of both to then map the chosen emotion from the Emotion Typology into the 2D matrix of the Circumplex Model of Affect, simplifying emotional states into their valence and arousal levels. By breaking down complex emotions into simpler components using this typology, novice interaction designers can more easily align their haptic designs with the desired emotional responses. The connection of these models forms the basis for the emotional mapping exercises within the proposed toolkit, aimed at enabling novice interaction designers to align tactile feedback with specific emotional states during the design process.

By integrating the Emotion Typology from TU Delft, which categorizes emotions by their core components, the toolkit allows novice interaction designers to align haptic design decisions with emotional states systematically. These models provide a foundation for translating abstract emotions into tactile feedback, ensuring emotional resonance in haptic interactions.

2.4 Wearable Technologies for Mental Wellness

Wearable technologies have rapidly evolved into sophisticated biofeedback systems capable of monitoring a range of physiological signals like heart rate variability (HRV), electrodermal activity (EDA), and respiratory patterns. These metrics can offer real-time feedback for managing stress and emotional well-being through haptic stimulation [3]. González Ramírez et al. (2023) provide a comprehensive review of these technologies, emphasizing their potential for stress management through biofeedback integration. This review identifies key advancements in how wearables leverage emotional data to enhance user well-being in real-time [23], opening up the possibility for haptic based stress interventions. Similaritly, Hickey et al. (2021) investigate the utility of wearable technology in the diagnosis and treatment of mental health issues, highlighting the significant advantages of haptic and auditory feedback systems in effective individualized approaches to anxiety and stress management [24].

Drawing the connection to haptics, MacLean (2022) explores how affective haptic feedback can be designed to support emotional well-being, particularly within wellness-focused applications. The study examines the use of haptic feedback as a tool for emotional regulation, suggesting that wearable technologies utilizing haptics can create calming, soothing sensations to help users manage stress and anxiety. Integrating personalized haptic feedback into wellness applications, such as meditation aids or stress-relief wearables, demonstrates the potential of these systems to provide real-time emotional support [34]. Such systems allow users to engage with their emotions in real-time, promoting greater self-awareness and emotional regulation through physical sensations [55]. This aligns with Hickey et al. (2021), who illustrates how wearable haptic technologies are increasingly used in mental health contexts, integrating biofeedback mechanisms for individualized stress and anxiety management [24].

As AI or any biofeedback model needs labeled data to reliably detect the emotional states of individuals with varying biosignal strengths, Tazarv et al. (2021) investigated the potential of personalized biofeedback systems to adjust to users' emotional and physiological states in real-time, providing targeted stress management interventions for everyday use. This study paves the way for future research into more advanced labeling strategies that may allow for context-aware, indivisualized models, which in turn will enable health professionals to offer more tailored interventions [53].

Alvarsson et al. (2010) studied the therapeutic effects of natural sounds on participants in stress recovery, suggesting that integrating auditory biofeedback with haptics could enhance the effectiveness of wearables for mental health interventions [4]. Since haptic feedback often uses soundwaves delivered via "voice-coil actuators," there is potential for sound and haptic feedback to work together in promoting relaxation and emotional regulation. Combining haptic, auditory, and visual feedback improves the ability of wearables to offer personalized, multi-modal interventions for managing stress and anxiety [2, 35].

Multi-modal feedback systems, which can combine haptic, auditory, and visual stimuli, offer significant potential for creating more immersive UXs. Kim et al. (2024) explore the synchronization of haptic and auditory cues through cross-modal pitch matching, demonstrating how combining sound and touch enhances users' emotional engagement, especially in music therapy and stress relief applications [30]. Jo et al. (2019) provided insights into how nature-based stimuli, such as auditory and visual inputs from forest environments, influence psychological well-being [27]. The exposure to natural environment stimuli can positively influence psychological and physiological well-being suggests that combining these stimuli with haptic feedback — such as gentle vibrations or the sensation of walking in the forest or a sensation of wind — could enhance wearable devices' effectiveness in regulating emotions. Integrating these nature-based stimuli with haptic biofeedback offers promising opportunities for stress management in mental wellness applications. Furthermore, this multi-modal emotional regulation research could be especially valuable in contributing valuable knowledge to the under explored application of Affective Haptic Design principles.

As biofeedback technology improves, adding artificial intelligence (AI) algorithms will let wearables better predict how people are feeling and customize multi-modal feedback interventions based on real-time physiological data [1].

This approach could provide novel technologies that support users in situations where conventional self-regulation methods are not available (i.e., going for a walk, working out), depending on the context of use (i.e., an office meeting, workday stress monitoring).

Additionally, AI-driven biofeedback is increasingly enhancing immersive feedback systems. Advanced wearables equipped with AI could predict emotional states based on real-time data. This would open the possibility to provide highly personalized intervention mechanisms tailored to the user's emotional and physiological context ultimately supporting their mental health in real-time.

As biofeedback systems become more sophisticated, the role of haptics in wearable technology will continue to grow, offering real-time emotional interventions through tactile feedback systems designed for stress management and emotional regulation yielding the potential for integration of affective haptic principles.

2.5 Design Frameworks and Toolkits Useful for Affective Haptic Design

LoFi Prototyping & Haptic Design Guidelines Designing affective haptic systems is complex due to the need to balance technical constraints with emotional interaction, making the development of accessible toolkits essential for novice interaction designers. In this regard, Breitschaft et al. (2022) propose the Haptic Fidelity Framework, which classifies haptic systems based on their ability to convey perceptual effects, rather than purely on mechanical precision. This framework introduces three fidelity levels — low (LoFi), medium (MidFi), and high-fidelity (HiFi) — allowing designers to match their system's capabilities to the emotional engagement they intend to evoke.

LoFi systems, such as simple vibrations, are useful for notification-based designs, offering straightforward feedback. Medium-fidelity systems simulate mechanical interactions, like button clicks, with more detail, while high-fidelity systems enable rich, immersive sensations, such as textures or material properties, crucial in virtual reality (VR) and automotive applications. This framework is particularly helpful for novice interaction designers by providing a structured guide to choosing the appropriate technology based on the desired emotional outcomes. By integrating this into their design process, novice interaction designers can match feedback fidelity to their project's emotional and technical requirements, enhancing both the UX and the system's emotional engagement [10].

The SkinKit construction toolkit developed by Ku et al. (2022) represents a significant advancement in simplifying the development of on-skin interfaces. SkinKit offers a low-barrier, plug-and-play approach, making it easier for designers — particularly those without advanced technical expertise — to experiment with on-body interactions. The toolkit enables rapid, low-fidelity prototyping through flexible, skin-conformable modules, which are directly applicable to the skin. This approach is crucial for affective haptic design, where designers need to quickly iterate on prototypes and test haptic feedback on the body to ensure emotional resonance [31]. The ability to quickly deploy functional on-skin prototypes and receive real-time feedback accelerates the prototyping process, making it ideal for novice interaction designers working with Affective Haptics.

In a follow-up to SkinKit, Ku et al. (2023) introduced SkinLink, which further enhances the flexibility and adaptability of on-skin interface construction. SkinLink allows users to prototype reconfigurable epidermal interfaces directly on the body, addressing the challenge of iterating designs in situ. For affective haptic designers, SkinLink offers an intuitive, beginner-friendly toolkit that adapts to dynamic and non-planar body surfaces, enabling them to create haptic feedback systems that respond to emotional states in real-time. The system's modular approach, combined with its focus on skin conformability and ease of modification, provides novice interaction designers with a powerful tool to rapidly prototype and test emotional haptic interactions on different body locations [32].

The SkinKit and SkinLink systems also support multi-modal feedback systems, combining haptic, visual, and auditory stimuli, which are essential for creating immersive and emotionally engaging user experiences. For instance, in affective haptic design, combining haptic feedback with other sensory modalities can deepen emotional engagement, particularly in applications such as mental wellness and stress management [31, 32]. These modular systems allow designers to explore different sensory combinations, facilitating the creation of more holistic emotional experiences.

In Moussette (2012), the concept of “simple haptics” is introduced to lower the complexity of haptic design by providing basic tools and frameworks that encourage experimentation with haptic stimuli. This method allows for an iterative design process where designers can frequently test and refine their work based on feedback, making it particularly valuable for novice interaction designers who may lack deep technical expertise but still wish to create affective haptic feedback [37].

The formentioned toolkits by Ku et al. (2022, 2023) align with Moussette’s (2012) ”simple haptics” concept, which emphasizes lowering the complexity of haptic design through basic tools and frameworks that encourage frequent experimentation with haptic stimuli. Both SkinKit and SkinLink reflect this philosophy by offering modular, reconfigurable systems that simplify complex design processes. By adopting this rapid, Lo-Fi prototyping approach, novice interaction designers can more easily test how different feedback patterns evoke specific emotions without becoming bogged down in technical complexities. These toolkits enable novice interaction designers to focus on emotional affect, iterating quickly to ensure that the haptic feedback they create aligns with the user’s emotional experience.

Building on this idea, Moussette (2012) also proposes the concept of “sketching haptics,” which emphasizes quick, Lo-Fi experimentation. By treating haptic design similarly to how visual designers sketch, this approach encourages designers to prototype tactile interactions using simple tools, enabling rapid iterations. The focus is on how different feedback patterns evoke specific emotions rather than on technical complexities. Through this iterative experimentation, designers can align their haptic systems more effectively with user emotions and responses [38]. By offering these ‘sketching’ tools to novice interaction designers, the proposed toolkit can simplify complex design processes, enabling early prototyping and quick testing, which is crucial for understanding how users emotionally respond to haptic feedback.

In addition to creating affective haptic feedback, ensuring comfort and realism is critical in designing haptic devices. Shor et al. (2018) compare two VR gloves and emphasize that user comfort, along with the haptic feedback quality, is crucial for maintaining immersion in virtual environments. Their study highlights the trade-offs between performance, comfort, and realism in designing haptic devices [48], which aligns with the need for novice interaction designers to consider both emotional and ergonomic factors when already developing LoFi haptic prototypes. This work emphasizes the importance of well-designed, immersive haptic feedback being both technically accurate and comfortable for prolonged use which has implications for wearable technology development in healthcare as well.

Embodied Metaphor Elicitation Embodied metaphors provide a powerful framework for translating abstract concepts into intuitive, physical interactions. As Bakker et al. (2012) emphasize, embodied metaphors leverage human experiences of physical movement to make sense of abstract concepts in tangible interaction design. Their work highlights how metaphorical mappings between input actions (e.g., physical movements) and output responses can enhance interaction design [5]. While the original study focuses on tangible interactions, the iterative, user-centered design approach proposed in their work — starting with enactment studies and moving through Lo-Fi prototypes to validate metaphors — provides a valuable structure for designers.

In the context of Affective Haptics, this thesis extends Bakker's framework to suggest that embodied metaphors can inform the creation of emotionally affective haptic feedback patterns. By using embodied metaphors, novice interaction designers can map physical sensations onto abstract emotional states. For example, a "warm, soft touch" could represent comfort, while a "sharp, quick vibration" might indicate urgency. Although Bakker's work does not explicitly focus on haptic feedback, the idea of using embodied schemata — cognitive structures derived from sensorimotor experiences — can be adapted to design haptic feedback that resonates with users' emotions [17, 39].

Daudén Roquet and Sas (2021) take this further by exploring embodied metaphors in meditation, focusing on interoceptive interactions. They demonstrate how metaphors can map bodily sensations, such as warmth, to meditation states like mindfulness or mind-wandering. This approach emphasizes the potential of using metaphor-inspired haptic feedback to influence emotional regulation, a key area for affective haptic design. By integrating thermal feedback, the authors show that interoceptive experiences can deepen emotional engagement and attention regulation, thus extending metaphorical mappings beyond traditional sensory modalities [17]. This insight is particularly relevant for Affective Haptics, as it suggests that novice interaction designers could use embodied metaphors to map emotional experiences directly onto bodily sensations such as heat, pressure, or vibration.

Nardon and Hari (2021) further elaborate on the power of Imaginative Metaphor Elicitation (IME) to generate deep introspective understanding in participants. They found that metaphors help individuals articulate and make sense of complex, non-tangible experiences, facilitating a renewed sense of empowerment and self-awareness. This aligns well with the goals of affective haptic design, where metaphorical mappings can help users and designers bridge abstract emotional states with physical feedback mechanisms. IME's emphasis on introspection and empowerment also supports novice interaction designers in Affective Haptics, providing them with a structured yet intuitive method for eliciting meaningful emotional responses from users [39].

Thus, while Bakker et al. (2012) demonstrate that embodied metaphors facilitate the translation of abstract concepts into intuitive physical interaction design, this thesis builds on their work to propose that embodied metaphors can help to teach novice interaction designers how to create single-modal affective haptic feedback patterns that affect the emotional state within specified user contexts.

Additionally taking into account the imaginative metaphor work by Daudén Roquet and Sas, as well as Nardon and Hari suggests that metaphors could allow designers to elicit rich, meaningful user experiences by applying them with somatic and emotional states. This is particularly valuable for designing single-modal Affective Haptics where designers must translate subjective, often nuanced emotional experiences into concrete haptic stimuli.

By incorporating these methodologies, the proposed toolkit applies embodied metaphor elicitation as a core component in affective haptic interaction design education. novice interaction designers can use these techniques to map user emotions correlated with an object onto haptic feedback systems, ensuring that the metaphors not only capture the essence of the emotional experience but also evoke a similar emotional resonance in users. In this way, embodied metaphor elicitation becomes a useful tool for enhancing the emotional effectiveness of haptic feedback systems designed by novice interaction designers.

Body Maps Cochrane et al. (2022) and Turmo Vidal et al. (2023) discuss body maps as a generative tool for capturing somatic experiences and emotions. Body maps allow users to visually document complex and non-explicit emotions by marking body parts that are physically and emotionally significant during specific interactions [15, 56]. In Affective Haptic Design, body maps can be particularly useful for identifying where emotional and tactile experiences converge. By mapping out where users physically feel emotions such as anxiety, calm, or stress, designers can create haptic feedback systems that target specific areas of the body, enhancing the emotional impact of haptic interactions.

Nummenmaa et al. (2014) extend this concept by revealing distinct bodily sensation maps associated with a wide range of emotions. Their research shows that emotions such as happiness, fear, and anger consistently activate distinct bodily regions, which are culturally universal across West European and East Asian populations. For instance, happiness induces heightened sensations across the entire body, while fear predominantly activates the chest and upper body [41]. These findings provide a solid empirical foundation for the use of body maps in affective haptic design, as they offer insight into how different emotions are somatically experienced and how these patterns can be translated into tactile feedback.

The flexibility of body maps allows designers to record patterns of bodily sensations during interactions, which can guide the development of haptic devices that respond to these sensations. For example, tracking changes in bodily experience over time could be crucial when designing haptic wearables that assist in real-time emotional regulation. Additionally, body maps can support the development of multi-modal feedback systems by integrating touch with other sensory inputs, such as sound or visual stimuli, to create more holistic emotional experiences.

This generative potential of body maps makes them an ideal tool for novice interaction designers working with Affective Haptics. By capturing users' somatic experiences, body maps offer insights into how haptic feedback could be personalized to evoke or modulate specific emotional states. The work by Nummenmaa et al. further reinforces the role of somatic feedback in emotional regulation and suggests that monitoring these bodily sensations could offer valuable input for designing emotionally affective haptic systems [41]. In the proposed toolkit, body maps could be used to prototype and evaluate the emotional effectiveness of different haptic designs, ensuring that the feedback aligns with users' bodily and emotional responses.

In addition to these frameworks, projects like the Haptic Bits Lab[4] demonstrate how acces-

[4] `https://lowingki.com/meet-the-haptic-bits-lab/`

sible, modular prototyping kits can facilitate hands-on experimentation for novice interaction designers, lowering the barriers to creating affective haptic systems.

2.6 Future Directions in Affective Haptic Design

The integration of haptic feedback with other sensory modalities, such as visual, auditory, and olfactory cues, is a promising direction for future research. Vyas et al. (2023) highlight the potential for combining multiple sensory channels to create more immersive and emotionally engaging UXs [57]. For instance, the combination of tactile feedback with visual or auditory cues in virtual reality environments can make digital interactions feel more realistic and emotionally immersive.

Underlining this statement, Shor et al. (2021) explore the potential of multi-modal systems in creating emotionally affective experiences through the 'Resonance Pod,' a multisensory installation combining haptics, sound, and light to promote relaxation. The study demonstrates how haptic feedback, when synchronized with visual and auditory stimuli, can enhance emotional regulation, particularly in stress and anxiety management. This highlights the potential of multi-modal feedback systems in wearable technologies for mental wellness, where emotional engagement can be enhanced through cross-modal integration [49]. The success of such systems underscores the importance of integrating multi-modal cues for novice interaction designers seeking to design for emotional well-being.

Haptic feedback's potential for cross-modal interaction, such as the combination of sound and touch, has also been explored by Kim et al. (2024), who demonstrated that cross-modal pitch matching can enhance how users perceive tactile stimuli. This integration allows for richer emotional engagement by synchronizing haptic feedback with auditory cues, particularly in applications like music therapy and stress relief [30].

The future of Affective Haptics lies in its potential to revolutionize interpersonal communication. Ju et al. (2021) explored how vibrotactile feedback could convey emotions such as empathy and support, offering users a tactile means of expressing complex emotional states [28]. Tsetserukou et al. (2009) proposed an affective haptic system, "iFeel_IM!", that enhances emotional communication in virtual environments by simulating real-world social touch, such as hugs, through haptic devices [55].

Affective Haptics research has increasingly drawn upon interdisciplinary collaboration, involving experts from fields such as neuroscience, psychology, and engineering. This collaboration has led to significant advancements in haptic feedback design and evaluation, with new insights into how touch influences emotional states. With the integration of diverse methodologies, researchers started to address complex issues, such as emotional regulation and bio-sensing, through more robust haptic systems [57]. Research in Affective Haptics has increasingly focused on emotion regulation, with many systems designed to help users manage stress and anxiety through biofeedback and tactile stimuli. Vyas et al. (2023) also note that over 50% of the recent studies in AHSD have explored how haptics can be used to support emotional regulation, emphasizing the potential of these systems for mental health interventions. The evaluation of affective haptic systems has primarily focused on non-clinical, lab-based studies, with limited real-world or clinical trials. While non-clinical evaluations are important for early-stage development, there is a critical need for more rigorous, clinically validated studies. This would ensure that affective haptic devices can effectively support emotional regulation and mental health interventions in real-world settings. These gaps underscore the need for more robust evaluation methods, particularly in clinical and real-world environments, to assess the impact and effectiveness of haptic devices in long-term emotional regulation [57].

This speaks for a growing need for advanced prototyping tools that enable real-time iteration and testing of AHSD. These tools would allow designers to refine haptic feedback based on immediate user feedback, making it easier to create emotionally effective haptic systems. As these tools evolve, they will lower barriers for novice interaction designers, enabling more efficient and user-centered design processes.

2.7 Prototyping and Real-Time Iteration

By enabling users and designers to actively engage with interactive haptic on-body prototype processes in real-world contexts (i.e. the interaction with their emotional object), Experience Prototyping, which Buchenau and Suri (2000) introduced, expands on participatory design [11] that suits the purpose of this workshop. This method in combination with the embodied metaphor elicitation [5] and body mapping techniques from Soma Design [15, 41] is critical for exploring complex systems where emotional and social interactions are central. By immersing users in tangible experiences, it becomes possible to capture the nuances of user emotions and interactions connected to their chosen object. In the context of Affective Haptics, Experience Prototyping allows for the rapid testing and refinement of emotionally affective feedback, ensuring that the emotional impact of haptic interactions is aligned with UXs in real-time environments. By following their example to focus on Low-Fidelity (LoFi) prototypes to convey concepts faster instead of focusing on the technical feasibility, this workshop emphasizes the importance of rapid iteration and user feedback. Low-fidelity (LoFi) prototypes enable participants to quickly explore different haptic feedback patterns and adjust them based on real-time user reactions. This approach fosters creativity and flexibility, allowing designers to focus on emotional resonance rather than technical constraints. The iterative cycles, in which participants alternated between the roles of designer and user, promoted empathy and a deeper understanding of the emotional states being conveyed. This iterative, hands-on process aligns with Schön's concept of reflective practice [16], where designers learn through direct interaction and continuous refinement. By prioritizing emotional engagement and user-centered design, this prototyping method ensures that haptic feedback systems not only function technically but also create meaningful emotional connections.

Rapid prototyping is key to designing haptic systems that deliver precise emotional engagement. Paneëls et al. (2010) developed HITPROTO, a tool specifically designed for the rapid prototyping of haptic user interfaces. Such tools allow designers to make real-time adjustments to feedback mechanisms, ensuring that iterative testing is possible during the early design stages and making haptic design more accessible to novice interaction designers. This ability to test and refine haptic systems based on user feedback lowers barriers for novice interaction designers and enhances the development of AHFS [42]. HITPROTO also exemplifies the need for real-time iteration and emotional mapping capabilities within affective haptic design.

2.8 Ethical Considerations in Affective Haptics

As Affective Haptics become more advanced, increasingly integrated into everyday technology, and compatible with artificial intelligence algorithms, the field raises critical ethical concerns, including emotional manipulation, informed consent, cultural sensitivity, and data privacy. The design and deployment of these systems require robust frameworks to ensure that emotional and personal boundaries are respected. The following papers reviewed here provide a comprehensive foundation for ethical practices within affective haptic design, aligned with the objectives of this research.

2.8.1 Autonomy, Consent, and User Control

Eid and Al Osman (2016) emphasize the necessity of user autonomy, asserting that haptic systems must empower users to control their emotional experiences. Providing users with the option to modify or opt-out of emotional stimuli is essential to avoid unwanted emotional influence, particularly in sensitive environments like mental health interventions and social communication [18]. Schoeller (2023) further highlights the potential risk of emotional manipulation in immersive environments, noting that haptic feedback may unconsciously alter users' emotional states. This unintentional influence risks crossing ethical boundaries, necessitating thoughtful system design to maintain users' agency and psychological safety [46].

Ju et al. (2021) introduce the concept of *haptic empathy*, exploring the ethical responsibilities involved in conveying emotional meaning through haptic interfaces. They stress that designers must remain vigilant in ensuring that haptic stimuli do not overwhelm or manipulate users, recommending iterative testing and close observation to maintain users' emotional well-being during interaction [28]. Similarly, Akshita et al. (2015) warn of the risks associated with multi-modal systems. While the combination of visual and haptic stimuli can enhance user experiences, it also carries the potential for overstimulation or unintended emotional arousal. Their study underscores the importance of transparency and obtaining informed consent when deploying such feedback systems [2].

2.8.2 Data Privacy and Emotional Surveillance

The ethical management of emotional data emerges as a significant concern in the literature. Vyas et al. (2023) explore the implications of using data-driven algorithms in real-time to predict and influence users' emotional states. They argue that while personalized haptic interventions can enhance emotional engagement, they also introduce the risk of emotional surveillance and potential misuse of emotional data [57]. Eid and Al Osman (2016) further stress that cultural differences in touch perception necessitate careful contextualization to avoid misinterpretation or intrusion. They call for stronger ethical frameworks to guide data collection, storage, and usage, ensuring that users retain control over how their emotional responses are monitored and shared [18].

2.8.3 Emotional Dependency and Psychological Impact

The emotional impact of haptic feedback requires cautious consideration, particularly in vulnerable populations. Macdonald et al. (2021) explore the role of calming haptics in addressing social anxiety, highlighting the benefits of these technologies in social environments. However, they also caution against the risk of emotional dependence, where users might over-rely on these stimuli to regulate their emotional states. This dependency underscores the need for designers to carefully evaluate the psychological consequences of their interventions and to incorporate safety mechanisms that promote emotional resilience [33].

Eid and Al Osman (2016) and Ju et al. (2021) advocate for collaborative development with clinical professionals, especially in mental health contexts, to ensure that haptic designs are aligned with therapeutic goals and do not inadvertently harm users. Integrating experts from psychology and mental health fields can provide essential oversight, helping to safeguard participants' emotional well-being throughout the design process [18, 28].

2.8.4 Cultural Sensitivity and Contextual Awareness

Designers must also consider the cultural contexts in which haptic systems are deployed. Tsetserukou et al. (2009) highlight the importance of cultural sensitivity when designing emotionally resonant haptic feedback. Their research on virtual social interactions reveals that different cultures may interpret touch-based feedback in varying ways, posing challenges for universal design. They recommend adaptive systems that align with cultural norms to prevent miscommunication or discomfort [55].

Similarly, Ju et al. (2021) emphasize that emotional meanings conveyed through haptic interfaces must be calibrated according to users' cultural expectations. They warn that failure to do so can result in unintended emotional responses, reducing the effectiveness of the system and potentially causing harm. This highlights the need for cross-cultural research and user-centered design processes that involve participants from diverse backgrounds [28].

2.8.5 Addressing Ethical Challenges Through Design

Given the profound psychological impact of Affective Haptics, this study was conducted with careful attention to ethical considerations. Participants were fully informed about the nature of the study and provided with opportunities to withdraw or modify their involvement at any stage. During emotionally sensitive discussions, care was taken to ensure that participants were not pressured to share or engage beyond their comfort levels, and appropriate support was made available as needed. These practices align with the principles set forth by the American Psychological Association (2017), which emphasize transparency, respect for autonomy, and participant well-being in research contexts [5].

In alignment with recommendations from Vyas et al. (2023) and Eid and Al Osman (2016), the study also incorporated strategies to mitigate emotional manipulation risks. This included limiting the emotional intensity of haptic stimuli and ensuring participants had control over their interactions. Moreover, participants' data was handled with strict confidentiality, adhering to data privacy standards and ensuring that emotional responses were not shared beyond the research context without consent.

2.8.6 Remark

The integration of Affective Haptics into everyday technology presents unique ethical challenges that must be navigated with care. This study has drawn from established ethical frameworks and best practices to ensure participant well-being, transparency, and respect for personal and cultural differences. Future research should continue to refine these practices, incorporating multidisciplinary perspectives and developing adaptive, user-centered systems that prioritize autonomy, emotional safety, and cultural sensitivity. By adhering to these principles, affective haptic technologies can be harnessed to enhance emotional well-being without compromising ethical integrity.

2.9 Summary

The field of HCI has undergone significant evolution, from its early focus on usability and efficiency in the first wave, to its current emphasis on emotional, experiential, and social dimensions in the third wave. Affective Haptics, which uses tactile feedback to evoke or communicate emotions, aligns with this third wave by focusing on enhancing emotional engagement through personalized and immersive UXs. As technologies such as wearable devices and virtual reality interfaces grow in prevalence, the potential for affective haptic feedback to foster or regulate user emotions has become a key area of research.

Despite its potential, Affective Haptics, specifically single-modal haptic feedback, remains technically complex and inaccessible to set up for novice interaction designers and researchers. Current haptic toolkits often require advanced technical skills, which limits the ability of new designers to experiment with and integrate affective haptic feedback into their work. To address this gap, this thesis proposes a modular toolkit that simplifies the design of single-modal affective haptic feedback, drawing from established frameworks and methodologies such as body maps (soma design), embodied metaphors (psychology, and cognitive neuroscience), the Circumplex Model of Affect (behavioral, cognitive neuroscience), and Experience Prototyping (interaction design).

[5]https://www.apa.org/ethics/code

3 Methodology

This section describes the methodology for designing, implementing, and evaluating a modular methodological toolkit aimed at helping novice interaction designers create single-modal emotionally affective haptic feedback designs based on a personal, emotionally attached object they brought to the workshop. The study combines theoretical frameworks, such as an Emotion Typology [20] and the Circumplex Model of Affect [43] with practical prototyping tools and frameworks like Experience Prototyping, body maps, and embodied metaphor elicitation [5, 11, 15, 56] to facilitate the learning and prototyping process of novice interaction designers for affective haptic feedback.

3.1 Participant Selection and Recruitment

The careful structuring of the participant selection for this study ensured that the modular toolkit's intended audience — novice interaction designers with little prior experience in designing AHFS — could test it. The study aimed to assess how well the toolkit facilitated the learning process for individuals unfamiliar with haptics, while also ensuring diversity in background and experience level to capture a broad range of perspectives.

3.1.1 Recruitment Process

Participants were students with a background in HCI and a background in coding front-end interfaces, targeting students enrolled in courses related to interaction design, UX design and research, and front-end development. The primary criteria for participant selection were as follows:

1. **Novice in Haptic Design**: Participants were required to have little to no prior experience in designing haptic feedback systems. This ensured that study participants for the toolkit workshop would be novice interaction designers and researchers who represent its primary target audience — designers with a basic understanding of interaction design but without a background in haptic design or coding haptic feedback.

2. **Interest in Affective Haptics**: Participants were selected based on their expressed interest in learning about Affective Haptics, as indicated in the recruitment phase of this thesis workshop. This was done to ensure participants had intrinsic motivation and were eager to engage with the emotional aspects of haptic feedback and share honest feedback about the methodology toolkit angle and effectiveness to teach them single-modal Affective Haptic Design.

3. **Diverse Backgrounds**: To capture a wide range of insights, participants from various disciplines within HCI and design were selected, including those with backgrounds in:

- **digital concept development**,
- **UX design**,

- **industrial product design**,
- **psychology & cognitive sciences**, and
- **multimedia technology development**.

This diversity helped assess the toolkit's usability across different fields within the design, software & hardware development, and cognitive science communities.

4. **International and Language Diversity**: Given the global nature of design communities, participants included only non-native English speakers to evaluate how well the toolkit communicated complex emotional and technical concepts to a linguistically diverse group.

3.1.2 Participant Demographics

A total of six participants were recruited for the study, divided into three pairs. Each pair worked together throughout the workshop sessions to foster collaboration and mutual learning. The small group size allowed for in-depth interaction with the toolkit during the workshop and ensured that participants received sufficient guidance and time for feedback during the workshop.

Gender Balance: Efforts were made to include both male and female participants to explore any potential gender differences in emotional perception and response to haptic feedback. All pairs were paired up differently to have all possible combinations(i.e. 1: (W, M) 2: (M, M) 3: (W, W)).

Age Range: Participants ranged in age from 22 to 30 years, reflecting the typical demographic of postgraduate design students and early-career professionals.

Cultural and Educational Backgrounds: Participants came from varied cultural backgrounds, ensuring a diverse set of perspectives on the emotional interpretation of haptic stimuli. This diversity also helped assess the toolkit's applicability across different cultural contexts. As shown in subsection 4.1, the participants had varied backgrounds, which enriched the workshop discussions and outcomes. Each phase of the workshop, detailed in Sections 3.2.4 to 3.2.7, was carefully designed to build upon the previous one, guiding participants through the process of designing affective haptic feedback using the toolkit's modular methodological processes.

3.1.3 Participant Pairing

All six participants were divided into 3 pairs to reflect the Tandem Design approach used in the study. The pairing was done strategically to mix different skill levels, ensuring that each pair had complementary strengths in either the theoretical or practical aspects of design and identified challenges that could be better weighted, based on the interpretation of the feedback and correlation to the participants' professional background. For example, BP1 had significant experience with prototyping tangible interactive products, making that participant a suitable candidate for pairing with BP2, who had less experience but contributed with conceptual understanding from a psychological academic background. This setup consideration along all three groups promoted peer learning.

Collaborative Learning: By working in pairs, participants engaged in continuous feedback loops, which are crucial for iterative prototyping. One participant would act as the designer, creating and adjusting the haptic feedback, while the other acted as the test subject, providing immediate feedback on the emotional impact of the design. This collaborative structure mimicked real-world design environments where teamwork is essential. These instructions were not set as rigid role assignments but rather as a guideline to ensure participants had a starting point and worked collaboratively on their AHSD.

3.1.4 Selection Rationale

The selection criteria aimed to create a participant group representative of novice interaction designers who might use the toolkit in real-world scenarios to develop haptic designs. The choice of recruiting students as described in the diverse background paragraph3.1.1, but were still unfamiliar with the specifics of affective haptic technology and its design. This balance was important for the exploratory nature of the research and for addressing the gap between conceptualizing single-modal affective haptic feedback design and technical haptic on-body prototyping.

With the selected participants fulfilling the criteria described previously, the workshop was able to assess not only the usability of the toolkit but also its capacity to support a wide range of users in different design contexts. This diversity in selection also ensured that any challenges related to learning curves, certain cultural interpretations of emotional feedback, and collaborative design dynamics could be identified and addressed in the final evaluation of the toolkit's proposition.

Participants were asked to bring an object of their choice that they have an emotional connection to and are willing to share details about in a group setting. They were informed that during the workshop conduction, they would be working in a Tandem Setup, in which participants were paired up and supposed to communicate their preferences to another fellow designer or elicit the emotional triggers for another participant's object.

3.1.5 Informed Consent and Ethical Considerations

The study was conducted in adherence to strict ethical guidelines to ensure the protection of participant rights, privacy, and well-being throughout the research process. This subsection details the procedures followed to secure informed consent, maintain confidentiality, and address ethical concerns related to the emotional nature of Affective Haptic Design.

Informed Consent Procedure Before the beginning of the study, all participants were required to provide informed consent (see Appendix 57). This process was designed to ensure that participants fully understood the nature of the study, the role they would play, and any potential risks or benefits associated with their participation. The consent form was sent to the participants 2 weeks before the workshop date and was filled out and received before starting the workshop.

Information Briefing : Each participant received a comprehensive information sheet that outlined the study's objectives, the workshop structure, the specific tasks they would engage in, and the types of data that would be collected. This document also provided a brief overview of haptic technology and the relevant methodologies mentioned in the introduction of this methodology section3, and the significance of their involvement in the study.

Consent Forms : After reviewing the information sheet, participants were asked to sign the informed consent form, indicating their voluntary participation. The consent form covered key aspects such as:

- The purpose of the study of testing a combination of methodologies to teach single-modal Affective Haptic Design and the participant's role.
- The right to withdraw from the study at any time without any penalty or explanation.
- Assurance of anonymity and confidentiality regarding any personal data collected.
- Consent to the collection of qualitative data (e.g., demographic survey, voice recorded discussion rounds, body maps, embodied metaphor sheets, haptic design patterns) and quantitative data (e.g., experience levels, haptic feedback patterns).
- The use of photographs or screenshots of the workshop setup, procedure, and Miro board content provided that no identifiable personal information was included in such materials.

Voluntary Participation : The informed consent process emphasized that participation was entirely voluntary, and participants were informed that they could withdraw at any time, with no negative consequences for their academic standing or professional reputation.

3.2 Research Design

This study utilizes a Tandem Design methodology, where participants work in pairs to design haptic feedback systems. This approach mimics real-world collaborative design processes often found in professional environments and emphasizes user-centered design based on the Experience Prototyping approach of Buchenau and Suri in 2000 [11]. Each pair consists of two novice interaction designers who work together to iterate on their on-body haptic prototypes, providing feedback and making adjustments in real-time.

The workshop followed a multi-phase structure, designed to build participants' skills in Affective Haptic Design incrementally. Each phase introduced core concepts of haptic feedback and emotion-based design, progressing from theoretical discussions to hands-on on-body haptic prototyping. Participants initially explored embodied metaphors, using body maps to express emotional associations with their objects. This phase was followed by iterative on-body prototyping, where participants used the Hapticlabs DevKit to design feedback patterns. The structured flow ensured a balance between emotional reflection and technical skills, which was intended to foster a gradual learning curve. However, qualitative feedback highlighted some issues with transitioning between phases, particularly related to the technical limitations of the hardware, such as connectivity problems and limited actuator types, which impacted the creative exploration of emotional design patterns (BP2, CP1).

Each tandem group was instructed to engage with an 'emotional object' that they brought to the workshop. These objects were introduced during an initial presentation round where participants described the emotions associated with their objects and used a body map to note areas of emotional resonance (see the result section 4). This phase allowed participants to reflect on how emotions were felt physically, mapping their object-related emotions to specific body parts. For example, Participant AP2 linked their object (a ring) to a feeling of support and admiration, mapping these emotions onto the chest and neck area. These body maps were then used as a basis for placing haptic actuators during the on-body prototyping sessions. Additionally, participants were guided through embodied metaphor elicitation, where metaphors linked to their objects (e.g., 'soft but supportive') were translated into vibration patterns."

Workshop Room Setup The workshop provided participants with a range of resources to facilitate both the theoretical understanding and practical application of haptic design. These materials were thoughtfully curated to guide participants through each phase of the workshop, enabling them to engage with the emotional, metaphorical, and physical aspects of haptic feedback design.

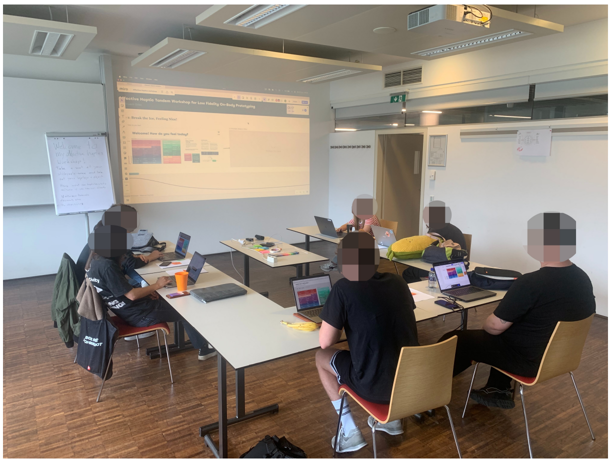


Figure 1: The workshop room setup with a U-shaped table arrangement and a projector displaying the Miro board for all participants. Each participant engaged with the workshop through both their personal devices and the shared projection. The setup fostered discussions and group activities.

Figure 1 shows the room setup used during the workshop. The U-shaped arrangement of tables was designed to promote interaction between participants during discussions and group activities. This arrangement allowed each participant to have personal space for their creative prototyping, while still enabling easy collaboration and observation of others' work. A projector was used to display the Miro board (updated template can be found in Appendix B, which participants could interact with on their personal devices or refer to on the screen during group presentations and activities. This dual engagement—through the shared projection and individual laptops—facilitated both independent exploration and group cohesion.

In the middle of the U-formation was a table containing additional materials such as the Hapticlabs DevKit, writing utensils, and post-it notes for brainstorming exercises (see Figure 4 for more details on the kit). This arrangement ensured that the necessary tools for both digital and physical prototyping were readily accessible, supporting the iterative and collaborative nature of the workshop.

3.2.1 Additional Materials for Prototyping

Figure 2: Table in the middle of the U-shaped configuration, providing colorful pencils, sticky notes, power plugs, power banks, crepe tape for on-body prototyping, and a voice recorder used to capture discussion rounds.

Figure 3: Additional materials for prototyping, including scissors, cardboard, slim tape, strings, cloth fabric, elastic mesh sleeves, and plastic styrofoam tubes. These materials were available on a separate table to facilitate creative, on-body haptic prototyping.

The workshop provided various materials to support both digital and physical prototyping during the sessions. The digital materials and results of the workshop can be found in the Mediacube Github in appendix B. As shown in Figure 2, a central table was placed in the middle of the U-shaped table configuration to offer participants quick access to essential materials. This included colorful pencils for body map creation, sticky notes for brainstorming, power plugs, and power banks for charging the Hapticlabs DevKit satellites, and crepe tape, which participants used for on-body prototyping due to the low adhesive strength that made it safe and comfortable to use on skin. Additionally, a voice recorder was operated by the researcher to capture qualitative feedback during the discussion rounds, enabling the participants to engage in conversational and unobtrusive feedback sessions.

Figure 3 shows a second table placed to the side, offering more physical materials for prototyping. These materials included scissors, cardboard for structure building, slimmer tape, strings, cloth fabric, elastic mesh sleeves for arm-based prototyping, and plastic styrofoam tubes. These items allowed participants to explore more creative and tangible approaches in their haptic design processes, giving them the flexibility to create more complex, embodied prototypes.

Hapticlabs DevKit The Hapticlabs DevKit[6] was the primary technical tool provided to participants (see Figure 4. It included three different types of actuators — ERM (Eccentric Rotating Mass) actuators, which produce vibrations through an off-center mass rotation; LRA (Linear Resonant Actuator) actuators, which generate vibrations via linear oscillations; and Piezoelectric actuators, which create precise vibrations using piezoelectric materials — each capable of producing varied haptic feedback. This allowed participants to explore a wide spectrum of tactile sensations, adjusting factors such as:

- **Intensity**: Participants could modify the strength of vibrations or force feedback.

[6]More information available at: `https://www.hapticlabs.io/devkit`

- **Frequency**: They could alter how fast or slow the vibrations occurred, simulating different emotional intensities.
- **Patterns**: Using the software, participants could choose pre-programmed vibration patterns or create their own, allowing for highly personalized affective feedback experiences.

The kit was connected to laptops via USB-C or Bluetooth and controlled through the Hapticlabs Studio software[7]. Participants were provided with access to the Pro License of the software before the workshop, ensuring they were familiar with its interface during hands-on prototyping.

The goal of the kit was to encourage rapid, iterative prototyping, enabling participants to experiment with one or two actuators to design haptic feedback designs that aligned with their emotional and metaphorical design concepts. The simplicity of the kit made it accessible, while its flexibility allowed for a range of creative outputs.

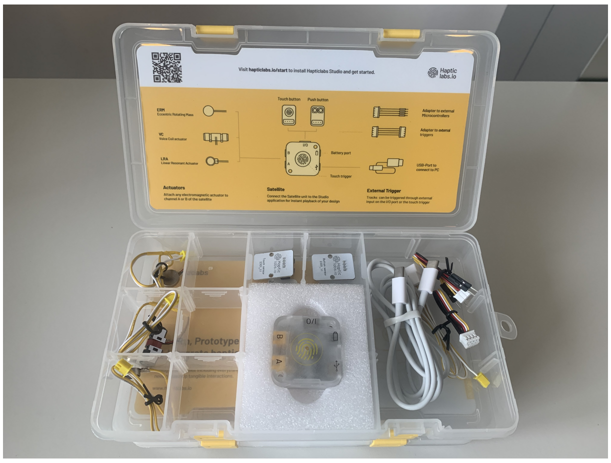


Figure 4: The Hapticlabs DevKit used during the workshop, containing actuators (ERM, LRA, VC), a satellite controller, touch triggers, and adapter cables. This kit was distributed to three tandem groups (A, B, and C) to prototype on-body haptic feedback systems. Participants used these components to design AHFS without the need for coding.

The Hapticlabs DevKit (Figure 4) served as the primary hardware resource during the workshop. Each tandem group received one kit, which included essential components for prototyping single-modal haptic feedback. This no-coding hardware kit allowed participants to focus on the emotional and design aspects of haptics without the barrier of technical programming knowledge. The toolkit contained:

- **Actuators:** Eccentric Rotating Mass (ERM), Linear Resonant Actuator (LRA), and Voice Coil (VC), which provided a range of tactile sensations.
- **Satellite Controller:** The main controller used to connect the actuators and configure haptic feedback patterns through the Hapticlabs Studio software.

[7]More information is available at: `https://www.hapticlabs.io/studio`

- **Touch Trigger:** Sensors that could activate haptic feedback based on touch, adding an interactive dimension to participants' designs.
- **Adapter Cables:** Used to connect actuators and other sensors to the satellite controller.

This kit enabled participants to explore different tactile sensations and translate emotional concepts into physical haptic feedback. Despite some technical challenges, such as connectivity issues, the DevKit played a crucial role in the iterative prototyping sessions described in the methodology section of this thesis.

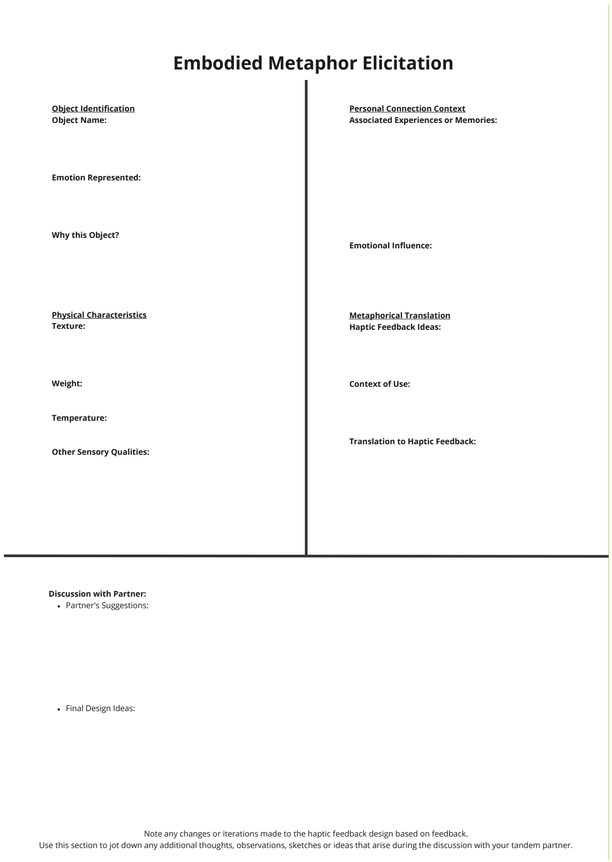
Embodied Metaphor Elicitation Template One of the central resources for translating abstract emotions into concrete haptic feedback was the embodied metaphor elicitation template, which is based on the concept presented by Bakker et al. [5] and was newly created for this workshop that can be examined in Figure 5. This worksheet guided participants through an in-depth exploration of the personal object they brought to the workshop, asking them to reflect on the emotional significance and sensory characteristics of the object. The template was divided into sections that helped participants articulate their thoughts systematically:

- **Object Identification**: Participants noted the object's name, the emotion it represented, and why it was personally meaningful.
- **Physical Characteristics**: This section focused on sensory details such as texture, weight, temperature, and any other qualities that could serve as metaphors for emotions.
- **Personal Connection Context**: Participants detailed associated memories or experiences that gave emotional weight to the object.
- **Metaphorical Translation**: This section prompted participants to brainstorm how the object's physical attributes could be transformed into haptic feedback, considering the context in which such feedback could be used and how it might evoke similar emotions in others.

The worksheet also included space for discussions with their tandem partner, allowing for feedback and the refinement of ideas. This process helped participants bridge the gap between emotional experience and technical prototyping, ensuring a thoughtful approach to design.

Body Map Templates The body map templates were essential for documenting how participants physically experienced emotions in their bodies. Participants were provided with both male and female body maps, enabling them to mark areas where they felt specific emotions related to the object they brought to the workshop. This exercise gave participants a visual reference for identifying emotional hotspots on the body, which later informed their decisions about where to place haptic feedback actuators during prototyping.

The following Figures 6 and Figure 7 present the body map templates provided to participants during the workshop, tailored for both male and female participants and taken as a royalty-free



Embodied Metaphor Elicitation

Object Identification
Object Name:

Emotion Represented:

Why this Object?

Physical Characteristics
Texture:

Weight:

Temperature:

Other Sensory Qualities:

Personal Connection Context
Associated Experiences or Memories:

Emotional Influence:

Metaphorical Translation
Haptic Feedback Ideas:

Context of Use:

Translation to Haptic Feedback:

Discussion with Partner:
- Partner's Suggestions:

- Final Design Ideas:

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 5: **Embodied Metaphor Elicitation Sheet.** This template was designed based on the principles of Experience Prototyping, aiming to elicit metaphors from objects brought by participants. The sheet helps document sensory, emotional, and metaphorical aspects of the objects, guiding participants through the translation of personal experiences into haptic feedback concepts. Key sections include object identification, emotional connections, and partner discussions, supporting collaborative design iteration during the workshop.

template from a stock foto and graphic website ”dreamstime.com” [8]. These templates were printed out and served as visual tools for marking emotional zones, actuator placements, and prototype testing areas during the on-body prototyping sessions. Participants used these maps to express the locations where specific sensations or emotions were felt and experimented with haptic feedback placements accordingly.

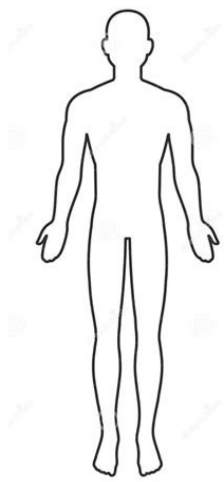


Figure 6: Body Map Template Provided For Male Participants.

Key components of the Body Mapping exercise included:

- **Front and Back Views**: The body maps included both front and back perspectives, encouraging participants to think about how emotions might be felt asymmetrically or in multiple areas.
- **Annotation of Sensations**: Participants were instructed to mark the maps with colors, symbols, or descriptions to convey sensations like warmth, tightness, tingling, or relaxation.
- **Reflection on Emotional Intensity**: They were asked to rate the intensity of emotions in different areas on a scale from 1 to 10, which helped guide the strength of haptic feedback during the prototyping phase.

[8] https://www.dreamstime.com/male-female-body-outline-male-female-body-silhouette-outline-blank-anatomy-template-medical-infographics-isolated-image150025863

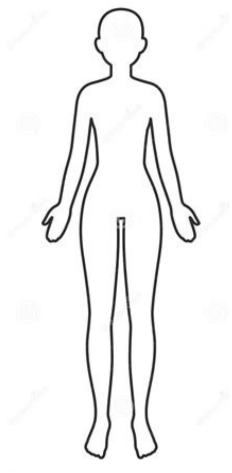


Figure 7: Body Map Template Provided For Female Participants.

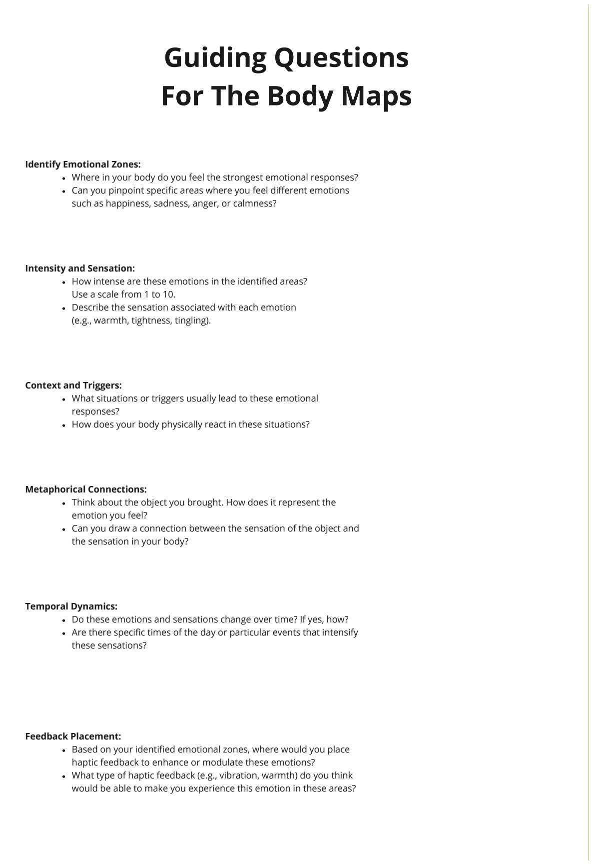
Body maps were introduced as a key tool to facilitate the translation of emotional experiences into physical sensations, offering participants a tangible framework to explore the relationship between affect and embodiment.

Body maps served as a foundational tool for participants to visually represent the connection between emotions and physical sensations.

Guiding Questions for Body Maps To support the body mapping exercise, participants were given a set of **Guiding Questions for Body Maps** (see Figure 8). These questions encouraged deeper reflection on how emotions were felt physically and how these sensations could be translated into haptic feedback. The guiding questions were structured around key areas such as:

- **Identify Emotional Zones**: Where in your body do you feel the strongest emotional responses? Can you pinpoint specific areas where you feel emotions like happiness, sadness, anger, or calmness?
- **Intensity and Sensation**: How intense are these emotions? Describe the sensation associated with each emotion (e.g., warmth, tightness, tingling).
- **Context and Triggers**: What situations or triggers usually lead to these emotional responses? How does your body physically react in these situations?

- **Metaphorical Connections**: How does the object you brought represent the emotion you feel? Can you draw a connection between the sensation of the object and the sensation in your body?
- **Temporal Dynamics**: Do these emotions and sensations change over time? Are there specific times or events that intensify them?
- **Feedback Placement**: Based on your identified emotional zones, where would you place haptic feedback to enhance or modulate these emotions? What type of haptic feedback (e.g., vibration, warmth) would evoke these emotions in the marked areas?



Guiding Questions For The Body Maps

Identify Emotional Zones:
- Where in your body do you feel the strongest emotional responses?
- Can you pinpoint specific areas where you feel different emotions such as happiness, sadness, anger, or calmness?

Intensity and Sensation:
- How intense are these emotions in the identified areas? Use a scale from 1 to 10.
- Describe the sensation associated with each emotion (e.g., warmth, tightness, tingling).

Context and Triggers:
- What situations or triggers usually lead to these emotional responses?
- How does your body physically react in these situations?

Metaphorical Connections:
- Think about the object you brought. How does it represent the emotion you feel?
- Can you draw a connection between the sensation of the object and the sensation in your body?

Temporal Dynamics:
- Do these emotions and sensations change over time? If yes, how?
- Are there specific times of the day or particular events that intensify these sensations?

Feedback Placement:
- Based on your identified emotional zones, where would you place haptic feedback to enhance or modulate these emotions?
- What type of haptic feedback (e.g., vibration, warmth) do you think would be able to make you experience this emotion in these areas?

Figure 8: Guiding questions provided during the workshop to inspire participants during the emotional mapping and prototyping processes.

The body maps and guiding questions were instrumental in helping participants navigate the design process. They facilitated the translation of subjective emotional experiences into tangible haptic feedback, promoting empathy and alignment between design intent and user experience. This iterative process allowed participants to align their prototypes with emotional concepts such as comfort, safety, and playfulness, ensuring a user-centric design approach.

These questions helped participants think more critically about the emotional and physical aspects of their design, ensuring that the haptic feedback was thoughtfully aligned with the emotional intent.

Designers can effectively map complex emotions into the Circumplex Model of Affect [43, 45] by using body mapping and embodied metaphors to link emotional experiences with physical sensations. They can then turn the derived valance and arousal into tactile sensations that can have emotional meaning for the user. To test H11.4, I implemented embodied metaphors and body maps in the design process and evaluated their impact on communication effectiveness among novice interaction designers.

Miro Online Platform The **Miro Online Platform** was used as a collaborative workspace where participants were presented with informative slides as explained in the next sections and documented their design processes. Using this platform allowed participants to:

- **Upload Body Maps and Templates**: Participants could photograph their completed body maps and upload them to Miro and fill out metaphor elicitation sheets for easy reference during the prototyping phase with their tandem partner.
- **Create Visual Notes**: The platform's virtual sticky notes and drawing tools enabled participants to jot down ideas, sketch feedback mechanisms, and annotate their designs.
- **Track Feedback and Iterations**: Miro allowed participants to share their work with their Tandem Design partners, facilitating real-time feedback and iterative design improvements.
- **Organize Prototypes**: Participants used Miro to document and share photos of their prototypes, making the process of refining and testing designs more interactive and collaborative.

Miro served as a vital tool for content presentation, organizing ideas, tracking progress, and ensuring collaboration between Tandem Design partners and all workshop participants.

Emotion Typology and Circumplex Model of Affect Two theoretical frameworks — the Emotion Typology and the Circumplex Model of Affect — were provided to help participants understand the emotional spectrum and map emotions onto haptic feedback patterns.

- **Emotion Typology**: Developed by the Delft Institute of Positive Design, this tool categorized emotions into pleasant and unpleasant states, providing participants with a wide range of emotional descriptors. This typology was essential for helping participants articulate emotions and identify target emotional states for their haptic designs.
- **Circumplex Model of Affect**: This model plotted emotions along two dimensions: valence (pleasantness) and arousal (activation). By using this model, participants could classify their emotional experiences and map them to specific haptic feedback designs. For example, high-arousal positive emotions might correspond to rapid, intense vibrations, while low-arousal negative emotions might call for subtle, slow feedback.

The combination of these materials and resources created a comprehensive environment in which participants could explore, document, and design AHFS. By integrating theoretical frameworks, practical tools, and collaborative platforms, the workshop aimed to equip novice interaction designers with both the knowledge and hands-on experience needed to engage with Affective Haptic Design and gain valuable insights into answering the research questions. The use of templates, guiding questions, and body maps fostered a deeper understanding of how emotions manifest in the body. At the same time, the Hapticlabs DevKit enabled participants to translate these insights into experimental, tangible haptic experiences.

3.2.2 Tandem Design Approach

The Tandem Design approach is a key component of the workshop methodology, facilitating both collaborative learning and iterative prototyping. In this approach, participants work in pairs, alternating between the roles of designer and user. This method builds on principles from participatory design and Experience Prototyping [11, 50], allowing participants to actively engage in both the creative process of designing and the experiential process of receiving and evaluating haptic feedback. By switching roles, participants gain a comprehensive understanding of both perspectives, which is essential for designing affective haptic feedback.

Roleplaying in Experience Prototyping Roleplaying is an integral part of the Tandem Design approach. In each pair, one participant takes on the role of the **designer**, responsible for creating and adjusting the haptic feedback, while the other participant acts as the **user**, experiencing the haptic feedback and providing real-time feedback based on their emotional responses. This approach encourages participants to think beyond their own experiences, engaging in role reversal to better understand how haptic feedback can be designed to elicit specific emotional responses in others.

Experience Prototyping, as outlined by Buchenau and Suri [11], emphasizes the importance of firsthand experience in the design process. By roleplaying both as a designer and user, participants can explore how haptic feedback interacts with emotional states, bodily sensations, and contextual factors. This not only helps participants refine their prototypes but also fosters empathy, as they are required to consider their partner's emotional and physical experiences. The Tandem Design approach mimics real-world collaborative environments but is particularly suited for emotional haptic design due to its emphasis on continuous peer feedback and iterative refinement, as supported by studies in Affective Haptics and participatory design mentioned in the introduction and related work section of this thesis12.

Designer Role The designer uses the **Hapticlabs DevKit** (see Section 4) to create on-body haptic feedback patterns, drawing from the embodied metaphor elicitation and body map templates to guide their design decisions. They are encouraged to consider the user's feedback in real-time, making iterative adjustments to the intensity, frequency, and patterns of the haptic feedback. The designer is also responsible for documenting the prototyping process, using platforms like **Miro** to track changes and refine ideas.

User Role The user's role is equally critical in the Tandem Design approach. As they experience the haptic feedback, they provide detailed feedback on how the sensations align with the emotional and physical experiences mapped during earlier phases. Users are encouraged to reflect on the quality and emotional resonance of the feedback, making annotations on their body maps to document areas where the feedback feels most relevant or effective. This ongoing dialogue between user and designer forms a continuous feedback loop, essential for refining the prototype.

Peer Learning and Feedback Working in pairs also facilitates peer learning, as participants are not only engaged in the design process but are also learning from one another's insights and feedback. This aligns with principles from participatory design, where collaboration and shared ownership of the design process are emphasized [50]. As participants alternate between roles, they must articulate their design rationale and provide constructive feedback to their partner. This back-and-forth dialogue ensures that both participants contribute to and learn from the design process, fostering a deeper understanding of creating AHFS.

Mutual Feedback Loops: The Tandem approach allows for continuous feedback loops, where the designer receives real-time input from the user and adjusts the design accordingly. This process is iterative and dynamic, reflecting the principles of participatory and Experience Prototyping [16]. The immediate feedback helps to refine the haptic feedback designs in ways that are responsive to the emotional and physical needs of the user, ensuring that the final design is both effective and meaningful.

Problem-Solving and Collaboration: The collaborative nature of the Tandem Design approach encourages problem-solving, as participants must work together to address design challenges. For instance, if the user finds the haptic feedback too intense or unaligned with their emotional state, the designer must quickly adapt and explore new patterns or placements. This iterative problem-solving process reflects real-world design team dynamics, where collaboration and communication are critical to achieving successful outcomes. By working together, participants learn to balance technical feasibility with emotional impact, a key skill in Affective Haptic Design.

Role Reversal and Reflective Practice

A crucial aspect of the Tandem Design approach is the role reversal that occurs midway through the workshop. After the first round of prototyping, participants switch roles, allowing the designer to become the user and vice versa. This shift is essential for fostering a holistic understanding of the design process, as participants experience both the creation and reception of haptic feedback. Role reversal also encourages reflective practice, as participants must reflect on their own experiences as users to inform their design decisions when they switch to the designer role.

Reflective practice is a key concept in design thinking, where designers are encouraged to reflect on their experiences and use those reflections to improve their designs [16]. By experiencing their own designs from the user's perspective, participants gain valuable insights into how their design choices affect the emotional and physical experiences of the user. This reflection helps to refine and improve the design, ensuring that the final haptic feedback system is not only technically sound but also emotionally affective.

Real-time Reflection: After each round of roleplaying, participants engage in brief reflection sessions, discussing their experiences as both designer and user. These discussions help participants identify key design decisions and reflect on their rapid on-body prototyping, fostering a deeper understanding of how to create effective haptic feedback systems. Participants are encouraged to document their reflections in Miro, creating a record of their iterative design process and the lessons learned from each round of prototyping.

Enhancing Iterative Prototyping The Tandem Design approach also enhances the iterative nature of prototyping, as participants continuously refine their designs based on feedback from their design partner. This iterative process is critical for Affective Haptic Design, where small adjustments to haptic feedback can have a significant impact on the emotional resonance of the system. By alternating between roles and continuously gathering feedback, participants can refine their prototypes in real-time, ensuring that the final design is both emotionally and physically engaging.

Rapid Prototyping Cycles: The workshop is structured around rapid prototyping cycles, where participants are encouraged to make quick, iterative design adjustments. This approach is informed by Experience Prototyping practices, where the focus is on creating a tangible experience that can be rapidly tested and refined through the direct feedback of the on-body prototype experience [11]. By iterating quickly, participants can test multiple versions of their haptic feedback systems directly on the user, gathering insights from each iteration and using them to improve the final design.

Simulating Real-World Design Environments Finally, the Tandem Design approach simulates real-world design environments, where designers often work in teams and must balance multiple perspectives and feedback sources. In a professional setting, designers must not only consider their own vision but also take into account the needs and preferences of users, clients, and collaborators. By working in pairs, participants in the workshop experience this dynamic firsthand, learning to balance their own creative ideas with the feedback and insights provided by their partners.

The collaborative, feedback-driven nature of the Tandem Design approach helps to prepare participants for real-world design challenges, where communication, empathy, and iteration are essential for success. By the end of the workshop, participants have gained both the technical skills and the collaborative mindset needed to design emotionally AHFS in a professional context.

The Tandem Design approach is a powerful method for fostering peer learning, collaboration, and iterative design in the context of Affective Haptics. By alternating between the roles of designer and user, participants gain a comprehensive understanding of both the technical and emotional aspects of haptic feedback design. This approach not only enhances the prototyping process but also encourages empathy, reflective practice, and collaborative problem-solving, all of which are essential skills for creating effective and meaningful haptic systems.

3.2.3 Ethical Considerations

Throughout the research design and execution, ethical considerations were rigorously addressed to ensure participant well-being, data privacy, and integrity of the study. First and foremost, informed consent was obtained from all participants, with a thorough explanation of the study's objectives, procedures, and any potential risks. Participants were briefed on the voluntary nature of their involvement, with the assurance that they could withdraw from the study at any time without any consequence. The consent forms clearly outlined how personal data, including any emotional or physiological feedback gathered during the workshops, would be anonymized to protect the privacy of participants (see Appendix 57.

Given the sensitive nature of some of the emotional and physiological data involved in haptic feedback design, particular attention was paid to data handling. Emotional experiences, body mapping annotations, and feedback related to the emotional resonance of haptic prototypes were treated with utmost confidentiality. The data was anonymized, with any identifying information being removed before analysis. Additionally, the research followed strict data storage protocols, ensuring that all information was securely stored and only accessible to authorized researchers involved in the project.

The study also emphasized emotional sensitivity throughout the workshop. Participants were encouraged to engage with positive emotional experiences, particularly in the metaphor elicitation and body mapping phases, to avoid inducing discomfort or distress. To further safeguard participants, the body mapping exercise — which involved identifying areas of the body where emotions were felt — was conducted with careful consideration of privacy and participant comfort. No sensitive areas were explored, and participants were instructed to disclose only what they were comfortable sharing.

In addition to protecting participant data, the study's ethical framework also emphasized the reciprocal nature of feedback in the Tandem Design methodology. The role reversal between designer and user not only encouraged empathy but also ensured that participants experienced the emotional and physical implications of their prototypes designed for another personalized UX. This helped mitigate the risk of unintended emotional or sensory discomfort in the final prototypes. Participants were constantly reminded that they had the right to pause or modify the activities if they felt uncomfortable at any stage.

The study's framework was further aligned with broader ethical principles within HCI and Affective Haptics, including respect for user agency, attention to emotional impact, and the importance of inclusivity in design. Ethical considerations thus shaped the study's design from inception to data analysis, ensuring a respectful, safe, and emotionally aware research environment.

The four steps of the toolkit testing workshop are designed to ensure a cumulative learning experience and enough participant feedback to make informed decisions for the next iteration of the methodological toolkit for Affective Haptic Design. Each phase builds on the one before it.

3.2.4 Phase 1: Introduction to Emotional Frameworks, Haptic Theory, and Initial Survey - 30 Minutes

Participants are introduced to the foundational concepts for this Affective Haptics workshop. This includes a presentation of the Emotion Typology, the Circumplex Model of Affect, which categorizes emotions based on their valence (positive-negative) and arousal (high-low), and an introduction to the basic terminologies of haptics, setting the focus on tactile feedback design. Participants are given an overview of the technical aspects of haptics, including how haptic actuators work, what tactile feedback entails, and the different types of sensations that can be generated through haptic devices. This model serves as a key theoretical tool for guiding participants in mapping emotional states to haptic feedback patterns. This phase provides participants with the necessary background to think critically about the emotional and technical components of haptic design.

Emotion Typology: Participants are introduced to the Emotion Typology, developed by the Delft Institute of Positive Design. This tool categorizes a wide range of emotions and serves as a conceptual framework to help participants understand the various emotional responses [20] that haptic feedback could be designed for and have a reference that also supports non-native English speakers to articulate their emotions precisely. The Emotion Typology by the Delft University of Technology is an open-access online database that contains thorough information on both positive and negative emotions, which suits this toolkit approach. It contains descriptions about 60 emotions, 24 of which are pleasant and 36 negative.

For each emotion, the database contains the following information:

- Formal definition of the emotion
- Explanation of causes and responses
- Three clips from popular movies expressing that emotion
- Typical verbal expressions
- Cartoon mini-story (currently available for negative emotions only)
- Comparisons with similar emotions (currently available for negative emotions only)
- References to scientific sources for further reading on emotions

In this thesis, the framework is used as a foundation for recognizing, identifying, and defining emotions during the design process. At the beginning of the workshop, participants were asked to place a colored dot on the emotion they felt right now to start the engagement and spark their interest in exploring the Emotion Typology. For the sake of straightforwardness, the color codes for emotions from the Emotion Typology were not used and were chosen by the participants based on personal preference. Also, participants were asked to pick positive emotions for this workshop to avoid unpleasant experiences during the object metaphor elicitation, body mapping, or prototyping sessions which aligns with the initiative of the Emotion Typology authors Delft Institute of Positive Design.

Figure 9: Workshop participants using the Emotion Typology framework. This activity helped participants explore and categorize a wide range of emotions, providing a structured approach to understanding emotional nuances in their designs. The Emotion Typology, developed by the Delft Institute of Positive Design, served as a key tool in the workshop. More information about the Emotion Typology can be found at `https://emotiontypology.com/`.

Circumplex Model of Affect: Building on the Emotion Typology, participants are introduced to the Circumplex Model of Affect [43], which plots emotions along two dimensions: valence (positive-negative) and arousal (high-low). This model provides a systematic way to map emotions to haptic feedback as described in section 2.3.

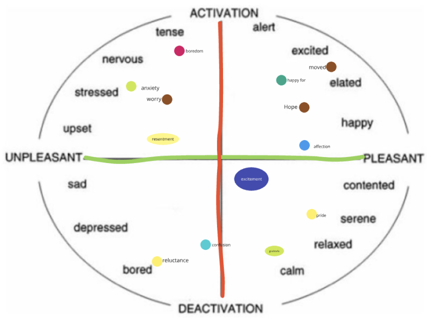


Figure 10: Workshop participants placing their emotions on the Circumplex Model of Affect [43, 45]. In this activity, participants reflected on their emotional states and categorized them based on valence (positive-negative, horizontal) and arousal (high-low, vertical). This exercise helped participants gain a deeper understanding of the emotional spectrum and how it could be translated into haptic feedback.

Introduction into Haptic Feedback: In the workshop's initial phase, participants were introduced to the foundational concepts of haptic feedback. Haptic feedback, as outlined in this session, refers to the use of touch sensations to communicate information to users through forces, vibrations, or motions applied by a device. This can enhance interactions by providing tactile signals, particularly in environments where visual or auditory feedback may be insufficient or overloaded. Participants were introduced to key terminology, including the distinction between single-modal experiences, where one sense is stimulated, and multi-modal experiences, where multiple senses such as sight, hearing, and touch are combined.

The session further differentiated between two primary forms of perception relevant to haptic feedback: kinaesthetic perception, which relates to muscle and joint feedback (such as "I feel how full my glass is"), and tactile perception, which involves the skin's receptor feedback regarding texture, material, vibration, and temperature. These perceptions play crucial roles in the design and reception of haptic systems, particularly in emotionally affective feedback.

Participants also got an introduction into the various types of haptic feedback, such as passive haptics, where physical object attributes like texture and weight are considered, and active haptics, which involve electric components like vibration motors and vibrotactile actuators. For the workshop, the focus was primarily on active tactile feedback systems, as these technologies allow for finer control and are central to many Affective Haptic Design projects.

Throughout this warm-up lecture, participants were made aware that haptic feedback is inherently personal, culturally specific, and context-dependent. This haptic introduction made participants familiar with the basics of tactile perception and how to evaluate and refine haptic feedback systems in a design context. This introductory phase drew heavily on resources from Hapticlabs' tutorial on haptic feedback, ensuring that participants had a solid technical foundation before moving on to hands-on prototyping activities with the Hapticlabs DevKit which will be discussed in more detail in the material section. More information on this tutorial is available through the Hapticlabs website[9].

Mapping Everyday Haptics to the Circumplex Model of Affect: To reinforce the theoretical frameworks, participants engage in an exercise where they are asked to recall and categorize everyday haptic experiences (e.g., the vibration of a mobile phone, the feel of a door closing, or a heartbeat simulation). They are, again, instructed to place these examples on the Circumplex Model of Affect, considering how the sensation corresponds to different combinations of valence and arousal. This exercise helps participants to get familiar with the emotion simplification process, actively engage with the emotional dimensions of haptic feedback and apply the frameworks to real-world examples.

The Circumplex Model of Affect was used to create an overview of haptic technology and haptic feedback they already know from everyday life. This phase aimed at giving a terminology overview of emotions in the English language, learning to simplify emotional stimuli onto the Circumplex Model of Affect. To introduce haptic technologies, explaining how actuators work, the types of tactile sensations (e.g., vibrations, pressure) that can be generated, and how these sensations are mapped to emotional experiences guided them into the first exercise of sorting haptic technologies they already are familiar with into the Circumplex Model of Affect, manifesting the concept of deriving an emotion into an interpretation of valance and arousal.

Following this theoretical introduction, participants are guided through key emotional frameworks that will serve as the basis for their haptic design process:

[9] `https://www.hapticlabs.io/tutorial`

Figure 11: Exercise: Mapping Everyday Haptics to the Circumplex Model of Affect. In this exercise, participants were asked to recall and categorize everyday haptic experiences, such as the vibration of a mobile phone or the feel of a door closing. They placed these examples on the Circumplex Model of Affect, mapping how the sensations corresponded to combinations of valence and arousal. This process familiarized participants with simplifying emotional stimuli into a two-dimensional representation, helping them connect emotional responses to haptic feedback in real-world contexts. The exercise also provided an introduction to various haptic technologies, explaining how tactile sensations (e.g., vibrations, pressure) are produced and how they relate to emotional experiences.

Demographic and Haptic Experience Survey: After the first exercise, participants complete the first haptic survey. The survey collects demographic information, their prior experience with haptic design, and their familiarity with the methodologies introduced. This survey helps to establish a baseline for participants' knowledge and comfort levels with the concepts that will be used throughout the workshop. This helped get an overview of the prior knowledge and was considered when evaluating the qualitative feedback from each participant, drawing correlations to their prior experience and demographic information. The questions for this survey can be looked up in the appendix 6.6.

- **Demographics:** Information such as age, education, previous education, current job title, field of profession, and pursuit career is collected. Here the participants also stated what emotionally connected object they have brought for the workshop, what emotion is attached to it, and an associated adjective for the object or emotion.
- **Prior Experience:** Participants note any prior experience with haptic design, embodied metaphors and body map methodologies.
- **Familiarity with Methodologies:** Participants self-assess their familiarity with relevant concepts on a Likert-scale from 1(not familiar) to 5(very familiar). The following skills were questioned: Haptic Prototyping, On-body prototyping, Coding, Haptic Design, Affective Haptic Design.

This introductory phase sets the foundation for the workshop, ensuring that participants are familiar with both the technical and emotional aspects of haptics, and providing a clear baseline for their starting knowledge and experience.

3.2.5 Phase 2: Embodied Metaphor Elicitation and Body Mapping - 50 Minutes

The second phase of the workshop is designed to deepen participants' engagement with both the emotional and physical aspects of haptic feedback design by using embodied metaphor elicitation and body mapping techniques. This phase involves multiple steps to guide participants through the process of translating abstract emotional experiences into tangible haptic feedback systems. Through structured activities, participants explore the emotional resonance of objects they brought with them and begin to associate specific bodily sensations with these emotions.

Each tandem group was instructed to engage with an emotional object that they brought to the workshop. These objects were introduced during an initial presentation round where participants described the emotions associated with their objects and used a body map to note areas of emotional resonance. This phase allowed participants to reflect on how emotions were felt physically, mapping their object-related emotions to specific body parts. For example, Participant AP2 linked their object (a ring) to a feeling of support and admiration, mapping these emotions onto the chest and neck area. These body maps were then used as a basis for placing haptic actuators during the on-body prototyping sessions. Additionally, participants were guided through embodied metaphor elicitation, where metaphors linked to their objects (e.g., "soft but supportive") were translated into vibration patterns.

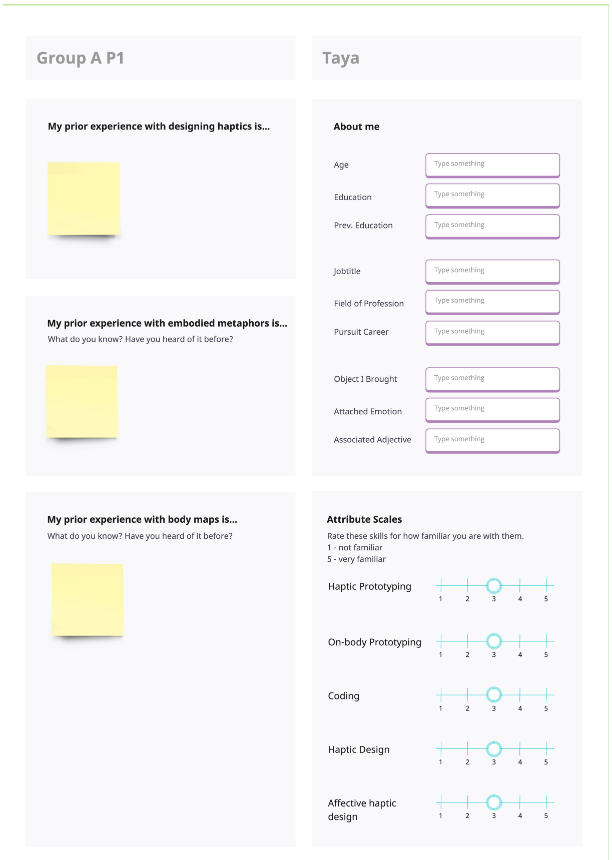


Figure 12: Demographic and Haptic Experience Survey. After the initial exercise, participants complete a survey to gather demographic data and assess their prior experience with haptic design and related methodologies. The survey covers demographic details such as age, education, profession, and career aspirations. Additionally, participants provide information on the emotionally connected object they brought to the workshop and its associated emotion and adjective. The survey also includes questions about participants' familiarity with concepts like haptic prototyping, on-body prototyping, coding, and Affective Haptic Design. This baseline data helps gauge each participant's starting knowledge and experience, which is later correlated with their qualitative feedback.

Embodied Metaphor Elicitation and Emotional Object Sharing This initial activity centers around the participants' objects that they were asked to bring for the workshop. The objects are meant to evoke specific emotions, which participants will use to inform their haptic design process. The sharing of these objects and the emotions attached to them acts as an icebreaker and a bridge into a more focused reflection on emotional design.

- **Object Introduction Round**: Participants are introduced to the concept of embodied metaphors. They are then asked to present their objects, explaining the personal emotional connection they have to them. Each participant shares why the object is significant, what emotions it evokes, and how the physical properties of the object relate to those emotions. This round is recorded and later transcribed to ensure that participants can refer back to their insights during the design process. This exercise also helps participants articulate emotional experiences, creating a shared understanding within the group and preparing them for deeper emotional exploration. The introduction serves to reinforce the role of metaphor in translating abstract emotions into tangible design elements [5, 39].
- **Exploring Emotional Metaphors**: After introducing their objects, participants are asked to reflect on and document the sensory qualities of their object, considering its emotional impact and the metaphors that can be drawn from its physical characteristics. For example, if a participant brought a soft blanket associated with comfort, they may describe the blanket's warmth and softness as metaphors for the feeling of emotional security. These reflections are shared with their Tandem Design partners to foster understanding and empathy in preparation for the prototyping phase. The discussions help participants develop early ideas about how to translate these emotional experiences into haptic sensations.

The purpose of this activity is to provide participants with a framework for thinking about how everyday objects can be imbued with emotional meaning. The process of discussing and documenting these emotions lays the groundwork for the more technical and physical elements of the workshop. For further details, please refer to section 4.

Body Mapping for Emotional Baseline (5 Minutes) Building on the insights from the metaphor elicitation exercise, participants are introduced to body mapping, a technique often used in soma-based design, to document how emotions are experienced physically. Participants use body maps to represent where they feel specific emotions in their bodies visually. This step aims to create an emotional baseline for each participant, guiding haptic feedback design later in the workshop.

- **Introduction to Body Mapping**: Participants are shown a series of slides that explain how body maps are used to document the location and intensity of emotions felt within the body. The introduction highlights differences in sensitivity across different body parts, drawing attention to how certain areas like the hands, feet, and face are more sensitive to tactile feedback than the back or limbs. This understanding helps participants make informed decisions later about where to place haptic feedback actuators on the body.

- **Activity Instructions**: Participants are given templates of male and female body maps, and instructed to mark areas of the body where they feel specific emotions associated with the object they discussed. They are encouraged to annotate the body map with colors, symbols, and descriptions that help convey the intensity and type of sensation (e.g., warmth, tightness, relaxation). They are also encouraged to document both the front and back of the body, noting any asymmetries in how the emotion is experienced across these areas.

- **Guiding Questions for Body Mapping**: To support the body mapping process, participants are provided with a set of guiding questions. These questions prompt participants to reflect on the intensity and quality of the emotion, asking them to rate sensations on a scale from 1 to 10, describe how the emotion manifests physically, and consider whether certain contexts or triggers intensify the sensations. Participants are also asked to think about how they might translate these sensations into haptic feedback. These questions encourage participants to internalize their emotional responses and connect these responses with tangible design concepts.

Documentation of Ideas for the Prototyping Session (20 Minutes) After introducing the body mapping exercise, participants started internalizing and creating body maps to document their emotional and sensory reflections in preparation for the upcoming prototyping session. They were instructed to also fill out the embodied metaphor elicitation template provided on their dedicated workspace. This documentation process helps them solidify their thoughts and prepare for collaboration with their Tandem Design partners.

- **Use of Embodied Metaphor Elicitation Workspace**: Participants use a pre-designed workspace to document their object and associated emotions. This workspace includes the Circumplex Model of Affect and the Emotion Typology to help participants simplify the emotional experience into valence and arousal dimensions. They are also encouraged to take photographs of their object and include descriptive notes that will serve as a reference point during the prototyping process. The worksheet asks participants to reflect on the emotional experience of interacting with their object and begin to ideate on potential haptic feedback mechanisms that could evoke similar emotions.

3.2.6 Phase 3: Prototyping Sessions - 2x 45 Minutes

The third phase of the workshop centered on the practical implementation of the theoretical and conceptual knowledge participants had gathered in the first two phases. During this phase, the Hapticlabs DevKit and previously created body maps and embodied metaphors were used to foster Lo-Fi, on-body affective haptic prototype design processes.

Participants were encouraged to engage in an iterative design process, where they would alternate between creating, testing, and refining their haptic feedback prototypes. They worked in pairs, with one participant taking on the role of the designer, and the other assuming the role of the user. This setup provided opportunities for both participants to contribute to the design process while experiencing the affective haptic feedback as intended for their partner's emotional object.

Hapticlabs DevKit Setup and Exploration (10 Minutes) The workshop started with participants setting up and exploring the Hapticlabs DevKit. This toolkit includes three actuators — ERM (Eccentric Rotating Mass), LRA (Linear Resonant Actuator), and Piezoelectric actuators — which are capable of generating various haptic feedback patterns.

ERM Actuators are simple, cost-effective components with limited control over feedback intensity but capable of creating strong vibrations.

LRA Actuators are more precise, offering responsive and complex vibrations, often used for more intricate haptic designs.

Piezoelectric Actuators offer the highest precision and fastest response but are more complex and expensive, allowing for high-fidelity prototyping.

Participants were asked to download and install the Hapticlabs software on their laptops prior to the workshop. Each group was provided with unique activation codes to enable them to use the software for prototyping purposes. Once the software was set up, participants connected the Hapticlabs satellite kit via USB and started exploring the functionality of the actuators through the software interface.

The setup allowed participants to adjust the following:

Intensity: Control over the strength of the feedback.

Frequency: Manipulation of how fast or slow the vibrations are produced.

Patterns: Participants could explore pre-programmed or customized vibration sequences, or create their own from scratch using the Hapticlabs Studio software with the Hapticlabs DevKit connected.

They were encouraged to experiment and familiarize themselves with the Hapticlabs DevKit and Hapticlabs Studio software, preparing them for the more detailed prototyping work to follow. This exploration phase helped them choose the appropriate actuator for their affective haptic feedback design.

Pairing Up and Prototyping Cheatsheet (5 Minutes) Once participants were familiar with the Hapticlabs DevKit, they were paired up with their tandem partner from earlier phases. Before diving into prototyping, they received a "Prototyping Cheatsheet" as a guideline, which reiterated key concepts to keep in mind during the prototyping sessions:

User-Centered Design: Focus on the emotional experience of the user, continuously gathering and incorporating feedback into the design.

Experience Prototyping: Roleplaying the interaction context to think about nuances and UXs. Participants were advised to keep their prototypes simple and focus on the conceptual ideas.

Hands-On Prototyping: Engage in designing and testing Lo-Fi, on-body haptic prototypes based on the body maps and embodied metaphor elicitation sheets.

Iterative Prototyping: Rapid prototyping followed by iterative testing. Feedback was to be documented through notes, photos, and short voice or video recordings.

The cheatsheet also reminded participants to utilize:

Body maps to identify where on the body emotions are felt, and where haptic feedback might be applied.

Embodied metaphor elicitation to guide the design of feedback patterns, considering how textures and sensations could be translated into haptic form.

This overview provided participants with structure and confidence as they began prototyping.

Prototyping Process (2 Rounds of 45 Minutes each) The prototyping session was structured into two rounds to ensure that both participants in each tandem team (A,B& C) had the opportunity to design and experience two affective haptic feedback designs. Participants engaged in two 45-minute prototyping sessions, during which they used the methodological toolkit and Hapticlabs DevKit to design and iterate on haptic feedback patterns based on their body maps and metaphor elicitation exercises. The workshop provided a limited set of actuators, which participants were encouraged to explore while iterating on their designs. Each round lasted 45 minutes, and roles were switched after the first round to give both participants the chance to take the perspective of both the designer and the user.

Prototyping Round One
Role Assignment:

Participant 1 took on the role of the User(U) and was testing and evaluating the haptic prototype.

Participant 2 took on the role of the Designer(D), developed the haptic feedback patterns, and discussed where actuator placement would be suitable.

User Role (Participant 1): The U tested the haptic prototype on the body, shared their embodied metaphor elicitation sheet with the D to start the ideation process, and provided real-time feedback. This feedback involved talking through their experiences, filling out body maps, and reflecting on how well the haptic feedback aligned with the affective impact of their emotional object.

Designer Role (Participant 2): The D developed AHFD using the Hapticlabs software and Hapticlabs DevKit. They attached actuators to specific locations on the U's body (as identified in the body map) and asked open-ended questions to gather more detailed feedback from the U.

Documentation and Iteration: Both participants were encouraged to document their process through Miro, taking photos, making voice recordings, and filling out notes and body maps. The D would iterate on the feedback patterns based on the U's reactions, continuously refining the prototype.

Prototyping Round Two In this round, the participants switched roles to ensure that both experienced being both the D and the U.

Role Switch:

Participant 1 became the Designer(D).

Participant 2 became the User(U).

The prototyping process continued as described in the first round, with the D creating haptic feedback designs based on the embodied metaphor and body map of the U. This switch allowed both participants to engage fully in the creative and experiential aspects of prototyping.

Feedback Loop and Documentation: Throughout both rounds, participants continued iterating on their designs and documented their process using the tools provided. They uploaded photos, notes, and screenshots of their work into the Miro workspace.

Documentation and Reflection (10 Minutes) After completing both prototyping rounds, participants were reminded to upload their design documentation, including their notes, photos, videos, and completed body maps, into the shared workspace. They were also asked to engage in a brief recorded discussion with their tandem partner to reflect on their experiences during the prototyping sessions.

Participants discussed the challenges they encountered, the insights they gained from their partner's feedback, and any potential improvements for their designs. This reflection session aimed to solidify their learning and prepare them for the next steps in refining their prototypes.

Create: Design and prototype Lo-Fi, on-body AHFS.

Document: Capture the design process, challenges, and outcomes using the provided templates and personal documentation.

Discuss & Reflect: Gather insights, iterate on the prototype, and prepare for further refinement of the affective haptic feedback design.

This methodology phase ensured that participants were able to fully engage with the practical elements of affective on-body haptic prototyping. By utilizing the Hapticlabs DevKit, applying their conceptual understanding of emotions and haptics, and working collaboratively with their partner in a Tandem Setup, they gained hands-on experience in creating AHFS.

3.2.7 Phase 4: Surveys and Group Reflection - 25 Minutes

In the last part of the workshop, participants were asked to give detailed feedback on how they felt about the Tandem on-body prototyping process, how useful the methodological toolkit was, and how well the Emotion Typology, the Circumplex Model of Affect, the embodied metaphor, and body mapping techniques helped them turn the emotions of their chosen object into haptic feedback. This phase involved two key activities: a final individually written quantitative survey and a final group discussion with six guiding questions. Both of these aimed to collect qualitative and quantitative data to inform the evaluation of the workshop and the methodological techniques directly linking back to the research questions and hypotheses of this thesis1.4.

Individual Survey: The individual survey included open-ended questions to capture participants' personal reflections on various aspects of the workshop, including the methodologies introduced and their experience with haptic feedback design. The survey questions were designed to provide insights into how the participants understood and applied the toolkit, as well as the emotional frameworks (such as the Circumplex Model of Affect and embodied metaphors) that underpinned the design process. The survey included the following sections:

- **General Usefulness:** This section asked participants to reflect on the overall usefulness of the workshop in helping them understand and apply haptic feedback in their designs. It explored which parts of the workshop were most beneficial and which were potentially challenging. This section directly relates to evaluating the toolkit's usefulness in fostering a comprehensive understanding of haptic design for novice interaction designers.
- **Body Maps and Embodied Metaphors:** These questions explored how participants used body maps and embodied metaphor elicitation in their design process. For example, participants were asked how useful they found the body maps in guiding their haptic design and whether they would use this methodology again. This data helps to assess the hypothesis that body mapping and embodied metaphor elicitation can be useful for novice interaction designers to translate emotional experiences into tactile feedback.
- **Prototyping and Toolkit Usage:** Participants were asked about the challenges they faced during the prototyping phase and how well the haptic feedback aligned with the emotions they intended to evoke. They were also asked to provide recommendations for improving the toolkit and suggest additional materials that could enhance the workshop experience. This section aimed to gather insights into the technical aspects of the toolkit, its accessibility, and its ease of use for novice interaction designers, aligning with the research question about the toolkit's usefulness.

Group Discussion: Following the individual survey, a group discussion was held to promote reflective thinking and to allow participants to share their experiences, insights, and challenges openly. The discussion was semi-structured, with guiding questions presented to steer the conversation toward specific aspects of the workshop. The group discussion was designed to encourage participants to think critically about the usefulness of the toolkit, the process of embodied metaphor elicitation, and their collaborative prototyping experience.

The discussion was framed around two core themes:

- **Insights and Challenges:** Participants were asked how the prototyping sessions helped them understand the emotional impact of their designs and whether the embodied metaphor exercises aided their emotional translation into haptic feedback. This section provided valuable information on how well participants engaged with the emotional dimensions of the design process, testing the hypothesis that embodied metaphor elicitation fosters a better understanding of emotional states in haptic design.

- **Future Improvements:** This section allowed participants to reflect on the toolkit's potential for improvement, as well as the overall workshop structure. Questions explored what features or tools would make the workshop more user-friendly for beginners, aiming to gather feedback on the ease of learning and prototyping with the toolkit. This feedback was essential for refining the toolkit for future use and validating the effectiveness of the methodology for novice interaction designers.

By collecting both individual and group feedback, this phase aimed to assess the participants' overall satisfaction with the workshop, their ability to design emotionally affective haptic feedback, and how well the embodied metaphor and body mapping techniques supported their creative process. The data collected directly informs the research question regarding how well the workshop facilitates emotional haptic design and provides insights into how the toolkit can be optimized for future workshops.

3.2.8 Data Collection and Analysis

Qualitative Data:

- **Observation Notes:** During the workshop, participants' interactions with the toolkit and their partner were documented and clarified through brief check-in discussions. This included noting significant breakthroughs, challenges, and the dynamics between the Tandem Design partners during the prototyping iterations.
- **Surveys and Group Discussions:** During the workshop, surveys and discussions provided insights into participants' experiences with the toolkit and their emotional design processes.
- **Design Artifacts:** Body maps, metaphor descriptions, and design sketches were collected and analyzed to uncover patterns in emotional engagement, haptic design choices, and the participant's expertise.

Quantitative Data:

- **Familiarity with Methodologies:** In Phase 1's demographic survey, participants' familiarity with certain skills was determined using **5-point Likert scales** to indicate their knowledge prior to the workshop and their correlated qualitative feedback.
- **Feedback Forms:** Participants rated various aspects of the toolkit, including its clarity, ease of use, and usefulness of the affective haptic feedback created and the workshop material used to teach the concepts of affective haptic design.

Data Analysis:

- **Thematic Analysis:** Qualitative data were analyzed for recurring themes related to **emotional resonance, usability, and creative exploration**. Themes were cross-referenced with design outcomes to evaluate the toolkit's overall usefulness.
- **Relationship of Skill level and Toolkit Feedback:** Quantitative data from the demographic survey about their skill level3.2.4 were taken into consideration when evaluating their qualitative feedback. This was done to put their input into context for the reader and draw conclusions for intersections of feedback throughout different professional backgrounds.

3.2.9 Summary

The workshop was meticulously structured to guide participants through the intricate process of affective haptic design, blending theoretical frameworks with hands-on, on-body prototyping activities to facilitate comprehensive learning. The session commenced with an introduction to Emotion Typology, a project developed by TU Delft, which categorizes emotions into positive and negative dimensions. Participants were instructed to lean towards positive emotions; however, the initial exercise invited them to express how they were feeling on the day of the workshop. This exercise was supported by an interactive website featuring detailed information cards for each emotion, including relatable scenarios, example movie clips, visual representations, and typical expressions. This resource proved particularly beneficial for non-native English speakers, as it provided accessible descriptions and context, aiding in the accurate articulation of complex emotions.

Subsequently, the workshop delved into the Circumplex Model of Affect, which maps emotions along two axes: valence (unpleasant to pleasant) and arousal (activation to deactivation). Participants were guided to distill their complex emotions into this model, simplifying their emotional landscape into manageable categories. This reduction facilitated a clearer understanding of how specific emotions could be translated into haptic feedback patterns. Following this, an activity focused on real-life applications of haptics encouraged participants to brainstorm various scenarios where tactile feedback could enhance UXs. This exercise broadened their perception of haptic design possibilities and underscored the versatility of haptic feedback in different contexts.

A pivotal component of the workshop was the embodied metaphor elicitation exercise. Participants were prompted to associate their emotionally significant objects with bodily experiences, translating abstract emotions into tangible design elements. For example, a participant who associated a basketball toy with feelings of calmness designed a haptic pattern mimicking the rhythmic motion of dribbling. This methodology emphasized the importance of metaphors grounded in physical experiences, enabling participants to create more nuanced and emotionally affective haptic feedback.

The body maps activity further reinforced this translation process. Participants were provided with pre-printed body map templates and instructed to denote areas of their bodies that corresponded with the emotions linked to their chosen objects. Guidelines included the use of colors and symbols to represent different emotions and areas of emotional sensitivity. Additionally, references to skin sensitivity across various body parts informed participants about the appropriate placement of haptic actuators. Guiding questions facilitated reflection on emotional zones, intensity, and temporal dynamics, enabling participants to make informed decisions about where and how to apply haptic feedback to evoke desired emotional responses.

The workshop culminated in Tandem Design prototyping sessions, where participants were divided into pairs and alternated between the roles of designer and user. Equipped with Haptic Labs hardware kits and access to specialized software, participants engaged in low-fidelity on-body prototyping, iteratively designing and refining haptic feedback patterns based on real-time user feedback. This hands-on approach emphasized user-centered design principles, encouraging collaborative problem-solving and immediate iteration to enhance the emotional impact of their designs.

4 Results

This section presents the comprehensive findings from the workshop, detailing the participants' demographic background, their engagement with the proposed methodological toolkit in the key activities, and the overall impact of the different phases of the workshop. It includes a detailed exploration of participants' feedback, emotional articulation, and technical experiences with haptic design. These findings directly address the research questions in section 1.4 and provide the groundwork for the subsequent discussion of the effectiveness, challenges, and areas for improvement in the single-modal affective haptic workshop.

4.1 Participant Demographics and Initial Survey Results

In the following findings from the initial surveys in phase 1 (3.2.4), the outcomes of the workshop, and the qualitative feedback provided by the participants is presented.

The initial survey at the end of phase 1 3.2.4 aimed to collect comprehensive demographic data, assess participants' prior experience with haptic design and related methodologies, and understand their expectations and qualitative feedback for the workshop structure. This baseline information was crucial for meaningfully interpreting the qualitative feedback. Knowing the participants' backgrounds made it possible to propose changes to the workshop structure and toolkit usage to the broad range of novice interaction designers and researchers' needs.

Taking the participants backgrounds into consideration gives a detailed correlation between their prior knowledge and feedback on the toolkit's perceived usefulness in teaching the nuances of affective haptic feedback design. This complex interdisciplinary field should be made accessible to novice interaction designers coming from a range of research fields described in paragraph 2.6.

Participant Demographics The workshop included six participants (AP1, AP2, BP1, BP2, CP1, and CP2), organized into three Tandem Design groups:

- **Group A**: AP1 and AP2
- **Group B**: BP1 and BP2
- **Group C**: CP1 and CP2

4.1.1 Age and Educational Background

Participants ranged from 24 to 30 years old, with an average age of 26. All participants held or were pursuing master's degrees in UX Design, HCI, or closely related fields. Their undergraduate backgrounds were diverse, spanning areas such as Cognitive Science, Psychology, Media Systems, and Industrial Product Design, reflecting a range of foundational knowledge intersecting with the fields contributing to affective haptic research mentioned in section 1 and section 2. This interdisciplinary knowledge laid a solid foundation for their engagement with haptic design.

Previous higher education of the workshop participants was as follows:

- AP1: B.A. and S., Cognitive Sciences
- AP2: B.Sc. in Media Systems
- BP1: B.A. in Industrial Product Design
- BP2: B.Sc. in Psychology
- CP1: B.Sc. in User Experience Design
- CP2: B.Sc. in Digital Concept Development

4.1.2 Professional Roles and Skill Levels

Participants occupied a mix of professional roles, including UX/UI designers, researchers, and developers as seen in table 4.1.2. Their skill levels, self-assessed on a 5-point Likert scale, revealed a wide range of familiarity with key skills related to haptic prototyping, on-body prototyping, coding, haptic design, and affective haptic design. BP1, AP1, and CP1 had moderate familiarity (4) with haptic prototyping, while others rated themselves lower, especially in affective haptic design. The self-assessment highlighted areas where participants would benefit most from hands-on learning and collaborative design opportunities.

- **Job Titles:**
  - AP1: Designer

  - AP2: Senior Application Developer
  - BP1: Interaction Designer
  - BP2: Junior Innovation Researcher
  - CP1: Student
  - CP2: UX/UI Designer

- **Fields of Profession:**
  - AP1: Creative Industries
  - AP2: Software Engineering
  - BP1: Product & Interaction Design
  - BP2: Research
  - CP1: User Experience Design
  - CP2: IT/Software Development

When asked about their career aspirations, responses varied widely without correlation to the discussed field of interest (e.g. affective haptic design, HCI, UX) and gave no valuable additional insight usable for the argumentative analysis.

Prior Experience with Designing haptics, the Concept of Embodied Metaphors and Body Maps Since affective haptic design is very interdisciplinary and the methodologies used in this toolkit draw from various theories and practices, knowledge about the prior experience provided more context for the categorization and interpretation of the qualitative feedback given by a certain participant. **Prior experience with Haptic Design:**

- **AP1:** Had prior experience, including designing haptics in a computer mouse for productivity and creativity enhancements.
- **AP2:** Reported no prior experience.
- **BP1:** Worked on creating a haptic designer tool for gaming contexts.
- **BP2:** Limited experience; developed a low-fidelity prototype for breath control on a smartwatch.
- **CP1:** Experience in designing tangible interactive products with haptic components; learned about haptic feedback during master's studies.
- **CP2:** No prior experience.

Prior Experience with Embodied Metaphors

- **AP1:** Familiar through psychology courses; read ”Metaphors We Live By” by Lakoff and Johnson.
- **AP2:** Knew what a metaphor is but not specifically an embodied metaphor.
- **BP1:** No prior experience.
- **BP2:** No practical experience; had read about embodied sketching and the ”somatic turn in HCI.”
- **CP1:** Unfamiliar or had forgotten.
- **CP2:** Heard the term during studies but lacked practical application.

Prior Experience with Body Maps

- **AP1:** Aware from classes but had not used them personally.
- **AP2:** Unfamiliar with the concept.
- **BP1:** Used body maps in wearable design projects and current master's thesis to identify pain points and contextual needs.
- **BP2:** Limited theoretical knowledge; no practical experience.
- **CP1:** Knew what they are but had not worked with them.
- **CP2:** General understanding but no application in specific projects.

Skill Level Assessment Participants detailed their prior experience with haptic design, embodied metaphors, and body maps, as well as their familiarity with specific skills on a 5-point Likert scale (1 = Not familiar, 5 = Very familiar).

Self-Rated Familiarity with Skills

Participants rated their familiarity with key skills relevant to affective haptic design. Table 1 summarizes their responses.

Table 1: Participants' Self-Rated Familiarity with Skills (1 = Not familiar, 5 = Very familiar)

Skill	**AP1**	**AP2**	**BP1**	**BP2**	**CP1**	**CP2**
Haptic Prototyping	4	1	4	2	4	1
On-Body Prototyping	2	1	5	2	2	1
Coding	2	5	2	1	3	2
Haptic Design	4	1	4	2	4	1
Affective Haptic Design	2	1	3	1	2	1

Key Observations: Concluding from this survey there are following details to considert about the participants of this study.

- **Haptic Prototyping:**
  - Participants AP1, BP1, and CP1 rated their familiarity as 4 (moderately familiar).
  - Participants AP2 and CP2 rated themselves as 1 (not familiar).
- **On-Body Prototyping:**
  - BP1 rated a high familiarity of 5.
  - Other participants rated low familiarity, ranging from 1 to 2.
- **Coding Skills:**
  - AP2 rated themselves as very familiar (5).
  - CP1 rated moderate familiarity (3).
  - Others rated low familiarity, between 1 and 2.
- **Haptic Design:**
  - Similar to haptic prototyping, AP1, BP1, and CP1 rated themselves as 4.
  - The rest rated between 1 and 2.
- **Affective Haptic Design:** All participants rated low familiarity, with BP1 being the highest at 3.

Interpretation:

- Participants had varied backgrounds, with some possessing moderate experience in haptic design but limited exposure to affective aspects.
- Coding proficiency varied significantly, indicating the need for tools that do not rely heavily on programming skills.
- The low familiarity with on-body prototyping and affective haptic design highlighted key learning opportunities.

4.1.3 Emotional Objects and Initial Expectations

Emotional Object For the Embodied Metaphor Elicitation As part of the workshop, participants brought emotionally significant objects, which anchored their emotional exploration throughout the design process. For instance, AP1 brought a ring associated with admiration and love, while CP2 brought a stuffed lion evoking calmness, comfort, and protection. These objects provided a personal and emotional starting point for participants to engage with affective haptic design, creating an immediate link between their emotional experiences and the workshop's goals.

Table 2 summarizes their responses of the object and the individual emotion attached to it.

Table 2: Participants' Emotional Objects and Associated Emotions

Participant	Object	Emotion / Adjective
AP1	A ring	Admiration / Loving
AP2	Mario Keychain	Hope / Supportive
BP1	Necklace	Hope / Confident
BP2	Basketball Toy	Childhood warmth / Safe
CP1	Plush Corn Toy	Gratitude / Nostalgia, Happiness, Memory, Fondness
CP2	Stuffed Lion	Calmness / Comfort, Protection

Derived Expectations for the Workshop While the initial survey did not explicitly ask for the participants expectations towards the workshop, insights can be inferred from participants' backgrounds and self-assessments that further inform the context of their qualitative feedback given.

Participants' expectations generally revolved around gaining foundational knowledge of Affective Haptics, exploring new design methodologies, and overcoming potential technical challenges (particularly for those with limited coding experience). The participants' varied skill levels required for affective haptic design and expectations towards the learning process highlighted the need for adaptable, accessible tools throughout the workshop.

- **Learning Objectives:**
  - Participants like AP2 and CP2, with minimal experience in haptic design, likely aimed to gain foundational knowledge.
  - Participants with some experience (e.g., BP1) might have sought to deepen their understanding, particularly in affective haptic design.
- **Anticipated Challenges:**
  - Those with lower coding skills (e.g., BP2) might have been concerned about technical aspects.
  - Participants unfamiliar with embodied metaphors and body maps might have anticipated challenges in applying these methodologies.
- **Collaboration Interests:** The diversity in skills suggested opportunities for peer learning, with participants potentially eager to collaborate and share their diverse expertise.

- The objects varied widely but were universally associated with positive emotions(aligning with the intent described in the related work section 2 by the TU Delft Emotion Typology 9) and personal significance.
- These objects served as focal points for the workshop's activities, grounding abstract emotional concepts in tangible experiences.

4.1.4 Summary of Initial Survey Insights

The initial survey revealed:

- **Varied Experience Levels:**
  - A mix of absolute novices and participants with moderate experience in haptic design.
  - Overall low familiarity with affective haptic design and related methodologies like Circumplex Model of Affect, embodied metaphors and body maps.
- **Diverse Skill Sets:**
  - A range of coding proficiencies, emphasizing the need for accessible tools.
  - Participants' backgrounds spanned design, engineering, psychology, and UX, offering a rich collaborative potential.
- **Emphasis on Emotional Connection:** Personal objects and associated emotions provided a meaningful starting point for the workshop, aligning with the focus on teaching single-modal affective haptic design.

4.1.5 Interpretation of Initial Survey Findings: Pros and Cons of the Participant Constellation

The initial survey revealed a diverse yet specialized group of six participants, each bringing unique backgrounds and varying levels of experience to the workshop. Pros of this constellation include a strong foundational knowledge in HCI and related disciplines, as evidenced by all participants holding or pursuing master's degrees in fields such as HCI, Multimedia Technology, Industrial Product Design, Psychology, UX Design, and Digital Concept Development. As the RQ1 1.4 This academic diversity fosters a rich interdisciplinary environment, encouraging the exchange of varied perspectives and fostering innovative approaches to affective haptic design. Additionally, the presence of participants with moderate experience in haptic prototyping and design (e.g., AP1, BP1, CP1) provides a balanced mix of novices and those with some practical exposure, facilitating peer learning and mentorship within Tandem Design groups. The varied professional roles, ranging from Industrial Designers and Interaction Designers to Senior Application Developers and UX/UI Designers, further enhance the collaborative potential, allowing participants to leverage their specific expertise to support each other's learning processes.

However, there are notable cons associated with this participant constellation. The small sample size of six limits the generalizability of the findings, as it may not capture the full spectrum of novice interaction designers' experiences and challenges. Moreover, the group exhibits significant variability in familiarity with key skills pertinent to the workshop, such as embodied metaphors, body maps, and affective haptic design, with most participants rating their familiarity as low to moderate. This disparity necessitates a highly adaptable workshop structure to cater to both relatively experienced individuals and complete beginners, potentially diluting the focus for those with existing knowledge. Additionally, the limited prior experience in affective haptic design and on-body prototyping among the majority highlights a steep learning curve, which could lead to uneven engagement and varying levels of success in applying the methodologies introduced. Technical proficiency also varied, particularly in coding skills, where only one participant (AP2) reported high proficiency, while others rated themselves significantly lower. This uneven distribution of technical skills underscores the importance of providing comprehensive, beginner-friendly tools and extensive support to ensure all participants can effectively engage with the prototyping toolkit. Furthermore, the homogeneity in educational backgrounds, predominantly rooted in HCI and design, may inadvertently narrow the range of emotional interpretations and design approaches, potentially overlooking insights from other relevant fields such as cognitive psychology or cultural studies. Lastly, the emotional objects brought by participants, while personally significant, were uniformly positive, which may limit the exploration of a broader emotional spectrum in haptic design applications.

In summary, the participant constellation presents a balanced mix of academic and professional backgrounds that enrich the collaborative environment and foster interdisciplinary learning. However, the small and somewhat homogeneous sample size, coupled with significant variability in prior experience and technical skills, introduces challenges in ensuring equitable engagement and comprehensive skill development. Addressing these cons through tailored instructional support, diversified participant recruitment, and enhanced toolkit features will be essential in future iterations to maximize the effectiveness and inclusivity of the workshop.

4.2 Key Activities

In order to understand the feedback given by the participants, the workshop activities and their contributed work have to be mentioned and explained. In the following paragraphs the emotional connection and usage of methodologies of each participant is explained in detail.

Remarks The iterative nature of the prototyping sessions was designed to allow for smooth transitions between phases, encouraging participants to refine their designs based on real-time feedback. However, in practice, these transitions were not always as fluid as anticipated. Technical issues, such as limited haptic actuators and challenges in understanding the functionality of the hardware, frequently interrupted the flow of the workshop. For instance, BP2 and AP1 both expressed frustration with the limitations of the provided tools, noting that the lack of diversity in haptic actuators constrained their creative output. Moreover, participants struggled with the practical application of the haptic toolkit, particularly in translating abstract emotional concepts into effective haptic feedback. While some, like BP1, found success in prototyping simple, repetitive patterns, others, like CP2, faced obstacles in generating more complex emotional representations. This disparity in outcomes indicates that the current iteration of the toolkit may require further refinement, particularly in terms of offering more technical guidance and time or pre-workshop preparation for the participants and expanding the range of haptic tools available. These findings suggest that while the iterative design approach holds promise, it must be supported by more robust technical frameworks and clearer instructional support to ensure a more seamless and productive workflow.

4.2.1 Emotion Mapping

AP1 Emotional Mapping of the Ring

In addition to describing the emotional significance of the ring (Figure 13, AP1's baseline body map (Figure 25) illustrates key physical areas, such as the chest and hands, where AP1 experiences warmth and grounding sensations. The embodied metaphor elicitation sheet (Figure 31) further expands on how these sensations could be translated into haptic feedback patterns, particularly through calming vibrations and minor rotations mimicking serenity.

AP2 Emotional Mapping of the Keychain AP2's body map (Figure 26) highlights the neck as a key area where warmth can be felt, reflecting her emotional connection to the keychain (Figure 14). The metaphor elicitation sheet (Figure 32) further explores potential haptic feedback, such as firm, familiar textures and comforting vibrations in the neck, which can evoke hope and gratitude.

BP1 Emotional Mapping of the Necklace BP1 mapped his emotional connection to the necklace (Figure 15), highlighting the chest and lower back areas (Figure 27) as key emotional zones. The metaphor elicitation sheet (Figure 33) explores how pulsing vibrations in these areas could evoke a sense of safety and confidence, reinforcing emotional grounding.

BP2 Emotional Mapping of the Basketball Flummi BP2's body map (Figure 28) shows how his emotional connection to the basketball toy (Figure 16) is centered on the hands and shoulders, where they associate rhythmic motions with nostalgia. The metaphor elicitation sheet (Figure 34) further details how rhythmic vibrations simulating dribbling could be translated into comforting haptic feedback for stress relief.

CP1 Emotional Mapping of the Corn-Shaped Plushie CP1's body map (Figure 29) illustrates how comfort and nostalgia associated with the plushie (Figure 17) are felt primarily in the arms and torso. The metaphor elicitation sheet (Figure 35) proposes that haptic feedback simulating the sensation of being held or hugged could replicate these comforting emotions.

CP2 Emotional Mapping of the Stuffed Lion CP2's body map (Figure 30) highlights the chest and arms as key areas where the stuffed lion (Figure 18) evokes feelings of calm and protection. The metaphor elicitation sheet (Figure 36) explores how rhythmic, wavy haptic feedback in the arms and warmth in the chest could replicate the feeling of being hugged or held, alleviating anxiety.

4.2.2 Baseline Body Mapping

Participants highlighted the value of body maps in visualizing where emotional experiences are felt in the body, which guided the placement of haptic actuators. For instance, CP1 noted,

> "I found the body map particularly useful in figuring out where I associate specific emotions. It gave me a clearer direction on where to start applying the haptic feedback designs."

Figure 13: AP1's emotional object: A ring gifted by her mother when they were 13-14 years old. AP1 mentioned that the ring symbolizes admiration for her mother and provides them with a sense of serenity and completeness. It represents a token of her mother's love, always close to them, offering support and comfort.

Figure 14: AP2's emotional object: A Mario extra life keychain gifted by an old roommate. AP2 explained that the keychain serves as a metaphor for hope and safety, symbolizing the idea of having an "extra life" to hold onto in difficult times. AP2 compared it to a stress ball, but more as a fidget toy instead of using it for particularly stressful situations.

. The correlated body map to this example and an explaination of the body map can be found in Figure 29.

The body maps allowed participants to ground their emotional objects in physical sensations. As seen in Figure X, BP1 mapped their emotional connection to a necklace around the neck and upper chest area, which they later used as guidance during on-body prototyping. CP2 noted,

> "This exercise helped me visualize where I feel certain emotions, especially when interacting with the plush toy."

The feedback gathered during the workshop highlighted varying experiences with the body maps. Participant AP1 noted,

> "I liked that [the body maps] gave me an initial idea of where I can place the actuators. However, placing actuators on the chest created a weird, eerie feeling".

Similarly, Participant BP1 appreciated the maps for visualizing how haptic feedback could be designed across different parts of the body, remarking that

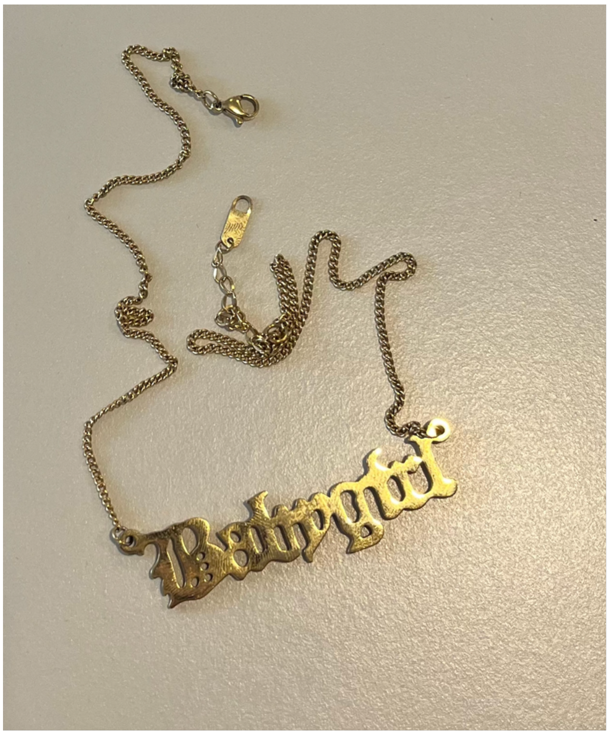


Figure 15: BP1’s emotional object: A necklace gifted by a friend during a meaningful summer. The necklace symbolizes hope and safety, serving as a reminder of the close friendships and family relationships formed during that time, providing confidence and comfort. When BP1 is stressed, this necklace alters his perspective and reminds him times are temporary and so are his stressful times.

> ”using body maps enabled me to also see my options, and having the same pattern on the chest and back creates different experiences.”

This feedback illustrates the value of body maps as a design tool but also reveals limitations, such as difficulties in translating abstract emotional experiences into physical stimuli.

4.2.3 Embodied Metaphor Elicitation

The embodied metaphor elicitation section of the workshop was designed to help participants translate abstract emotional experiences into tangible haptic feedback. Each participant shared a personal object associated with a particular emotion and then mapped that emotion onto their body through the process of embodied metaphor elicitation.

In general, participants provided detailed descriptions of their emotional connection to the object, the physical characteristics of the object, and how these qualities might be translated into haptic feedback. The discussions facilitated between participants and their partners were recorded, and these provided further insights into how their initial design ideas evolved through the elicitation exercise.

Figure 16: BP2's emotional object: A small basketball Flummi toy, which evokes nostalgic memories of his father and childhood. BP2 associated the object with a sense of safety and comfort, recalling the warmth of familial experiences.

Participants leveraged their emotional connections to the objects to inform their haptic feedback designs, aiming to map their bodily sensations and emotional states directly onto the proposed affective haptic feedback patterns. This process helped them understand how (embodied) metaphor and emotion can be translated into affective haptic feedback.

However, some participants found that complex or abstract emotions posed challenges in translation. As AP2 reflected,

> "I feel like this method can work well if you have a metaphor that can be translated easily into haptics, but I also feel like there is a limit to how well this can be transferred. The more complex the initial embodied metaphor, the harder it is to translate, I assume."

This suggests that while embodied metaphors can be powerful tools, their effectiveness is contingent upon their simplicity and the ease with which they can be mapped onto affective haptic modalities.

The detailed insights provided in these metaphor elicitation sheets served as a strong foundation for the next phase of prototyping.

Figure 17: CP1's emotional object: A large corn-shaped plushie bought during an exchange semester in Korea. The plushie is a symbol of nostalgia and gratitude, reminding CP1 of happy memories and experiences with loved ones.

4.2.4 Prototyping Documentations

AP1 Prototyping Body Maps

In this section, the first two iterations of prototyping conducted by AP1 are documented, which used haptic actuators to explore emotional resonance with different body placements. Two body maps were created to reflect changes in actuator placement and the participant's sensory feedback during the prototyping process.

The first iteration (Figure 37) focused on multiple placements, including the neck, chest, and finger, but revealed discomfort in some areas. The most favorable placement was on the finger where the haptic ring is usually worn. The actuator placement on the nose and ear was less successful, as the feedback was either audible or created unpleasant sensations, particularly on the stomach area.

The second iteration (Figure 38) refined the design, focusing on more successful placements like the chest and wrist. This iteration adjusted the haptic feedback pattern to improve the user's sensory experience, noting that the new configuration on the wrist and chest provided a pleasant sensation for AP1.

Additionally, Figure 39 shows the physical prototype of the haptic ring being tested during the

Figure 18: CP2's emotional object: A stuffed lion that has been with the participant since childhood. CP2 associated the stuffed lion with feelings of calmness, comfort, and protection, especially during moments of travel or solitude.

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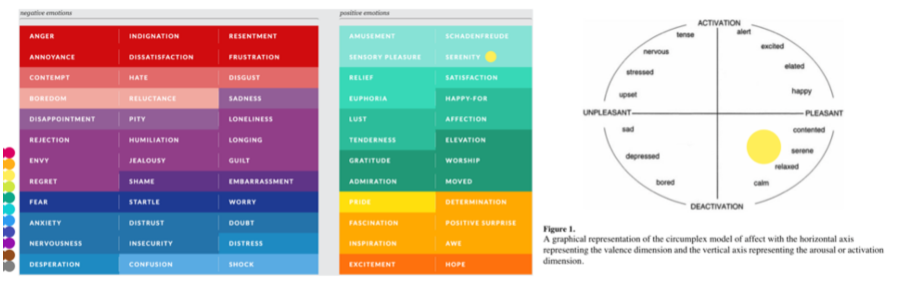


Figure 19: AP1's emotional body map and her use of the Emotion Typology and Circumplex Model of Affect. AP1 selected emotions like serenity, satisfaction, and admiration, associated with the ring given by her mother. The neck and chest were marked as key areas where AP1 feels the strongest emotional connection, symbolizing the calmness and completeness provided by her attachment to the object. These areas were used as a reference for actuator placement during on-body prototyping.

first iteration. Figure 40 demonstrates a preferred actuator placement on the neck of AP2, as tested by AP1 during the group prototyping session. These images correspond with the body maps and highlight the hands-on process of testing and refining actuator placements.

AP2 Prototyping Body Maps In this section, the two iterations of prototyping conducted by AP2 are documented, who explored emotional resonance through actuator placements and different haptic patterns. The first body map (Figure 41) was created before prototyping and illustrates potential areas for actuator placement, including the back of the neck and the hand. AP2 described that the actuator on the neck should provide a secure feeling without causing

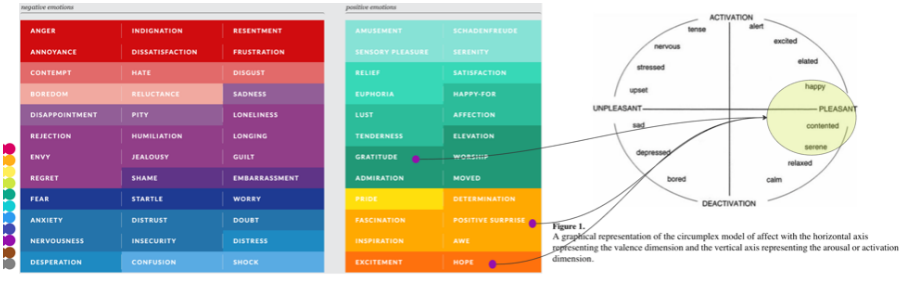


Figure 20: AP2's emotional body map and his use of the Emotion Typology and Circumplex Model of Affect. AP2 selected emotions such as happiness, contentment, and gratitude, associated with his Mario keychain. The hands and arms were highlighted as key emotional areas, where AP2 felt a sense of protection and hope tied to the keychain. These regions were used to guide actuator placement during the on-body haptic prototyping.

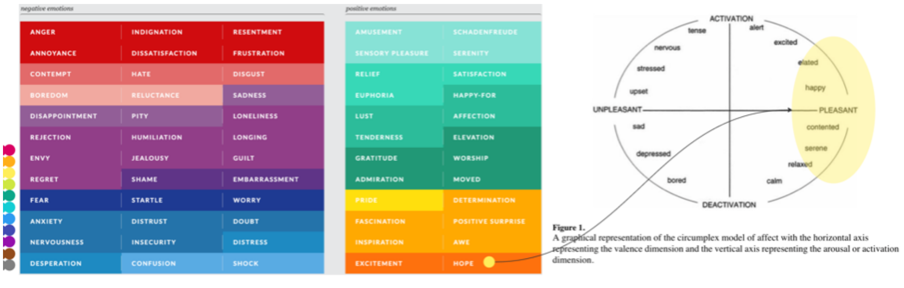


Figure 21: BP1's emotional body map and his use of the Emotion Typology and Circumplex Model of Affect. BP1 selected emotions such as happiness, satisfaction, and hope, all associated with the necklace they received from a close friend. The chest and lower back were identified as key emotional zones, representing areas where BP1 experiences the warmth and safety associated with the object. These regions were used as a basis for actuator placement during the on-body haptic prototyping.

discomfort from tickling. The prototype was envisioned as having a mushroom shape to create this sensation.

The second body map (Figure 42) shows the actuator placements after testing, which focused on the wrist, forearm, and neck. AP2 noted that a cat-like purring sensation was pleasant on the neck, as long as the intensity was kept low to avoid vibrating the skull. Multiple locations, including the forearm, responded well to this pattern. The annotations reflect AP2's feedback on the tested haptic feedback patterns, specifically highlighting how the rising and falling intensities produced calming sensations.

Figures 43 and 44 depict AP2's hands-on prototyping process. In Figure 43, AP2 can be seen placing the actuator on the forearm, one of the favorable areas from the second body map. Figure 44 shows AP1 testing the actuator on the back of AP2's neck, aligning with the initial intention to create a secure sensation without tickling.

BP1 Prototyping Body Maps

Figure 22: BP2's emotional body map and his use of the Emotion Typology and Circumplex Model of Affect. BP2 selected emotions such as excitement, happiness, and serenity, associated with the basketball Flummi toy from his childhood. The hands and shoulders were identified as key emotional zones, reflecting the connection BP2 has with the physical sensations of playing with the toy and the comfort it brings. These regions informed the placement of haptic actuators during on-body prototyping.

Figure 23: CP1's emotional body map and her use of the Emotion Typology and Circumplex Model of Affect. CP1 selected emotions such as happiness and contentment, associated with the corn-shaped plushie. The arms and torso were identified as key emotional areas, reflecting where CP1 experiences the sense of comfort and nostalgia tied to the object. These areas were used to guide the placement of actuators during on-body haptic prototyping.

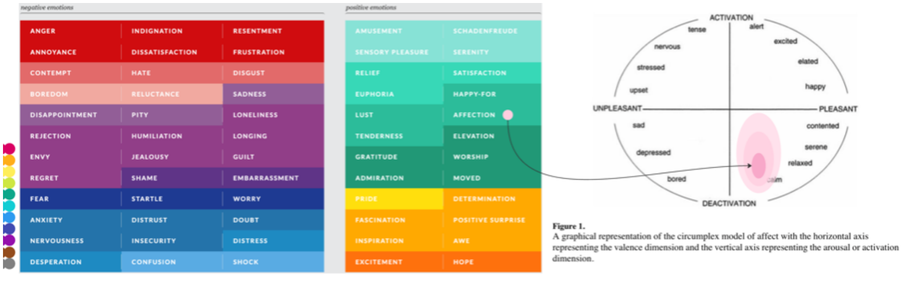


Figure 24: CP2's emotional body map and her use of the Emotion Typology and Circumplex Model of Affect. CP2 selected emotions such as calmness and affection, associated with the stuffed lion from her childhood. The chest and hands were identified as key emotional areas, where CP2 feels a sense of calm and protection when interacting with the object. These areas guided the placement of actuators during the on-body haptic prototyping.

BP1's pre-prototyping body map illustrates how the participant envisioned the placement of the actuators. The conceptual design was focused on creating feedback along the spine and shoulders, with a secondary focus on the upper arms. The intensity of the feedback was likely intended to reflect a sense of comfort and security, with specific areas marked for stronger versus lighter sensations.

The second body map demonstrates how the group implemented their vision of "confidence" using two actuators. The CRA actuator was used on the lower back, and the Voice Coil actuator on the mid-back. Together, these produced a pulsating sensation moving upwards, designed to evoke a comforting, confidence-boosting feeling. The team paid particular attention to the intensification of vibrations to ensure the sensation would be noticeable and consistent with their intended emotional effect.

In the final image, one can see the prototyping in action. BP1 and BP2 are engaged in the tandem on-body testing of the actuators, checking the sensation as it moves upwards along the spine. The placement mirrors the areas highlighted in the pre-prototyping sketches and body maps, ensuring consistency between the initial design and the physical sensation produced during testing.

BP2 Prototyping Body Maps

BP2 began by translating emotional and physical sensations into a haptic feedback representation. As depicted in Figure 48, BP2 associated the hands with the sensation of a toy (a small basketball-like object), which triggered activation input representing the rubbery, warm, and squishy feel. Additionally, BP2 hypothesized a calming reoccurring pattern that could be applied to the temples for a sense of relaxation.

In the second body map (Figure 49), BP2 explored memories of childhood play with a focus on "flow" in a playful mindset. The body map highlights physical sensations of sweating and running, particularly in the neck, chest, and armpit regions. The upper legs are marked as areas of physical activation during play, transitioning into relaxation after the activity. The sensation of holding the toy is emphasized, with distinct feelings of rubber, warmth, and squishiness connected to the hands.

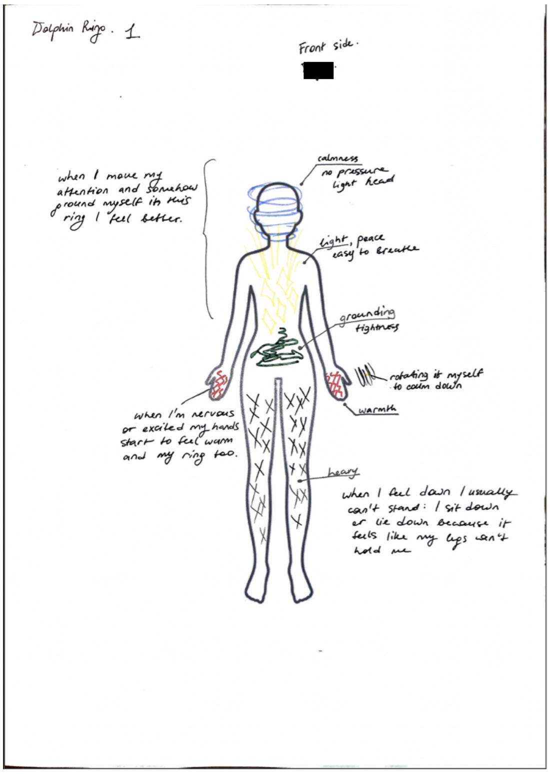


Figure 25: AP1's baseline body map representing the emotional connection to her ring. AP1 reported feeling a sense of calmness in the head, lightness in the chest, grounding tightness in the abdomen, warmth in the hands, and heaviness in the legs when emotionally connected to the ring. The key notes from the Figure highlight how the embodied experience changes during moments of stress or calm. For example, the participant feels tightness in the abdomen when grounding themselves, and warmth in the hands when nervous or excited.

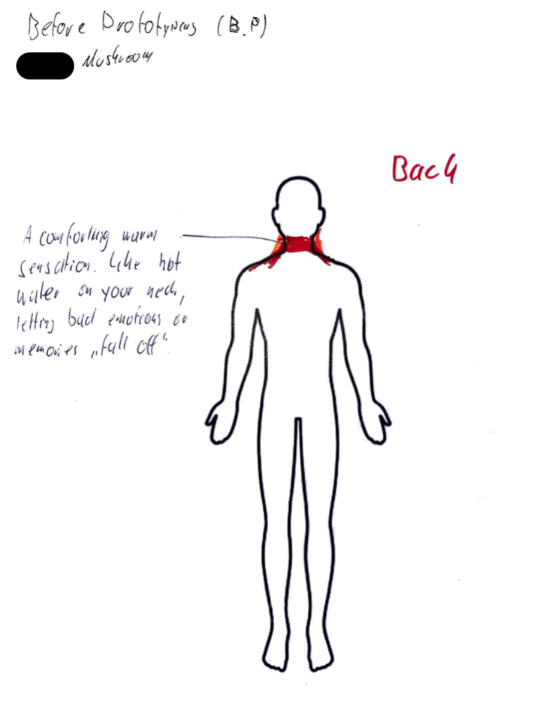


Figure 26: AP2's baseline body map representing his emotional connection to the mushroom object. AP2 described a comforting warm sensation around the neck, comparing it to hot water, which helped release bad emotions or memories. This emotional connection highlights the role of haptics in providing comfort, with the warmth radiating around the neck being particularly soothing for AP2.

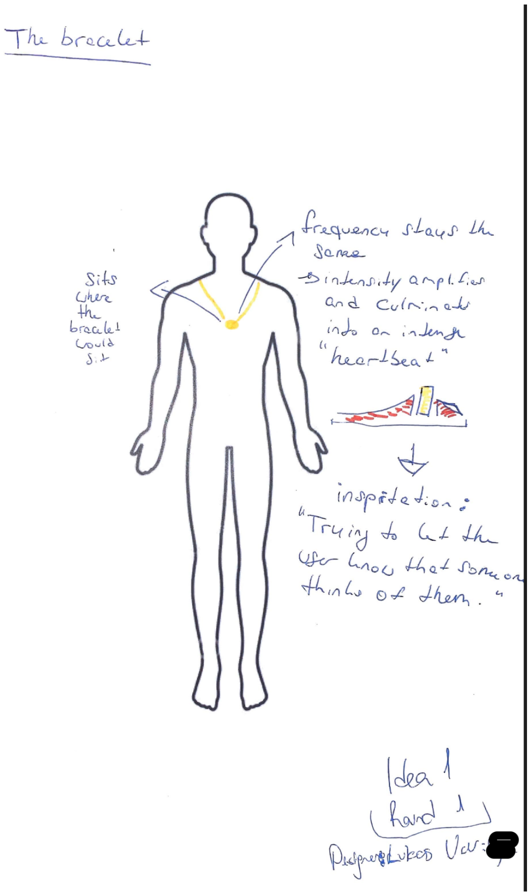


Figure 27: BP1's baseline body map represents his emotional connection to the bracelet. BP1 described a vibration pattern that mimics a heartbeat, where the intensity amplifies and culminates into a strong pulse, symbolizing that someone is thinking of the wearer. The body map reflects how the bracelet's emotional connection resonates in the chest, and it demonstrates how frequency and intensity can be manipulated to create a haptic experience that elicits feelings of emotional connection and care.

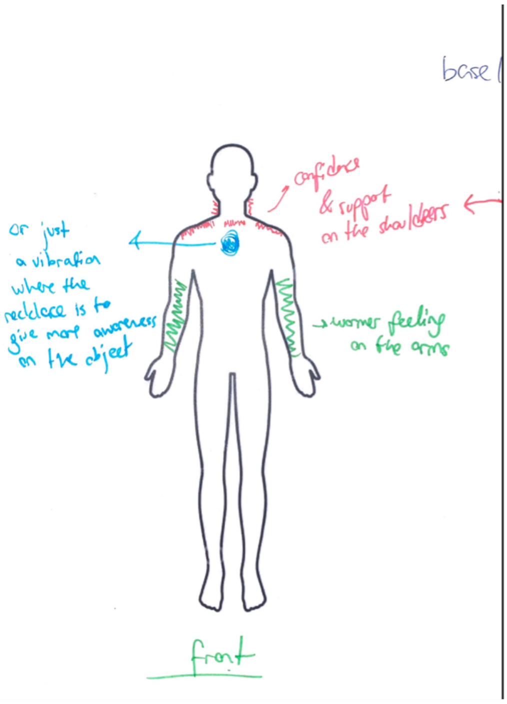


Figure 28: BP2's baseline body map reflects the emotional connection to his object, which elicits confidence and support, particularly in the shoulder area. They described how the vibration of the necklace could heighten awareness of the object, creating a supportive sensation on the shoulders. Additionally, BP2 noted a warm feeling extending along the arms, suggesting that haptic feedback in these areas would reinforce feelings of safety and emotional warmth.

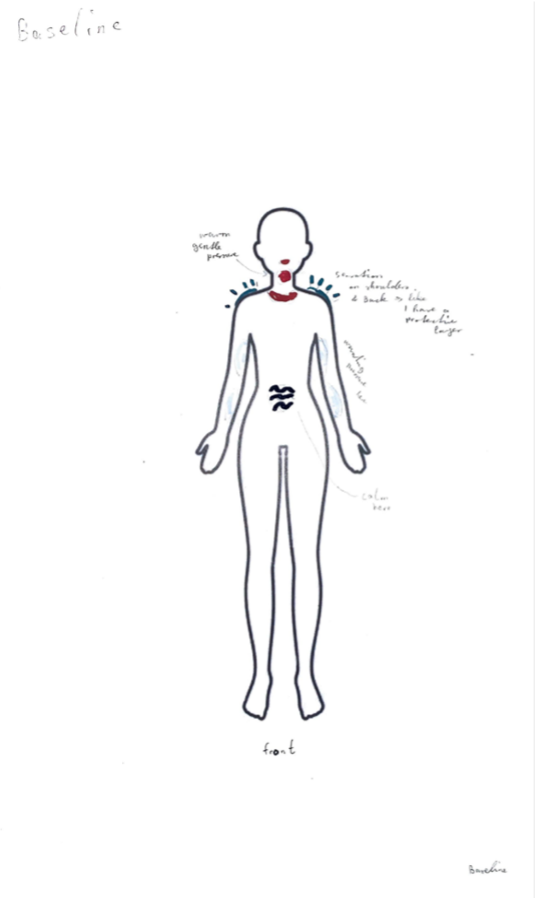


Figure 29: CP1's baseline body map reflects the emotional connection to her plushie. CP1 described a warm, gentle pressure on the shoulders and back, which evoked feelings of calmness and protection. Additionally, CP1 noted sensations in the abdomen that provided a sense of grounding and relaxation. This body map illustrates how specific areas of the body respond to haptic feedback, emphasizing emotional warmth and security.

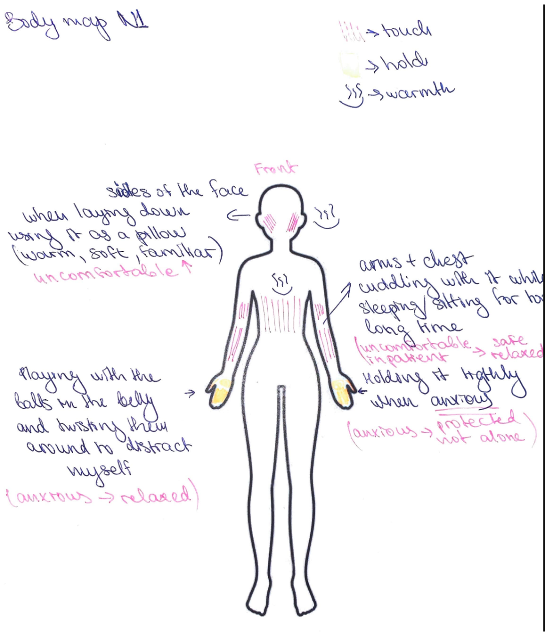
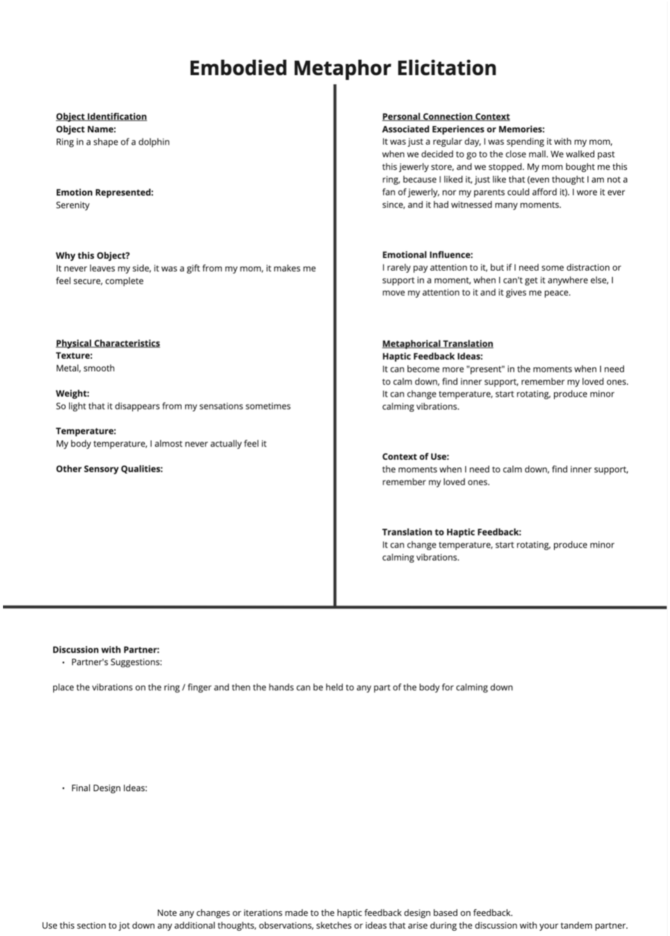


Figure 30: CP2's baseline body map reflects her emotional connection to her stuffed lion. CP2 noted that holding the object against the arms and chest created a safe, warm feeling, particularly when sitting or lying down. The act of cuddling the object helped alleviate feelings of anxiety, providing comfort, protection, relaxation and a feeling of not being alone. Additionally, CP2 described how interacting with the object by playing with the pearls in the belly helped them relax when feeling anxious. The body map captures the warmth, touch, and holding sensations, which contribute to her emotional relief and security.



Embodied Metaphor Elicitation

Object Identification
Object Name:
Ring in a shape of a dolphin

Emotion Represented:
Serenity

Why this Object?
It never leaves my side, it was a gift from my mom, it makes me feel secure, complete

Physical Characteristics
Texture:
Metal, smooth

Weight:
So light that it disappears from my sensations sometimes

Temperature:
My body temperature, I almost never actually feel it

Other Sensory Qualities:

Personal Connection Context
Associated Experiences or Memories:
It was just a regular day, I was spending it with my mom, when we decided to go to the close mall. We walked past this jewerly store, and we stopped. My mom bought me this ring, because I liked it, just like that (even thought I am not a fan of jewerly, nor my parents could afford it). I wore it ever since, and it had witnessed many moments.

Emotional Influence:
I rarely pay attention to it, but if I need some distraction or support in a moment, when I can't get it anywhere else, I move my attention to it and it gives me peace.

Metaphorical Translation
Haptic Feedback Ideas:
It can become more "present" in the moments when I need to calm down, find inner support, remember my loved ones. It can change temperature, start rotating, produce minor calming vibrations.

Context of Use:
the moments when I need to calm down, find inner support, remember my loved ones.

Translation to Haptic Feedback:
It can change temperature, start rotating, produce minor calming vibrations.

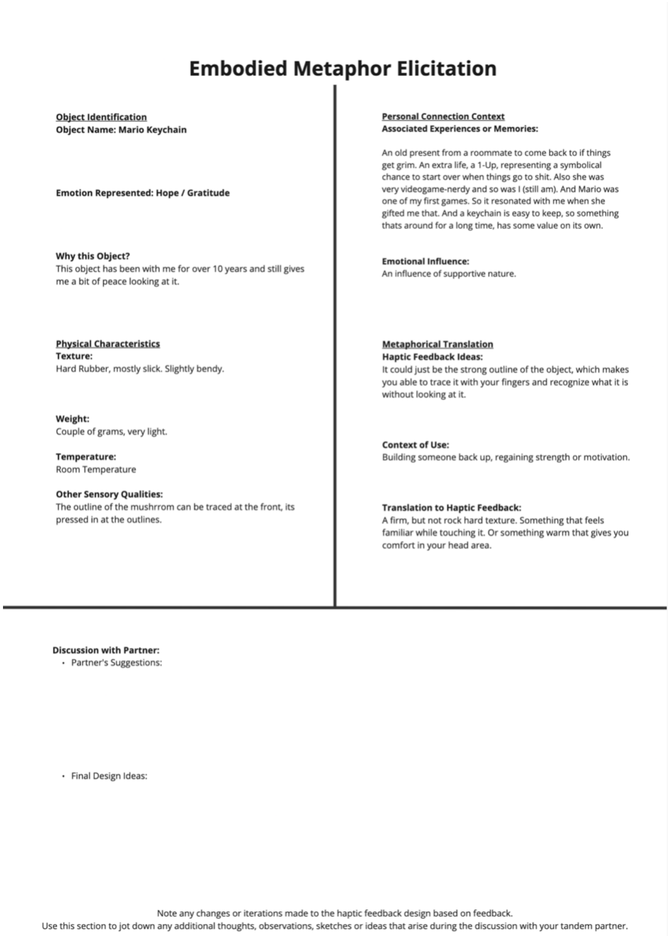
Discussion with Partner:
- Partner's Suggestions:

place the vibrations on the ring / finger and then the hands can be held to any part of the body for calming down

- Final Design Ideas:

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 31: AP1's embodied metaphor elicitation sheet detailing the emotional connection to her ring, which represents serenity. The metaphor elicitation describes the personal context, emotional influence, and how haptic feedback, such as calming vibrations or temperature changes, could mimic the ring's comforting presence in moments of need.


Embodied Metaphor Elicitation

Object Identification
Object Name: Mario Keychain

Emotion Represented: Hope / Gratitude

Why this Object?
This object has been with me for over 10 years and still gives me a bit of peace looking at it.

Physical Characteristics
Texture:
Hard Rubber, mostly slick. Slightly bendy.

Weight:
Couple of grams, very light.

Temperature:
Room Temperature

Other Sensory Qualities:
The outline of the mushrrom can be traced at the front, its pressed in at the outlines.

Personal Connection Context
Associated Experiences or Memories:
An old present from a roommate to come back to if things get grim. An extra life, a 1-Up, representing a symbolical chance to start over when things go to shit. Also she was very videogame-nerdy and so was I (still am). And Mario was one of my first games. So it resonated with me when she gifted me that. And a keychain is easy to keep, so something thats around for a long time, has some value on its own.

Emotional Influence:
An influence of supportive nature.

Metaphorical Translation
Haptic Feedback Ideas:
It could just be the strong outline of the object, which makes you able to trace it with your fingers and recognize what it is without looking at it.

Context of Use:
Building someone back up, regaining strength or motivation.

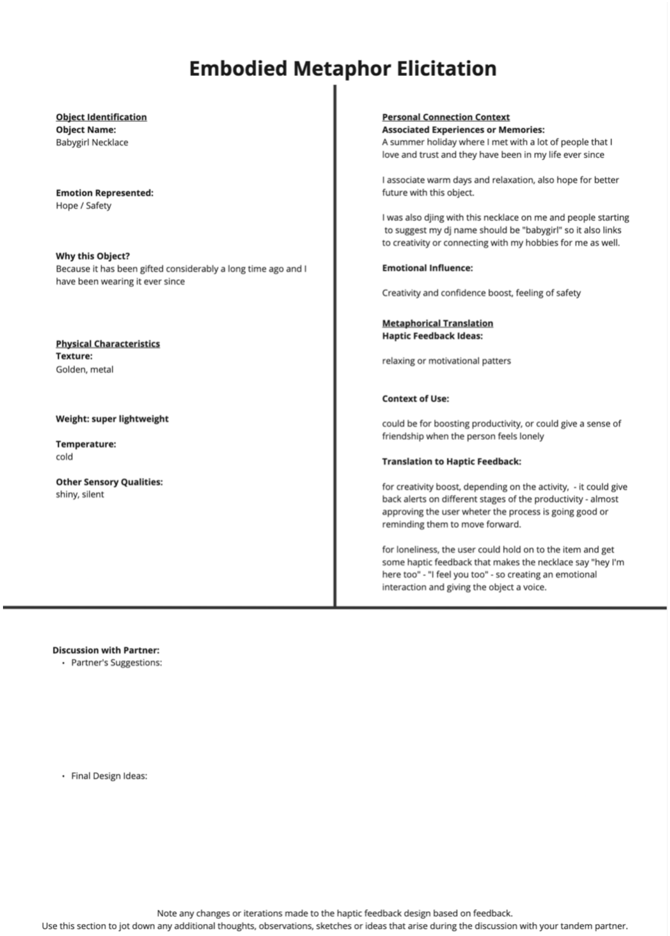
Translation to Haptic Feedback:
A firm, but not rock hard texture. Something that feels familiar while touching it. Or something warm that gives you comfort in your head area.

Discussion with Partner:
- Partner's Suggestions:

- Final Design Ideas:

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 32: AP2's embodied metaphor elicitation sheet for his Mario keychain, representing hope and gratitude. The metaphor elicitation describes the personal connection and symbolic significance of the object, such as the "1-Up" as a metaphor for restarting or regaining strength. The tactile feedback ideas focus on the firm, familiar texture and how the keychain could convey a comforting presence, especially around the head area.



Embodied Metaphor Elicitation

Object Identification
Object Name:
Babygirl Necklace

Emotion Represented:
Hope / Safety

Why this Object?
Because it has been gifted considerably a long time ago and I have been wearing it ever since

Physical Characteristics
Texture:
Golden, metal

Weight: super lightweight

Temperature:
cold

Other Sensory Qualities:
shiny, silent

Personal Connection Context
Associated Experiences or Memories:
A summer holiday where I met with a lot of people that I love and trust and they have been in my life ever since

I associate warm days and relaxation, also hope for better future with this object.

I was also djing with this necklace on me and people starting to suggest my dj name should be "babygirl" so it also links to creativity or connecting with my hobbies for me as well.

Emotional Influence:

Creativity and confidence boost, feeling of safety

Metaphorical Translation
Haptic Feedback Ideas:

relaxing or motivational patters

Context of Use:

could be for boosting productivity, or could give a sense of friendship when the person feels lonely

Translation to Haptic Feedback:

for creativity boost, depending on the activity, - it could give back alerts on different stages of the productivity - almost approving the user wheter the process is going good or reminding them to move forward.

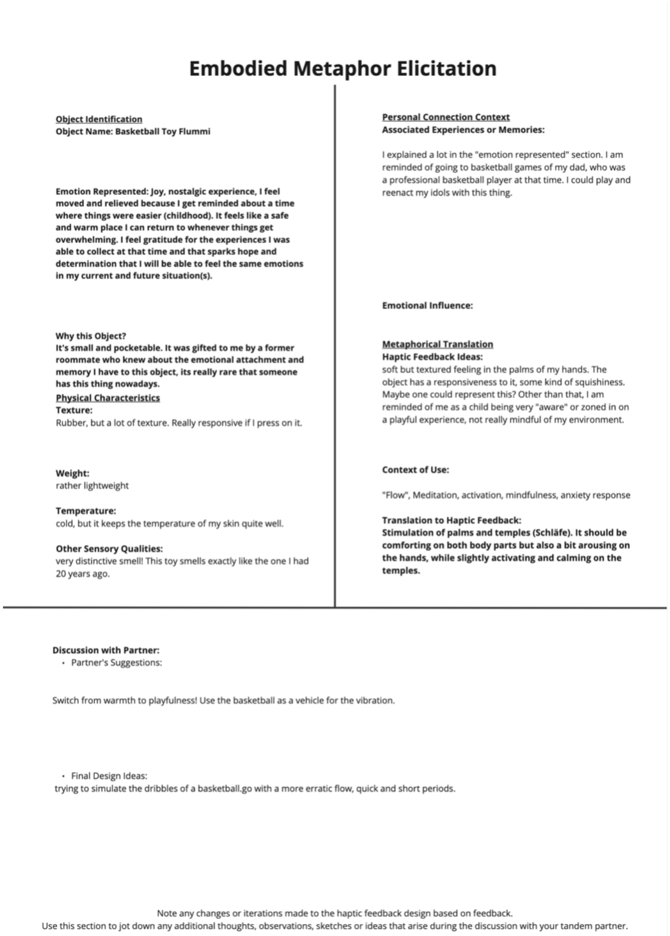
for loneliness, the user could hold on to the item and get some haptic feedback that makes the necklace say "hey I'm here too" - "I feel you too" - so creating an emotional interaction and giving the object a voice.

Discussion with Partner:
- Partner's Suggestions:

- Final Design Ideas:

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 33: BP1's embodied metaphor elicitation sheet for his "Babygirl" necklace, representing hope and safety. The metaphor elicitation outlines BP1's connection to the necklace, which evokes feelings of creativity, confidence, and safety. The haptic feedback ideas explore how the object could provide motivating patterns for boosting productivity or comforting patterns to alleviate loneliness, creating an emotional connection with the user.



Embodied Metaphor Elicitation

Object Identification
Object Name: Basketball Toy Flummi

Emotion Represented: Joy, nostalgic experience, I feel moved and relieved because I get reminded about a time where things were easier (childhood). It feels like a safe and warm place I can return to whenever things get overwhelming. I feel gratitude for the experiences I was able to collect at that time and that sparks hope and determination that I will be able to feel the same emotions in my current and future situation(s).

Why this Object?
It's small and pocketable. It was gifted to me by a former roommate who knew about the emotional attachment and memory I have to this object, its really rare that someone has this thing nowadays.

Physical Characteristics
Texture:
Rubber, but a lot of texture. Really responsive if I press on it.

Weight:
rather lightweight

Temperature:
cold, but it keeps the temperature of my skin quite well.

Other Sensory Qualities:
very distinctive smell! This toy smells exactly like the one I had 20 years ago.

Personal Connection Context
Associated Experiences or Memories:

I explained a lot in the "emotion represented" section. I am reminded of going to basketball games of my dad, who was a professional basketball player at that time. I could play and reenact my idols with this thing.

Emotional Influence:

Metaphorical Translation
Haptic Feedback Ideas:
soft but textured feeling in the palms of my hands. The object has a responsiveness to it, some kind of squishiness. Maybe one could represent this? Other than that, I am reminded of me as a child being very "aware" or zoned in on a playful experience, not really mindful of my environment.

Context of Use:

"Flow", Meditation, activation, mindfulness, anxiety response

Translation to Haptic Feedback:
Stimulation of palms and temples (Schläfe). It should be comforting on both body parts but also a bit arousing on the hands, while slightly activating and calming on the temples.

Discussion with Partner:
- Partner's Suggestions:

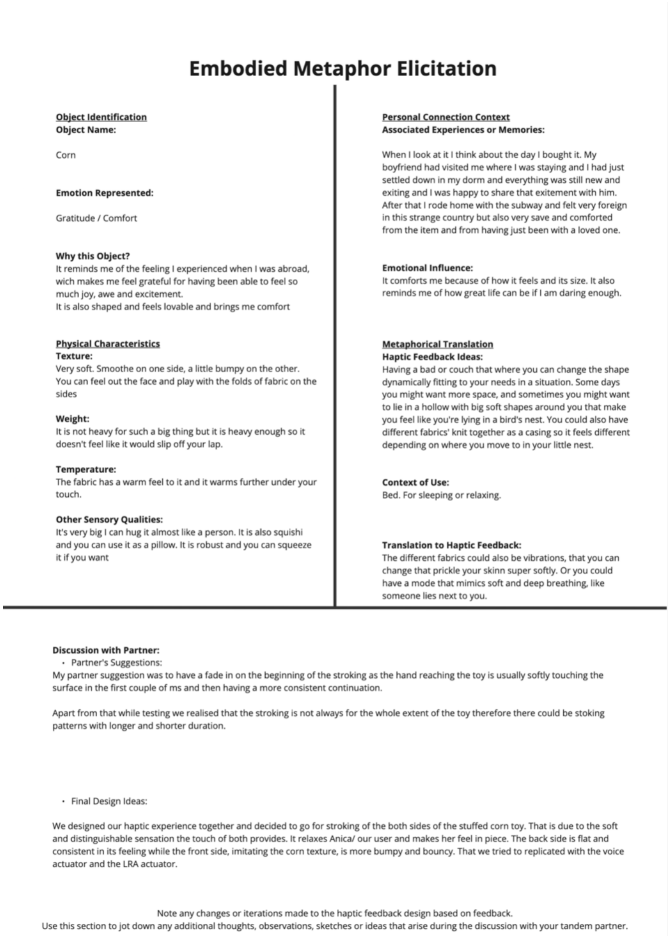
Switch from warmth to playfulness! Use the basketball as a vehicle for the vibration.

- Final Design Ideas:

trying to simulate the dribbles of a basketball.go with a more erratic flow, quick and short periods.

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 34: BP2's embodied metaphor elicitation sheet for his basketball toy flummi, representing joy and nostalgia. The metaphor elicitation outlines BP2's emotional attachment to the object, recalling childhood memories and a sense of safety. The haptic feedback ideas explore how soft, textured feedback could simulate playful sensations, such as dribbling a basketball, with stimulating feedback on the palms and temples to evoke both arousal and calmness.



Embodied Metaphor Elicitation

Object Identification
Object Name:

Corn

Emotion Represented:

Gratitude / Comfort

Why this Object?
It reminds me of the feeling I experienced when I was abroad, wich makes me feel grateful for having been able to feel so much joy, awe and excitement.
It is also shaped and feels lovable and brings me comfort

Physical Characteristics
Texture:
Very soft. Smoothe on one side, a little bumpy on the other. You can feel out the face and play with the folds of fabric on the sides

Weight:
It is not heavy for such a big thing but it is heavy enough so it doesn't feel like it would slip off your lap.

Temperature:
The fabric has a warm feel to it and it warms further under your touch.

Other Sensory Qualities:
It's very big I can hug it almost like a person. It is also squishi and you can use it as a pillow. It is robust and you can squeeze it if you want

Personal Connection Context
Associated Experiences or Memories:

When I look at it I think about the day I bought it. My boyfriend had visited me where I was staying and I had just settled down in my dorm and everything was still new and exiting and I was happy to share that exitement with him. After that I rode home with the subway and felt very foreign in this strange country but also very save and comforted from the item and from having just been with a loved one.

Emotional Influence:
It comforts me because of how it feels and its size. It also reminds me of how great life can be if I am daring enough.

Metaphorical Translation
Haptic Feedback Ideas:
Having a bad or couch that where you can change the shape dynamically fitting to your needs in a situation. Some days you might want more space, and sometimes you might want to lie in a hollow with big soft shapes around you that make you feel like you're lying in a bird's nest. You could also have different fabrics' knit together as a casing so it feels different depending on where you move to in your little nest.

Context of Use:
Bed. For sleeping or relaxing.

Translation to Haptic Feedback:
The different fabrics could also be vibrations, that you can change that prickle your skinn super softly. Or you could have a mode that mimics soft and deep breathing, like someone lies next to you.

Discussion with Partner:
- Partner's Suggestions:

My partner suggestion was to have a fade in on the beginning of the stroking as the hand reaching the toy is usually softly touching the surface in the first couple of ms and then having a more consistent continuation.

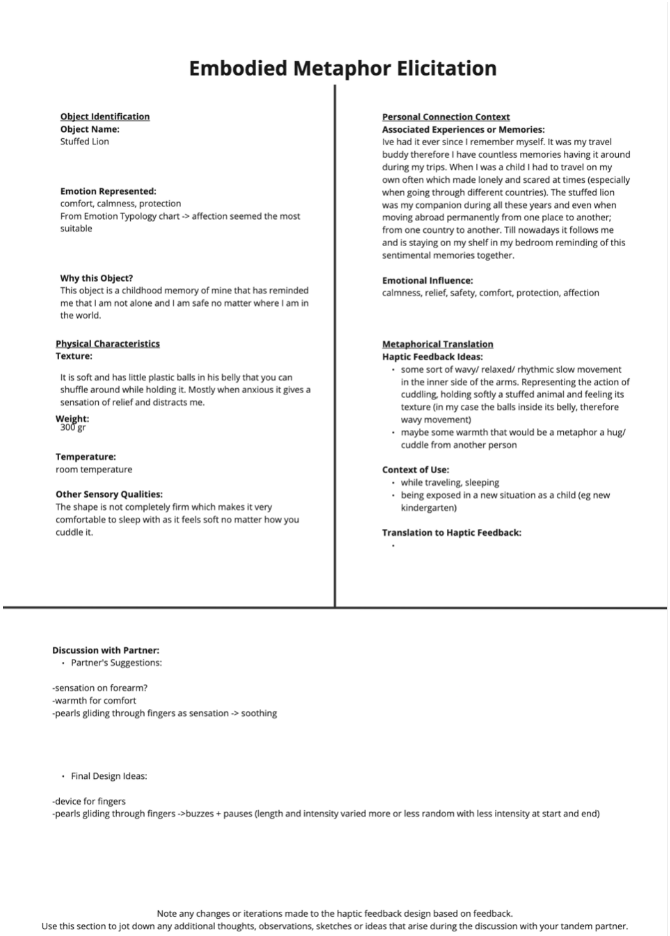
Apart from that while testing we realised that the stroking is not always for the whole extent of the toy therefore there could be stoking patterns with longer and shorter duration.

- Final Design Ideas:

We designed our haptic experience together and decided to go for stroking of the both sides of the stuffed corn toy. That is due to the soft and distinguishable sensation the touch of both provides. It relaxes Anica/ our user and makes her feel in piece. The back side is flat and consistent in its feeling while the front side, imitating the corn texture, is more bumpy and bouncy. That we tried to replicated with the voice actuator and the LRA actuator.

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 35: CP1's embodied metaphor elicitation sheet for her corn-shaped plushie, representing gratitude and comfort. The metaphor elicitation describes CP1's emotional connection to the plushie, which brings back memories of feeling safe and loved during an exchange semester. The haptic feedback ideas suggest how the object could create a comforting tactile sensation, mimicking a cozy, enveloping feeling like lying in a bird's nest or the sensation of a loved one lying beside you.



Embodied Metaphor Elicitation

Object Identification
Object Name:
Stuffed Lion

Emotion Represented:
comfort, calmness, protection
From Emotion Typology chart -> affection seemed the most suitable

Why this Object?
This object is a childhood memory of mine that has reminded me that I am not alone and I am safe no matter where I am in the world.

Physical Characteristics
Texture:

It is soft and has little plastic balls in his belly that you can shuffle around while holding it. Mostly when anxious it gives a sensation of relief and distracts me.

Weight:
300 gr

Temperature:
room temperature

Other Sensory Qualities:
The shape is not completely firm which makes it very comfortable to sleep with as it feels soft no matter how you cuddle it.

Personal Connection Context
Associated Experiences or Memories:
Ive had it ever since I remember myself. It was my travel buddy therefore I have countless memories having it around during my trips. When I was a child I had to travel on my own often which made lonely and scared at times (especially when going through different countries). The stuffed lion was my companion during all these years and even when moving abroad permanently from one place to another; from one country to another. Till nowadays it follows me and is staying on my shelf in my bedroom reminding of this sentimental memories together.

Emotional Influence:
calmness, relief, safety, comfort, protection, affection

Metaphorical Translation
Haptic Feedback Ideas:
- some sort of wavy/ relaxed/ rhythmic slow movement in the inner side of the arms. Representing the action of cuddling, holding softly a stuffed animal and feeling its texture (in my case the balls inside its belly, therefore wavy movement)
- maybe some warmth that would be a metaphor a hug/ cuddle from another person

Context of Use:
- while traveling, sleeping
- being exposed in a new situation as a child (eg new kindergarten)

Translation to Haptic Feedback:
-

Discussion with Partner:
- Partner's Suggestions:

-sensation on forearm?
-warmth for comfort
-pearls gliding through fingers as sensation -> soothing

- Final Design Ideas:

-device for fingers
-pearls gliding through fingers ->buzzes + pauses (length and intensity varied more or less random with less intensity at start and end)

Note any changes or iterations made to the haptic feedback design based on feedback.
Use this section to jot down any additional thoughts, observations, sketches or ideas that arise during the discussion with your tandem partner.

Figure 36: CP2's embodied metaphor elicitation sheet for her stuffed lion, representing comfort, calmness, and protection. The metaphor elicitation describes CP2's emotional attachment to the stuffed lion, which has been her companion since childhood and evokes feelings of safety during times of anxiety or loneliness. The haptic feedback ideas focus on rhythmic, wavy movements in the arms and warmth to simulate a hug or the feeling of being held, mimicking the comfort and protection of cuddling the lion.

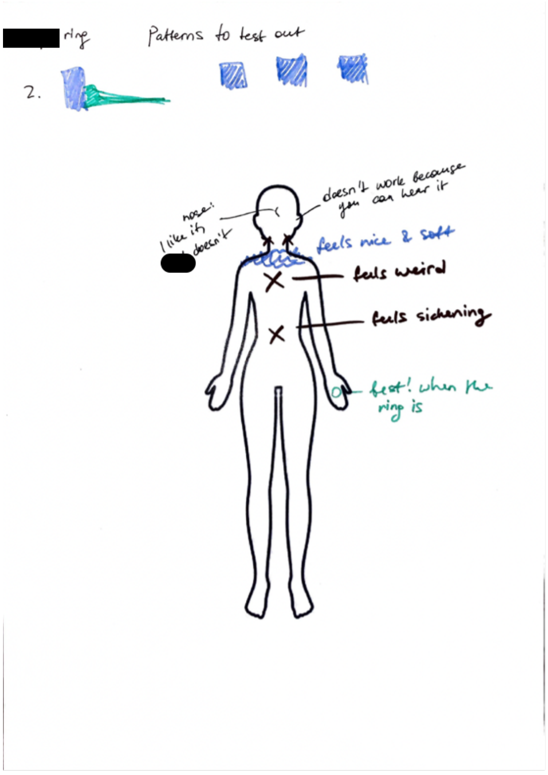


Figure 37: AP1's first body map iteration indicating initial actuator placements and associated sensations. Key insights included discomfort on the chest and stomach areas, and a favorable sensation on the finger where the ring was worn.

The third body map (Figure 50) represents BP2's attempt to recreate the sensation of dribbling a basketball through haptic feedback on the palms. The aim was to evoke a feeling of "playful calmness," using rhythmic patterns that mimic the bouncing sensation during dribbling. BP2 sketched a pattern that reflects the start of a dribble, transitioning into the powerful bounce and rhythm of the basketball.

As shown in Figure 51, the prototype involved actuators taped onto a small basketball object to simulate the dribbling sensation described in the body maps. BP2 used this tactile object to explore how physical feedback relates to the sensation of dribbling a basketball.

CP1 Prototyping Body Maps

CP1's prototyping process aimed to recreate the sensation of petting a plushy toy through haptic feedback. The participant focused on mimicking the stroking and petting of the soft object using different actuators to simulate the feeling of the plush fabric's texture. The goal was to provide the sensation of petting without physically performing the hand or arm movement.

The first body map (Figure 52) shows the hands as the primary areas of interaction, marked with annotations to mimic the motion of stroking the soft object. CP1's first approach focused on simulating the smooth texture of the plushy toy using an LRA actuator, designed to produce a smooth and gradual petting sensation with a single peak. The metaphor for this pattern was

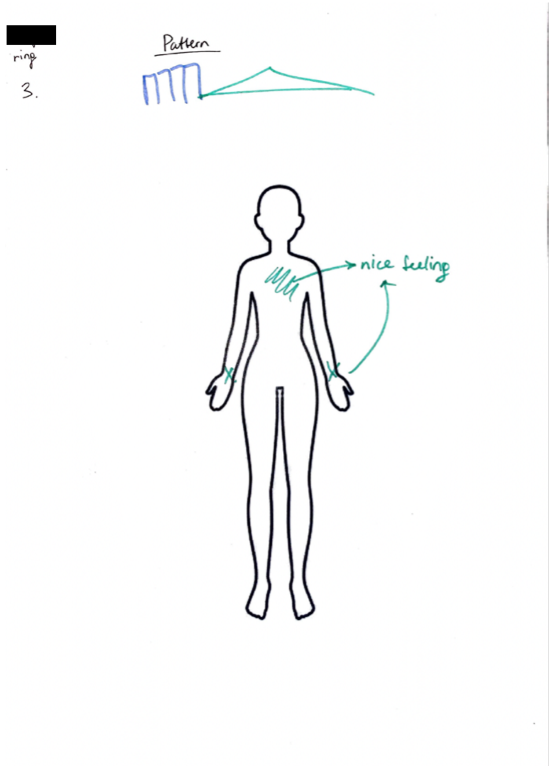


Figure 38: AP1's second body map iteration showing refined placements on the wrist and chest after adjusting the haptic feedback pattern. The new placements provided a more pleasant sensory experience.

described as a quick petting stroke that fades out, mimicking the decrease in pressure when lifting the hand after stroking. The second approach simulated the bumpier side of the plushy toy's fabric using a Voice Coil actuator, with a pattern that includes multiple peaks, representing the uneven texture.

The second image (Figure 53) shows CP2 testing the prototype by comparing the real sensation of the plushy toy with the recreated haptic feedback pattern from the actuators, a crucial step in their iterative prototyping process. CP2 is seen holding both the plushy toy and the actuator to simulate the sensation as closely as possible.

Finally, the third image (Figure 54) is a screenshot from HapticsLab Studio, documenting the specific haptic feedback patterns created during the prototyping session. These notes show the stroke times and patterns for both the smooth and bumpy sides of the plushy, illustrating the translation of CP1's conceptualization into the final prototype.

CP2 Prototyping Body Maps

The goal of CP2's prototype was to recreate the tactile experience of interacting with the pearls inside the stuffed lion's belly. This was an important activity for the participant, offering a sense of safety and comfort during the interaction. The prototype aimed to replicate this sensation through haptic feedback on the hands. The pattern designed had an arrhythmic, non-linear

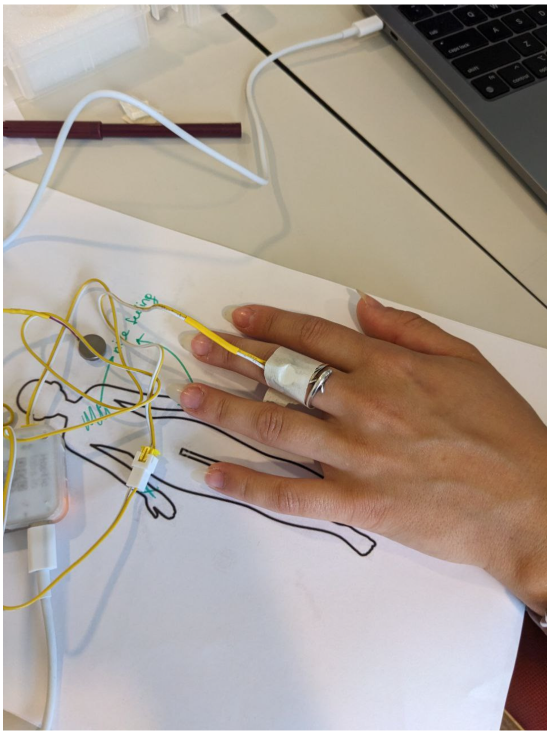


Figure 39: Physical prototype of the haptic ring being tested during the first iteration of AP1's prototyping process.

frequency to match the irregular movement of the pearls, and the intensity remained moderate, aligning with the real-life interaction with the toy.

Figure 40: AP1 demonstrating a preferred actuator placement on the neck of AP2 during the group prototyping session.

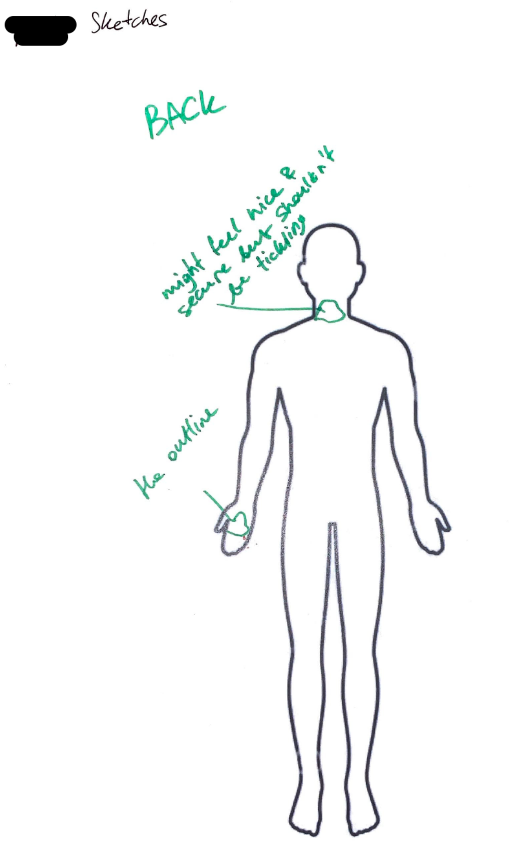


Figure 41: AP2's first body map iteration indicating potential areas for actuator placement, including the neck and hand. The goal was to create a secure sensation with a mushroom-shaped actuator.

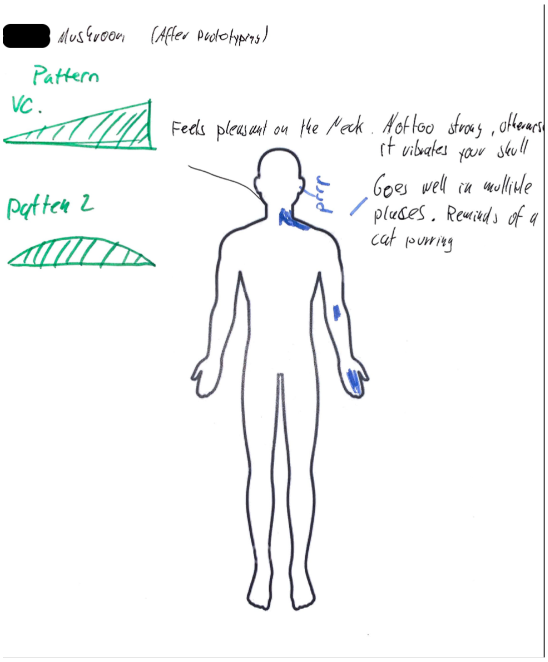


Figure 42: AP2's second body map iteration showing tested actuator placements on the wrist, forearm, and neck. The patterns created pleasant sensations, particularly the purring-like pattern on the neck.

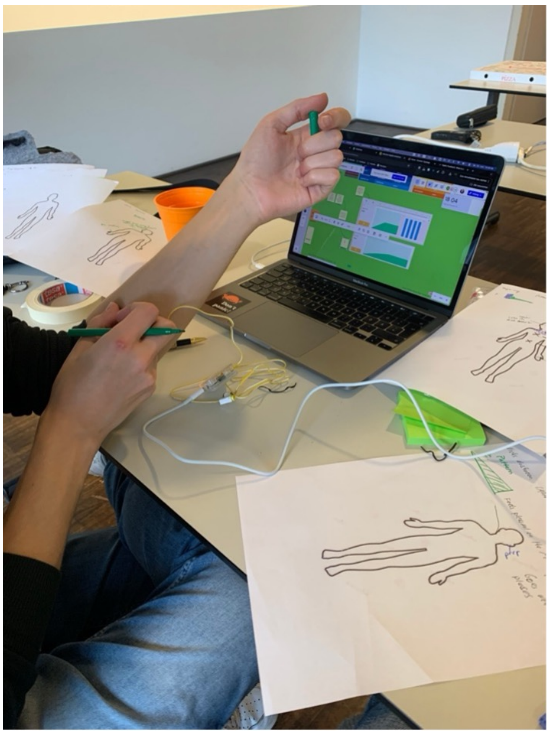


Figure 43: AP2 applying the actuator to the upper forearm during the prototyping process, refining placements identified in the second body map.

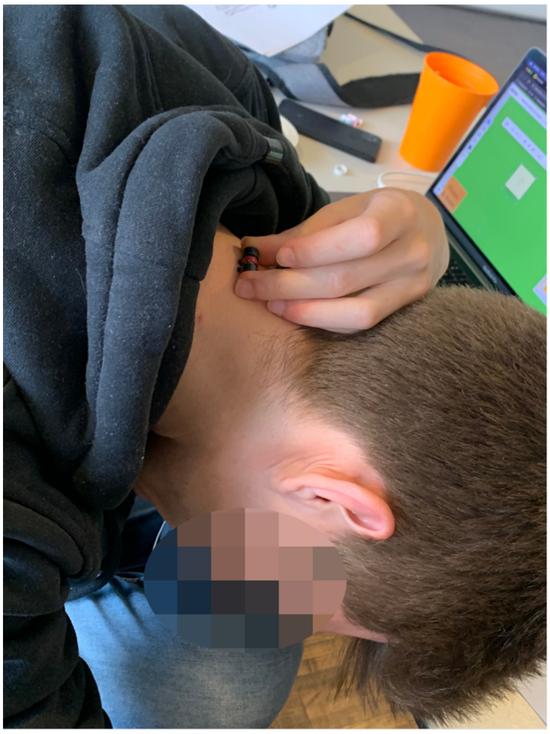


Figure 44: AP1 testing the actuator placement on AP2's neck, as suggested in the first body map to create a secure and pleasant sensation.

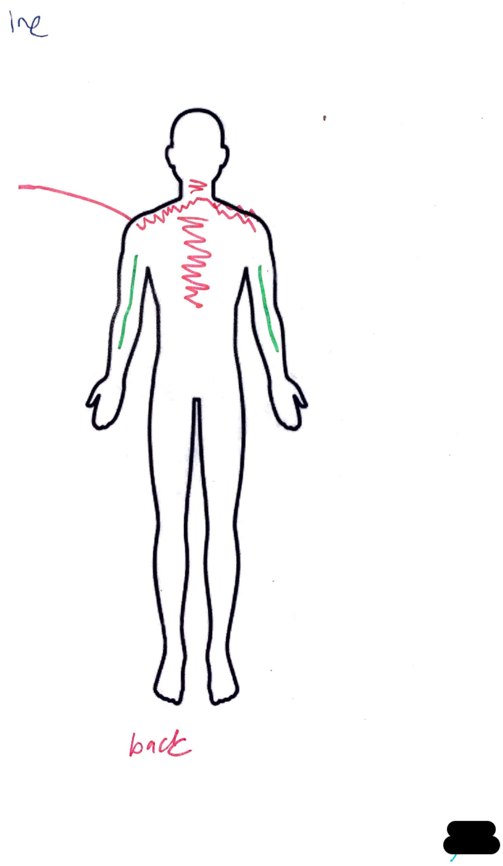


Figure 45: This Figure shows the initial conceptual sketch of BP1's body map before the prototyping session began. The areas marked on the back, specifically the shoulder and spine, were identified as possible actuator placement locations with the zigzag lines indicating higher-intensity haptic feedback. In contrast, the straight lines on the upper triceps region suggest lighter feedback.

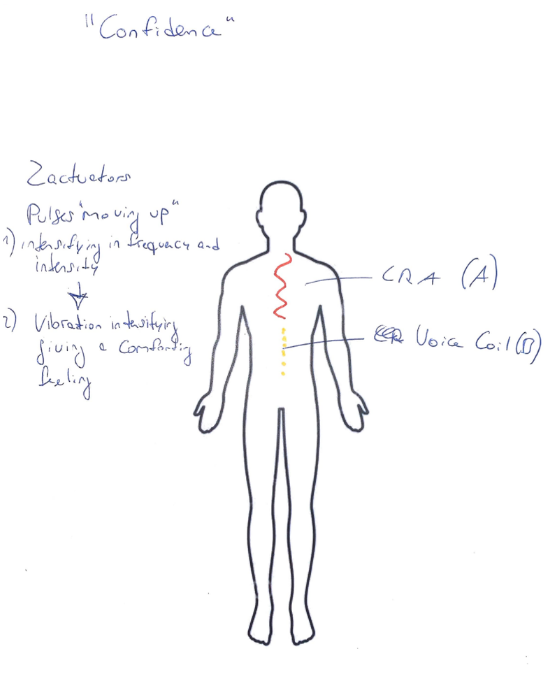


Figure 46: The body map here represents the first iteration of BP1's prototype, where they aimed to create a "confidence" feeling through haptic feedback. The prototype used two actuators: a CRA actuator and a Voice Coil actuator. The design is based on creating a pulsing sensation that travels upwards along the spine, intensifying both in frequency and strength and offering a comforting sensation as the vibration reaches the upper back.

Figure 47: This photo shows the tandem on-body prototyping process where BP2 is applying the actuator to BP1's back, targeting the areas marked in the earlier body maps. The testing focused on ensuring the placement and the intensity of the vibration matched the original concept of generating a confidence-building sensation along the back.

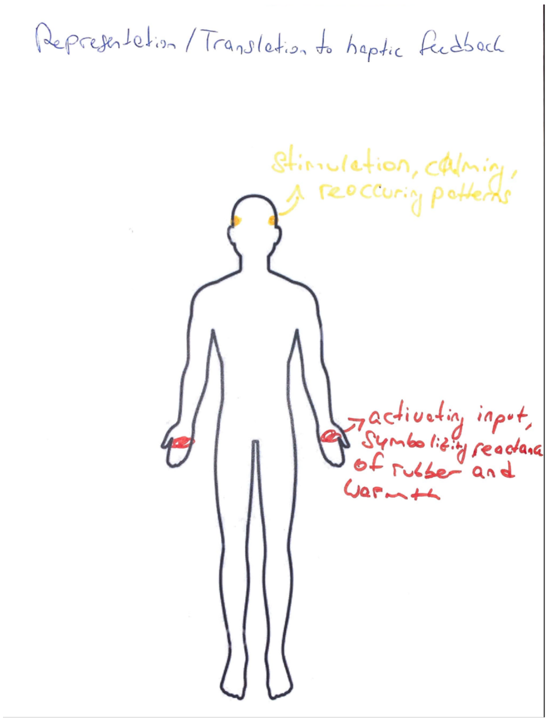


Figure 48: BP2's initial conceptualization of the prototyping. The hand is identified as a key area for activating the haptic feedback, symbolizing the sensation of rubber and warmth from a toy. BP2 also marked the temples as potential areas for a calming, reoccurring pattern.

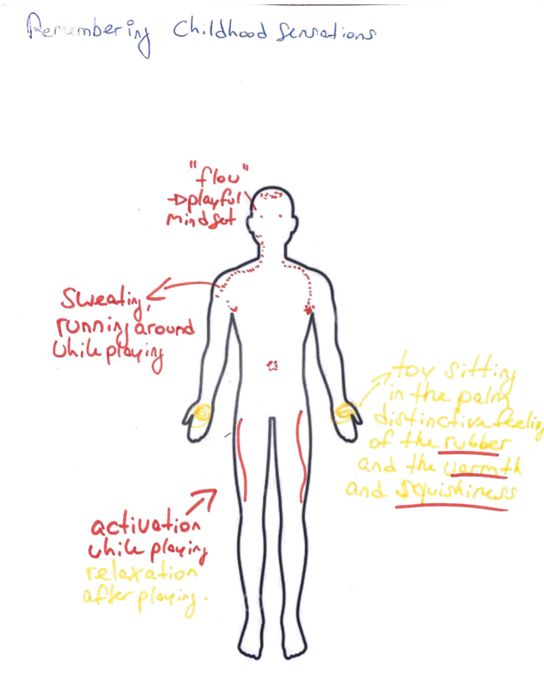


Figure 49: BP2's body map reflecting childhood sensations. The body map marks sweating and physical activation while playing, and relaxation afterward. Specific tactile sensations in the palms are linked to holding the toy.

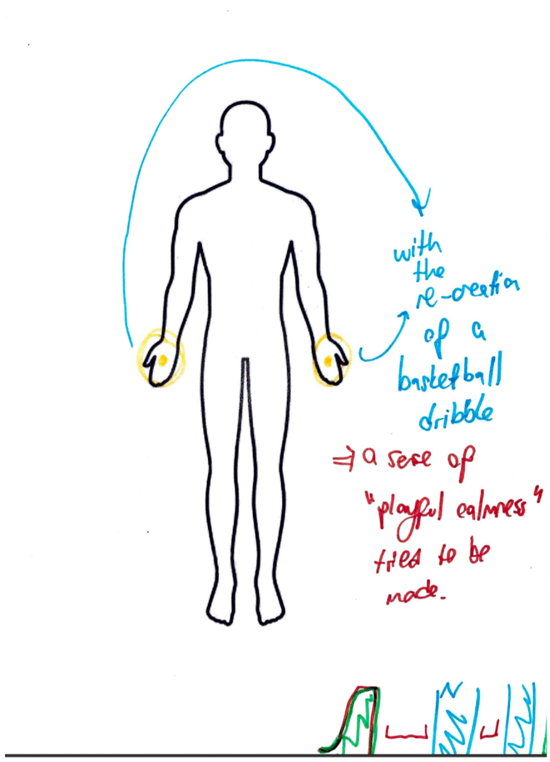


Figure 50: BP2's body map concept of recreating the dribbling sensation of a basketball on the palms. The aim was to evoke a sense of ”playful calmness” through haptic feedback resembling the strong bouncing of a basketball.

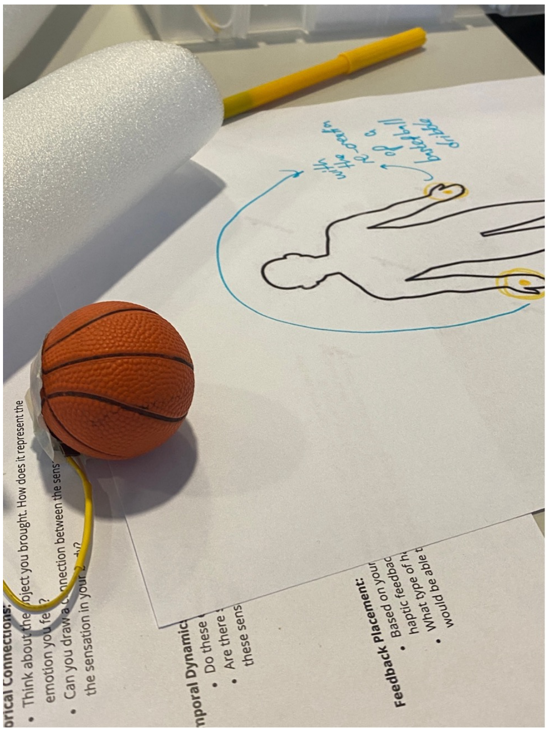


Figure 51: Prototyping of BP2's object: actuators taped onto the basketball object. This setup aimed to recreate the dribbling sensation envisioned in the body maps.

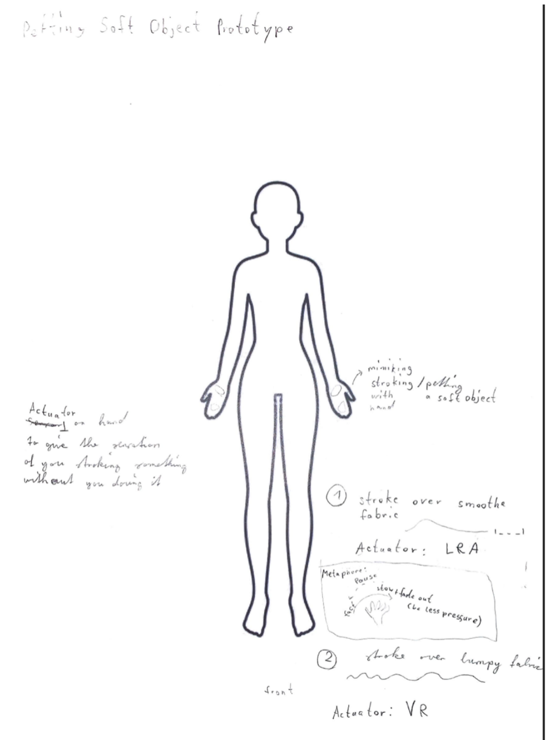


Figure 52: CP1 Body map conceptualizing the sensation of petting a plushy toy.

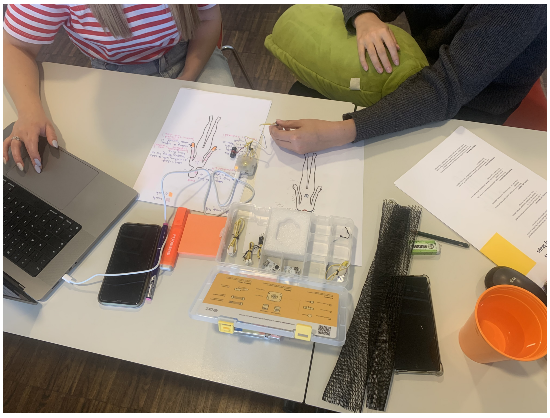


Figure 53: CP2 testing the plushy toy and actuator during the prototyping process.

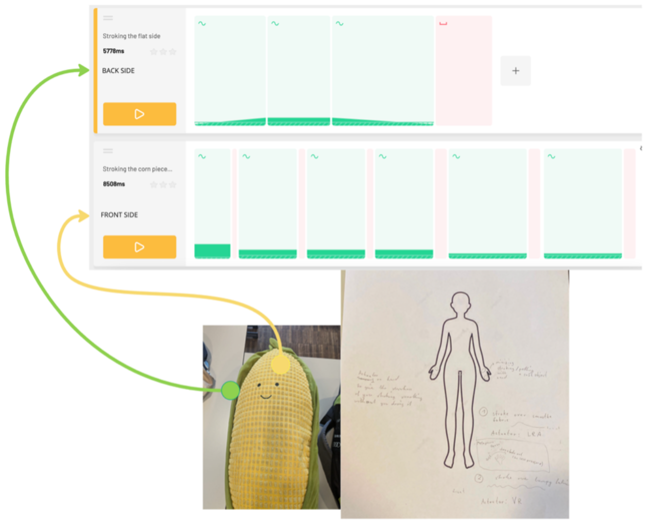


Figure 54: HapticsLab Studio prototype documentation showing the created patterns for the smooth and bumpy sides of the plushy.

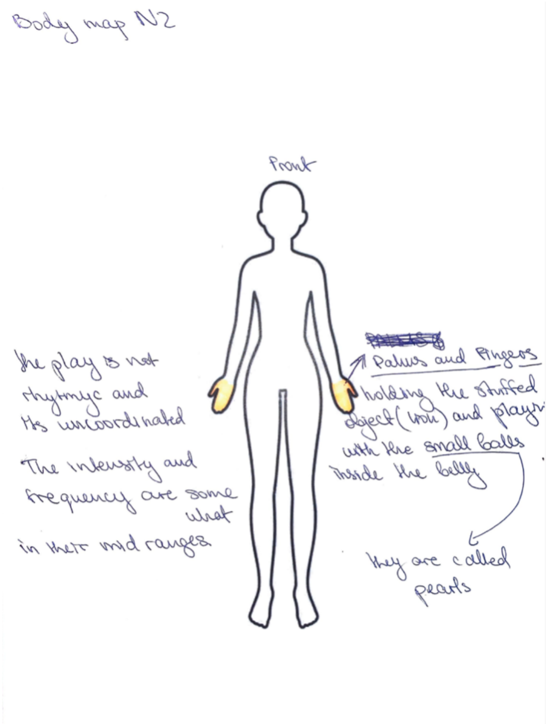


Figure 55: CP2 Body Map 1: Representation of the haptic feedback location to simulate the sensation of playing with the pearls inside the stuffed lion toy. The primary focus is on the hands, where the participant simulates the experience of playing with the plastic pearls inside the toy's belly. The feedback is characterized by mid-range intensity and frequency, replicating an uncoordinated and arrhythmic sensation, much like the irregular movement of the pearls inside the toy.

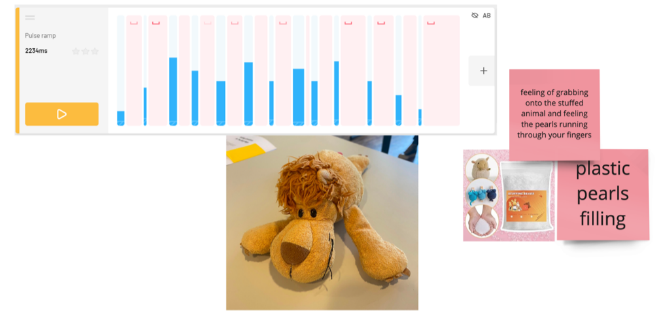


Figure 56: CP2 Prototyping Documentation: The participant created a pattern in Hapticlabs Studio to replicate the feeling of plastic pearls running through her fingers when holding the stuffed lion toy. The sensory interaction aimed to evoke a sense of calmness and reduce anxiety, much like the real object. The haptic pattern uses mid-range intensities and irregular frequencies to resemble the movement of pearls. The documentation also includes images of the stuffed lion and explanations of the intended sensation.

4.2.5 Tandem On-body Prototyping

Building on the initial survey results, the workshop outcomes can be further detailed by analyzing how the participants' expectations and prior knowledge influenced their engagement with the toolkit and their success in creating haptic prototypes.

Connection Between Prior Experience and Prototyping Success:

- Participants with more technical backgrounds (e.g., those with higher coding proficiency) generally found it easier to grasp the technical aspects of the toolkit, such as actuator programming and integration. However, they sometimes struggled more with the creative aspects of translating emotions into haptic feedback.
- Participants with less technical experience but a stronger background in emotional design or UX found the creative exercises, such as embodied metaphor elicitation, to be more intuitive. They excelled in designing prototypes that were emotionally affective, even if they required more support with the technical setup.

Role of Collaboration in Learning:

- The tandem approach facilitated peer learning, particularly for participants who were less confident in certain areas. For example, participants with stronger coding skills were able to assist their partners with the technical setup, while those with a better understanding of emotional design helped translate these concepts into haptic feedback.
- Collaboration also helped participants overcome anticipated challenges by pooling their knowledge and skills, which was crucial in creating useful, educative affective haptic prototypes within the limited workshop timeframe.

Usefulness of the Hapticlabs DevKit in Meeting Expectations:

- Overall, the toolkit was well-received in terms of its usability and educational value in helping participants achieve their learning objectives. Those with less technical experience particularly appreciated the clear instructions and step-by-step guidance.
- However, some participants felt that the DevKit's software Hapticlabs Studio could benefit from additional features, such as more advanced tutorials or options for customizing haptic feedback designs, which would help them push the boundaries of their designs and experiment more freely.

4.3 Impact of Emotion Typology and Circumplex Model Introduction

4.3.1 Structured Emotional Articulation

The introduction of Emotion Typology and the Circumplex Model of Affect was one of the most impactful elements of the workshop. These frameworks helped participants articulate and categorize complex emotions associated with their personal objects, which was particularly valuable in the context of having non-native English speakers as participants but executing the workshop in English. BP2, for example, expressed that the structured approach expanded their emotional vocabulary, making it easier to convey nuanced feelings through their designs:

> ”What I really liked was that you in the beginning brought in the scope of, for me, emotions and how these are called or how they feel because... it would be hard to come up with the description that I came up with without looking at the emotions that you presented us today.”

This sentiment was echoed by AP2, who noted the value of clear emotional frameworks:

> ”I also thought the basis of the emotions was very nice because I also hadn't had some of these words or emotions that clear.”

4.3.2 Visual Representation and Emotional Scope

The visual tools provided as part of the Emotion Typology allowed participants to visualize and articulate their emotional states more effectively. The circumplex model's division of emotions into dimensions such as valence and arousal provided a structured means to explore how specific emotions could be translated into haptic sensations. Participants reported that these resources enabled them to connect the abstract concept of emotion with physical sensations and subsequently into haptic feedback design.

However, while the typology was beneficial, some participants noted that the range of emotions presented was somewhat limited. For example, participants generally brought objects associated with positive emotions, which might have restricted the exploration of a broader emotional spectrum.

4.4 Usefulness of Embodied Metaphors and Body Maps

The workshop outcomes were assessed based on the usefulness of the toolkit in aiding participants in designing affective haptic feedback prototypes. The analysis focuses on how participants used body maps and embodied metaphors to translate emotions into haptic feedback, as well as the overall success of the prototyping sessions.

Body Maps Participants used body maps to visually represent the areas of the body where they believed haptic feedback would be most effective in conveying specific emotions. The use of body maps proved instrumental in helping participants conceptualize the placement and impact of haptic actuators on the body. As explained in section 4.2.

Participants found body mapping to be beneficial in recognizing, reflecting, and connecting emotions to specific body parts. AP1 stated, “I agree with the whole method of body maps helping to understand the emotion and where I feel it, and you can just become more aware of your own body.” However, they faced challenges when attempting to directly translate these emotional locations into actuator placements during prototyping. AP1 noted, “When it comes to translating now this body map to the haptic design, I think it’s sometimes not really straightforward or that obvious that if you experience something in your chest or in your head, then you should use the actuators in that place.” Specifically, placing actuators on emotionally significant areas like the chest created discomfort: “Some places that are being emotionally influenced (like chest, for example) shouldn’t be externally stimulated with vibrations because it creates a weird, eerie feeling.” This feedback highlights that while body maps are useful for understanding emotional experiences, designers must carefully consider the appropriateness and comfort of actuator placement, rather than relying solely on the locations identified in the body maps.

With AP1 noting that placing actuators on emotionally significant areas, like the chest, created an ”eerie feeling”, specifically when placed around the heart, it emphasises the importance of carefully selection of the appropriate area of haptic affect through vibrotactile stimulation. BP1 also highlighted how ”the same vibration pattern on the chest and back created different emotional responses” demonstrating the importance of body maps in refining the placement of haptic actuators to better align with emotional intentions.

AP1 stated,

> ”I agree with the whole method of body maps helping to understand the emotion and where I feel it and you can just become more aware of your own body. When you recall a memory for example you recall your attitude towards an object.”

aligning with the intent of **RQ1**1.4 of investigating the impact of body maps and embodied metaphor elicitation on the design and communication process of haptic feedback.

Yet, AP1 criticises:

> ”But when it comes to translating now this body map to the haptic design, I think it’s sometimes not really straightforward or that obvious that if you experience something in your chest or in your head then you should use the actuators in that place or you use the vibration in that place. Because it’s one thing to have this feeling coming from the inside just naturally and just recording it and then it’s another thing to provoke it with the external stimulator or the trigger.

Even though AP1 did not find it useful to translate the location of felt emotion directly into the suitable location for the haptic prototype to induce the emotion, the participant further stated,

> ”I liked that it gave me an initial idea of where I can place the actuators, although placing them on emotionally charged areas like the chest created a strange, eerie feeling”

Similarly, Participant BP1 appreciated the maps for visualizing how haptic feedback could be designed across different parts of the body, remarking that

> ”using body maps enabled me to also see my options, and having the same pattern on the chest and back creates different experiences.”

This feedback illustrates the value of body maps as a design tool but also reveals limitations, such as difficulties in translating abstract emotional experiences into physical stimuli. The feedback was mixed regarding their overall effectiveness. While some participants, like CP1, found body maps useful for organizing emotions, others, such as CP2, struggled to translate these emotional representations into effective haptic feedback. While body mapping can be a helpful reflective tool, its role in aiding the haptic design process may require further refinement or additional support to be fully effective. While the tool provided an entry point for this exploration, the process was not universally straightforward for all participants. Feedback revealed a significant variability in how participants engaged with body mapping. Participants, such as CP1 and BP3, found it useful for organizing their thoughts and guiding the prototyping process. Others, like CP2, reported difficulty in converting the abstract emotions identified on their body maps into actionable haptic feedback. This highlights that while body mapping can serve as a valuable reflective exercise, it may require additional support, iteration, or simply more time for internalization (i.e. the body mapping activity) to bridge the gap between the conceptual and the practical application of haptic design. The varying levels of success observed with body mapping suggest that it may function more as a starting point for emotional reflection, rather than a comprehensive solution for translating emotional states into tactile outputs.

- **Emotional Localization:** Participants successfully identified and targeted specific areas of the body that corresponded with the emotional states they aimed to evoke. For example, feedback associated with stress relief was often applied to areas such as the shoulders or back, while feedback intended to evoke excitement was focused on areas like the chest or hands.

- **Design Precision:** The use of body maps allowed participants to refine their designs with greater precision, ensuring that the haptic feedback was not only conceptually aligned with the intended emotion tied to the brought object but also physically effective in delivering that UX.

Embodied Metaphors: The embodied metaphor elicitation exercise played a crucial role in helping participants translate abstract emotional concepts into tangible haptic designs.

- **Metaphor Application:** Participants were able to create haptic feedback patterns that reflected the metaphors they had chosen. For instance, one participant associated the feeling of calmness with the metaphor of ”waves on a beach,” leading them to design a rhythmic, pulsing feedback that mimicked the sensation of waves gently rolling over the body.
- **Emotional Resonance:** The metaphors helped participants connect emotionally with their designs, resulting in feedback patterns that were not only technically sound but also resonant with the desired emotional experience.

Participants, such as BP2, successfully utilized metaphors to translate their emotional connection with objects. For instance, BP2 described the metaphor of “confidence as an upright posture” and mapped this to vibrations along the upper body to reflect their emotional experience. BP2 explained in the individual survey,

> “The necklace of [BP1] represents a kind of confidence that we connected with posture. An upright posture has some kind of interoceptive elements (the internal lived experience, feeling your own body). We tried approaching this by introducing a stimulating trigger through vibration that ‘travels’ and connects with certain muscles that are involved when you stand upright.”

This use of metaphors guided the translation of abstract emotions into concrete designs. The prototype illustrating this concept is shown in Figure 47. The next section will explore how these metaphors informed design choices and their emotional affect on the participants.

4.4.1 Facilitating Emotional Translation

Embodied metaphors and body maps were introduced to help participants translate abstract emotions into tangible haptic feedback. This process grounded emotional experiences in physical sensations and participants explored the spatial and metaphorical dimensions of their object’s emotions. For example, BP1 used the metaphor of a basketball dribble to evoke a feeling of calmness, successfully incorporating this metaphor into the design of haptic feedback patterns. CP1 similarly reflected on the usefulness of body maps in directing their design:

> ”I found the body map particularly useful in figuring out where I associate specific emotions. It gave me a clearer direction on where to start applying the haptic feedback designs.”

4.4.2 Enhancing Communication Between Designers and Users

The Tandem Design setup, in which participants alternated between the roles of designer and user, coupled with embodied metaphors and body maps, significantly enhanced communication. Participants found that by discussing their personal emotional experiences, they were better able to translate and fine-tune haptic feedback to resonate with their design partner. BP2 emphasized the importance of communication in the design process, stating,

> ”Through communication, I felt like it was way better that we expressed the first-person felt experience. So we had to communicate inside out what we felt.”

4.4.3 Challenges in Translating Complex Metaphors

Despite the usefulness of embodied metaphors, some participants struggled with translating more complex or abstract metaphors into haptic feedback. AP2 observed:

> ”I feel like this method can work well if you have a metaphor that can be translated easily into haptics, but... the more complex the initial embodied metaphor, the harder it is to translate.”

AP1 also noted that certain body map locations, such as the chest, were difficult to stimulate comfortably with vibrations, raising the issue of user discomfort in specific body areas:

> ”Some places that are being emotionally influenced (like chest, for example) shouldn’t be externally stimulated with vibrations because it creates a weird, eerie feeling.”

These challenges highlighted the need for further refinement in how embodied metaphors and body maps are utilized, especially when dealing with complex emotional states and sensitive body areas.

4.5 Challenges Faced During Prototyping Sessions

Tandem On-Body Prototyping Sessions The iterative nature of the prototyping sessions allowed participants to test, refine, and improve their designs based on real-time feedback from their partners. BP1 emphasized the benefits of this approach:

> “With some iterations, we managed to create the feeling we went for.”

However, participants also faced challenges due to technical limitations and the subjective nature of emotional interpretation. BP2 highlighted the importance of communication in this process:

> “Through communication, I felt like it was way better that we expressed the first-person felt experience. So we had to communicate inside out what we felt.”

This underscores that while iterative prototyping and collaboration are valuable, they require effective communication and may be hindered by individual differences and technical constraints.

- **Iterative Real-Time On-Body Design Process:** Participants engaged in continuous testing and refinement of their affective haptic on-body prototypes, using feedback from their partners to make adjustments. The iterative nature of the prototyping sessions allowed participants to refine their designs. For example, BP2 highlighted how the trial-and-error approach of their body-storming helped them explore first-person emotional experiences, making the process of designing haptic feedback more tangible and meaningful in real-time. This process was critical in helping them understand the nuances of single-modal affective haptic feedback and how small changes could significantly impact the emotional experience.

- **Successful Outcomes:** By the end of the workshop, all participants managed to develop and test affective haptic feedback that resembled their personal object's emotion. The ideation and Lo-Fi on-body prototyping for achieving the subjective emotional affect successfully resembled the intended emotional trigger. These outcomes demonstrated the toolkit's ability to support novice interaction designers in creating emotionally affective haptic feedback, even with minimal prior experience.

4.5.1 Technical Complexity and Learning Curve

One of the main challenges participants encountered was the technical complexity of on-body haptic design. For example, CP1 experienced connectivity issues with the hardware, stating,

> ”Bluetooth connection was very bad and hindered the process.”

While most participants found the hardware (Hapticlabs DevKit) relatively easy to connect, the software interface still presented some struggles in its intuitive usage.

While participants found the hardware straightforward to connect, they faced challenges with the software interface.

BP1 expressed frustration with the learning curve associated with the Hapticlabs Studio software:

> ”Understanding the software was a bit challenging; the hardware is very straightforward to connect... The software wasn't very intuitive... The interface could be more user-friendly.”

Specific issues included difficulty in navigating the interface and a lack of guidance on the effective integration of pre-built haptic patterns.

This difficulty was exacerbated for participants with lower coding skills, further emphasizing the need for more intuitive, beginner-friendly software for novice interaction designers.

4.5.2 Subjectivity of Emotional Interpretation

The subjective nature of emotional interpretation presented another significant challenge. Participants found that designing for affective experiences was inherently difficult because emotions are experienced differently by different individuals. BP2 remarked:

> ”It was his really subjective feeling that I tried to resemble and implement... we had to give feedback to each other and communicate really well what we were trying to do.”

This difficulty in achieving universal emotional resonance through haptic feedback was a recurrent theme, highlighting the importance of communication and iterative feedback during the prototyping process.

4.6 Technical Limitations of the Toolkit

4.6.1 Hardware Constraints

Participants encountered several hardware limitations during the prototyping sessions, which impacted their ability to fully explore haptic designs. The Hapticlabs DevKit’s Bluetooth connectivity issues and the limited number of actuators were particularly frustrating for participants. CP1 noted:

> ”Hardware challenges: Bluetooth connection was very bad and hindered the process... wire connection didn’t work.”

BP2 expressed concern over the narrow range of actuator options:

> ”Only having two actuators was difficult because they unfolded their impact only locally.”

AP1 noted a limitation in prototyping spatial haptic experiences due to the availability of only one actuator of each type:

> ”Can’t prototype spatially, only one actuator of one type.”

This constraint hindered the ability to create more complex, multi-point haptic feedback patterns.

These hardware constraints limited the spatial and dynamic variety of haptic feedback that participants could create, restricting their creative potential and exploration of more complex emotional designs.

4.6.2 Software Usability Issues

Participants also struggled with the software's usability, which was not as intuitive as expected. BP1 mentioned:

> ”The software wasn't very intuitive... The interface could be more user-friendly.”

This issue hindered some participants' ability to experiment freely and iterate on their designs, underscoring the need for improved software that caters to novice users, offering clear instructions, pre-designed haptic patterns, and more intuitive controls.

4.7 Participant Feedback and Recommendations

4.7.1 Positive Feedback

Participants appreciated several aspects of the workshop and the toolkit. The introduction of the Emotion Typology, the collaborative Tandem Design approach, and the hands-on nature of the activities were frequently cited as strengths of the workshop. Participants appreciated the hands-on activities and collaborative environment of the workshop. CP2 commented:

> ”They were great! Much needed to have a detailed overview of the design process... This setup provided an opportunity to do so and freedom to do it the way you wish as a designer.”

Qualitative feedback from participants provided valuable insights into their experiences with the toolkit and the overall workshop structure. This section summarizes the key themes that emerged from the feedback, highlighting both the strengths of the workshop and areas for potential improvement.

- **Toolkit Usability:** Participants praised the user-friendliness of the toolkit, particularly the Hapticlabs hardware and software. They found the interface intuitive and appreciated the clear instructions provided for setting up and using the actuators.
- **Collaborative Learning:** The tandem approach was well-received, with participants noting that working in pairs allowed them to exchange ideas, provide mutual support, and learn from each other's experiences. This collaborative environment was seen as a key factor in the success of the workshop.
- **Creative Freedom:** Participants valued the creative freedom afforded by the workshop structure, which encouraged them to experiment with different designs and iterate based on feedback. They appreciated the balance between guidance and autonomy, which allowed them to explore their ideas while still receiving support when needed.

4.7.2 Areas for Improvement:

Participants suggested several possible improvements to the chosen haptic hardware actuator and software kit, including the introduction of more diverse actuators (e.g., those that can produce pressure, temperature, or texture sensations), enhanced software usability with pre-built (affective) haptic example patterns, and easier accessible wireless powering options for actuators to facilitate on-body prototyping without cumbersome wires. The following list contains the details:

- **More Diverse Materials:** Some participants suggested that the toolkit could be enhanced by including a wider variety of hardware actuators and materials, allowing for more diverse haptic experiences. This would enable designers to experiment with different types of feedback and explore a broader range of emotional responses. Practical enhancements such as providing extension cords and magnets could improve the usability of the toolkit. AP1 suggested,

  > ”Include more actuators for better creativity, include extension cords[...]Maybe some magnets to attach the actuators more easily.’

  These additions would facilitate easier placement of actuators on different body parts and support more complex prototyping scenarios.

- **Enhanced Feedback Mechanisms:** Participants expressed a desire for more structured feedback mechanisms within the toolkit, such as predefined feedback loops or prompts that could guide them through the iterative design process more usefully.

- **Wireless Options:** Several participants mentioned that wireless actuators would have made the prototyping process more seamless, allowing for greater flexibility in testing and iterating on designs.

- **Streamline Workshop Structure:** Although the workshop was received as helpful in teaching the concept of affective haptic design, participants had problems with the completion of the number of activities within the scheduled workshop timeframe. This made the workshop feel rushed in some parts and should be considered for future conductions or applications of certain methodologies of this proposed theoretical toolkit.

4.7.3 Unexpected Challenges and Benefits

Participants faced a number of technical challenges throughout the prototyping sessions. Several participants encountered issues with the DevKit’s Bluetooth connectivity disabling the actuators, which led to interruptions in their design process. CP1 and BP1 both mentioned that connectivity problems disrupted the flow of their iterative prototyping. Additionally, BP2 remarked on the limitations imposed by the narrow variety of actuators available, explaining that it restricted their ability to experiment with more complex emotional patterns. These technical difficulties highlight the need for more robust hardware and troubleshooting documentation to ensure smoother workflows in future iterations of the workshop.

Unexpectedly, participants also gained valuable emotional insights through the embodied metaphor elicitation and body mapping exercises. AP1 expressed that these activities helped them become

> ”more aware of bodily sensations”

tied to emotions, while BP1 noted that the exercises allowed them to

> ”translate these sensations into physical prototypes”

in a more useful, educative manner. However, the process was not without its challenges. CP2, for instance, struggled to apply abstract metaphors like ”comfort” to specific affective haptic feedback. This participant feedback underscores the importance of providing additional guidance and expanding the diversity of hardware (i.e., actuators, easier wireless setup) to better support the undisrupted design process and therefore the translation of complex emotional concepts into affective haptic feedback designs.

Participants provided detailed feedback on various elements of the workshop. The introduction to the Emotion Typology and the circumplex model was widely appreciated, particularly for their utility in helping participants categorize and articulate complex emotions. BP1 and CP2 both mentioned that these models provided a useful structure for thinking about emotion in more concrete terms, especially when trying to translate abstract feelings into haptic feedback designs.

However, the embodied metaphor elicitation and body mapping activities, while well-received, revealed several challenges. CP1 expressed that while the body maps helped conceptualize the connection between emotion and the body, translating those concepts into haptic feedback was ’not always intuitive.’ This sentiment was echoed by BP2, who struggled to apply abstract metaphors, such as ’comfort,’ to specific haptic designs. The difficulty in bridging the conceptual understanding of emotions and the practical application of haptics underscores a critical limitation of the workshop: while the exercises successfully facilitated emotional introspection, the toolkit lacked the necessary diversity in actuators and design options to fully realize these ideas in practice.

During the prototyping sessions, the technical challenges that emerged also impacted participants’ creative processes. The limited variety of actuators constrained some participants’ ability to explore more diverse emotional representations through haptics. BP2 explicitly mentioned that the narrow range of actuators ’limited the ability to experiment with more complex emotional patterns.’ Additionally, CP1 and BP1 both faced connectivity issues, which further hindered their ability to iterate on their designs smoothly. These technical limitations suggest that while the workshop succeeded in promoting emotional exploration, the current iteration of the toolkit does not yet fully support the technical needs of novice interaction designers in translating these explorations into tangible prototypes.

Overall, while participants recognized the value of the workshop and its ability to support emotional engagement through haptic design, their feedback indicates several key areas for improvement. As demonstrated in the workshop feedback, participants, such as CP1, described how the tactile sensation of a plush toy evoked feelings of gratitude and nostalgia. This feedback reinforces how specific textures or patterns can anchor emotions within tangible interactions, highlighting the potential of haptic design to deepen emotional engagement through personalized tactile feedback.

The Hapticlabs DevKit, while lowering technical barriers, presented challenges that impacted the design process. Participants faced issues such as limited actuator types and connectivity problems. CP1 expressed frustration:

> "Hardware challenges: Bluetooth connection was very bad and hindered the process, wire connection didn't work, and we had some issues with the interactions with the program as well."

Similarly, BP2 noted,

> "Only having two actuators was difficult because they unfolded their impact only locally."

These technical limitations suggest that the toolkit requires more diverse actuator options and more reliable technical infrastructure to ensure smoother workflows and greater creative flexibility. An image of the Hapticlabs DevKit used is provided in Figure 4.

4.7.4 Suggestions for Improvement

Participants also offered constructive feedback for improving the workshop and toolkit. Common suggestions included the introduction of more diverse actuators, improved software usability, and wireless options for actuators. BP2 remarked:

> "Material that spreads a sensation over the skin! Or a sequence of actuators... The small local impact is not versatile enough."

AP1 suggested allowing for more creative freedom in the workshop, particularly in the exploration of emotions:

> "Maybe in the future it makes sense to let people describe their own words, feelings, and not try to limit those to emotions... so that the exploration part is there."

Participants emphasized the importance of wearability in haptic prototyping. BP1 recommended,

> "The toolkit could be more focused on wearables as well; it's lacking that aspect now—either wireless or easier to attach on the body."

This suggests that making the actuators more wearable could enhance the iteration speed of Experience Prototyping and the realism of the prototypes.

4.8 Summary of Results

The findings demonstrate that the proposed methodological toolkit aided participants in designing emotionally affective haptic feedback by:

- **Enhancing emotional articulation**: The Emotion Typology and circumplex model provided a structured approach for participants to articulate and categorize their emotions.
- **Facilitating emotional translation**: Embodied metaphors and body maps were instrumental in helping participants conceptualize and design haptic feedback patterns.
- **Improving communication**: The Tandem Design approach fostered empathy and effective communication between participants, allowing for better translation of emotional experiences into haptic designs.

The methodological toolkit aided participants in articulating emotions, translating them into haptic designs, and improving communication during the design process. However, challenges such as technical limitations and the subjective nature of emotions highlight areas for improvement in making the toolkit more versatile and user-friendly for novice designers.

5 Discussion

This section interprets the key findings from our study, connecting them to the research questions outlined in Section 3.2, the theoretical frameworks discussed in the Introduction and Related Work (Section 1 and Section 2), and the broader goals of the study. Through an examination of direct citations from participants and relevant literature, this section discusses the usefulness of the proposed methodological toolkit in assisting novice interaction designers in the creation of emotionally affective haptic feedback prototyping. The identified limitations and challenges, establishing a foundation for the conclusion, and future research directions are also addressed.

5.1 Impact of Emotion Typology and Circumplex Model on Affective Haptic Design

The introduction of the Emotion Typology and the Circumplex Model of Affect had a reportedly significant impact on participants' ability to articulate and categorize emotions during the workshop, providing insights into RQ2: "How can low-fidelity on-body prototyping sessions be structured to facilitate the design and iterative improvement of affective haptic feedback? " from Section 1.4. These tools offered a structured approach to understanding and expressing emotions, which is crucial in affective haptic design, where nuanced subjective emotional experiences are translated into tactile sensations aimed at invoking those same experiences.

Participants appreciated the provided comprehensive resources related to emotional mapping during the workshop. These resources are available on the TU Delft website, including detailed descriptions and relatable scenarios for each emotion, which were particularly beneficial for non-native English speakers in phase 3.2.4 of the workshop, especially for expanding their emotional vocabulary. Participant BP2 found the Emotion Typology helpful in articulating emotions, stating:

> ”What I really liked was that you in the beginning brought in the scope of, for me, emotions and how these are called or how they feel because when I look at my object that I brought today, it would be hard to come up with the description that I came up with without looking at the emotions that you presented us today.”

This indicates that the provided emotional frameworks assisted participants in expressing their feelings more precisely and aligns with the use of Russell’s (1980) Circumplex Model of Affect and the refinement proposal by Posner et al. (2005), which provides a structured approach to organize, understand, and reduce the complexity of emotions into valence and arousal dimensions [43, 45]. Ju et al. (2005) proved the utility of such models in Affective Computing and design [28].

AP2 expressed that the Emotion Typology helped expand their emotional vocabulary, stating:

> ”It actually did open my mind what’s possible in terms of vibration patterns and styles, and how to convey emotions with them. I thought vibration is very one-dimensional, present or not. But there is a lot of variation possible, which was new to me.”

However, some participants felt constrained by the predefined emotional categories. AP1 suggested allowing for more personal and nuanced expressions of emotions:

> ”I think it also makes sense to not limit a person into the exploration journey... It doesn’t have to be an emotion. It can be just a feeling... something that I can’t translate to an emotion, but I mean, I can if I’m forced to, but I would choose different words for it.”

This highlights the limitations of relying solely on predefined emotion typologies and suggests that future iterations of the toolkit should allow for more flexibility in how emotions are expressed and explored. This is consistent with Eid and Al Osman(2016) emphasis on the importance of personal and contextual factors in affective design [18] and the principles of emotional design proposed by Norman(2004) [40].

As mentioned, the Emotions Typology was particularly beneficial for non-native English speakers. AP2 remarked:

> ”I also thought the basis of the emotions was very nice because I also hadn’t had some of these words or emotions that clear.”

This underscores the importance of accessible language and resources in supporting emotional articulation, which is essential in the initial stages of affective haptic design.

However, despite the success in emotional articulation, some participants expressed that the Emotion Typology and Circumplex Model of Affect might have constrained the emotional scope explored. The personal objects participants brought to the workshop were mostly associated with positive emotions, limiting the exploration of a more diverse emotional spectrum or even leaving the terminology ”emotion” and including a broader definition of sensations and feelings as possible affect states to design for. This suggests that future iterations of the workshop should consider introducing additional emotional dimensions, including negative or ambivalent emotions, to ensure a more comprehensive exploration of affective design possibilities. However, these research efforts must be ethically considerate and well-structured to ensure the participant’s safety and emotional well-being.

5.2 Embodied Metaphors and Body Maps: Enhancing Emotional Translation and Communication

The integration of embodied metaphors and body maps was instrumental in helping participants translate and communicate abstract emotional concepts into tangible haptic designs, addressing RQ1: ”How do embodied metaphors in combination with body maps impact the design and communication process of affective haptic feedback for novice designers?” from Section 1.4.

5.2.1 Embodied Metaphors

The use of embodied metaphors was instrumental in helping participants shape abstract emotional concepts into tangible haptic designs. Bakker et al. (2012) highlighted the effectiveness of embodied metaphors in interaction design, arguing that they facilitate a deeper connection between the user’s physical experiences and the design outcome [5].

Participants used embodied metaphors to conceptualize haptic patterns. This was successfully applied in the case of BP1, who used the metaphor of a basketball dribble to evoke feelings of nostalgic calmness in their haptic design for BP2. By anchoring emotions in physical sensations and spatial representations, participants were able to create more meaningful haptic feedback designs. This methodology facilitated a deeper emotional connection to the designs, fostering more meaningful and individualized user-centered single-modal haptic interaction making usage of the emotional memory of the user aligning with the principles of emotional design by Norman (2004) [40] mentioned in Section 2.

The participants’ feedback illustrates that a useful basis for communication was fostered, even though it was still challenging to express subjective emotional experiences to one another, which group B adapted to by extending the tandem on-body prototyping with the term ”bodystorming”.

BP1 contributed the following to the group discussion:

> ”So he [BP2] had an object as a small basketball and then when he shared his story with me about how he used to go to playing with his dad, etc. I understood what kind of emotion he connected with the object and maybe without the object I wouldn’t have been able to understand that good.”

This feedback contributes towards the clarification of RQ1 and RQ2 in Section 1.4 and demonstrates how embodied metaphors serve as a bridge between the emotional significance of an object and the haptic patterns designed to evoke similar feelings and how they can be integrated into haptic design processes. By anchoring the design in a familiar physical action or sensation, BP1 could create a more meaningful and resonant haptic experience for BP2.

BP2 further remarked,

> ”And then when I was designing, I tried to recreate a dribble of a basketball and that’s maybe not necessarily the feeling that he had or the exhaustion he felt or the playfulness during the match but that was what could I correlate with haptics. And in order to find that connection, the pattern, I think this metaphor was really useful for me to go through there and see that. And maybe I couldn’t have been able to do or find this easily if we hadn’t the metaphor or the story behind.”

This puts the object in a real-life setting, supporting the user empathizing process for user-centered design and therefore supporting the theory of the Experience Prototyping approach [11].

CP1 explained how the physical attributes of their object inspired their haptic design:

”I mainly used the part of ’physical characteristics.’ I found the size and texture of my object very inspiring... We translated the different textures into different haptic patterns.”

However, some participants found it challenging to translate complex or abstract metaphors into haptic feedback.

AP2 observed:

> ”I feel like this method can work well if you have a metaphor that can be translated easily into haptics, but... The more complex the initial embodied metaphor, the harder it is to translate.”

This suggests that while the methodology is effective for straightforward emotions, additional strategies may be needed to address more abstract or nuanced emotional states.

AP1 mentioned the desire for more creative freedom beyond straightforward translations:

”It helped identifying certain qualities or emotions I can focus on when designing haptics, but I also don’t find it very interesting translating it this straightforwardly. I want to be more creative, and body maps are better for that.”

This suggests that while embodied metaphors are valuable, they may require careful selection and simplification to be effectively integrated into haptic designs, particularly for novice interaction designers.

5.2.2 Body Maps

Body maps contributed to the emotional translation process by helping participants identify where emotions are felt in the body and consider appropriate actuator placement. Nummenmaa et al. (2014) explored body maps of emotions, showing how certain emotional states (e.g. Anger, Fear, Disgust, Happiness, Sadness, Neutral, Anxiety, Love, Depression, Contempt, Pride, Shame, Envy) have overlapping commonality in their physical experience in the body, reinforcing the important concept of norming considerate spatial placement of actuators to foster the research of recreational affective haptic feedback principles. Cochrane et al. (2022) further emphasized the importance of body mapping in understanding and documenting the somatic aspects of emotional experiences in design [15].

AP1 shared:

> ”I agree with the whole method of body maps helping to understand the emotion and where I feel it, and you can just become more aware of your own body.”

This self-awareness is crucial in affective design, as it allows designers to create more personalized and impactful haptic feedback. The activity encouraged participants to consider the physiological aspects of emotional experiences, such as the heightened sensitivity of certain body parts like the face, hands, and feet. This further emphasizes the role of embodied cognition (Hollan et al., 2000) [25] - emphasising the significance of bodily experiences and sensorimotor interactions in shaping cognitive processes - in the field of affective design, where the body becomes both a site of emotional experience and a design canvas constantly affecting each other.

However, challenges arose when attempting to stimulate certain body parts with haptic feedback. AP1 further explained:

> ”When it comes to translating now this body map to the haptic design, I think it's sometimes not really straightforward... Because it's one thing to have this feeling coming from the inside... and then it's another thing to provoke it with the external stimulator.”

CP1 noted a disconnect between initial mapping and later stages:

”We focused a lot on creating a certain sensation with the vibration motors and then didn't think all that much about where this sensation would work best because prototyping was easiest on the hands and we didn't really adapt it after—maybe because of lack of time.” This highlights the importance of allocating sufficient time for exploration and iteration in the design process. Future workshops should consider extending the duration or streamlining activities to allow participants to experiment with different actuator placements and refine their designs based on the insights gained from body mapping.

Participants reported discomfort when actuators were placed on sensitive areas like the chest or stomach, highlighting the need for careful consideration of actuator placement and the type of haptic stimuli used. This matches with Tsetserukou et al.'s (2009) findings on the importance of user comfort and the emotional appropriateness of stimuli in Affective Haptics [55].

5.2.3 Complementary Use of Embodied Metaphors and Body Maps

While embodied metaphors provided a valuable method for translating abstract emotions into haptic designs, the integration of body maps further enriched this process by helping designers consider the physical manifestation of emotions in the body. This complementary use of methodologies offered a multi-dimensional approach to affective haptic design, enhancing the depth and relevance of the prototypes developed. While both tools were valuable individually, their combined use presented some challenges. BP2 mentioned:

> ”In the second step... the body maps were just, for me, documentation... We didn’t use it for that type [on-body prototyping feedback] of communication.”

This indicates that participants may have struggled to integrate the insights from embodied metaphors and body maps seamlessly into their prototyping design process but they provided a valuable foundation for the preparation process. Future workshops could provide more guidance on how to effectively combine these methodologies before the prototyping process or enhance the usefulness of emotional translation and communication within (tandem) design teams during the on-body prototyping processes.

CP2 also emphasized the value of the methodology templates offered and the workshop workspace setup in the room (see Figure 1, Figure 2, Figure B) and on Miro (see Appendix B in the design process:

> ”They were great! Much needed to have a detailed overview of the design process. As you need to zoom in and out multiple times on the emotions, body parts, feelings, haptics, etc. This setup provided an opportunity to do so and freedom to do it the way you wish as a designer.”

Overall the use of embodied metaphors and body maps in the workshop helped participants articulate their emotions more effectively. Turmo Vidal et al. (2023) have shown how body maps serve as an insightful tool for understanding and documenting where emotions manifest physically [56], which aligns well with the proposed approach in the workshop. Additionally, Nardon and Hari (2021) emphasize the role of metaphors in bridging the gap between abstract emotional concepts and physical sensations, enhancing user engagement and emotional communication [39].

5.3 Technical and Conceptual Challenges in Affective Haptic Design

In response to RQ3: ”What challenges do novice designers face when designing affective haptic feedback, and how can these challenges be overcome?”, the study identified several obstacles that novice designers encountered, primarily related to technical complexity and the subjective nature of emotional interpretation. The varying levels of familiarity with haptic prototyping and coding skills among participants necessitated a workshop structure that could accommodate both relatively experienced individuals and complete novices. While the Haptic Labs toolkit provided a user-friendly interface, the technical limitations and the need for a deeper understanding of haptic software hindered some participants' ability to fully engage with the prototyping process. Furthermore, the subjective interpretation of emotions presented a challenge in designing universally resonant haptic feedback, as personal experiences and emotional responses varied widely among participants.

AP2's observation that

> ”applying the haptics to the body feels like you always come back to the same thing... I find it hard to see a completely different application”

underscores the constraints posed by limited actuator types and placement options. This suggests that expanding the variety of actuators and exploring alternative body areas could facilitate more diverse and innovative haptic designs, allowing designers to move beyond standard applications and explore new possibilities in affective haptic feedback.

Participant BP2 suggested that incorporating predefined haptic patterns and intensity settings into the software could enhance the usability and usefulness of the Hapticlabs Studio in the context of this affective haptic workshop toolkit.

> ”The software wasn't very intuitive. If you work with the body, you can already provide patterns and intensities reflecting on the type of feedback you want to get.”

This feature could help novice designers more quickly create and test haptic feedback aligned with specific emotional states.

5.3.1 Technical Complexity and Toolkit Limitations

Participants faced several technical challenges with the Hapticlabs DevKit and Hapticlabs Studio Software, including connectivity issues and a restriction of their design exploration through the limited amount of actuators - one of each kind, and two connectable at the same time to the hardware satellite - contained within the Hapticlabs DevKit. CP1 experienced hardware issues that hindered the design process and noted following feedback down in their concluding survey:

> ”Hardware challenges: Bluetooth connection was very bad and hindered the process, wire connection didn't work, and we had some issues with the interactions with the program as well (dragging, resizing, copying, selecting, going back).”

Similarly, BP2 highlighted the limitations of the Hapticlabs DevKit satellite that allowed the usage of two actuators at the same time:

> ”Only having two actuators was difficult because they unfolded their impact only locally.”

Technical limitations of the Haptic Labs toolkit, such as restricted actuator types and software usability issues, posed significant challenges. Participants like CP1 experienced connectivity problems and software glitches, which impeded the seamless execution of their design processes. Additionally, the limited number of actuators constrained the complexity and spatial distribution of haptic feedback patterns, potentially limiting the emotional expressiveness of the designs. These technical barriers suggest a need for more versatile and beginner-friendly prototyping tools to fully realize the potential of low-fidelity haptic prototyping in affective design.

These technical issues hindered participants' ability to fully explore and prototype their LoFi designs, suggesting the need for more robust and versatile non-coding hardware toolkits. This aligns with Seifi et al.'s (2019) emphasis on the importance of accessible, versatile, and user-friendly haptic design tools in their Haptipedia project [47].

AP1 also mentioned the constraints imposed by the hardware of the Hapticlabs Devkit:

> ”It's hard to design something when you only have one instance of a type of actuator... the kit didn't limit us in terms of ideation but implementation.”

BP2 suggested expanding the types of sensations available:

> ”Material that spreads a sensation over the skin! Or a sequence of actuators... The small local impact is not versatile enough.”

AP1 proposed practical additions to the kit:

> ”Maybe some magnets to attach the actuators more easily.”

This highlights the gap between creative ideas and the practical ability to realize them with the available tools.

5.3.2 Subjectivity of Emotional Interpretation

The subjective nature of emotions posed challenges in designing universally applicable affective haptic feedback, further proving the need for accessible research and design tools for affective haptic feedback to standardize haptic stimuli in a database as proposed by Eid and Al Osman(2016) [18] and mentioned in Section 1.5. BP2 observed:

> ”It was his really subjective feeling that I tried to resemble and implement... we had to give feedback to each other and communicate really well what we were trying to do.”

AP1 highlighted the difficulty in provoking internal feelings with external stimuli:

> ”It’s one thing to have this feeling coming from the inside... and then it’s another thing to provoke it with the external stimulator.”

This underscores the importance of communication and empathy in the design process, as well as iterative feedback to align the designer’s intent with the user’s experience. Ju et al. (2021) emphasized that empathy plays a crucial role in effective emotional design, highlighting that haptic interfaces need to convey nuanced emotional meanings to match user expectations accurately. Similarly, Vyas et al. (2023) identified individual emotional differences as a central challenge for designers of affective systems, suggesting the need for iterative prototyping and real-time feedback mechanisms. Eid and Al Osman (2016) further discussed the complexities of Affective Computing, noting that individual variability in emotional response requires systems that are adaptive and capable of multimodal interaction to ensure a meaningful user experience. These works illustrate that aligning technological intent with user experience in affective design demands a comprehensive, iterative, and user-centered approach [18, 28, 57] and suggest that designing affective haptic feedback requires a nuanced understanding of both the emotional and physiological aspects of the haptic UX.

BP2’s observation,

> ”It was his really subjective feeling that I tried to resemble and implement... we had to give feedback to each other and communicate really well what we were trying to do,”

highlights the challenge of interpreting and translating another person’s subjective emotional experience into a haptic design. This underscores the importance of effective communication and empathy in collaborative design processes, as well as the need for methods that can help bridge the gap between individual emotional perceptions.

Similarly, AP1’s reflection,

> ”It’s one thing to have this feeling coming from the inside... and then it’s another thing to provoke it with the external stimulator,”

emphasizes the complexity of eliciting internal emotional states through external stimuli. This points to the viability of incorporating both cognitive and somatic approaches in affective haptic design to create more authentic and tailored affective user experiences.

5.4 Tandem Design Approach: Enhancing Collaboration and Iterative Learning

One of the most significant contributions of the thesis and the workshop was the introduction of the Tandem Design approach, where participants alternated between the roles of designer and user. This collaborative methodology facilitated peer learning and fostered empathy between participants as they worked together to translate emotions into haptic feedback.

Low-fidelity on-body prototyping sessions were useful in facilitating immediate feedback and iterative design improvements, allowing participants to refine their haptic feedback patterns in real-time. This hands-on approach enabled participants to experiment with different haptic modalities and intensities, enhancing their understanding of how tactile feedback can evoke specific emotional responses. BP1's reflection,

> ”With some iterations, we managed to create the feeling we went for,”

highlights the potential of this iterative process in achieving the desired emotional affect.

5.4.1 Tandem Design Approach

The Tandem Design approach, where participants alternated between the roles of designer and user, facilitated collaboration and empathy. This approach aligns with participatory and user-centered design principles, as advocated by Buchenau and Suri (2000) in their work on Experience Prototyping [11].

Participants found value in this collaborative methodology. BP1 reflected:

> ”By hearing [BP2]'s story, I was able to do the design way easier, but still there is a gap on how I interpret the haptic feedback and how he interprets it and that also connects to the emotionality of the process.”

BP2 added:

> ”Through communication, I felt like it was way better that we expressed the first-person felt experience.”

This approach allowed participants to gain insights into each other's emotional experiences and tailor their designs accordingly.

However, the subjectivity of emotions still posed challenges, as participants had to navigate differences in emotional interpretation and ensure that their designs resonated with their partners.

BP2 highlighted the importance of communication in navigating subjective emotional experiences:

> ”It was his really subjective feeling that I tried to resemble and implement... We had to give feedback to each other and communicate really well what we were trying to do.”

5.4.2 Impact of the Tandem Design Approach versus single-designer Setting

The Tandem Design approach employed in our study significantly enhanced the affective haptic design process by embodying principles of Experience Prototyping as described by Buchenau and Suri (2000) [11]. This approach aligns with their assertion that ”Experience Prototyping simulates important aspects of the whole or parts of the relationships between people, places, and objects as they unfold over time” (p. 431), contributing to design in three key ways: understanding existing user experiences, exploring and evaluating design ideas, and communicating ideas to an audience.

By alternating roles between designer and user, participants engaged in a form of experiential learning that allowed them to gain firsthand appreciation of each other’s emotional and somatic experiences. This facilitated a deeper understanding of the essence of the emotional states they aimed to evoke through haptic feedback. BP2 reflected on this process:

> ”Through communication, I felt like it was way better that we expressed the first-person felt experience... we had to give feedback to each other and communicate really well what we were trying to do.”

This collaborative dynamic mirrors Buchenau and Suri’s (2000) emphasis on the importance of shared experiences in developing a common vision within a multidisciplinary team:

> ”To work effectively as a design team it is important to develop a common vision of what the team is trying to bring into being. Therefore, it is a powerful asset to have tools and techniques, which create a shared experience, providing a foundation for a common point of view” [11]

In the context of our study, the Tandem Design approach enabled participants to explore and evaluate design ideas more effectively. By experiencing the haptic feedback designed by their partners, participants could provide immediate, subjective feedback, facilitating iterative refinement. BP1 noted:

> ”By hearing [BP2]’s story, I was able to do the design way easier.”

This experiential engagement resonates with the idea that

> ”Information becomes more vivid and engaging when it resonates with personal experience” [11]

, leading to designs that are more attuned to users’ emotional needs.

Conversely, a single-designer setting, where individuals design haptic feedback for themselves, lacks this level of collaborative insight. While designing for oneself allows for an intimate understanding of personal emotions, it may also introduce limitations related to personal biases and a narrower perspective. AP1 expressed challenges in articulating personal feelings:

> ”It’s one thing to have this feeling coming from the inside... and then it’s another thing to provoke it with the external stimulator.”

This introspective approach might limit the exploration of diverse emotional expressions and reduce opportunities for validation through external feedback. Buchenau and Suri (2000) caution that

> ”The tools we use to design, such as prototypes, influence the way we think. Solutions, and probably even imagination, are inspired and limited by the prototyping tools we have at our disposal” [11]

. In a single-designer setting, the lack of collaborative tools like the Tandem Design approach may constrain the designer’s ability to think beyond their own experiences.

Moreover, the Tandem Design approach helps designers

> ”[..] get away from technological limitations [and] focus on exploring the human perspective, somatic experience.” [11]

Participants in our study emphasized the value of focusing on the user’s bodily experiences rather than being constrained by technical aspects. BP2 stated:

> ”We were kind of narrowing ourselves a bit because we were having this kind of metaphor in our head and trying to re-enact it through the vibration... But for the first part, I would definitely say that it was nice to think about where emotion happens and how that could be.”

This reflects the importance of prioritizing the human experience in design, a core tenet of Experience Prototyping.

However, the Tandem Design approach also presented challenges. Participants had to navigate subjective interpretations of emotions and ensure clear communication to align their design intentions. BP2 observed:

> ”It was his really subjective feeling that I tried to resemble and implement... and that also connects to the emotionality of the process.”

This highlights a potential limitation, as effective Experience Prototyping requires careful consideration of

> ”[..]setting the stage[..]”

and being explicit about context, as Buchenau and Suri (2000) suggest:

> ”To create an appropriate prototype we need to determine [..] what context surrounds the user experience.”[11]

In comparing the two approaches, it becomes evident that the Tandem Design method enhances the design process by fostering empathy, collaborative exploration, and richer communication of ideas. It supports the three key contributions of Experience Prototyping identified by Buchenau and Suri (2000):

1. **Understanding existing user experiences and context**: By engaging with a partner’s emotional experiences, designers gain insights that might be inaccessible in a single-designer setting.
2. **Exploring and evaluating design ideas**: Collaborative prototyping allows for immediate feedback and iterative refinement, aligning with the notion that:

   > ”Experience Prototyping can provide inspiration, confirmation or rejection of ideas based upon the quality of experience they engender.” [11]

3. **Communicating ideas to an audience**: Shared experience facilitates a common understanding, essential for multidisciplinary collaboration.

In a single-designer setting, while the designer may have a deep understanding of their own emotions, the lack of external input may limit the design’s applicability and resonance with others. As AP1 suggested, allowing for personal expression is valuable, but incorporating others’ perspectives enriches the design process:

> ”Maybe in the future it makes sense to let people describe their own words, feelings, and then try to limit those. But initially, so that the exploration part is there.”

In conclusion, the Tandem Design approach, embodying the principles of Experience Prototyping, significantly enhances the affective haptic design process by enabling designers to engage more deeply with users’ emotional and somatic experiences. It overcomes some limitations of designing solely for oneself by fostering empathy, promoting collaborative exploration, and improving communication of design ideas. This approach aligns with Buchenau and Suri’s (2000) emphasis on the value of active engagement and shared experiences in design, ultimately leading to more meaningful and resonant haptic feedback systems.

5.5 Methodological Considerations

The study’s methodology provided valuable insights but also presented certain limitations.

5.5.1 Workshop Structure

While the workshop provided valuable insights, some participants found the structure confusing or rushed. AP1 commented:

> ”I thought there were multiple activities throughout the workshop that you kind of skipped and moved to the bigger ones... which kind of made me feel confused.”

AP2 echoed:

> ”There was a part where we kind of did some small things very quickly and then moved on right away to the next thing. But it felt like just a little bit quick or something.”

These remarks indicate a necessity for more explicit instructions, improved pacing, and more seamless transitions between activities in forthcoming workshops.

BP1 appreciated the interactive nature of the workshop:

> ”I love that you made it more interactive... Having like your part of like how I did it then was easier for me to understand the whole situation and I went onwards.”

CP2 described the initial challenge and eventual benefit of the workshop:

> ”It was new to me which made it challenging at first. However, the structured and organized approach used during the workshop made it a guided process.”

The suggestion by CP1 to include a physical prototyping phase—

> ”brainstorm on metaphors and where you could possibly put the device... and maybe also prototype with fabrics or other things before using the software”

— indicates a need for more tactile exploration in the design process. Incorporating this step could help designers better visualize and test how the haptic feedback device integrates with the body, potentially leading to more innovative and user-friendly designs.

Participants expressed a desire for more exploratory and creative processes within the workshop. BP2 mentioned, ’

> ”I would love to keep an explorative and creative process, something like body-storming.”

Incorporating such methodologies could foster innovation and allow designers to experiment more freely with haptic feedback concepts.

After considering how the body map and embodied metaphor elicitation sheet templates were used during the prototyping process, they were useful in establishing a baseline using the materials provided for collaborative prototyping. However, during the prototyping phase, the workshop structure should encourage unrestricted exploration, regardless of whether it incorporates previously introduced methodologies from the tandem on-body prototyping.

5.5.2 Use of Personal Objects

Using personal objects helped ground the emotional exploration but also limited the scope of emotions considered. CP1 mentioned:

> ”Having the comfort objects here for inspiration was very helpful, though I do think they guided our design very strongly, maybe a bit too strongly.”

This indicates that while personal objects provide a relatable starting point, they may constrain creative exploration if relied upon the contained emotion or interaction with it exclusively. Future workshops could encourage participants to explore a wider range of emotions beyond those associated with their personal objects and just use them for the introduction of metaphorical thinking.

While personal objects helped ground the emotional exploration, participants like CP1 felt that they might have guided the design too strongly, potentially limiting creativity:

> ”I do think they guided our design very strongly, maybe a bit too strongly.”

This suggests that while personal objects provide a relatable starting point, they may constrain designers to specific emotions associated with those objects. Future workshops could encourage participants to explore a wider range of emotions beyond those directly associated with their personal items, promoting a more comprehensive understanding of affective haptic design principles.

AP1 advocated for allowing participants to define their own emotional terms:

> ”Maybe in the future it makes sense to let people describe their own words, feelings, and not try to limit those to emotions... So that the exploration part is there.”

Although using personal objects helped ground the emotional exploration by providing tangible references, this approach may have inadvertently limited the scope of emotions considered. Participants primarily associated their objects with positive emotions, which constrained the exploration to a narrower emotional spectrum. To encourage a wider range of emotional exploration, future workshops could introduce neutral or unfamiliar objects or encourage participants to consider emotions beyond those directly associated with their personal items. This would promote a more comprehensive understanding and application of affective haptic design principles.

6 Conclusion

This study explored the development and evaluation of a modular methodological toolkit designed to support novice interaction designers in creating affective haptic feedback systems.

By integrating established psychological models such as the Circumplex Model of Affect [45], Emotion Typology [43], along with embodied metaphor elicitation [5] and body mapping [15], the toolkit aimed to bridge the gap between abstract emotional concepts and tangible haptic prototypes. The findings from this study address the initial research questions (see in Section 1.4) and contribute valuable insights into the fields of Affective Haptics and HCI.

6.1 Summary of Key Contributions

The most significant contribution of this research is the demonstration of how a structured methodological toolkit can aid novice interaction designers in the complex task of creating affective haptic feedback. The integration of theoretical frameworks and practical methodologies provided participants with tools to articulate emotions, translate them into haptic designs, and iteratively refine their prototypes based on user feedback.

6.1.1 Emotion Articulation and Translation

The use of the Emotion Typology and the Circumplex Model of Affect significantly enhanced participants' ability to articulate and categorize emotions. As BP2 noted:

> "What I really liked was that you in the beginning brought in the scope of, for me, emotions and how these are called or how they feel because... it would be hard to come up with the description that I came up with without looking at the emotions that you presented us today."

This structured approach enabled participants, including non-native English speakers like AP2, to expand their emotional vocabulary and provided a foundation for designing haptic feedback that aligns with specific emotional states. This aligns with Russell's (1980) and Posner et al.'s (2005) emphasis on the utility of such models in organizing emotional experiences [43, 45].

6.1.2 Embodied Metaphors and Body Maps

The methodologies of embodied metaphors and body maps proved instrumental in bridging the gap between abstract emotions and tangible haptic designs. Participants like BP1 and BP2 successfully used embodied metaphors to inform their designs. Participant BP1 explained:

> "When I was designing, I tried to recreate a dribble of a basketball... And maybe I wouldn't have been able to... find this easily if we hadn't the metaphor or the story behind."

This approach resonates with Bakker et al.'s (2012) findings on the effectiveness of embodied metaphors in interaction design [5]. Body maps further aided in visualizing where emotions are felt in the body, assisting in actuator placement decisions. AP1 highlighted:

> ”I agree with the whole method of body maps helping to understand the emotion and where I feel it, and you can just become more aware of your own body.”

These tools collectively enhanced the emotional translation process, enabling participants to design haptic feedback that is more aligned with users’ emotional experiences.

6.1.3 Tandem Design Approach

A Tandem Design approach was used in the workshop of this study, where participants alternated between the roles of designer and user, fostering collaboration, empathy, and iterative learning. This participatory methodology allowed for real-time feedback and refinement, essential in affective haptic design where emotional nuances are critical. BP2 reflected:

> ”Through communication, I felt like it was way better that we expressed the first-person felt experience.”

This approach aligns with Buchenau and Suri’s (2000) concept of Experience Prototyping, emphasizing the importance of designers immersing themselves in the user’s experience to create more effective designs [11].

6.1.4 Toolkit Usefulness and Limitations

The use of the Hapticlabs DevKit lowered some technical barriers by eliminating the need for coding, allowing participants to focus more on the creative aspects of haptic design. However, limitations in hardware diversity and software usability constrained participants’ ability to fully explore and prototype their designs. CP1 mentioned:

> ”Hardware challenges: Bluetooth connection was very bad and hindered the process... we had some issues with the interactions with the program as well.”

These limitations highlight the need for more versatile and user-friendly tools to support novice interaction designers, as emphasized by Seifi et al. (2019) in their Haptipedia project [47].

6.2 Addressing the Research Questions

The following section will address the research questions of this thesis one by one, which were proposed in section 1.4.

6.2.1 RQ1: Impact of Embodied Metaphors in Combination with Body Maps

Embodied metaphors and body maps improved the design and communication process for novice interaction designers by providing concrete tools to articulate and translate experiential emotions into haptic designs. Participants reported that these tools helped them map emotional experiences to physical sensations, leading to more meaningful and personalized haptic feedback.

For instance, participant BP1 used the metaphor of a basketball dribble to create haptic patterns that resonated with their partner's emotional narrative, enhancing empathy and user-centered design. BP1 noted:

> ”By hearing [BP2]'s story, I was able to do the design way easier.”

Additionally, body maps enabled designers to identify where emotions are physically felt, informing actuator placement and haptic intensity. Participant AP1 expressed:

> ”I agree with the whole method of body maps helping to understand the emotion and where I feel it, and you can just become more aware of your own body.”

These tools also enhanced communication among designers and between designers and users. By using shared metaphors and visual representations of emotional experiences, participants found it easier to convey abstract feelings and collaborate effectively.

However, challenges were encountered when dealing with complex or abstract metaphors that were difficult to translate into haptic feedback. Participant AP2 observed:

> ”I feel like this method can work well if you have a metaphor that can be translated easily into haptics, but... the more complex the initial embodied metaphor, the harder it is to translate.”

Furthermore, certain body areas were sensitive or uncomfortable for actuator placement, limiting the use of body maps in some cases. Participants reported discomfort when actuators were placed on areas like the chest or stomach.

To mitigate these challenges, future applications should provide additional guidance on selecting and simplifying metaphors, perhaps incorporating workshops on metaphor creation and translation. Alternative strategies, such as offering a library of sample metaphors or encouraging iterative testing with user feedback, can aid in translating complex emotions. Designers should also consider user comfort and preferences when determining actuator placement, possibly by allowing users to select preferred stimulation areas.

Overall, embodied metaphors and body maps proved to be valuable tools that, when carefully adapted, can greatly enhance the affective haptic design process for novice designers by fostering empathy, improving communication, and grounding abstract emotions in tangible designs.

6.2.2 RQ2: Structuring Low-Fidelity On-Body Prototyping Sessions

The structured low-fidelity on-body tandem prototyping sessions centered around the Tandem Design approach significantly enhanced participants' ability to test and refine their designs based on real-time feedback iteratively. This hands-on, collaborative process fostered empathy and a deeper understanding of users' emotional experiences.

By alternating roles between designer and user, participants gained firsthand insights into how their designs impacted others, leading to more emotionally resonant haptic feedback. Participant BP2 remarked:

> ”Through communication, I felt like it was way better that we expressed the first-person felt experience... we had to give feedback to each other and communicate really well what we were trying to do.”

This collaborative environment enriched perspectives and improved communication, enabling designers to receive immediate feedback and make adjustments accordingly.

However, technical limitations hindered the sessions. Hardware constraints, such as limited actuator types and connectivity issues with the Hapticlabs DevKit, restricted the scope of exploration and sometimes caused frustration. Software usability issues also impeded the smooth execution of prototypes.

Additionally, participants identified a need for clearer communication strategies to effectively convey and interpret emotional feedback. The subjective nature of emotions meant that without effective dialogue, designers might misinterpret user responses.

To improve future prototyping sessions, it is recommended to incorporate more robust and versatile hardware, such as devices with a greater variety of actuators and reliable connectivity. Providing training on effective communication techniques, including active listening and articulating emotional experiences, can enhance collaboration. Structured communication exercises or guidelines could be integrated into the sessions to support this.

By addressing technical limitations and enhancing communication strategies, future low-fidelity on-body prototyping sessions can further optimize the benefits of the Tandem Design approach, leading to more effective and emotionally resonant haptic designs.

6.2.3 RQ3: Challenges Faced by Novice Interaction Designers

Novice interaction designers faced several challenges during the integration of haptic feedback into low-fidelity prototypes. Technical complexities, such as software glitches and limited hardware capabilities, impeded their ability to create diverse and sophisticated haptic designs. For example, participant CP1 experienced hardware issues:

> ”Hardware challenges: Bluetooth connection was very bad and hindered the process... we had some issues with the interactions with the program as well.”

The limited number of actuators and types available restricted creative possibilities, making it difficult to prototype complex haptic patterns or spatially distributed feedback. Participant AP1 noted:

> ”It’s hard to design something when you only have one instance of a type of actuator... the kit didn’t limit us in terms of ideation but implementation.”

The subjective nature of emotional interpretation added another layer of difficulty. Designers grappled with translating personal emotions into haptic patterns that would be universally understandable and emotionally impactful. As participant AP1 expressed:

> ”It’s one thing to have this feeling coming from the inside... and then it’s another thing to provoke it with the external stimulator.”

Individual differences in emotional experiences and perceptions made it challenging to create designs that resonated with others.

To overcome these obstacles, several mitigation strategies are suggested:

- **Technical Enhancements**: Providing more intuitive and reliable technical tools can reduce technical barriers. This includes hardware with diverse and multiple actuators, stable connectivity, and beginner-friendly software interfaces with features like predefined haptic patterns.
- **Prior Comprehensive Training**: Offering training prior to the main activities that cover both the technical aspects of haptic design and the nuances of emotional translation can better prepare novice designers and therefore make better use of the limited time for the exploratory experience prototyping process. Workshops on haptic technology, emotional expression, and user experience design can enhance the competence and confidence of novice interaction designers.
- **Emphasis on Communication and Empathy**: Encouraging open dialogue, active listening, and empathy in the design process is crucial. Techniques such as empathic interviewing and collaborative reflection can help designers understand users’ emotional states more deeply.
- **Mentorship and Support**: Providing access to experienced mentors or facilitators can guide novice designers through challenges, offering advice and sharing best practices.

By implementing these strategies, novice interaction designers can be better equipped to navigate technical complexities and the subjective nature of emotional interpretation, leading to more effective and innovative haptic designs.

6.2.4 RQ4: Accessibility Through the Proposed Modular Toolkit

The study found that making on-body affective haptic prototyping accessible to novice interaction designers requires a synergistic combination of user-friendly tools and well-structured methodologies. In response to this need, this thesis proposes a modular toolkit approach that integrates both hardware and methodological components specifically designed to lower technical barriers and enhance the learning experience for novices as described in table 3.

Description of the Modular Toolkit:

The proposed modular toolkit comprises:

No.	Component Description
1.	**Hardware Component** - *Simple Haptic Hardware Kit*: A no-coding-based haptic hardware toolkit that includes a variety of actuators (e.g., vibration motors, linear resonant actuators) designed for ease of use (e.g., Hapticlabs DevKit). - *Possible Enhancements and Accessories*: Extension cords, magnets, and wireless connectivity options to facilitate flexible actuator placement and improve usability.
2.	**Software Component** - *User-Friendly Interface*: An intuitive software platform with compatibility with the chosen hardware kit, offering predefined haptic patterns and intensity settings to simplify the design process. - *Compatibility Features*: Support for multiple actuators simultaneously, allowing for more complex and spatially distributed haptic feedback.
3.	**Methodological Framework** - *Embodied Metaphors*: Techniques to help designers translate abstract emotions into tangible haptic experiences. - *Body Mapping*: Tools for identifying where emotions are felt in the body to inform actuator placement. - *Tandem Design Approach*: A collaborative method where designers alternate roles between designer and user during on-body prototyping, fostering empathy and iterative refinement. - *Expanded Emotional Scope*: Flexibility for participants to define their own emotional terms and explore beyond predefined categories.

Table 3: Overview of Toolkit Components and Methodological Framework

How the Toolkit Answers RQ4:

The modular toolkit directly addresses RQ4: "What tools and methodologies are needed to make on-body affective haptic prototyping accessible to novice interaction designers?", by providing guidelines for an integrated solution of methodological tools and hardware kits that makes on-body affective haptic prototyping accessible to novice interaction designers.

Lowering Technical Barriers: The hardware and software components eliminate the need for coding expertise, allowing novices to focus on creative design aspects. Participant CP2 appreciated this ease of use:

> ”It was new to me which made it challenging at first. However, the structured and organized approach used during the workshop made it a guided process.”

Enhancing Creative Exploration: The methodological framework guides participants in articulating emotions and translating them into haptic feedback, enhancing both the design process and the communication of ideas. The flexibility to define personal emotional terms encourages unrestricted creative exploration.

Facilitating Empathy and Collaboration: The Tandem Design approach fosters a collaborative environment where participants gain firsthand insights into user experiences, leading to more emotionally resonant designs.

Evidence from the Study:

Participants in the workshop effectively utilized the toolkit to create affective haptic prototypes. Despite some limitations, the toolkit’s combination of user-friendly hardware and supportive methodologies enabled novices to engage with haptic design in meaningful ways.

However, limitations were observed, and participants suggested improvements:

Hardware Constraints: Limited actuator types and connectivity issues restricted exploration. Participant BP2 suggested:

> ”Only having two actuators was difficult because they unfolded their impact only locally... Material that spreads a sensation over the skin! Or a sequence of actuators... The small local impact is not versatile enough.”

Methodological Constraints: Some participants felt constrained by predefined emotional categories. Participant AP1 recommended:

> ”Maybe in the future it makes sense to let people describe their own words, feelings, and not try to limit those to emotions... So that the exploration part is there.”

Future Improvement Suggestions: To enhance the toolkit’s usefulness and accessibility, future efforts should focus on:

Hardware Enhancements: Incorporating more versatile actuators, improving connectivity, and providing accessories for easier on-body prototyping.

Software Preparation or Introduction: Developing more intuitive interfaces with additional features like customizable haptic patterns and multi-actuator support and giving a thorough introduction to the basic functionalities is recommended.

Methodological Refinements: Expanding the methodological framework to include practices like body-storming and allowing for greater flexibility in emotional expression.

Comprehensive Support Materials: Providing detailed guides, tutorials, and prior introduction activities to aid novices in using the toolkit effectively before diving into the main activities.

Conclusion:

By proposing and evaluating this new modular toolkit, this section provides a concrete answer to RQ4: "What tools and methodologies are needed to make on-body affective haptic prototyping accessible to novice interaction designers?". The workshop outcomes and participants' feedback demonstrate that a carefully designed combination of user-friendly hardware, intuitive software, and supportive methodologies can make on-body affective haptic prototyping accessible to novice interaction designers. This integrated approach addresses technical limitations, supports creative exploration, and substantially fosters the prototyping stage for the development of affective haptic feedback systems.

6.3 Implications for Future Research and Practice

The findings from this study have several implications for future research and practice in affective haptic design and HCI:

6.3.1 Enhancing Educational Tools and Resources

Integrating structured emotional frameworks and practical methodologies into interaction design education can aid novice interaction designers in their affective haptic prototyping processes. As participant AP1 suggested, providing more vague and broader emotional vocabularies can encourage greater creativity and personal expression.

The use of the toolkit could enhance the learning process for novice interaction designers by providing structured methods for prototyping, aligning with Spinuzzi's (2005) principles of participatory design and Buchenau's approach of Experience Prototyping [11, 51]. By further expanding and incorporating methods like Moussette's (2012) "sketching in hardware," the toolkit could lower learning barriers, making haptic prototyping more accessible and engaging for those without a deep technical [38] or psychology background.

6.3.2 Improving Haptic Prototyping Toolkits

Developing more versatile and beginner-friendly haptic prototyping toolkits and frameworks is essential. This includes incorporating a wider variety of actuators capable of producing diverse sensations (e.g., pressure, temperature, texture), improving software interfaces to be more intuitive and supportive of creative exploration, and offering accessible methodologies to bridge the psychological component of emotional design with the technical development of prototypes. Improving the control software interfaces of the haptic hardware kits to be more intuitive and supportive of creative exploration is equally important. Simplifying the interaction with software and including pre-designed haptic feedback patterns and interactive tutorials could lower the entry barrier for novice interaction designers. This enhancement would allow designers to focus more on the creative aspects of haptic design without being hindered by technical complexities.

6.3.3 Emphasizing Collaborative and User-Centered Design Approaches

Encouraging collaborative methodologies like the Tandem Design approach can enhance empathy and communication in the prototyping design process, leading to more effective and emotionally resonant haptic feedback systems. This approach fosters a deeper understanding of users' emotional experiences and supports iterative refinement based on real-time feedback, facilitating greater empathy and iterative refinement of designs.

6.3.4 Expanding Research Contexts and Participant Diversity

Future research should involve a larger and more diverse participant pool to capture a broader range of experiences and perspectives. Involving participants from different cultural backgrounds, age groups, and levels of design experience would enhance the validity and applicability of the results, ensuring that the toolkit and methodologies are applicable to a broader audience.

Testing the components of the modular toolkit in various application domains, such as mental health therapy, entertainment technology, and social communication, can provide deeper insights into its effectiveness, usefulness, and versatility. This broader application could reveal unique challenges and opportunities specific to different contexts.

6.3.5 Conducting Longitudinal Studies

Longitudinal studies would allow for the assessment of the sustained impact of the individual components of the modular toolkit (e.g., hardware, software, methodologies) on participants' skills and their ability to engage in affective haptic design over time. This could inform the development of more effective educational programs and resources. By tracking participants' progress over extended periods, researchers can gain insights into how proficiency and confidence in affective haptic design develop and how sustained use of the toolkit influences design practices.

6.3.6 Improving Workshop Structure and Communication Strategies

Feedback indicated that aspects of the workshop structure could be improved to enhance participant engagement and learning outcomes. AP1 mentioned feeling confused due to skipped activities and redundant information.

Addressing these issues by providing clearer instructions, better pacing, and ensuring that all activities are meaningfully integrated could improve the overall effectiveness of the workshop.

Future workshops should strive for a balance between structured guidance and flexible exploration to support learning and creativity.

Additionally, participants identified a need for clearer communication strategies to effectively convey and interpret emotional feedback. The subjective nature of emotions means that without effective dialogue, designers might misinterpret user responses. Providing training on effective communication techniques, including active listening and articulating emotional experiences, can enhance collaboration and reduce misunderstandings.

6.4 Limitations of the Study

Several limitations must be acknowledged:

- **Sample Size and Diversity**: The small and relatively homogeneous participant sample limits the generalizability of the findings. All participants were advanced students in HCI-related fields, which may have influenced their engagement with and comprehension of the proposed methodologies and tools used in this workshop.
- **Technical Constraints**: Hardware limitations, such as the limited number and type of actuators, impacted participants' ability to fully explore and implement their haptic design ideas. Software usability issues also hindered the design process for some participants.
- **Workshop Structure**: Some participants found parts of the workshop confusing or rushed, indicating a need for prior familiarization sessions with the hardware and software used in the workshop, considerate time planning for the included activities of the workshop, clearer instructions and better pacing during the execution of it.

These limitations suggest that the findings may not fully represent the challenges faced by a broader or more diverse group of novice interaction designers in learning the principles of affective haptic feedback design. Regardless, the limited number of participants is only sufficient to explore Europe's cultural differences and needs further exploration in future studies to investigate cultures that have stronger differences in perception of affective touch or haptic technologies.

6.5 Ethical Considerations

Given the deeply personal nature of affective haptic design, ethical considerations were paramount in this study. Participants engaged with intimate emotional experiences, necessitating careful handling to ensure their well-being. This thesis adhered to ethical guidelines by obtaining informed consent, ensuring participants were fully aware of the study's objectives and their right to withdraw at any time. During discussions of personal emotions, it was made sure to not overwhelm or force any participant to share and notice attentive to signs of discomfort, and provide support or time as needed. Additionally, this study avoided eliciting negative emotions that could cause distress, aligning with the American Psychological Association's (2017) Ethical Principles of Psychologists and Code of Conduct [10].

6.6 Final Remarks

A modular methodological toolkit was created to support novice interaction designers in creating AHFS. By combining theoretical frameworks with practical methodologies, collaborative approaches, and the creation of a workshop structure and methodological templates specified for single-modal affective haptic design with a no-coding haptic hardware toolkit, this thesis addresses key challenges in teaching and researching affective haptic prototyping.

While technical limitations and the subjective nature of emotions present ongoing challenges, the positive reception of the toolkit and methodologies indicates a promising direction for future development. As BP1 suitably concluded:

> ”Connecting emotions through the objects creates a very important baseline and conceptual understanding for the haptic design.”

This thesis addresses key challenges in teaching and researching affective haptic prototyping by combining theoretical human-centered methodologies and a version of a commercial non-coding haptic prototyping kit. It further emphasizes the importance of emotional resonance and human-centered design in technological innovation regarding the imitation and utilization of human touch properties, i.e. vibrotactile haptic feedback, and the impactful reactions that can be triggered within the users of these affective haptic systems. Refining the toolkit and enhancing educational resources will empower new interaction designers to engage deeply with the emotional aspects of haptic human-computer interaction through collaborative, user-centered practices.

The insights gained from this study provide a foundation for future work aimed at developing more sophisticated, user-centered, and emotionally personalized affective haptic interaction prototypes. By managing the pinpointed challenges and incorporating the suggested workshop refinements, future iterations of the toolkit and workshop structure can further advance the field, ultimately enhancing the research and prototyping processes of how we interact with technology on an emotional level and therefore empowering novice interaction designers to create AHFS that genuinely connect with target users on a profound personal emotional level. This ensures that this delicate third-wave HCI topic steers the development and research of Affective Haptics in a positive, empowering, and ethically considerate direction.

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Appendices

Include any additional materials, such as detailed survey questions, workshop scripts, or extended data analysis, that support the main text. These appendices provide transparency and allow for a deeper understanding of the research process.

A Survey Questions

Here is the complete list of survey questions used during the initial and final surveys, with clear distinctions between pre- and post-workshop items. This helps to illustrate how participants' understanding and skills evolved throughout the workshop and provided valuable qualitative feedback to critically reflect on the toolkit, Hapticlabs DevKit, and workshop structure.

Pre-Workshop Survey Questions

1. **Haptic Experience** *What is your prior experience with designing haptics?*
2. **Embodied Metaphors**
    - *What is your prior experience with embodied metaphors?*
    - *What do you know about embodied metaphors? Have you heard of them before?*
3. **Body Maps**
    - *What is your prior experience with body maps?*
    - *What do you know about body maps? Have you heard of them before?*
4. **Demographics**
    - *What is your age?*
    - *What is your level of education?*
    - *What is your previous education?*
    - *What is your current job title?*
    - *What is your field of profession?*
    - *What career are you pursuing?*
5. **Object-Based Questions**
    - *What object did you bring to the workshop?*
    - *What emotion is attached to this object?*
    - *What adjective would you use to describe this object?*

6. **Attribute Scale** *Rate your familiarity with the following skills (1 = not familiar, 5 = very familiar):*

    - Haptic Prototyping
    - On-body Prototyping
    - Coding
    - Haptic Design
    - Affective Haptic Design

Post-Workshop Survey Questions

1. **Workshop Usefulness** *How useful do you think the workshop was in helping you understand and use haptic feedback in your designs?*

2. **Body Maps and Embodied Metaphors**

    - *How helpful did you find the body maps in guiding your design process? Would you use this methodology again?*
    - *How useful were the embodied metaphors in translating emotions into haptic patterns? Would you use this methodology again?*
    - *Can you provide an example of how a specific embodied metaphor influenced your design?*

3. **Prototyping and Toolkit Usage**

    - *What were the main challenges you faced during the prototyping process?*
    - *How did the haptic feedback designs align with the emotions you intended to evoke?*
    - *What materials would you suggest including in the workshop kit to improve the prototyping process?*
    - *Do you have any suggestions for improving the toolkit or the prototyping process?*

B Supplementary Materials

A FH Salzburg Mediacube git-Repository

Github Repository for the methodological toolkit materials and exemplary user data from the workshop: `https://gitlab.mediacube.at/fhs49792/affective-haptic-labs-workshop-documents.git`

B Miro Board Template

The workshop utilized a Miro board as a central tool for guiding participants through the various stages of the workshop, including the body mapping, metaphor elicitation, and prototyping phases. The board provided a shared digital space for all participants to collaborate and reflect on their design processes.

To allow for replication or adaptation of the workshop structure, a template of the Miro board used during the workshop can be accessed via the following link:

Workshop Miroboard Template: `https://miro.com/app/board/uXjVLZy8Sr4=/?share_link_id=272522379747`

This link leads to a copy of the Miro board without any participant data, enabling future researchers or practitioners to use the template for their own studies or workshops.

C Informed Consent - Workshop

In this appendix section, the informed consent document used for the Affective Haptic On-Body Tandem Workshop is presented (Figure 57). The document ensures participants are fully informed about the workshop's purpose, procedures, data collection methods, and their rights as participants, including confidentiality and the option to withdraw at any time.

This form was handed out to the participants before the conduction of the workshop. This ensured they were informed about the workshop procedures, had the time to gather information about haptic design, and freely decide whether they wanted to participate.

C Glossary of Terminologies

Haptic Feedback: The use of tactile sensations (e.g., vibrations, forces) to simulate touch experiences or convey information through a user interface, commonly applied in devices like smartphones and wearables.

Circumplex Model of Affect: A framework for categorizing emotions across two dimensions: valence (positive-negative) and arousal (low-high). It is used to map and understand emotional experiences in affective computing and design.

Valence: In the Circumplex Model of Affect, valence refers to the emotional dimension ranging from negative (unpleasant) to positive (pleasant) feelings, indicating the positivity or negativity of an emotional experience.

Arousal: In the Circumplex Model of Affect, arousal denotes the intensity of emotional or physiological activation, ranging from low (calm, relaxed) to high (excited, alert).

Informed Consent Document for Affective Haptic On-Body Tandem Workshop

Master Thesis Workshop by Vincent Göke

Date & Location:

23.06.24: 11:00 AM to 03:00 PM

FH Salzburg Campus Urstein SE 357

Workshop Overview

Welcome to the Affective Haptic On-Body tandem Workshop!
This workshop is designed to introduce you to the basics of haptic technology and guide you through creating and prototyping emotionally affective haptic systems. Within 4 hours, you will work in pairs to explore the potential of haptic feedback in enhancing user experience through emotionally resonant designs.
Please **bring an object that evokes a specific emotion you feel comfortable sharing in a group activity** to help us understand embodied metaphor elicitation.

Purpose of the Study

This FH-Salzburg master thesis workshop is designed to **explore the design process of low-fidelity (LoFi) affective haptic on-body prototyping**. This study aims to understand the **usefulness of embodied metaphors, body maps, and a haptic hardware toolkit in helping novice haptic designers** create emotionally resonant haptic feedback systems.

The workshop will investigate the following research questions:

1. What is the impact of using embodied metaphors and body maps on the design and communication process of haptic feedback for novice haptic designers?
2. How can low-fidelity on-body tandem prototyping sessions with haptic feedback be structured to elicit valuable insights into emotional responses from users?
3. What specific challenges do novice haptic designers encounter when integrating haptic feedback into low-fidelity on-body prototype design concepts?
4. How can the use of a haptic hardware toolkit make on-body affective haptic prototyping accessible to novice haptic designers?

Figure 57: Informed Consent Document for the Affective Haptic On-Body Tandem Workshop Page 1

Data Collection

Data will be collected through various means during the workshop to ensure comprehensive insights into the research questions:

- Pre-workshop surveys collect participants' experiences and feedback.
- Documentation on the Miro board including body maps, metaphor elicitation sheets, notes, photos, short prototyping videos, and voice recordings.
- Group discussions to capture qualitative data on participants' experiences and insights.

Participant Rights

- Participation in this study is voluntary.
- You may withdraw from the study at any time without any consequences.
- All data collected will be kept confidential and used solely for research purposes and deleted after the final submission of the master thesis document.
- Results from this study may be published, but no personally identifiable information will be shared.

Contact Information

If you have any questions or concerns about the study, please contact:

Vincent Göke
Ratsbriefstraße 4
5020 Salzburg
vgoeke.hcie-m2022@fh-salzburg.ac.at
Tel: +436787816122

Or my master thesis supervisor at FH Salzburg

Bernhard Maurer
Campus Urstein
Urstein - 318
bernhard.maurer@fh-salzburg.ac.at
Tel: +43-50-2211-1259

Figure 58: Informed Consent Document for the Affective Haptic On-Body Tandem Workshop Page 2

–

By signing below, you acknowledge that you have read and understood the information provided above, and you consent to participate in this research study.

Salzburg, June 04 2024

Place, Date, Signature Researcher

____

Place, Date, Signature Participant

Additional Resources

To enhance your understanding of haptic feedback, I recommend reviewing the following resources:
- **Haptics 101**(https://www.hapticlabs.io/haptics1x1) page on the Hapticlabs website.
- **Circumplex Model of Affect**(https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2367156/)
- **Emotion Typology**(https://emotiontypology.com/)
- **Tangible Metaphor Elicitation**(https://link.springer.com/article/10.1007/s00779-011-0410-4)
- **Body Maps**(https://www.researchgate.net/publication/358575123 Body Maps A Generative Tool for Soma-based Design)
- **Experience Prototyping**(https://dl.acm.org/doi/10.1145/347642.347802)

Figure 59: Informed Consent Document for the Affective Haptic On-Body Tandem Workshop Page 3

Body Mapping: A technique used in soma-based design to visually represent how individuals experience emotions in different parts of the body. This informs the design of affective systems and haptic feedback mechanisms.

Embodied Metaphor Elicitation: A design approach that translates abstract emotional concepts into physical and tangible design elements by using metaphors grounded in bodily experiences.

Experience Prototyping: A prototyping method focused on evaluating and iterating on user experiences. It emphasizes immersing designers and users in interactive prototypes to understand experiential aspects.

Lo-Fi Prototyping: The creation of low-fidelity, simplified prototypes that capture basic design ideas. Lo-fi prototyping is often used in early design stages for quick iteration and feedback gathering.

Tandem Design: A collaborative design process in which two participants alternate between the roles of designer and user. This iterative approach helps refine the design by continuously incorporating feedback from both perspectives.

Hapticlabs DevKit: A toolkit designed for creating and testing haptic feedback. It includes various haptic actuators and a user-friendly interface that enables the design of haptic patterns without requiring programming skills.

ERM (Eccentric Rotating Mass) Actuators: A type of actuator that produces vibration by spinning an unbalanced mass. Common in mobile devices, it is used for basic vibration feedback such as alerts or notifications.

LRA (Linear Resonant Actuator) Actuators: Actuators that generate vibrations through linear oscillations. These actuators are known for delivering precise and efficient haptic feedback with fast response times and low energy consumption.

Piezoelectric Actuators: Actuators that leverage piezoelectric materials to create precise, rapid vibrations when subjected to an electric current. These are commonly used in high-fidelity haptic systems requiring fine control.

D Additional Tools Used

For preliminary research, I used the PDF scan and summary functionality of ChatGPT[11] to sort the papers into relevant clusters and compare the results on a MIRO board[12] with my notes and the feedback given by my supervisor. The selected, relevant paper categories were then refined manually and assessed for their correlations and contribution to the thesis after a personal full read. As for my writing, I wrote the content of this thesis myself and refined it by integrating

[11] https://chat.openai.com/

[12] https://miro.com/

grammatical feedback suggestions from Quillbot[13] and Grammarly[14] to make sure my writing style was concise, straightforward, correctly spelled, and in active voicing. After finishing my writing phase, instead of using ChatGPT's capabilities to help me verify my data citations and completeness of my thesis, I utilized a local Large Language Model (LLM) of Metas "LLama-4"[15] in the open-source GitHub project "LocalGPT"[16] to get structural feedback on my thesis writing. Based on the feedback, I simplified my table of contents for the sake of readability, clarity, and logical narrative of argumentations, wrote up suggested transitional paragraphs between the sections, and corrected grammatical and careless errors in my thesis draft. The choice of using a local LLM was made to get continuous feedback on my drafts, and, for the included participant data, it was crucial to maintain a high level of data protection of the participant's sensitive qualitative data presented in the thesis when accessing the logical argumentation structure of my discussion and conclusion sections in correlation to the qualitative user data.

To preserve anonymity and discretion in photographing the workshop and participants during their design processes, the image web tool "Picdefacer"`https://picdefacer.com/en/` was used to pixelate participants' faces.

The LaTeX markup language platform Overleaf [17] was used to write this thesis, and templates from the official Overleaf documentation [18] were utilized to include figures and tables in a correct and structured manner.

[13]https://quillbot.com/
[14]https://www.grammarly.com/
[15]https://github.com/meta-llama/llama3
[16]https://github.com/PromtEngineer/localGPT
[17]Overleaf: `https://www.overleaf.com/`
[18]Overleaf Documentation: `https://www.overleaf.com/learn`

This work has the following word count (counted by texcount):

```
File: body.tex
Encoding: utf8
Sum count: 41559
Words in text: 37981
Words in headers: 731
Words outside text (captions, etc.): 2847
Number of headers: 163
Number of floats/tables/figures: 59
Number of math inlines: 0
Number of math displayed: 0
Subcounts:
  text+headers+captions (#headers/#floats/#inlines/#displayed)
  345+1+0 (1/0/0/0) Section: Acknowledgments
  0+1+0 (1/0/0/0) Section: Introduction
  1804+27+3 (4/0/0/0) Subsection: Background of Human-Computer Interaction(HCI) Methodologies
  465+5+0 (1/0/0/0) Subsection: The Role of Haptic Feedback
  532+13+3 (1/0/0/0) Subsection: Problem Statement: The Need for a Modular Methodological Toolkit for Novice Interaction Designers
  505+4+0 (1/0/0/0) Subsection: Research Questions and Hypothesis
  586+4+2 (1/0/0/0) Subsection: Contribution of the Thesis
  25+2+0 (1/0/0/0) Section: Related Work
  289+5+0 (1/0/0/0) Subsection: Emotional Design and User Experience
  853+13+0 (3/0/0/0) Subsection: Affective Haptics and Emotional Engagement
  238+6+0 (1/0/0/0) Subsection: Emotion Typology and the Circumplex Model
  739+5+0 (1/0/0/0) Subsection: Wearable Technologies for Mental Wellness
  1910+19+3 (4/0/0/0) Subsection: Design Frameworks and Toolkits Useful for Affective Haptic Design
  570+6+0 (1/0/0/0) Subsection: Future Directions in Affective Haptic Design
  373+4+0 (1/0/0/0) Subsection: Prototyping and Real-Time Iteration
  900+31+4 (7/0/0/0) Subsection: Ethical Considerations in Affective Haptics
  192+1+0 (1/0/0/0) Subsection: Summary
  85+1+0 (1/0/0/0) Section: Methodology
  1304+26+0 (10/0/0/0) Subsection: Participant Selection and Recruitment
  8957+187+593 (41/12/0/0) Subsection: Research Design
  83+1+0 (1/0/0/0) Section: Results
  1839+67+17 (11/2/0/0) Subsection: Participant Demographics and Initial Survey Results
  2633+36+2211 (10/44/0/0) Subsection: Key Activities
  279+16+0 (3/0/0/0) Subsection: Impact of Emotion Typology and Circumplex Model Introduction
  1538+25+0 (6/0/0/0) Subsection: Usefulness of Embodied Metaphors and Body Maps
  517+18+0 (4/0/0/0) Subsection: Challenges Faced During Prototyping Sessions
  208+10+0 (3/0/0/0) Subsection: Technical Limitations of the Toolkit
  1363+16+0 (5/0/0/0) Subsection: Participant Feedback and Recommendations
  127+3+0 (1/0/0/0) Subsection: Summary of Results
  91+1+0 (1/0/0/0) Section: Discussion
  653+11+0 (1/0/0/0) Subsection: Impact of Emotion Typology and Circumplex Model on Affective Haptic Design
  1459+22+0 (4/0/0/0) Subsection: Embodied Metaphors and Body Maps: Enhancing Emotional Translation and Communication
  1072+17+0 (3/0/0/0) Subsection: Technical and Conceptual Challenges in Affective Haptic Design
  1286+20+0 (3/0/0/0) Subsection: Tandem Design Approach: Enhancing Collaboration and Iterative Learning
  677+8+0 (3/0/0/0) Subsection: Methodological Considerations
  86+1+0 (1/0/0/0) Section: Conclusion
  540+20+0 (5/0/0/0) Subsection: Summary of Key Contributions
  1623+34+7 (5/1/0/0) Subsection: Addressing the Research Questions
  606+36+0 (7/0/0/0) Subsection: Implications for Future Research and Practice
  202+4+0 (1/0/0/0) Subsection: Limitations of the Study
  114+2+4 (1/0/0/0) Subsection: Ethical Considerations
  313+2+0 (1/0/0/0) Subsection: Final Remarks
```