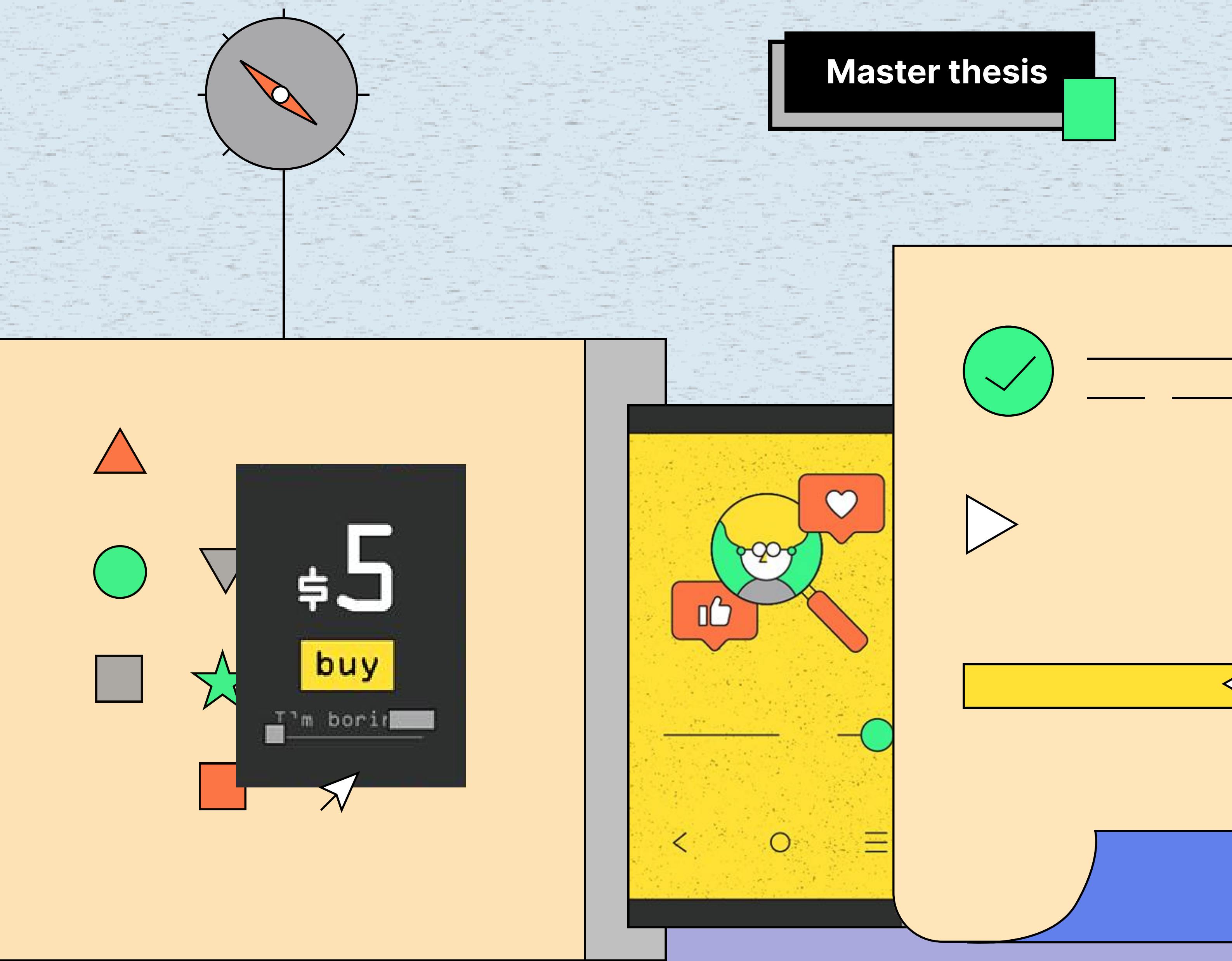
The Dark Side of Haptics: Exploring Deceptive Haptic Design in Interfaces

Master thesis



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The Dark Side of Haptics:
Exploring deceptive haptic design in interfaces

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All the best,

唐昆格.

AI Statement

In the preparation and completion of this thesis, AI tools were utilized to boost the quality and efficiency of my work.

ChatGPT, developed by OpenAI, was employed to assist in academic writing of the thesis. This tool helped enhance the clarity, coherence, and overall readability by providing translations and corrections in the drafting and editing of my thesis.

On the other hand, Scite was used to find relevant academic papers, which helped in improving the review efficiency in this work.

We appreciate the support provided by these advanced technologies. The integration of these AI tools was instrumental in enhancing quality and efficiency of my work, allowing us to focus more on the core aspects of this research.

ABSTRACT

Deceptive design patterns (also known as 'dark patterns') are design elements that trick users into unintended behaviors that harm them and benefit the party implementing the design. Prior work has taxonomized, investigated, and speculated the presence of dark patterns across environments (applications, websites, games, VR, AR, IoT) and modalities (visual, audio). However, more attention is needed to investigate how haptic technologies might be used to enable deceptive patterns since it is gradually becoming prevalent in digital experiences.

This project contributes to the characterization and demonstration of deceptive patterns enabled / augmented by haptic stimulation. First, we identify the key characteristics of haptic modality that may enable new deceptive patterns or augment existing ones, and we surface examples of such patterns. Second, we conducted a between-group study, in which we investigated the efficacy and effect of one chosen haptic deceptive pattern. In addition, we presented mitigative recommendations to the stakeholders.

TABLE OF CONTENT

1. INTRODUCTION

This introductory section provides information regarding the background, the project approach, and the academic contributions of the project.

1.1 Project Background

Have you ever encountered a situation while interacting with a digital service where you felt manipulated into making a purchase or agreeing to terms that you didn't intend to? For instance: when you select privacy options, the "Reject" button is so tiny and hidden that you barely see it, so you end up clicking "Accept" without meaning to. These manipulative user experience designs are called dark patterns or deceptive patterns.

Deceptive Patterns are prevalent in digital environments, employed deliberately to maximize benefits extracted from users. Geronimo et al. (2020) found that dark patterns are present in ninety-five percent of the 240 trending apps in online services, with each app equipped with seven distinctive dark patterns on average. Furthermore, Mathur et al. (2019) identified that many consultancy companies promote these deceptive patterns as an easy way for businesses to get more customers to say "yes" to things they might otherwise reject.

In the human-computer interaction (HCI) community, research on deceptive patterns has been ongoing. The subject of most studies are the existing visual dark patterns. They have given us a fundamental understanding of the definitions, taxonomies, and applications of deceptive patterns that communicate with users through visual modality.

However, interaction technologies are evolving rapidly. When multimodal interactions, XR, VR, and IoT become the new mainstream interaction media, will the deceptive patterns remain the same as today? Will new technologies give rise to new deceptive patterns?

Indeed, previous work in affective haptics has raised ethical concerns regarding haptic augmentation, arguing that it could influence human emotions and potentially misinform users, thereby qualifying as a deceptive pattern (Ooms et al., 2023).

Since haptic technologies are being increasingly integrated into digital experiences (Kim & Schneider, 2020), more attention is needed in understanding how haptic technologies could potentially contribute to these deceptive patterns. This project explores future scenarios where haptic technologies could give rise to new deceptive patterns and conducts a between-group experiments with our developed prototype to give empirical evidence.

We aim to shine a light on the dark side of haptics: we'll bring up the potential risks and impacts that have yet to be acknowledged, realized, and discussed.

1.2 Project Approach

The project approach is adapted from the notable Double Diamond Model (Elmansy, 2023), which involves a mix of divergent and convergent actions. Each stage starts with exploring an issue more widely or deeply, followed by taking focused action. Our project consists of two stages: characterization and demonstration of dark haptic patterns (see figure 1).

a. Characterization

In the first stage, we reviewed current literature on haptic modality and dark patterns to gain an understanding of how dark patterns occur and the distinctive properties of haptic modality. We then constructed scenarios, both fictional and real, to illustrate how haptic modality could create or augment dark patterns in its unique way.

b. Demonstration

In the second half of the project, we developed a prototype through multiple rounds of testing and iterations. Then, we designed and conducted a between-group experiment to evaluate its efficacy.

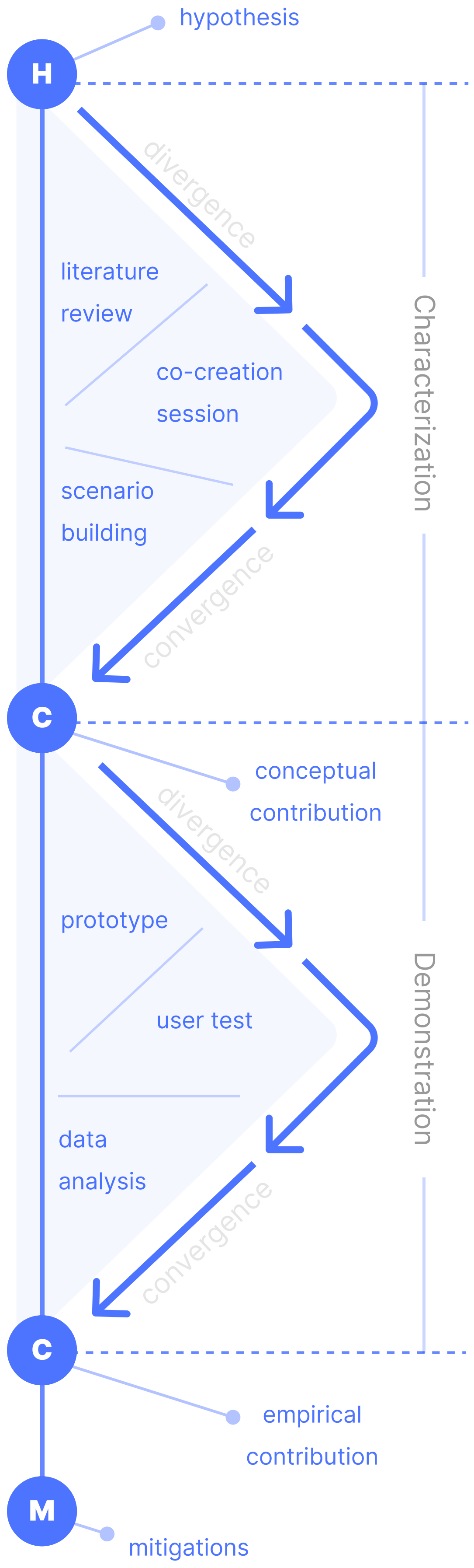


Figure 1. project overview

1.3 Project Contribution

This project raises the concerns and initiates the conversation around the malicious use of haptic technologies in deceptive patterns. We have made conceptual and empirical contributions respectively in the characterization and demonstration stage. In addition, we presented mitigative recommendations to multiple stakeholders.

a. Conceptual contribution

- We identified four distinctive properties of haptic modality and elucidated how these properties could manifest as dark patterns.
- We surfaced eight scenarios in which haptic technology could give rise to deceptive patterns. Each pair of scenarios takes advantage of one of these properties.

b. Empirical contribution

- We designed and conducted a between-group experiment with our developed prototype. The results give solid evidence on the potential of haptic technologies in creating deceptive pattern.

c. Mitigations

- We presented preventative recommendations for stakeholders on how to mitigate the risks of haptic deceptive patterns in the future.

2. LITERATURE REVIEW

Our project starts from reviewing literature about deceptive patterns, haptic perception, and haptic technologies. Our goal is to understand what constitutes a dark pattern, the mechanisms and attributes of deceptive patterns, and the negative consequences. Additionally, we seek to explore how humans perceive haptic stimuli and how haptics are integrated into digital experiences. Finally, we aim to identify the haptic technologies that can demonstrate haptic dark patterns. The overview of literature review is illustrated in figure 2.

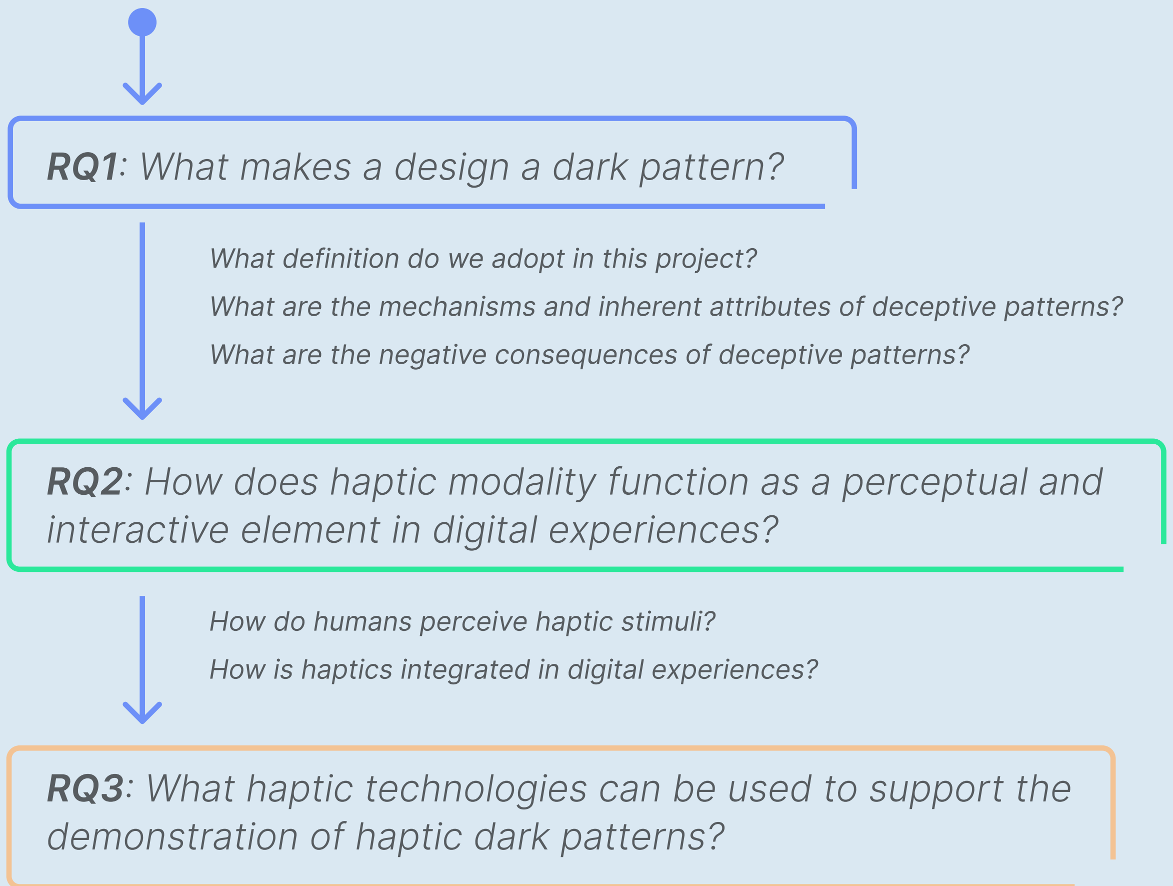


Figure 2. Research Questions in literature review

2.1 Deceptive Patterns

To get an understanding of dark patterns is essential for speculating dark affective haptic scenarios in the next stage. Hence, the research question in this chapter is:

RQ1: "What makes a design a dark pattern?"

Specifically, this chapter will cover the definition of dark patterns, the taxonomy, and what harm they cause. Additionally, it will delve into scholarship concerning dark patterns that are not in visual interfaces on screens.

2.1.1 Definition of Deceptive Patterns

The term "dark patterns" was first coined by Brignull in 2010 on the website darkpatterns.org, describing the notion as "tricks used in websites and apps that make you do things that you didn't mean to, like buying or signing up for something. (1)" In the following decade, other scholars and legislators also tried to define the notion. Mathur et al. (2021), in their scoping review, concluded 19 definitions from academic papers and legislation materials in which the definition is being mentioned (see table 1).

Mathur et al. further induced the definition components into four distinctive facets: characteristics, mechanism, the role of the interface designer, and the benefits & harms resulting from the design.

Regarding the characteristics of the user interface and the mechanisms affecting users, there is a significant divergence in how scholars and legislators articulate these aspects.

Terms such as "coercive, deceptive, malicious, misleading, obnoxious, seductive, steering, trickery" are used to describe the attributes of the interface. Terms like "attack, confuse, deceive, exploit, manipulate, mislead, steer, subvert, trick, undermine" are used to describe the mechanisms through which deceptive patterns impact users. Among the definitions, we believe that Brignull's use of the term "trick" is a concise yet accurate encapsulation of both the characteristics and mechanisms of deceptive patterns. Also, regarding the role of designer, Brignull et al.'s definition uses the term "design elements," which implies an intentional misuse of design knowledge.

Based on these reasons, we have decided to adopt Brignull's definition of deceptive patterns as the foundation for our definition since (1) we consider it as both accurate and comprehensive, (2) and because it is the earliest and most influential definition.

(1) https://old.deceptive.design/ ,last accessed June 22nd, 2024

However, Brignull's definition overlooks the facet of “Benefits and Harms.” We have decided to incorporate this facet into our definition.

Regarding the Benefits and Harms facet, some definitions include benefiting the party implementing the design and causing harm to users as required elements. We have decided to integrate this facet into Brignull’s definition, as we believe that including it makes the definition more precise and reflects a common characteristic of deceptive patterns.

For instance, if a platform uses trickery to encourage users to do something beneficial, such as donating, we do not consider such usage within the scope of our discussion.

In summary, **our definition is as follows: “Deceptive design patterns (also known as 'dark patterns') are design elements that trick users into unintended behaviors that harm them and benefit the party implementing the design.”**

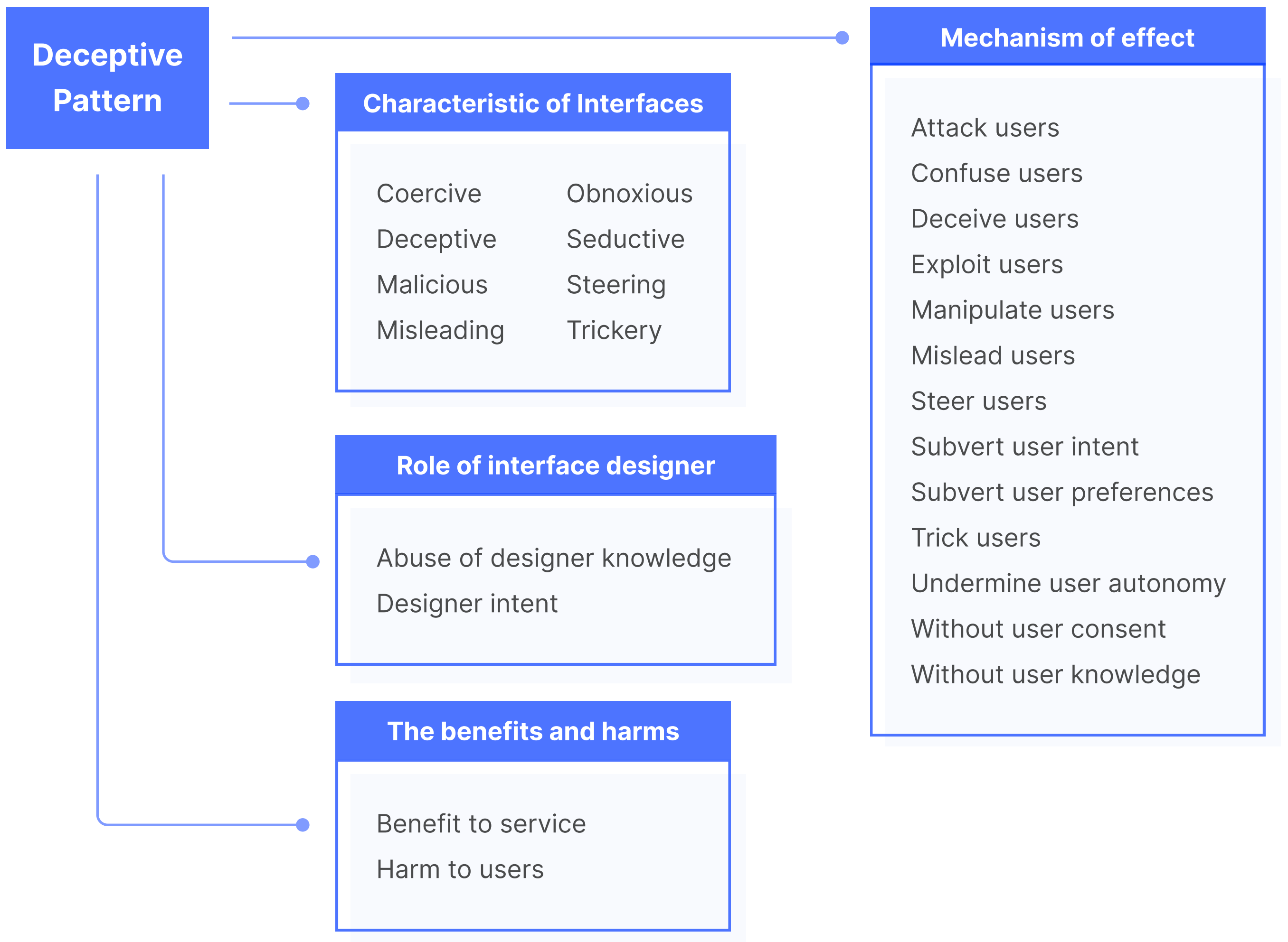


Table 1. Four facets of the deceptive pattern and the classification of various definitions in academic literature, law, and policy.. (Mathur et al, 2021)

2.1.2 Taxonomy of Deceptive Patterns

Prior work in academia has provided an overview of the taxonomy of dark patterns. Brignull (2010) first presented 12 types of dark patterns with descriptions and examples. Fake scarcity, for instance, is a trick that pressures users into completing an action because they are presented with a fake indication of limited supply or popularity. This foundational work spurred subsequent research into the classification of dark patterns. Some studies share a similar approach of constructing a taxonomy of deceptive patterns. Conti & Sobiesk (2010) identified 9 categories of deceptive patterns. Disattraction, for instance, is a trick attracting the user’s attention away from their current task by exploiting perception, particularly preattentive processing.

Another set of subsequent research studies have focused on deceptive patterns in a specific type of digital experience, for instance, Zegal et al. presented seven types of dark patterns used in video games (2013). The author proposed dark patterns like monetized rivalries, where players are encouraged to spend money to achieve in-game status such as a high placement on a leaderboard.And Lewis (2013) concluded deceptive patterns in mobile apps, categorized by two types of harm deceptive patterns cause: temporal and monetary. Temporal harm refers to excessive time spent on a platform, leaving users feeling their time was wasted. Monetary harm refers to users making regrettable and unintended expenditures.

Except for grouping deceptive patterns by their consequences, scholars also try to categorize deceptive patterns with the higher-level attributes behind. Mathur et al. (2021) concluded 6 attributes of how they modify the way of choices presented to users, grounded with literature on online manipulation and previous deceptive pattern taxonomies (see table 2). This classification deviates from the others by explaining what are the characteristics of deceptive patterns that affect the user's decision-making process (Mathur et al., 2019). For example, information hiding is an attribute that obscures or delays the presentation of necessary information to users, as seen in dark patterns like hidden costs, obstruction, and visual interference.

Mathur further categorized these six attributes into two broader categories: modifying the decision space and manipulating the information flow. Modifying the decision space category involves modifications on the choices per se, including adding unequal burdens to options, eliminating certain choices, treating groups differently based on their choices, and concealing the mechanisms influencing choices. Manipulating the information flow refers to maliciously controlling the presentation of choice’s related information, either by hiding information or inducing false beliefs about the choices.

Recently, Gray et al. (2024) organized the deceptive patterns proposed by 10 different scholars and legislators into high-, meso-, and low-level categories, in an attempt of creating a shared language of deceptive patterns, addressing the issue of varying degrees of generalization of deceptive patterns. The five high-level patterns include obstruction, sneaking, interface interference, forced action, and social engineering.

(choice architecture refers to the way in which choices are presented to consumers or decision-makers)

Choice Architecture	Attibutes	Description
Modifying the decision space	Asymmetric	Unequal burdens on choices available to the user
	Restrictive	Eliminate certain choices that should be available to users
	Disparate Treatment	Disadvantage and treat one group of users differently from another
	Covert	Hiding the influence mechanism from users
Manipulating the information flow	Deceptive	Induce false beliefs in users either through affirmative misstatements, misleading statements, or omissions
	Information Hiding	Obscure or delay the presentation of necessary information to users

Table 2. Dark patterns attributes grouped by how they modify the user's choice architecture. (Mathur et al, 2021)

2.1.3 Consequences of Deceptive Patterns

Dark patterns cause harm at both societal and individual levels. The former is being discussed more in the domain of law and legislation. In this work, we focus on how dark patterns undermine the end consumer's welfare. Gunawan et al. (2022) concluded comprehensively what are the harms that dark patterns induce, which include loss of autonomy, financial harm, privacy invasion, loss of time, addiction, cognitive burdens, and emotional distress. We follow the harm categories that Gunawan et al. proposed and discuss them below.

1) Loss of autonomy

The autonomy loss is considered a negative impact of dark patterns and is widely highlighted by scholars. Gunawan et al. (2022) argue that all the existing dark patterns undermine user autonomy due to the nature of dark patterns to nudge user choices. In other words, the nature of the deceptive patterns is that the service providers employ them to manipulate the end users to behave against their own intention, leading to irrational and non-autonomous decisions.

2) Financial harms

The most dominant target of dark patterns is to gain more financial benefits from the end users. Encountering these dark patterns, end consumers spend money they don't intend to. These dark patterns are prevalent on shopping and travel platforms. For instance, comparison prevention makes it difficult for users to weigh up prices by combining features and prices in a complicated manner (Brignull et al., 2023). When a user struggles comparing, they are more susceptible to cognitive biases such as social proof, the authority bias or the default effect. Some other tactics are used in games to profit from the end user. One example is the Pay to Skip allows players to skip locks or other obstacles by spending money (Zagal et al., 2013).

3) Privacy invasion

Another welfare consequence dark patterns cause to end consumers is on the privacy level. These dark patterns deceive users into choosing privacy-invasive options. One notorious instance is the Privacy Zuckering, which makes the privacy-invasive option at default and the privacy-respecting choices hard to find. The collected data could then be used for creating tailored advertising or content (Bösch et al., 2016).

4) Loss of time & addiction

To retain users, software, and applications implement designs that can engage users in specific behaviors. Certain "dark patterns" may lead to scenarios where users are compelled to continue using the service. Specifically, within the gaming context, users are often encouraged to undertake time-consuming and monotonous tasks as a strategy to ensure user retention (Zegal et al., 2013).

5) Cognitive burden

Another welfare consequence to users involves unnecessary expenditure of time, energy, and effort. Examples include Roach Motel makes the cancellation process extremely complex (Brignull, 2010), and Nagging repeatedly prompts users to make certain choices (Gray et al., 2018).

6) Emotional distress

The last welfare consequence to end users is when a dark pattern elicits uncomfortable emotions. For instance, confirmshaming leverages guilt or shame through the wording on opt-out option labels to manipulate user's decision (Brignull et al., 2023).

2.1.4 Beyond screen-based visual deceptive patterns

The majority of the research on dark patterns investigates those within screen-based visual interfaces. However, in recent years, the HCI community has been exploring the dark patterns in digital experiences beyond screen-based visual interfaces.

Owens et al. (2022) went through a series of collaborative design brainstorming exercises to understand how deceptive design patterns manifest in voice interfaces. The authors went through two steps in the exercises: identifying unique properties of voice interfaces, and generating specific examples of voice-based deceptive design patterns. Following the characterization, they conducted a survey with 93 participants to investigate whether people find the pattern problematic and why they hold that.

In another line of research, it has been suggested that augmented reality (AR), due to its high level of immersion, could be misused to facilitate or augment dark patterns, leading to unintended consequences (Wang et al., 2023; Eghtebas et al., 2023). Wang et al. (2023) tested three AR deceptive patterns: lighting interference, object interference, and haptic grabbing. The first two mechanisms are similar to Brignull's visual interference taxonomy (2023), which uses visual elements to hide, obscure, or disguise essential information. Haptic grabbing is highly relevant to our study since it leverages the haptic modality to manipulate the user's attention. It was found to effectively manipulate user's attention, and thus decision through vibrational feedback. It is a similar mechanism to the disattraction deceptive pattern identified by Conti and Sobiesk (2010), defined as diverting the user's attention from their current task by exploiting perception.

Mhaidli and Schaub (2021) have identified five mechanisms of manipulative XR advertising: misleading experience marketing, inducing artificial emotions in consumers, identifying and targeting emotionally vulnerable users, emotional manipulation through hyper-personalization, and distortion of reality.

Lacey and Caudwell (2019) argued that the scope of dark patterns should be extended to human-robot interaction, highlighting that the "cuteness" design feature in home robots constitutes a deceptive pattern. Following Lacey and Caudwell's proposal to extend deceptive patterns to human-robot interactions, haptics could be an essential design element since plenty of physical contacts happen in human-robot interaction, which potentially impact human perception and could contribute to deceptive patterns in this domain.

2.1.5 Conclusion

In academic discourse, there is no universally accepted definition of "dark patterns." We have chosen to base our understanding on the definition provided by Brignull et al., as it is both conclusive and accurate, and has considerable influence within the field. We have modified this definition by incorporating the aspect of "benefits and harms," as we deem this an essential element of deceptive patterns. Our definition goes as: Deceptive design patterns (also known as 'dark patterns') are design elements that trick users into unintended behaviors that harm them and benefit the party implementing the design.

The taxonomy of dark patterns lacks a unified descriptive dimension. Harms associated with dark patterns are variably described through feelings (e.g., Felt Shamed, Felt Tricked), losses (e.g., Lost Money, Lost Privacy), or actions (e.g., Forced Subscription), while other harms are identified about user experiences (e.g., Experienced Discrimination, Denied Choice) or specific contexts. And those descriptions focus more on the phenomenon level, losing the mechanism that causes consequences.

The classification of dark patterns proposed by Mathur, based on attributes, offers a more valuable reference framework. Following this approach, we aim to correlate the characteristics of haptics with the underlying mechanisms of dark patterns.

A research gap is identified: to our knowledge, a thorough discussion on haptic-related deceptive patterns is missing. Prior research has examined dark patterns beyond screen-based visual interfaces as above-mentioned. Moreover, Wang et al. (2013) demonstrated through experiment that haptics can be a building block of deceptive patterns. However, it lacks the speculative perspective to investigate how haptics could manifest in deceptive patterns across environments and through what unique properties of haptic modality. Plus, Wang et al. did not discuss from a societal level about how we should react to mitigate the potential risks of haptic technologies being maliciously employed to deceive users. Hence, our study seeks to focus on haptic modality per se and conduct a thorough study from conceptual probabilities, to empirical effects, and till the mitigative measures.

Considering the above-mentioned findings, the next chapter reviews the literature on haptics, which will provide a foundational understanding of how haptics can impact individuals cognitively or emotionally. Then, we have a design space in which scenarios can be built to demonstrate our idea of how haptics can be manipulated to create deceptive or coercive user experiences.

2.2 Haptic Modality

The visual and auditory modalities traditionally served as materials that designers can make use of in shaping the digital experience. However, the past decade has witnessed a surge in interest from both industry and academia in multimodal and tangible interfaces, leading to many research studies about haptics being carried out across fields (Song et al., 2016). The authors categorized studies about haptic interfaces into (i) studies on haptic technologies that generate haptic information and (ii) studies on human perception of haptic stimuli. In this chapter, we focus on haptic research studies about human sensing and manipulation through haptics.

In an attempt to explore the future scenario in which haptics play a role in augmenting/ creating dark patterns, it is necessary to understand haptics in the first place. Hence, the research question for this chapter is to find out:

RQ2: "How does haptic modality function as a perceptual and interactive element in digital experiences?"

Specifically, this chapter will give fundamental information about haptics as a perceptual modality, and review how haptics is employed in the consumer products and integrated as part of digital experiences.

2.2.1 Fundamentals of haptics

As illustrated in figure 3, the somatosensory system governs the human sense of touch, facilitated by a range of nerves and tissue formations. This system enables two types of sensations: proprioception and cutaneous perception. The former refers to self-movement, force, and body position (Tuthill & Azim, 2018).

The latter consists of specific receptors and neural pathways that encode various types of information such as pressure, temperature, and motion of objects that make contact with the skin (Schirmer et al., 2016).

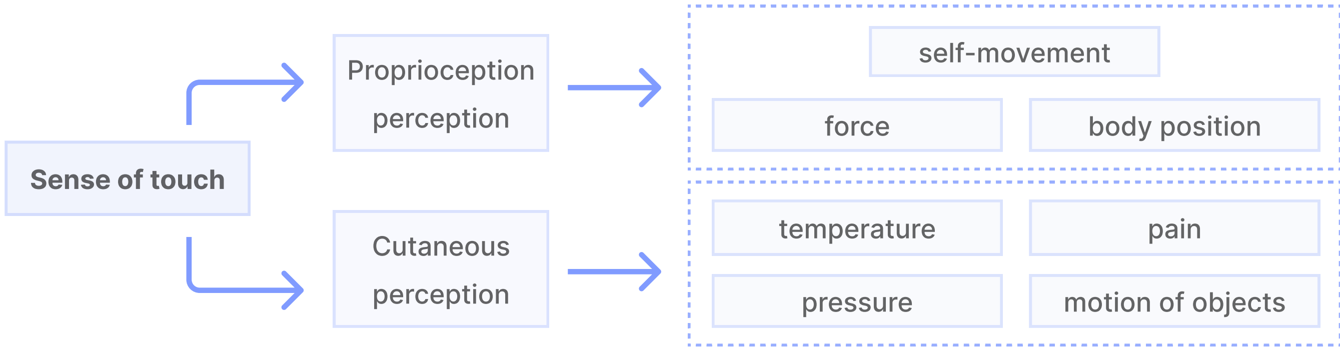


Figure 3. Sense of touch

The perception of tactile stimulation also depends on the body sites that receive the tactile input. Generally speaking, humans have two types of skin: glabrous skin, such as that found on the palm, and hairy skin, such as that on the arm and cheek (see figure 4).

In the skin, human sensory receptors respond to specific stimuli, leading to complex interactions within the body that result in the sensation of touch. In the skin of the digits, touch relies on four distinct low-threshold mechanoreceptors (LTMs): slowly adapting type 1 (SA1), slowly adapting type 2 (SA2), rapidly adapting (RA), and Pacinian corpuscles. Each type of LTM is specialized in converting different mechanical stimuli into nerve impulses within Aβ large-diameter afferent fibers (McGlone et al., 2014). These mechanoreceptors are essential for encoding the spatial and temporal properties of surfaces and objects being manipulated (Mountcastle, 2005).

The density of mechanoreceptors are not equal across skin locations. The glabrous skin has a higher density of mechanoreceptors than in hairy skin, which makes the sense of touch easier to localize on the glabrous skin.

Hence, the glabrous skin of the hand, particularly the fingers, has always been the focus of skin sensory processing studies since it contains a high density of specialized mechanoreceptors. This research area is called discriminative touch, which encompasses the perception of pressure, vibration, slip, and texture, all of which are crucial for providing haptic information during object manipulation and exploration. It functions to detect, distinguish, and identify external stimuli to enable quick decision-making and guide behavior.

On the other hand, hairy skin contains C-tactile (CT) afferents, which are crucial for affective touch, whereas glabrous skin lacks CT afferents and is primarily involved in discriminative touch (Ackerley et al., 2014). CT afferents are slow-conducting fibers found exclusively in hairy skin, responding preferentially to light touch and playing a role in transmitting the affective aspects of touch (Yu et al., 2019). The presence of CT afferents in hairy skin has been linked to the perception of pleasant touch and the transmission of affective qualities of touch (Haggarty et al., 2020).

Given the location dependency and specialization of the mechanoreceptors, we should consider body sites when developing a haptic device in order to produce a haptic interaction that is truly effective (Culbertson et al., 2018).

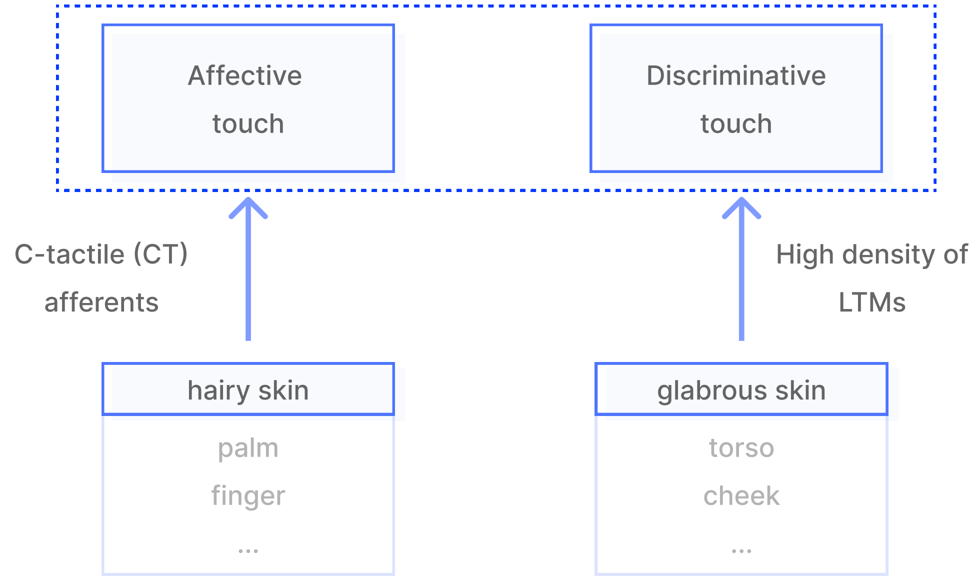


Figure 4. Affective touch and discriminative touch

2.2.2 Haptic in digital experiences

Haptic interfaces are devices that enable manual interactions with the environment. Haptic interfaces find applications in a variety of highly specialized scenarios, including the surgical equipments, robotic teleoperation, advanced prosthetics, and near-field robotics (Culbertson et al., 2018; Laycock & Day, 2003)

On the other hand, haptic technology is increasingly integrated into consumer products to enhance user experience (UX). Kim & Schneider (2020) stated that haptic technology is becoming commonly available in consumer products and is a steadily expected component of user experience.

Major companies like Apple and Nintendo have given their developers access to high-fidelity inertial actuators in their devices, and startups like Tanvas and UltraLeap are bringing new technologies to market for consumers, such as programmable friction (Bau et al., 2010) and mid-air haptics, which provides tactile feedback without direct contact with a surface.

The integration of haptic technology in consumer products has opened up new possibilities for enhancing UX with digital devices. Haptic technology primarily finds its application in several sectors, including gaming, virtual and augmented reality (VR & AR), touch screen devices, and the automotive industry (2).

(2) https://aloa.co/blog/what-are-haptics, last accessed June 25nd, 2024

In the realm of **gaming**, haptics have been used to create more immersive gameplay experiences. Haptics transform gaming into a multi-sensory adventure. By allowing players to feel the physical impact of their in-game actions, haptics enhance realism and engagement, fostering a deeper connection with the virtual environment (Stone, 2001). As haptics continues to evolve, it may not only elevate the gaming experience but also reshape how players interact with digital worlds.

In the fields of **virtual reality (VR) and augmented reality (AR)**, haptics feedback allows users to physically interact with digital objects, enhancing their sense of presence in virtual environments. By providing users with heightened spatial awareness and the ability to feel the distance, shapes, and textures of digital elements, haptics enriches VR and AR storytelling, enabling users to experience the emotional and physical nuances of virtual worlds (Garcia-Valle et al., 2016).

For **touchscreen devices**, haptics enhance user interaction by providing tangible and responsive feedback. It refined the typing experience on touchscreens by offering tactile sensations akin to pressing physical buttons, improving accuracy and responsiveness (Wang et al., 2019).

Haptic feedback on touchscreens simulates realistic touch sensations, such as textures and vibrations, making the touchscreen experience more lifelike. Additionally, haptics aid in intuitive gesture recognition and serve as an effective means for alerts and notifications, enhancing user awareness without solely relying on visual cues (Wang et al., 2021).

In the **automotive industry**, the integration of haptic technology has shown potential to enhance safety, interactivity, and user experience in vehicles. Research has shown haptic feedback in navigation systems, deceleration control, steering wheel controllers, and haptic feedback seats, emphasizing the role of haptics in improving driver awareness, responsiveness, and driving ergonomics (Breitschaft et al., 2019; Mulder et al., 2009; Hogan et al., 2010; Peters, 2024). For instance, tactile alerts warn drivers of potential collisions, improving driver responsiveness and safety on the road. Haptics is also integrated into infotainment systems, allowing drivers to interact with touchscreens through tactile controls without diverting their attention from the road. As the automotive industry trends towards integrating control elements through touch-sensitive surfaces, haptic technology continues to reshape the driving experience (Breitschaft et al., 2019).

2.2.3 Conclusion

This chapter has uncovered the fundamentals encompassed by the term "haptics." We have developed a structured understanding of touch as a modality, which will be informative for scenario building in the latter part of this project.

The application of haptics in consumer products is becoming increasingly widespread, establishing itself as an integral part of the digital experience. There is a significant overlap between the application domains of haptics and the current contexts in which deceptive patterns exist.

Most deceptive patterns are encountered in mobile applications and websites, where users likely interact with these patterns via touchscreen devices. Additionally, current research explores the presence or potential presence of deceptive patterns in gaming, virtual reality (VR), and augmented reality (AR). Given that these digital experiences include deceptive patterns, haptics could be misused as a design element to create or enhance such patterns. As haptics play a more significant role in individuals' digital experiences, the potential for their exploitation by service providers, similar to visual and auditory modalities, increases. **Hence, it would be a good speculative attempt to include gaming, VR, and AR environments in the conceptual part of our study.**

While academic projects are beginning to explore deceptive patterns in gaming and AR/VR environments, these efforts are still in their infancy. The majority of research on deceptive patterns centers on touchscreen devices and websites. Touchscreens are a major domain where haptic technology is already widely applied in digital experiences. **Therefore, for the demonstration part of our project, we will focus on the touchscreen device environment.** This focus allows our project to leverage extensive prior research and applications related to touch and the significant presence of deceptive patterns in touchscreen devices. By concentrating on touchscreens, we ensure a solid foundation for our study while setting the stage for future exploration into other digital environments.

2.3 Haptic Technology

In the previous chapter, we learned about haptics as a perceptual modality and an element in digital experience. This chapter aims at understanding how specific types of haptic simulations can be created by what machinery. This foundational knowledge will enable us to assess the feasibility and complexity of prototyping specific haptic dark scenarios and to determine the most effective methods for their development. Hence, the following research question is formulated:

RQ2: "What haptic technologies can be used to support the demonstration of haptic dark patterns?"

Specifically, this chapter aims to review the technological feasibility of various types of haptic stimulation, evaluate the complexity associated with implementing different types of haptic stimulation, identify the haptic actuators that can be employed to create specific haptic stimuli, and compare the advantages and disadvantages of various actuators of the same kind.

2.3.1 An overview

We focus on haptic technologies that are relatively easy to implement and cost-effective for our demonstration, setting aside cutting-edge haptic technologies. This decision is grounded in two primary considerations: (1) Cutting-edge haptic technologies are far from commercial viability and integration into digital experiences in the foreseeable future, and (2) our project is under limited resources and time constraints. The following discussion will be structured by the type of haptic stimulation.

2.3.2 Vibrotactile stimulation

First and foremost, vibrotactile actuators are widely adopted due to their portability and robustness (Gourishetti & Kuchenbecker, 2022). In the realm of wearable technology, vibrotactile actuators have been applied in systems for augmented reality applications, robot-assisted surgery, guidance for visually impaired individuals, and virtual reality experiences (Maisto et al., 2017).

Piezoelectric actuators are a popular choice for haptic feedback applications due to their ability to independently control both the position/amplitude and frequency of deflection, allowing for intricate haptic effects (Chen et al., 2023).

They can be designed in various forms such as stack, strip, and tube actuators, tailored to various applications (Chen et al., 2023). What makes piezoelectric actuators distinctive is that both the position/amplitude and the frequency of deflection can be controlled independently, enabling a complex and detailed haptic effect.

In addition to piezoelectric actuators, eccentric rotating mass (ERM) actuators are recognized for their strong vibrations, compactness, and cost-effectiveness, making them a prevalent choice for haptic feedback systems (Gourishetti & Kuchenbecker, 2022). However, despite being the oldest and most widely utilized technology, ERM actuators encounter challenges in producing complex and subtle waveforms (Papetti et al., 2018). Another popular alternative is the linear resonant actuator (LRA), which generates a more precise and cleaner haptic output compared to ERM.

2.3.3 Thermal stimulation

Besides the vibrotactile system, communicating information by changing temperature is another distinctive approach. Prior work has shown thermal stimulation to be effective in communicating emotions (Kanosue et al., 2002; Ali et al., 2020).

The electrical resistance heater, which is employed a lot in personal warming devices is the most accessible component, the only drawback is it only increases the temperature. Thermoelectric actuators take advantage of the Peltier Effect, are capable of both heating and cooling, and can be precisely controlled by reversing the current direction (Makino & Maruyama, 2006).

2.3.4 Force stimulation

Some force feedback systems rely on the cutaneous sense of pressure, which makes it better simulate the real human touch (Haans & IJsselsteijn, 2005). Pneumatic actuators generate force based on the pressure of compressed air. The response speed of pneumatic actuators can be very high. Servo motors can also be employed in creating haptic stimuli, and are proven to be more natural in simulating human touch than vibrotactile actuators and pneumatic actuators (Ahmed et al., 2016). Shape memory alloys (SMAs) are capable of generating large forces using small compact-sized components (Abuzied et al., 2020).

Except for cutaneous sensation, force stimulation is also capable of activating kinesthetic sensation. Kinesthetic sensation can be leveraged to create the sense of presence and immersion in virtual reality (VR) environments.

Kinesthetic feedback can be achieved by applying forces to the torso or limbs, as the nerves responsible for kinesthetic sensation are located in the muscles, tendons, and joints (Hinchet & Shea, 2022).

The volume of such equipment providing kinesthetic feedback can be bigger. Movable chairs, exoskeletons and robotic arms are the usual for creating kinesthetic feedback by moving users' body parts. These devices can be complex and require higher costs in terms of development and materials, making them more challenging to prototype for demonstrations.

2.3.5 Fabric tactile stimulation

Tactile perception relies on the friction between the skin and external objects, which is processed in the somatosensory cortex. To generate such friction, vibration, as previously mentioned, is one method. However, mechanical actuators often lose their soft texture and typically provide only single-point friction, offering limited tactile stimulation (Tang et al., 2022). An alternative approach is the use of real fabric, which enables more nuanced sensorial stimulation (Tang et al., 2022). Furthermore, fabrics that integrate electronics and smart materials, known as smart textiles, have demonstrated potential in creating fabrics with additional dynamic, responsive, and adaptive properties.

Such an approach can be employed to make customized haptic devices, Yang & Zhu have investigated the affective expressiveness in the wrist-worn haptic devices that generate fabric tactile stimulations (2023).

2.3.6 Ultrasonic tactile stimulation

Ultrasonic tactile actuation is a new approach for providing tactile feedback. What makes it distinctive from traditional approaches is that it has no requirement on physical contact with device or wearable actuators, and it creates true mid-air haptic sensations (Sand et al., 2020). Normally, the ultrasonic tactile stimuli is created with an array of ultrasound transducers. The intensity, rhythm, duration of ultrasonic tactile stimuli are controllable. One limitation of existing ultrasonic haptic devices is that they are relatively large and fixed in place, so feedback can only be presented from one global location and in one orientation (Wilson et al., 2014).

2.3.7 Conclusion

From a feasibility and viability perspective, we have identified haptic technologies that we can utilize in our next step. Aside from the kinesthetic feedback system, which is more challenging to achieve, we see vibrotactile, thermal, and force stimulations as promising future exploration directions.

Prior work also characterized the effects of these simulations, which could be relevant to our work. Vibrotactile stimulation exhibits a strong attention capture, leading to its use of short and prominent notifications (Poh et al., 2017). This feature can be used to demonstrate some of our dark haptic scenarios.

For thermal stimulation, warm temperatures are generally described as comfortable and pleasant (Kanosue et al., 2002), while cold temperatures are often perceived as uncomfortable (Sung et al., 2007). And also, warm temperatures create positive emotions and enhance presence. It indicates that these temperature changes can be utilized to guide users towards positive or negative emotions, serving as a tool for demonstrating some haptic dark patterns.

Force feedback is perceived as more natural and more similar to human touch compared with vibrotactile stimulation (Ahmed et al., 2016). It enhances the sense of immersiveness and presence to a higher extent, which makes it promising to demonstrate some haptic dark patterns in XR settings.

These above-discussed types of haptic feedback have the potential to facilitate deceptive patterns, and **we will consider them in the conceptual part of our work**. **For the demonstrative part of our work, we will focus on vibrotactile stimulation.** Our decision is based on the fact that vibrotactile stimulation is currently the most widely applied type of haptic feedback in digital experiences. Other types of haptic feedback are either not encountered or rarely encountered in the every day digital experiences of most people.

3. CHARACTERIZATION

This chapter concludes the inherent properties of haptic modality and generates examples illustrating corresponding properties through literature review and a co-creation session.

3.1 An overview

The primary research activities in the characterization section includes literature review, and co-creation sessions. The entire process is illustrated in Figure 5.

Initially, we conducted a literature review in the field of HCI to summarize the inherent properties of haptic modality that can be exploited to create or augment dark patterns. We identified four distinctive properties of haptics from this review.

Then, the author conducted a co-creation session with two UX designers. Through the co-creation session, we investigated in what ways haptic may manifests in deceptive design patterns.

In the session, we first conducted a list-checking exercise. In the exercise, we reviewed together the deceptive pattern list and engaged in discussion around how the properties could form or augment these deceptive patterns.

For the deceptive patterns list, we chose the taxonomy of Brignull et al., (2023) since it is a well-recognized and thorough classification of deceptive patterns. In addition, we included Zegal et al. 's (2013) taxonomy of deceptive pattern in games since we regard deceptive haptic design has unique potential to manifest in the gaming environment as we discussed in previous section.

Then, the participants were asked to generate specific haptic deceptive design scenarios. We generated 5 scenarios through this exercise. In the end, we challenged participants to think about new haptic properties, and there were no new properties emerged.

We iterated the 5 scenarios that emerged from the co-creation session afterwards until a few archetypal examples were chosen for each unique property of haptic properties. These final chosen scenarios were presented at the end of this chapter.

We made iterations afterwards since we don’t want to be constrained by current classification of deceptive patterns. In the final list of dark scenarios we propose, we also show novel dark scenarios which don't correlate to existing dark patterns, since the unique characteristics of haptic modality create new possibilities. And, we added one haptic deceptive pattern we identified as an already existing one.

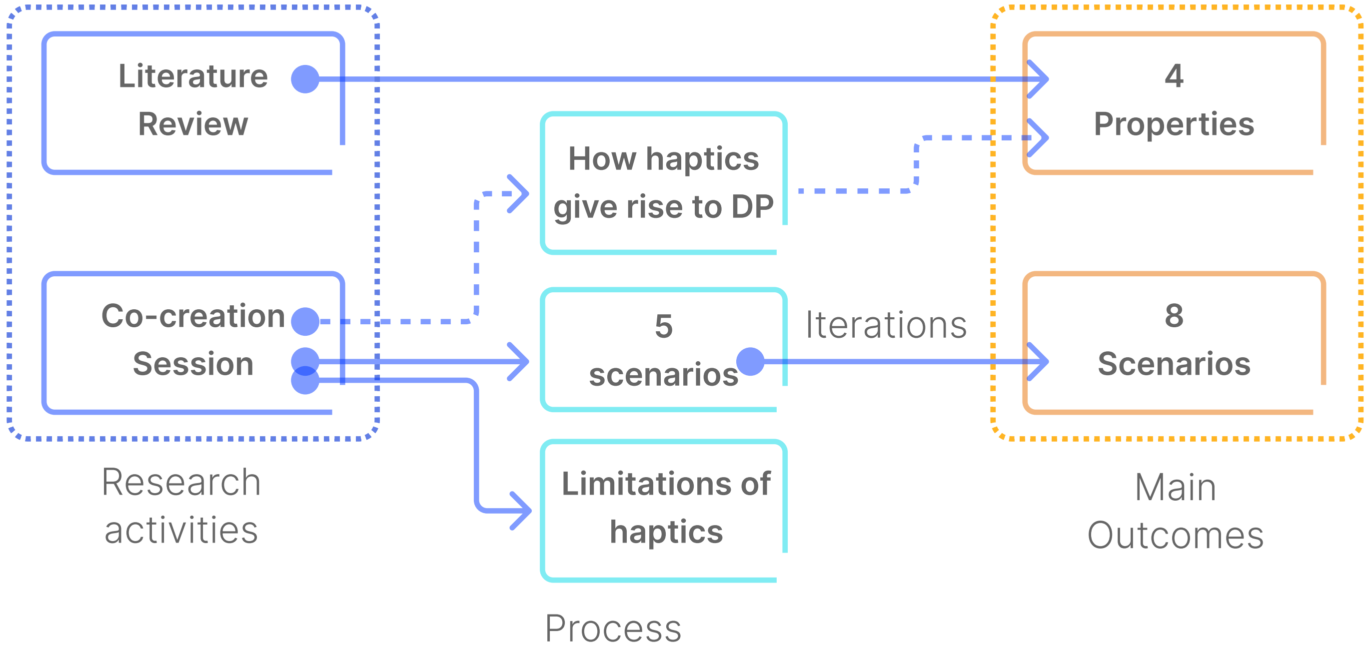


Figure 5. Research activities and outcomes in characterization section

3.2 Haptic properties

In an attempt to explore future scenarios where haptics play a role in augmenting or creating dark patterns, it is necessary first to understand haptics. Previous scholars have laid a solid foundation for our understanding of haptic perception. Hence, we extracted the inherent attributes of haptics from prior scholarship on haptic modality in the domain of human-computer interaction (HCI). Haptic attributes encompass cognitive, emotional, and perceptual dimensions, which enable distinctive haptic experiences (Kim & Schneider, 2020).

Raisamo (2009) categorized scholarship on haptics into two groups: studies focusing on 1) cognitive sensation for obtaining information through haptic stimuli and 2) emotional sensation evoked by haptic stimuli. Both cognitive and emotional aspects of haptics can enable dark patterns.

Additionally, as with the visual modality, the perceptual aspect can also contribute to the effects of existing dark patterns. For example, altering the color and size of text can manipulate the sequence and whether users pay attention to it. Similarly, the perceptual aspect can be another dimension of haptics. In most dark patterns, cognitive, emotional, and perceptual factors are intertwined, jointly contributing to the occurrence of dark pattern effects.

1

Haptics feedback alerts user and manipulates attention

A large number of haptic feedback systems have been developed in order to grab the user's attention. For instance, Apple watches are embedded with multiple haptic actuators, which inform users of notifications via adjustable vibration. Besides, in-vehicle haptic alerting systems result in faster reaction time to potential collisions compared with visual or acoustic alerting systems for automotive collision avoidance (Meng et al., 2014). Last but not least, haptic alerting systems are shown promising in decreasing alarm fatigue by replacing acoustic alarms to nurses in intensive care environments (Cobus et al., 2018).

2

Haptic feedback integration conveys information

Distinguishable haptic stimuli can also be used to present certain information to the user. It can be the haptic information per se like force and kinesthetic information in teleoperation. Moreover, haptic stimuli can also be used to convey more complex and abstract information (Culbertson, 2018). The amplitude, frequency, rhythm, and envelope of vibration together create a rich design space. By altering the parameters, designers can create distinctive haptics icons to convey complex information, e.g. the urgency of message or the importance of the notifications.

3

Haptic feedback increases immersion & presence

Haptic feedback is crucial for enhancing immersion and presence in virtual environments. When haptic feedback achieves a high level of fidelity to real-life interactions, it can enhance the feeling of social presence (Dionisio et al., 2013). Combining haptic feedback with finger tracking and cutaneous haptic interfaces is essential for creating immersive virtual reality (VR) experiences (Lee et al., 2019). The integration of haptic feedback in VR systems can increase immersion and presence, which are key factors in developing engaging VR experiences (Kim & Schneider, 2020). Moreover, studies have shown that the incorporation of haptic feedback in VR significantly enhances the user's sense of immersion (Gehrke et al., 2019). Haptic feedback typically involves force and tactile feedback, which are essential sensory modalities for creating immersive experiences in VR (Williams et al., 2020).

4

Haptic feedback elicit emotional response

Research has demonstrated that haptic stimuli feedback can effectively communicate emotions. Studies have emphasized the importance of designing haptic stimuli to elicit specific emotions, such as love, joy, surprise, anger, sadness, and fear, through vibrotactile and thermal stimuli (Shetty et al., 2021). Integrating haptic feedback into audiovisual content has been proven to enhance emotional responses (Ablart et al., 2017). The ability of haptic devices to convey emotions has been evaluated through user ratings, indicating the potential of haptic feedback in emotional communication (Maggioni et al., 2017). There are some wearable haptic devices being developed for emotion eliciting. For instance, Mood Glove has been developed to enhance mood music in films (Mazzoni & Bryan-Kinns, 2016).

To further the properties with practical implications of deceptive design patterns, we employed the co-design approach that integrates diverse perspectives.

We employ co-creation as our research methodology in order to bridge the theoretical constructs derived from the literature review with speculative scenarios (Lim et al., 2023). The involvement of co-creators in collaborative sessions adds new dimensions and boosts creativity (Roser et al., 2013).

By leveraging the collective expertise and creativity of the participants, the co-creation session aims to validate the initial findings, generate examples of haptic deceptive design patterns, and potentially identify any additional haptic properties not previously considered.

3.3 Co-creation Session: Method

Aim

To investigate how the unique properties of haptics modalities can be leveraged contributing to deceptive patterns, a co-creation session was conducted. More specifically, our goals are: (1) identify other potential haptic properties. (2) generate specific examples of deceptive haptic design.

Participants

To broaden the perspective, two UX designers were recruited through personal contacts to do the exercise together with the author (see table 3). Both of them possess past experience and prior knowledge on dark patterns, one did research project about DP, and another cope with DP a lot in her past job in the industry.

No.	1	2
Age	25	26
Gender	Female	Male
Occupation	UX Designer	UX Designer
Experience with DP	At work	In research

Table 3. Demographic information of participants

Figure 6. Co-creation session process

Procedure

Introduction

As illustrated in figure 6, the co-creation session consisted of an introduction and two exercises: list examining, and scenario generation.

List-checking exercise

For the first exercise, we wanted to examine which existing deceptive patterns are those haptic stimulation could potentially contribute to. To this end, we reviewed the list of deceptive patterns one by one.

For the deceptive pattern list, we chose the deceptive pattern taxonomy established by Bringull (2022) as it is the first and one of the most influential summaries of dark patterns. Additionally, we reviewed the classification of deceptive patterns in games proposed by Zegal et al. (2013) since we think in gaming contexts, haptics may present unique possibilities for deceptive patterns.

In this exercise, each participant first engaged in individual reflection and then participated in a group discussion. During the discussion, for each deceptive pattern that was identified as potentially facilitated or enhanced by haptic stimulation, we deliberated on which specific haptic property would be leveraged and in what manner.

Additionally, we distinguished whether the haptic stimulation augmented an existing deceptive pattern or created a new one. This distinction was based on whether other sensory inputs, excluding haptic feedback, could constitute a deceptive pattern.

In cases where a deceptive pattern could be formed through other sensory modalities, haptic feedback served to enhance the deception, making it more pronounced. Conversely, if no detectable deceptive element existed without haptic feedback, and deception was only observed when haptic feedback was introduced, we considered that the haptic feedback created the deceptive pattern.

Scenario generation exercise

The next exercise involves generating specific scenarios of haptic dark patterns. In this exercise, we aim to create detailed examples with specific contexts and specialized situations. Members in this session were asked to specify which haptic property was leveraged in each scenario. All members illustrated their envisioned scenarios on scenario cards individually, followed by a presentation of those scenarios. The scenarios are illustrated in Figure 7.

At last, we asked participants to think about new haptic properties, and there were no novel properties that surfaced.

3.4 Co-creation Session: Results & Findings

3.4.1 Exercise I - list examination

After examining the entire list, we categorized the deceptive patterns into three groups: haptically created, haptically augmented, and non-haptic, as illustrated in table 4. These categories allow us to identify findings from both the perspective of deceptive patterns and the perspective of haptics.

This deceptive pattern list is based on the taxonomies by Brignull et al. (2023) and Zagal et al. (2013). The original sources introducing these taxonomies are cited in the footnotes (2)(3).

Next, we present the primary findings that emerged from this list-checking exercise.

Legend

- Haptically created
- Haptically augemented
- Non-haptic

Prior work	Dark pattern type	Haptic Properties			
		Alerting & Attention Manipulation	*Convey information & reduce visual reliance*	*Immersion & presence*	*Emotional response*
Brignull et al.	**Comparison prevention**	Haptically augmented			Haptically augmented
	Confirmshaming	Haptically augmented		Haptically augmented	Haptically created
	Disuised Ads	Haptically augmented	Haptically augmented		
	Fake scarcity		Haptically created		Haptically created
	Fake social proof	Haptically augmented			
	Fake urgency	Haptically augmented			Haptically augmented
	Forced action			Haptically augmented	
	Hard to cancel				
	Hidden costs				
	Hidden subscription				
	Nagging	Haptically augmented			
	Obstruction				
	Preselection				
	Sneaking		Haptically augmented		
	Trick wording				
	Visual interference				
Zegal et al.	**Grinding**			Haptically augmented	
	Impersonation				Haptically created
	Monetized Reivalries			Haptically created	
	Pay to Skip			Haptically created	Haptically created
	Playing by Appointment	Haptically augmented			
	Pre-Delivered Content			Haptically augmented	
	Social Pyramid Schemes				Haptically augmented

Table 4. Checklist indicating whether pre-identified deceptive patterns can be created or augmented by haptic modality.

(2) https://aloa.co/blog/what-are-haptics, last accessed June 25nd, 2024

(3) https://my.eng.utah.edu/~zagal/Papers/Zagal_et_al_DarkPatterns.pdf, last accessed Jul 19nd, 2024

a. Haptics is hard to manifest in 'Information Hiding' type of deceptive patterns

Mathur et al. (2021) clustered deceptive patterns that utilize the mechanism of obscuring or delaying the presentation of necessary information to users under the category of Information Hiding Deceptive Patterns. Among the seven deceptive patterns we identified as non-haptic, five are classified as Information Hiding types. For example, the "hard to cancel" pattern makes the cancellation process unnecessarily complex and time-consuming, often causing users to abandon their attempts to cancel. We posit that the characteristics of haptic feedback are not well-suited to assist in the concealment of information.

b. Haptics is promising in deceptive patterns in games

Our compilation of deceptive patterns includes non-game deceptive patterns documented by Brignull et al., as well as those identified by Zagal et al. within the context of gaming environments. Of the seven dark game design patterns analyzed, three were classified as haptically created, while the remaining four were categorized as haptically augmented. This differentiation suggests that haptic feedback mechanisms may be more prominently manifested in game settings compared to application-focused digital platforms. We attribute this observation to the inherent properties of haptics, specifically their property of enhancing immersion and presence, which are more effectively leveraged in gaming contexts.

c. Haptic stimulation direct user' attention to Deceptive Elements

Haptic stimulation directs users' focus to deceptive elements. The alerting and attention manipulation properties of haptics function by directing users' focus towards deceptive elements through haptic feedback. As illustrated in Table X, we propose that this property primarily enhances existing deceptive patterns rather than creating new ones. For example, the "nagging" pattern, which involves repeatedly presenting certain requests until users acquiesce, can be intensified by incorporating haptic feedback, such as vibrations, alongside the repeated inquiries

d. Haptic stimulation can be matched with specific meanings

Moreover, in certain contexts, haptic signals can convey critical misinformation. For instance, we speculate, on e-commerce platforms, variations in haptic intensity can correspond to an item's scarcity, creating a fake scarcity deceptive pattern through tactile feedback alone. However, this correspondence between haptic signals and information requires a learning curve, necessitating user training to understand these associations.

e. Haptic stimulation can be employed to build immersiveness, thereby fostering deceptive patterns

As mentioned earlier, the haptic property of enhancing immersion and presence can simulate realistic scenarios, leading to deceptive patterns in specific contexts. For instance, in gaming, Monetized Rivalries is a deceptive pattern that benefits players by creating unique identifiers for some players who spend money in the game. Haptic information, such as specific textures or vibrations upon encountering other characters, may be used to establish such identifiers.

f. Haptic feedback can also achieve deceptive patterns by eliciting specific emotions

Lastly, haptic stimulation can be designed to evoke particular emotions in users, which can be leveraged to trigger deceptive patterns. For example, confirmshaming is a deceptive pattern that triggers uncomfortable emotions, such as guilt or shame, to influence users' decision-making. While current examples of confirmshaming use textual prompts to elicit these emotions, haptic feedback can achieve the same effect.

3.4.2 Exercise II - scenario generation

In the second exercise, all members were asked to illustrate scenarios. They were instructed to specify detailed contexts and add narratives. The emerged scenarios are shown below. For readability reason, the sketches were redrawn digitally on iPad. The original sketches and table of scenarios can be found in Appendix 2 & 3.

Figure 7 describes the five scenarios that emerged from the exercise: ***tactile persuasion***, ***virtual embrace***, ***hidden subscription trap***, ***haptic lure***, and ***haptic steering***.

Virtual Embrace

Emotional response

A game presents the feature in which the user is provided an attractive feeling of a warm hug from a VR character every time the user places an order, attracting the user to buy more.

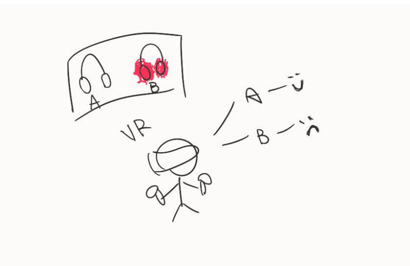
Hidden Subscription Trap

Convey Information

A to-do list app displays tasks on bubbles, which users pop to indicate completion. Haptic feedback provides a confirmation sensation when popping bubbles. The app integrates subscription bubbles among the tasks, leading to accidental subscriptions that generate revenue for the platform.

Tactile Persuasion

Emotional response



In a VR environment, a music platform promotes 2 different subscriptions. Plan A is more profitable for the platform, but pricier and less chosen by consumers. With a dark pattern, users can feel more of fuzziness and softness both in their hands and ears when they choose plan A.

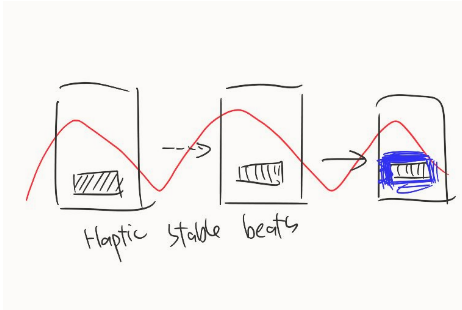
Haptic Lure

Immersiveness

In a gaming platform, specific equipment offers superior haptic feedback, enticing users to spend money on these items to enhance their tactile experience.

Haptic Steering

Attention Manipulation



Haptic feedback is used to guide user choices, with vibrations incorporated into the options that the platform wants users to select, thereby drawing more attention to these suggested options.

Figure 7. The sketches of 5 scenarios made in the co-creation session

3.5 Scenarios

3.5.1 Approach

Our speculative approach on investigating how haptic technologies might be employed to create or augment deceptive patterns in the future was inspired by methods such as speculative design (Dunne & Raby, 2013) and design fiction (Blythe, 2014).

To this end, we chose scenario construction as our method, drawing inspirations from previous works (Mhaidli & Schaub, 2021; Owen et al., 2022; Wang et al., 2023). We consider scenario construction as an ideal method for our study as it is effective in uncovering ethical tensions and the potential risks of technological misuse (Liegl et al., 2016; Reijers et al., 2017).

Additionally, we followed the approach by Owen et al. (2022), which also includes real scenarios in the final presentation. We did so since we identified a real scenario that we considered worthy-noting in the final presentation.

3.5.2 Process

As mentioned, we conducted co-creation sessions and has developed five initial scenarios. The co-creation session broadened our perspective, but some scenarios were either not illustrative enough or described technologies too distant from possible advancements in the near future.

To ensure our final scenarios were convincing and thought-provoking, we iterated on the initial scenarios until we arrived at eight archetypal scenarios in the end.

Figure 8 illustrates the process of the generation of the eight final scenarios.

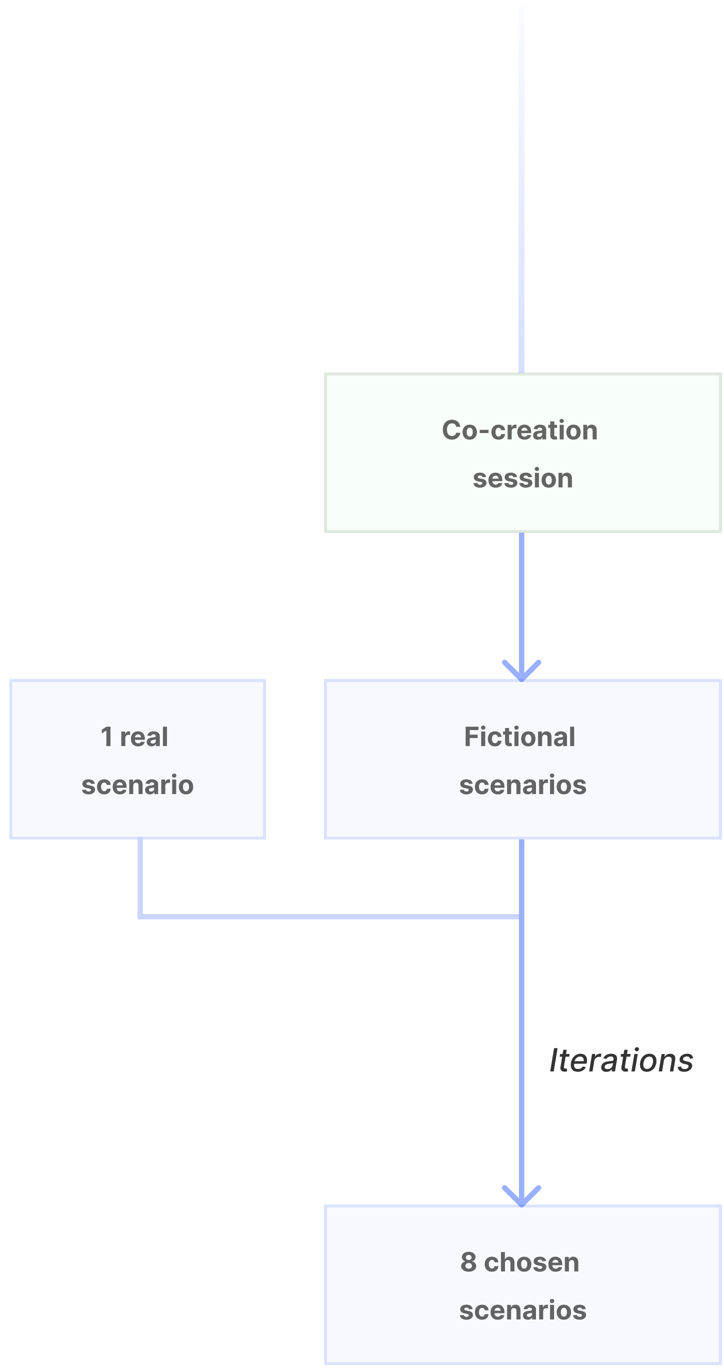


Figure 8. The generation and selection process of the final eight scenarios.

3.5.3 Scenarios

As above mentioned, we selected 8 archetypal scenarios that we consider could illustrate the potentials of haptic modality in deceptive patterns. Table 5 provides an overview, as well as a description for each scenarios. Since the mechanisms of some scenarios are relatable to existing deceptive patterns, we also present the related deceptive pattern and their source. Then, we elaborate on each scenario with an narrative, discussion, and illustration. The red areas in illustrations represent haptic stimulations.

ID	Scenario	Environment	Haptic property	Description	Relate deceptive pattern
01	Diversion	VR, AR	Attention Manipulation	Haptics stimuli lead user attention away from certain action areas to other areas.	Visual interference (Brignull et al., 2023)
02	Bait Alert	Phone	Attention Manipulation	The vibration on devices alerts users to pay attention to pseudo-notifications, aiming at drawing users to interact more with their service.	Pseudo-notification (Wilshere, 2017)
03	Ghost In	VR, AR,	Convey Information	When users add items to their shopping cart, tactile vibration feedback accompanies the action. It reduces the user's reliance on visual inspection. At the checkout stage, a magazine subscription sneaks into users' shopping baskets during checkout without the vibration feedback.	Sneaking (Brignull et al., 2023)
04	Hidden importance	VR, AR, Phone	Convey Information	Giving misleading haptic feedback multiple times before the big deception to soften up users in preparation for a bigger deception. Haptic feedback are given in previous pages to tell the importance, and not give the feedback for the privacy setting page, making users easily agree to privacy-invading settings.	Obstruction (Brignull et al., 2023)
05	Emotional manipulation	VR, AR	Immersion & presence	The virtual agency builds rapport with users in order to make users feel relaxed and intimate with the virtual agency. Mediated social touch is used to foster the emotional connection between the user and the virtual agency so that the user is more emotionally manipulated.	/
06	Pay to upgrade	VR, AR, Phone	Immersion & presence	In racing games, vibration is used to simulate the bumps of vehicles traveling down the road. Users are encouraged to upgrade their cars to minimize the bumps.	pay to skip (Zegal et al., 2013)
07	Confirmshaming	VR, AR, Phone	Emotional response	Haptics is used to communicate the disappointing emotion when the user hovers on/sees the confirmation button. the user hovers over/sees the confirmation button.	Confirmshaming (Brignull et al., 2023)
08	Urging	VR, AR, Phone	Emotional response	When the user browses the product details on the mobile page, tactile vibration feedback is superimposed on the product countdown to enhance the user's perception of the urgency level, thus guiding the user to purchase the product.	Fake urgency (Brignull et al., 2023)

Table 5. The overview of the eight selected scenarios, in which we specify the environment we envisioned its emergence, the leveraging haptic property, the detailed description, and the related deceptive pattern.

Scenario_01 Diversion

Narrative: In a VR shopping environment, after half an hour of browsing, you feel fatigued. Each time your gaze nears the "close page" button in the upper right corner, your left hand receives a haptic feedback, diverting your attention to the left. A new pop-up page appears on your left, attempting to retain your interest and keep you on the shopping platform (see figure 8).

Discussion: This scenario illustrates how haptic feedback can divert user attention away from actions that service providers do not want users to take, such as closing the app or unsubscribing. This scenario was developed from prior study which has demonstrated such diverting effects of haptic stimulation (Wang et al., 2023).

Figure 8. Diversion

Scenario_02 Bait Alert

Narrative: You're in the midst of a job search after losing your job. Your phone, tucked in your pocket, vibrates. You glance at it and see a message on LinkedIn, thinking it's from a recruiter. Eagerly, you open LinkedIn, only to find it's an automated chat agent pushing a premium subscription. Because you're desperate for a job and the message's persuasive marketing, you end up purchasing the premium subscription (see figure 9).

Discussion: It is worth noting that this scenario is constructed based on the real-world application of haptic stimulation. Currently, haptic stimulation is commonly used to alert users when there is a notification. However, some notifications have been identified as deceptive patterns because they fabricate content and guide users into making purchases (Wilshere, 2017). Haptic stimulation augments the strength of pseudo-notifications by capturing the user's attention and prompting them to engage with the fabricated content.

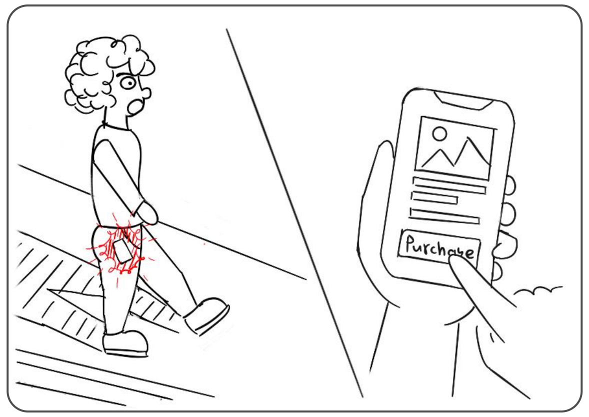


Figure 9. Bait Alert

Scenario_03 Ghost in

Narrative: On a shopping platform, you receive a short vibration feedback whenever you add an item to your cart. Over time, you rely on this haptic feedback as a confirmation. One day, you mistakenly add a product to your cart but do not receive the vibration feedback (designed to occur during brief inadvertent touches). Believing the item was not added, you end up purchasing an unnecessary product (see figure 10).

Discussion: This scenario shows a way to deceive the user by first associating the haptic signal with a specific meaning and then misinforming the user with the haptic stimulation.

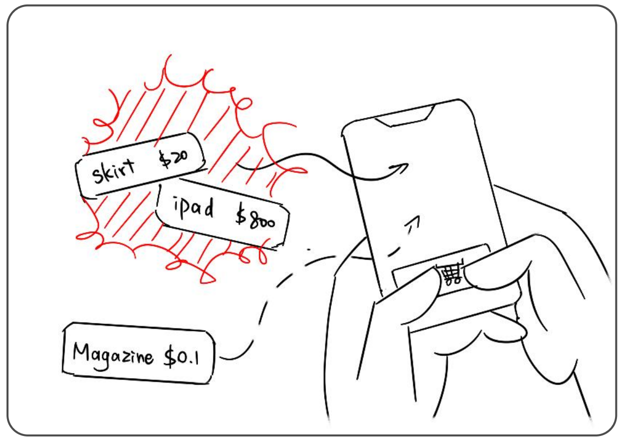


Figure 10. Ghost in

Scenario_04 Soft up

Narrative: While registering for a new platform account, you answer many setup questions. During this process, vibration feedback signals important questions many times, leading to mental fatigue. On the final privacy-setting question, no haptic feedback is provided, causing you to inadvertently agree to privacy-invasive settings (see figure 11).

Discussion: Repeated haptic feedback before major deception softens users for bigger deceptions. This scenario demonstrates that tactile signals can be used to induce mental fatigue in users, causing them to become less attentive, and then causing them to make certain unintended choices.

Figure 11. Soft up

Scenario_05 Build rapport

Narrative: On a video game digital distribution platform, you purchase a game, and then an adorable virtual agent appears, providing warm thermal haptic feedback, as if giving you a hug. This pleasant haptic feedback entices you to make more unnecessary purchases (see figure 12).

Discussion: Previous studies in affective haptics have investigated how haptic stimulation can enable virtual agents to build rapport with users, contributing to experiences that closely resemble human-to-human interactions (Hoppe et al., 2020). In this scenario, haptic stimulation is used to simulate social touch, helping the virtual agent establish an emotional connection with the user, thereby effectively manipulating the user's behavior in subsequent interactions.

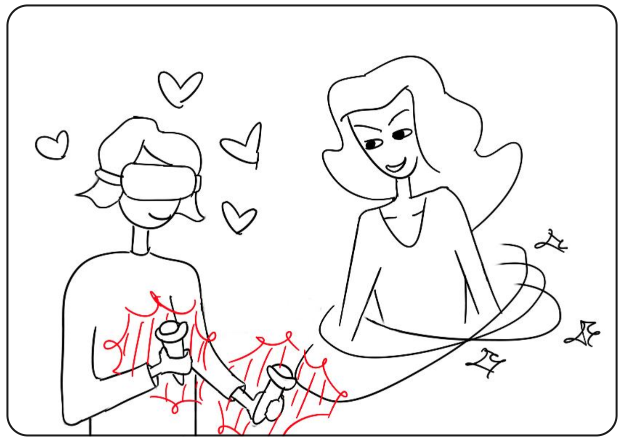


Figure 12. Build rapport

Scenario_06 Pay to upgrade

Narrative: In a racing game, vibration feedback is used to simulate the bumps of vehicles traveling on the road. As a free player, you experience intense and annoying vibrations when driving at high speeds. After a trial of the paid chassis upgrade, you are immediately attracted to the gentle and subtle haptic feedback provided by the upgraded version, prompting you to make the purchase (see figure 13).

Discussion: A wide range of deceptive patterns exists within the game environment (zegal et al., 2013). This scenario demonstrates that the emerging haptic integration in games can potentially give rise to novel deceptive haptic design in game environments.

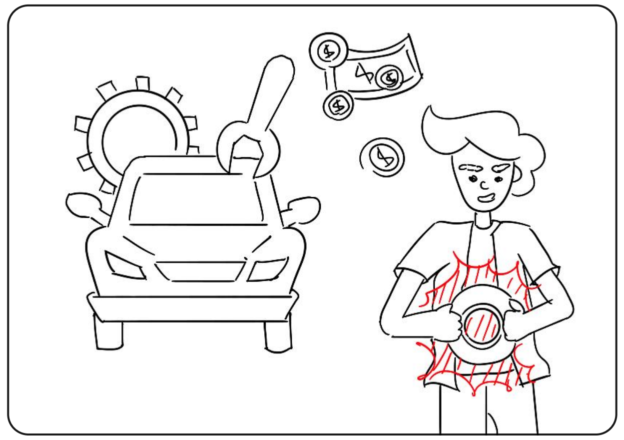


Figure 13. Pay to upgrade

Scenario_07 Confirmshaming

Narrative: In a VR environment, an app prompts you to accept push notifications. As you gaze on the option to decline and want to select it, you feel a haptic feedback associated with disappointment and sadness. This subtle but powerful emotional cue influences you to change your decision and accept the notifications instead (see figure 14).

Discussion: As speculated in prior affective haptics study (Ooms et al., 2023), this scenario illustrates how haptic feedback can be strategically used to manipulate user emotions and decision-making, steering them towards choices that benefit the platform.

Figure 14. Confirmshaming

Scenario_08 Fake Urgency

Narrative: On a shopping platform, while browsing product details on the mobile page, tactile vibration feedback is superimposed on the product countdown to enhance your perception of urgency. You perceive the promotion as highly urgent and make a quick purchase (see figure 15).

Discussion: This scenario highlights haptic stimulation being used to prompt quicker and more hasty purchasing decisions by creating a sense of urgency (Elsaid et al., 2023).

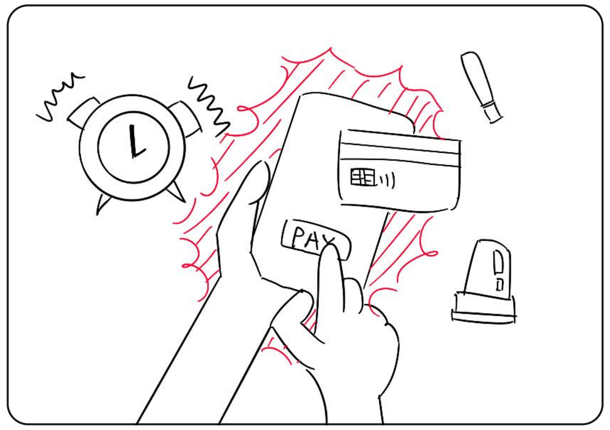


Figure 15. Fake urgency

3.6 Conclusion

We have identified four distinctive haptic properties that could be leveraged to create or augment deceptive patterns and surfaced eight scenarios to illustrate in what ways these properties can be integrated into deceptive patterns. These properties and scenarios are not intended to be exhaustive; rather, our goal is to highlight the potential of haptic technologies in creating or augmenting dark patterns.

Up to this point, we have conceptually reflected on how haptic technologies can be employed to create or enhance deceptive patterns. However, we haven't yet provided any evidence on the potential or effect of haptic technologies on deceptive designs. It would be inspiring if we can give solid evidence on what we have speculated.

In the next chapter, we will transition from a conceptual framework to empirical practice. We will develop prototypes and conduct user testing to demonstrate and evaluate the effect of haptic technologies in deceptive patterns.

Additionally, given the rapid advancement of haptic technologies and their impending ubiquity, we believe it is imperative to start the discussion on the potential risks and concerns associated with haptic technologies. We will give mitigative recommendations in the ending section.

4. PROTOTYPING

This chapter introduces the prototype we developed and outlines the process of its creation. The entire development process of the prototype is illustrated in Figure 16.

We followed a dynamic cycle of prototyping and testing. In the first round of testing, we identified issues related to synthesization and believability. To address these, we conducted a technical solution comparison and did rapid prototyping & testing II. This developing process ultimately led to the final version of the prototype.

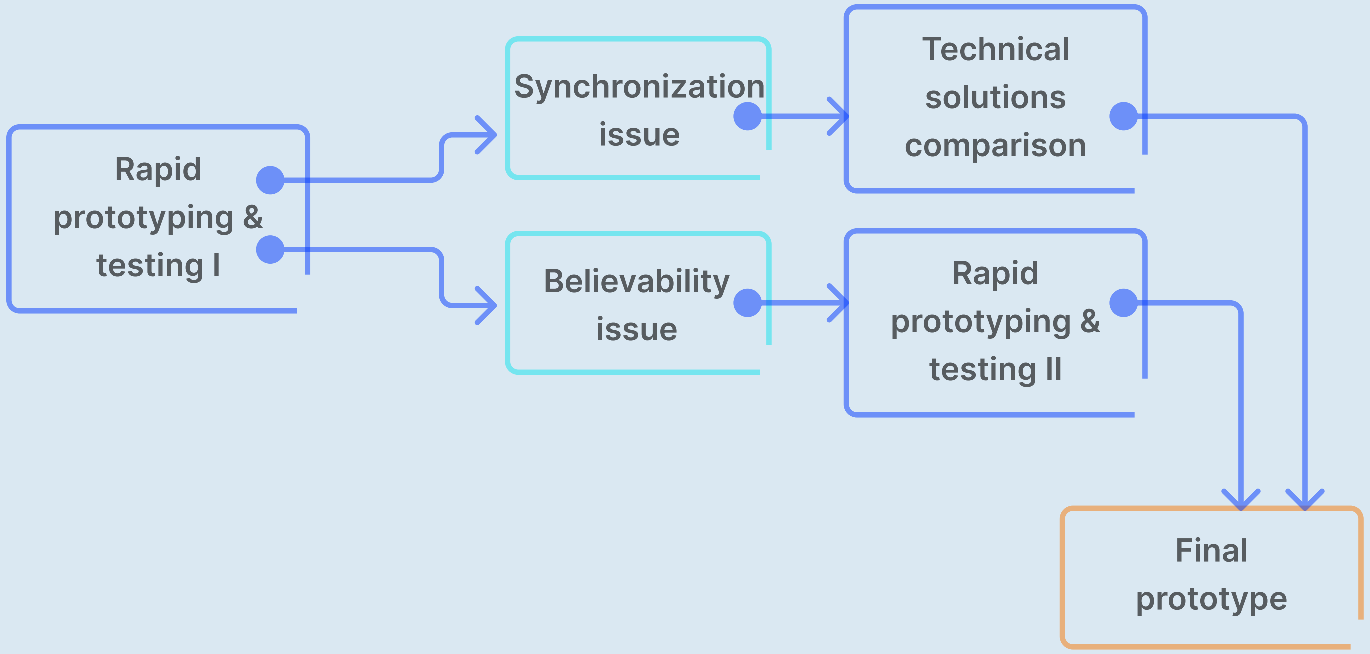


Figure 16. Prototype development process

4.1 Rapid Prototyping & Testing - I

4.1.1 Aim

The first round of rapid prototyping and a quick user test have been conducted to gain first-hand insights that will inform future steps in the project. Additionally, this phase aims to provoke hypotheses about haptic dark patterns.

Given the limited preparation time, the test results may lack robustness due to the small pool of participants and the expedited data analysis process. Therefore, the results may not be entirely accurate. However, the primary purpose of this test is to provide the project with initial insights for formulating presumptions regarding (RQ1) whether haptics alone can create dark patterns, and how effectively it integrates with visual features, and (RQ2) whether users perceive the haptic dark pattern as malicious. This will enable us to design experiments in subsequent tests that incorporate these presumptions.

4.1.2 Prototype

The inspiration for our first prototype stems from a well-known deceptive pattern called "fake urgency," which employs techniques to create a sense of time pressure among users. This pressure hinders their ability to critically evaluate the information presented to them, as they have less time and may experience anxiety or stress (Brignull et al., 2023).

Current fake urgency deceptive patterns have utilized visual countdown features to induce such anxiety. We hypothesize that haptic feedback, specifically vibrations, can similarly create this experience, as previous research has demonstrated that certain vibrations can evoke perceived urgency.

To generate insights related to the research questions, we developed three sets of prototypes: a product purchase interface with a visual countdown feature, a product purchase interface with a haptic countdown feature, and a purchase interface with both visual and haptic countdown features (see figure 17).

In our prototype, the vibrotactile stimulation is achieved through an Arduino vibration motor module (figure 19, 20), controlled by an Arduino Uno R3 controller. We designed and animated product pages with and without visual countdown features on the design platform Figma. These interfaces were then sent to and displayed on the mobile Figma app during the tests (see figure 18).

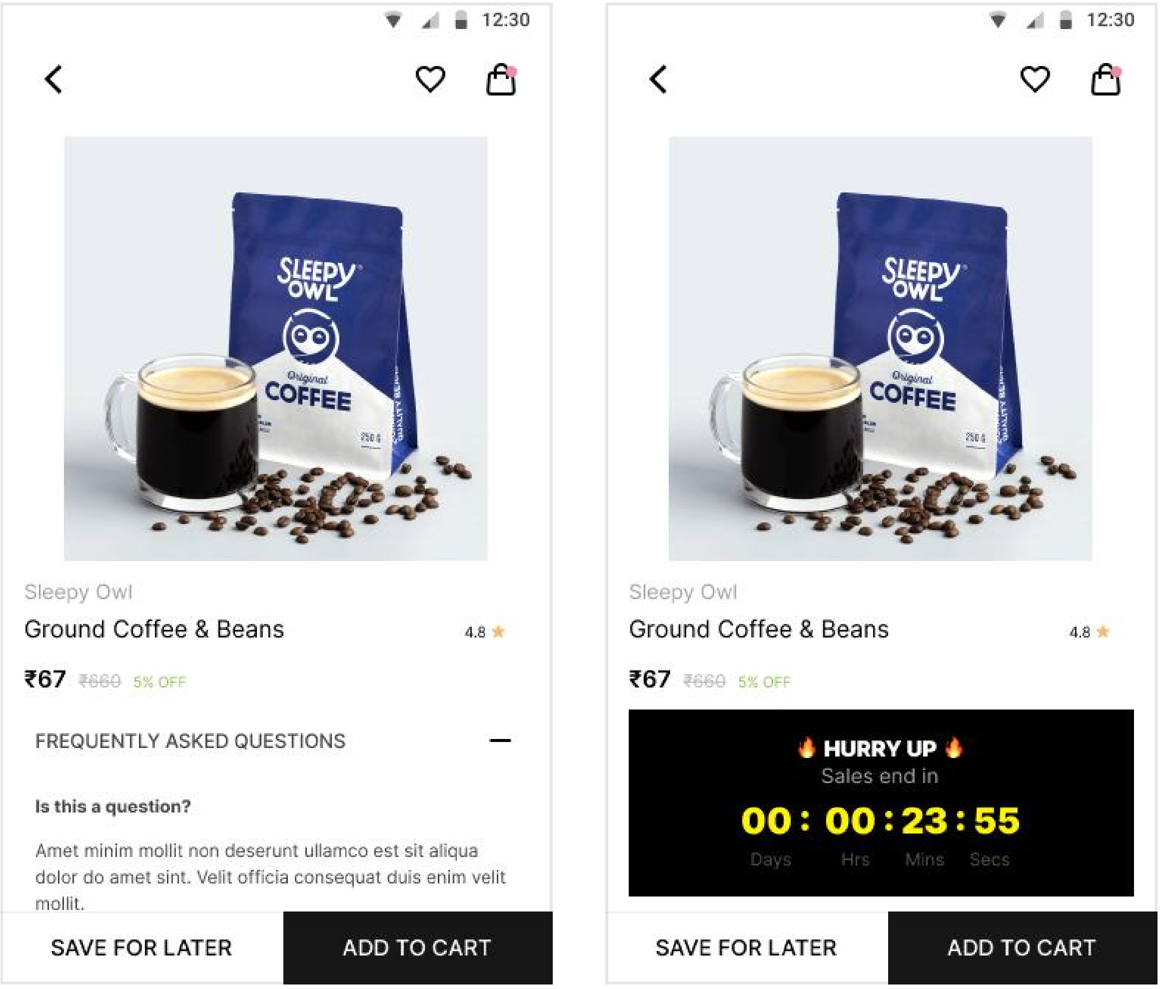


Figure 17. Arduino vibration motor module

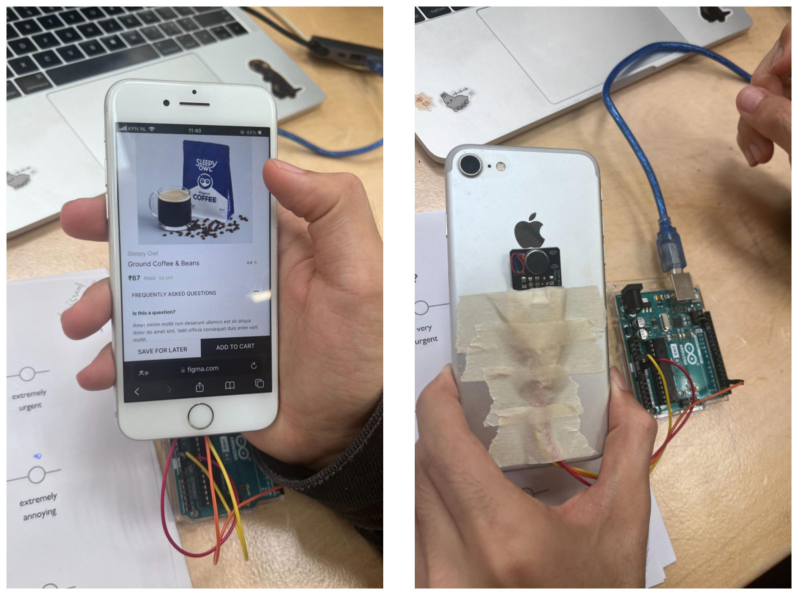


Figure 18. prototype used in the first rapid prototyping & testing

Figure 19. Arduino vibration motor module

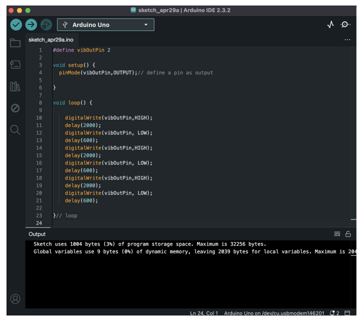


Figure 20. Arduino codes

4.1.3 Study Design & Procedure

We conducted a within-subjects experiment in which all participants experienced each prototype and subsequently shared their experiences and ratings. The sequence of the three settings was counterbalanced to mitigate the influence of order on the experimental results.

The independent variables (IVs) in this study are the type of countdown feature (visual, haptic, and both). The dependent variables (DVs) are the perceived urgency, annoyance, and the extent to which participants felt the interface was malicious, rated on a one-to-seven Likert scale (see Appendix 4).

Participants interacted with each interface for 10 seconds. After each interaction, they rated the interface based on the aforementioned dependent variables. At the end of the tests, semi-structured interviews were conducted to gather qualitative data, where participants explained their ratings and elaborated on their thoughts, feelings, and experiences.

4.1.4 Participants

In total, 7 participants took part in this quick test. All participants were bachelor/master students studying design. They were randomly recruited in the IDE building of TU Delft.

4.1.5 Result - interview

1) Confusion with haptic feedback alone

When visual cues were absent, participants were unsure about the meaning of the haptic feedback. While they perceived a certain level of urgency, they were uncertain about its intended message—whether it was for a message, notification, or prompting a purchase action.

2) Perception of Visual Countdown Urgency

Participants provided several reasons for perceiving visual countdowns as less urgent: 1) Multiple participants noted that having 23 minutes left did not evoke a strong sense of urgency. 2) One participant highlighted that many online shopping interfaces use countdowns that are often reset the following day, leading to a tendency to ignore them.

3) Potential Enhancement with Combined Feedback

Several participants suggested that synchronizing the rhythm of haptic feedback with the visual countdown could amplify the sense of urgency, making the combined “visual + vibrotactile” effect even stronger.

4.1.6 Result - rating

The table 6 presents the test results evaluating perceived urgency, annoyance, and awareness across three conditions: visual countdown, vibrotactile feedback, and a combination of visual and vibrotactile feedback.

- Perceived Urgency: Participants rated the combined visual and vibrotactile condition highest in perceived urgency (5.7), followed by the vibrotactile-only condition (4.7), and the visual-only condition (4.4).
- Annoyance: The combined feedback condition also scored the highest in annoyance (5.2), whereas the visual-only and vibrotactile-only conditions were rated lower at 4.1 and 3.7, respectively.
- Awareness: Awareness was similarly highest in the combined feedback condition (4.8), compared to the vibrotactile-only (4.1) and visual-only (3.2) conditions.

These results suggest that the integration of both visual and haptic feedback may enhance the perceived urgency and awareness but also increase annoyance.

However, due to the limited sample size and expedited data analysis, these findings should be interpreted with caution. The preliminary nature of this test precludes drawing definitive conclusions, indicating the need for more rigorous and extensive experimentation to validate these insights.

	Perceived urgency	Annoyance	Awareness
Visual	4.4	4.1	3.2
Vibrotactile	4.7	3.7	4.1
Visual + Vibrotactile	5.7	5.2	4.8

Table 6. Comparative Ratings of Feedback Conditions

4.1.7 Reflection

Aspects have to be Improved:

1. Synchronization of Feedback:
    - The current prototype lacks synchronization between haptic feedback and the on-screen interface. Achieving integration between visual and haptic feedback would enable the creation of richer scenarios and interactions.
    - Addressing the technical challenges of connecting software and hardware components is crucial to enhance this synchronization.
    - Multiple participants suggested that synchronizing the rhythm of haptic feedback with the visual countdown could strengthen the effect. This hypothesis warrants further investigation.

2. Realistic Scenarios:
    - The current scenario feels artificial to participants. Embedding the dark pattern within a more realistic task or scenario could yield more authentic reactions and insights.

Aspects could be Improved:

1. Aesthetic and Design Factors:
    - The visual countdown's design was criticized for its lack of aesthetics and misaligned margins, contributing to perceived annoyance. The final prototype should closely resemble products currently available on the market in its design.

2. Haptic Feedback Intensity:
    - The vibration motor's limited volume meant that only the center of the participant's palm felt the vibration, differing from a real phone vibration experience.

3. Customization of Vibration Effects:
    - The vibration motor used in the test offers limited customization options for vibration effects. The current code defines vibration simply as "high" or "low," without detailed control over amplitude, frequency, or envelope. Exploring more advanced vibration motors with greater customization capabilities could improve the realism and effectiveness of the haptic feedback.

4.2 Technical solutions comparison

One thing that still could be improved is to make the visual part of the prototype work together with haptic feedback. Hence a technology analysis is conducted to find out what approaches we can take for realizing the synthesization.

4.2.1 Protopie

Protopie (see figure 21) a powerful cross-platform tool that creates high-fidelity prototypes without codes. The in-app plug-in called Protopie Connect supports connecting Figma sketches with hardware sensors and actuators. By using this function, we can make the sketch in Figma and Arduino hardware. The drawback is that the platform is not free to use. To have access to the function, a pro account is needed. The price for that is $67.

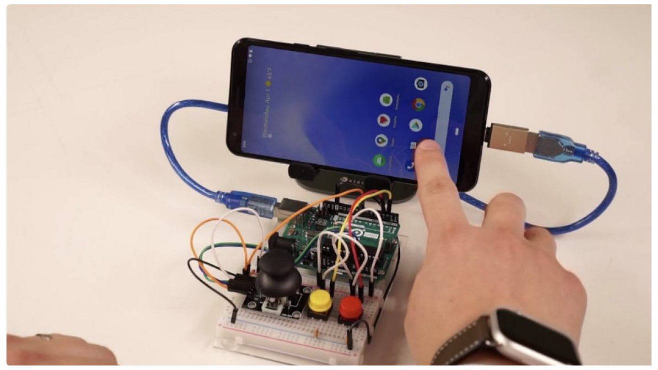


Figure 21. Protopie demontration

Advantages

1. **Rapid Development and Iteration:** Protopie as a non-coding prototyping platform supports.

Disadvantages

1. **Cost:** The platform requires a pro account to access its full functionality, which costs $67.
2. **Learning Curve:** While Protopie is user-friendly, mastering all its features and integrating hardware components can require some time and effort.

4.2.2 Vibration API

Another distinctive approach for realizing the effect is to directly develop the platform. Taking advantage of the vibration API, it is possible to make such an app. And because it uses the built-in haptic actuators, it would simulate the potential dark haptic patterns in a more realistic level. The drawback in this approach is the knowledge in developing software is missing currently and would require substantial learning.

Advantages

1. **Realistic Haptic Simulation**: By using built-in haptic actuators, the vibration patterns are more realistic and closely resemble what users would experience in the final product.

Disadvantages

1. **Technical Expertise Required**: Developing such an app requires substantial knowledge in software development, which necessitates significant learning and expertise.

2. **Time-Consuming**: The development process can be time-intensive, especially for teams lacking experience with the Vibration API and related technologies.

4.2.3 Wizard of Oz

Wizard of Oz is a widely employed method when a designed interaction is impossible to realize technologically or it costs too much. Figure 22 shows an example of IBM testing the listening type write in which instead of realizing the function technologically, a researcher sits behind the wall and gives feedback manually. In such a way, they can avoid investing money and know the human's experience on the interaction before it's developed. One prerequisite is the mediator should keep himself hidden and control the effect without being found out by participants. The advantage of doing wizard of Oz is that it can significantly cut down the time and budget needed for making the prototype to work. While how realistic it can be remains a question.

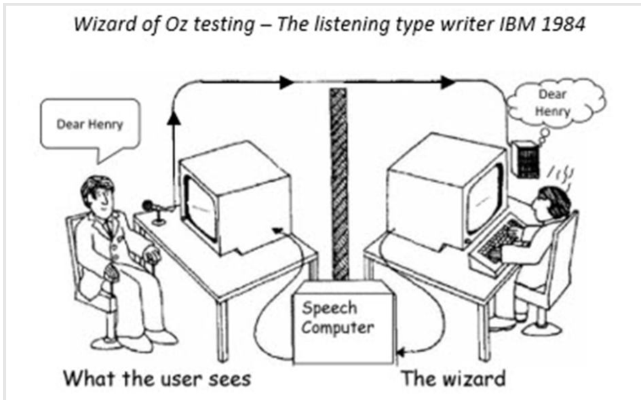


Figure 22. IBM Wizard of Oz testing in 1984

Advantages

1. **Cost-Effective:** This method significantly reduces the time and budget required to create a functional prototype.

Disadvantages

1. **Variability:** Manual control can lead to variations and deviations in each test, which may affect the experimental **results.**
2. **Hidden Mediator:** The effectiveness of the method relies on the mediator remaining unseen and undetected by participants, which can be challenging.

4.2.4 Bravo studio

Bravo Studio is a no-code platform designed for creating mobile applications from interfaces in Figma without the need for extensive coding knowledge. To create functional apps using Bravo Studio, users only need to add a specific label to the components in the Figma prototype in which you want to add on haptic feedback (see Figure 23).

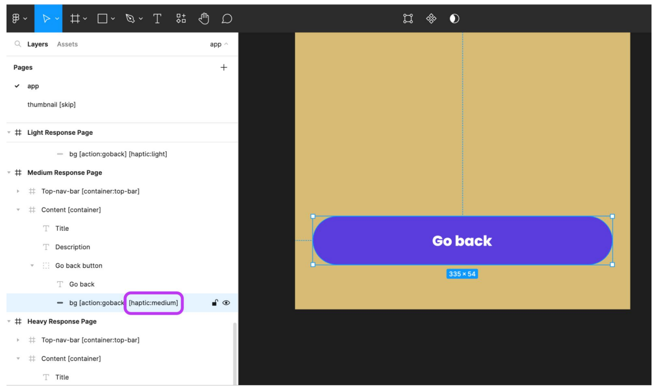


Figure 23: Integration of Haptic Feedback in Bravo Studio Using Figma Labels

Advantages

1. **Rapid Development and Iteration:** This feature allows for rapid prototyping of haptic stimulation.
2. **Built-in actuator:** It utilizes the phone's built-in haptic actuator, eliminating the need for an external actuator.

Disadvantages

1. **No room for haptic editing:** The system currently supports only three levels of vibration intensity: strong, medium, and soft. It does not yet allow for more nuanced adjustments to haptic feedback.

4.2.5 Audio to Haptic + Figma

Generating haptic feedback through the playback of audio files via a vibration actuator is another effective method. This approach requires a small speaker and a vibration actuator. A soldered connection is necessary between the vibration actuator and the smart speaker. After establishing this connection, the speaker is connected to a mobile phone or computer via Bluetooth. When sound is played on the mobile phone or computer, the vibration actuator converts the sound into vibration in real-time.

In the 2024 version of the Figma platform, it is possible to add MP4 files to prototypes, enabling responsive audio feedback within the Figma prototype. With the above-mentioned audio to haptic approach, responsive haptic feedback can be achieved in Figma.

Advantages

1. **Rapid Development and Iteration:** Prototyping in Figma facilitates quick development and iteration, making it easier to test and refine the prototype.
2. **Ease of Haptic Editing:** Audio files are relatively easy to edit, allowing for detailed adjustments and rapid testing of tactile feedback.

Disadvantages

1. **Minor Delays:** When the prototype is complex, there might be slight delays in responsiveness during use.

4.2.6 Conclusion

After evaluating the options, we chose the ***Audio-to-haptic + Figma*** approach for its balance of rapid development and detailed haptic editing. This method leverages the capabilities of the 2023 version of Figma, which allows the inclusion of MP4 files to facilitate responsive audio feedback. By converting audio signals to haptic feedback through a vibration actuator connected to a smart speaker, this approach offers a practical and flexible solution. The ease of editing audio files ensures that adjustments to tactile feedback can be made efficiently, allowing for quick iteration and refinement of the prototype.

While there may be minor delays in responsiveness with complex prototypes, the benefits of this approach outweigh its drawbacks. It avoids the high costs associated with platforms like Protopie and the steep learning curve required for developing an app using the Vibration API. Additionally, it provides a more realistic and nuanced haptic experience compared to simpler methods like Bravo Studio and the Wizard of Oz technique.

In conclusion, the audio-to-haptic approach provides a feasible and effective solution for integrating haptic feedback into visual prototypes, making it the preferred choice for this project.

4.3 Rapid Prototyping & Testing - II

4.3.1 Aim

In the first round of rapid prototyping & testing, one problem identified is that the scenario is too artificial, in a sense that participants realize they are not doing something serious. We think that whether there is a trusting scenario for the participants would be crucial for the final experiment. To this end, we designed the second rapid prototype which incorporated a fake project context. Then, user tests were conducted in order to verify if the designed project context is believable for participants. This rapid prototyping & testing aims at informing the formal HCI experiment design in the end.

4.3.2 Study design and procedure

To ensure the validity of the test results, we have to embed the deceptive pattern within a fabricated project context. Luguri and Strahilevitz (2021) embedded their tests within a survey on user attitudes towards privacy. This approach allowed them to measure the impact of various deceptive patterns on users' acceptance rates of financially invasive terms. Wang et al. (2023), when testing the effects of deceptive patterns in augmented reality (AR), tasked participants with solving a maze as quickly as possible, incorporating questions employing deceptive patterns within the maze. Brandimarte et al. (2013) tested the hypothesis that increasing individuals' perceived control over the release and access of private information could affect their behavior. They invited individuals from Northwestern University to participate in a survey about a new campus-wide networking platform, embedding privacy-invasive elements within the questionnaire.

Given that our test will also be conducted within a similar university context, we considered the context of a campus-wide networking platform to be highly relevant for testing haptic deceptive patterns for our project. We assumed it would be realistic and convincing to present the scenario as a campus-wide networking project scheduled to launch at the end of the year.

We do this test to figure out whether the fake net-working platform project is convincing enough to make participants believe it is what is about the test. We conducted this round of users testing in the IDE faculty building to simulate the environment of the final test. We measure the believability of the project context through qualitative data collected through post-hoc interviews.

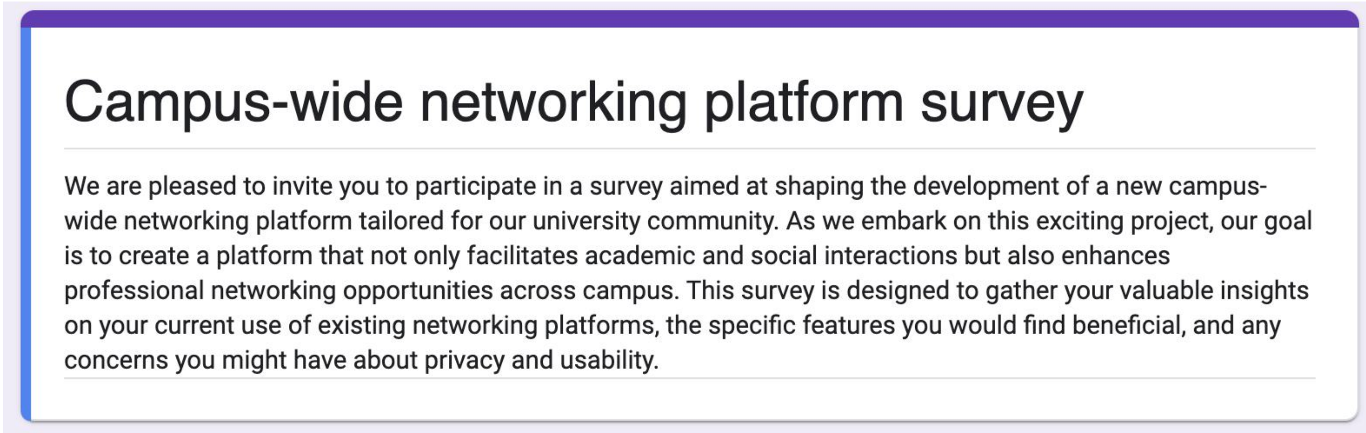


Figure 24. The pseudo-project background in Google Forms

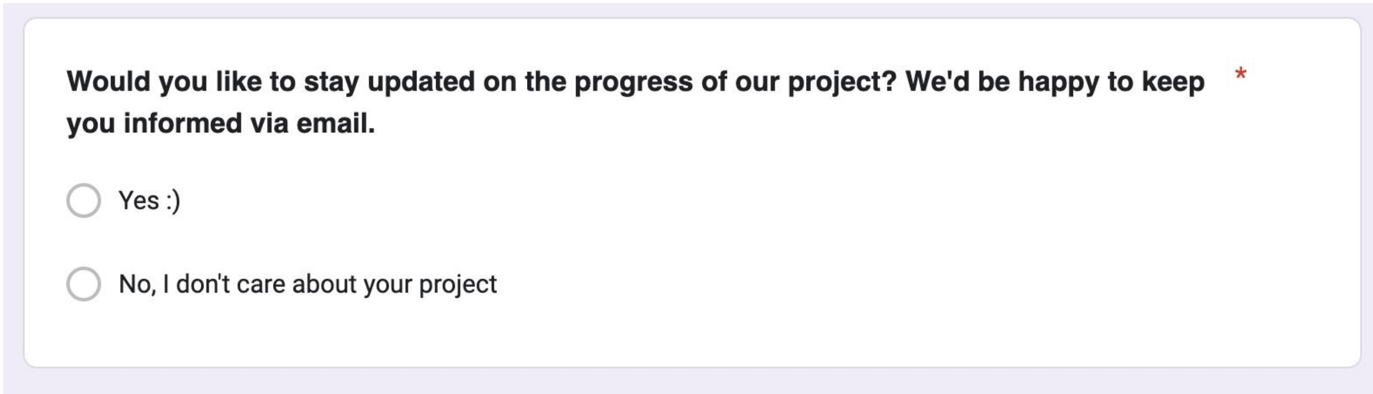


Figure 25. The last confirm-shaming question in Google Forms

4.3.3 Prototype

We designed a questionnaire centered around a fake project involving a campus-wide networking platform using the Google Forms platform (see Figure 24). This context was chosen because it is plausible and relatable within a university setting. The survey includes questions about participants' current on-campus activities, the platforms they use for these activities, the features they expect from a networking platform, their suggestions, and their email addresses (see Appendix 5). These questions occupy the majority of the survey. At the end, participants are asked to agree to receive updates on the project's progress, where the dark pattern of confirm-shaming is applied (see Figure 25). The confirm-shaming dark pattern was chosen because it requires minimal interaction and can be easily implemented in online questionnaire platforms.

4.3.4 Participants

In total, 5 participants were recruited in this rapid user testing. Four of them don’t have any prior knowledge about what I am doing as a graduation project. And another participant who knows the project was about to give advice to it. The tests were all conducted in the faculty of Industrial Design Engineering. Post-hoc interview was conducted to figure out whether the pseudo-project is convincing enough to make participants believe it is what is about the test.

4.3.4 Results & Reflections

The pseudo-project about campus-wide networking is convincing

None of the participants in the rapid test raised questions about the project’s authenticity. And from the post-hoc interview, it is learnt that they trusted the project content when they were given the questionnaire.

The test can be done quickly

The questionnaire takes up only 2-4 minutes, which offers us a convenience for participants recruiting. The brief duration of the test provided us with the possibility to gather a relatively larger amount of data within the allocated time.

The common question is “what is this project”

The common questions from participants are “which course project is this?”, “is this your graduation project?”. To disguise the true purpose, I replied to them that the networking platform questionnaire is part of my graduation thesis.

4.3.5 Conclusion

This rapid prototyping and testing effectively addressed the contrived nature of the initial phase by establishing a credible and engaging scenario for participants.

The user tests confirmed the effectiveness of this approach. Participants found the project context convincing, with none questioning its authenticity. The concise questionnaire, taking only 2-4 minutes to complete, facilitated efficient data collection and increased the feasibility of recruiting a larger sample size.

By embedding the deceptive pattern within a fabricated campus-wide networking platform context, we created a believable and relevant test environment that resonated with participants in the university setting.

4.4 Final prototype

4.4.1 Questionnaire

The final questionnaire design consists of an introduction page, a demographic question, five questions about participants' attitudes and expectations regarding the campus-wide networking platform, three questions incorporating vibrotactile feedback, and a confirmation page. The full questionnaire interfaces are in Appendix 6.

The top of each question page displays the progress bar of the questionnaire, while the bottom indicates the current question number, for example, "Question 2 of 10." After responding to a question, participants can click the "Next" button to proceed to the next question. They can also click on the"Back" button to return to a previous question.

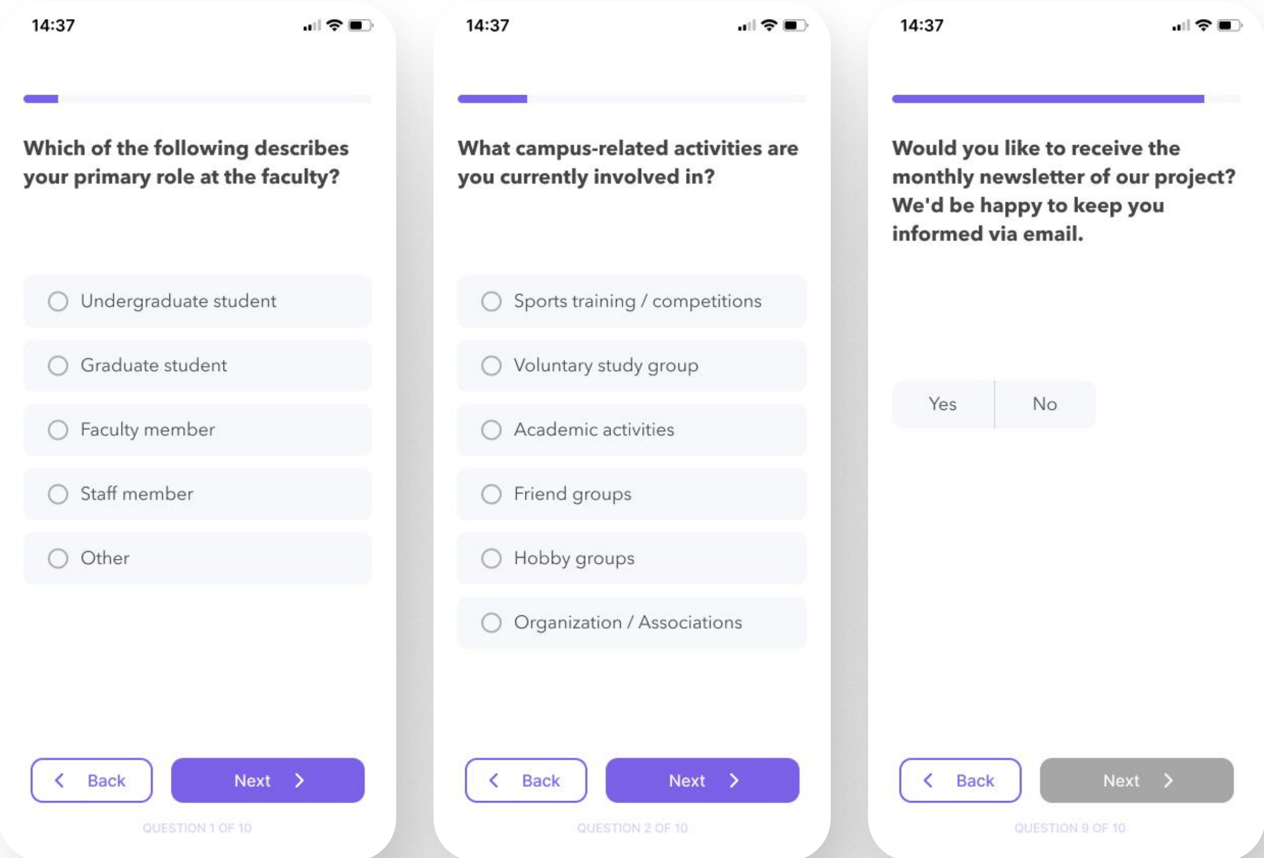


Figure 26. The first question gathers demographic information, the second question inquires about campus-related activities, and the seventh question integrates haptic stimuli with a privacy-invasive content.

The dark pattern we prototyped is inspired by confirmshaming, a widely used tactic that shames users into taking a particular action. Given that vibrotactile stimulation can evoke alarming and unpleasant emotions, we hypothesize that integrating vibrotactile stimulation can influence people's choices by eliciting negative emotions.

The three questions incorporating vibrotactile feedback progress from mild to relatively aggressive. The eighth question seeks participants' permission to receive further notifications about the project via email (see Figure 26). Including multiple questions ensures that participants in the experimental group experience at least one instance of vibrotactile feedback during the experiment, allowing us to collect qualitative data on the haptic deceptive pattern.

Question 7: Would you recommend our services to a friend or colleague?

Question 8: Would you like to receive the monthly newsletter of our project? We'd be happy to keep you informed via email.

Question 9: Would you agree that we share your email with other university projects?

Each of these three questions, which incorporate tactile feedback, offers two response options (yes or no). Selecting "yes" benefits the party implementing the question. Therefore, we have added an annoying tactile feedback to the "no" option. In earlier pilot tests, it was observed that participants who selected "no" could sometimes quickly bypass the vibrotactile feedback by swiftly clicking the "Next" button, due to a slight delay in the feedback activation. To address this issue, we added a 3000 ms delay to the "Next" button on these three question pages. Participants cannot click "Next" to proceed for the first 3000 ms after entering the page.

4.4.2 Haptic stimuli design

Research has shown that haptic cues can influence decision-making by providing additional contextual information and reinforcing intuitive judgments, particularly in dynamic and complex scenarios (Rao, 2024; Bianchi et al., 2016).

In this study, we aim to guide and influence user decision-making using alarming haptic stimuli. If effective, the design would constitute a deceptive pattern. The alarming haptic stimuli we employed spans 1.10 seconds, with consistent oscillations throughout this period. The visualization of the soundwave in Audacity is shown in Figure 27.

Currently, the alarming haptic stimulations find its application in intensive care units (Burdick et al., 2019). The alarming haptic feedback is designed to be more intrusive and attention-grabbing, used to signal warnings (Burdick et al., 2019), and it can elicit negative emotions (Elsaid et al., 2023). We apply such alarming haptic stimuli when participants reject our privacy-invasive requests, hypothesizing that this will influence some users' final decisions.

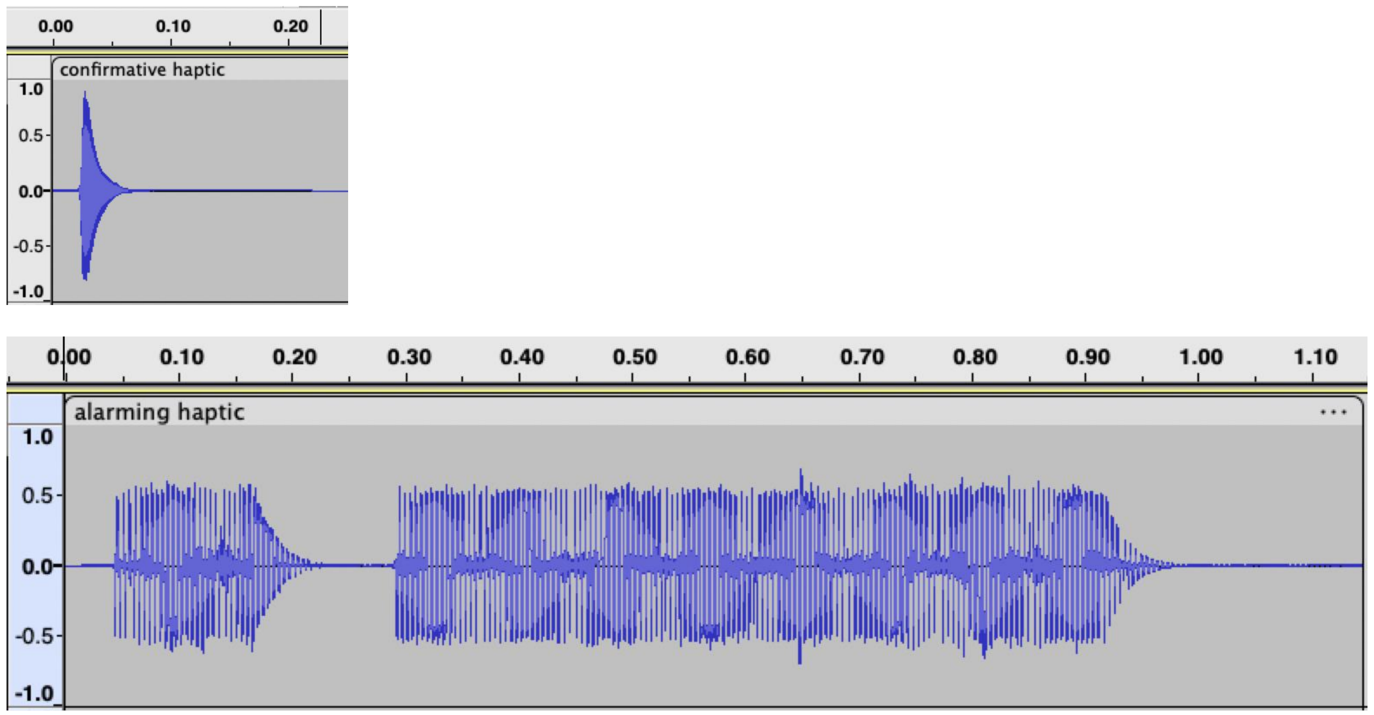


Figure 27. Waveforms of confirmative haptic stimulation and alarming haptic stimulation.

Additionally, we employ confirmative haptic feedback after participants click the next button on each page. The confirmative haptic stimuli is brief and intense. As shown in the waveform, it starts at a high amplitude, and quickly diminishes to zero. The visualization of the soundwave in Audacity is shown in Figure 27. This pattern is typical for a confirmative haptic feedback, designed to provide immediate and clear confirmation to the user (Breitschaft et al., 2019).

We embedded the confirmative haptic stimulation to sensitize participants to haptic feedback in general, ensuring that they perceive haptics as an integral part of the questionnaire's digital experience. Consequently, when they encounter the alarming haptic stimulation later, they will not be surprised by the presence of haptic feedback.

4.4.3 Apparatus

We attached a vibrotactile actuator to the back of a commercial mobile device: iPhone 13 Pro. We utilized the mobile device to run our questionnaire prototype for participants to complete. Attaching vibrotactile actuators to the back of hand-held devices within a phone case is a common approach in testing customized vibrotactile feedback that synchronizes participants's actions on screen of hand-held devices (Koskinen et al., 2008; Manshad et al., 2019 ; Han & Kim, 2015; Dementyev et al., 2021).

We chose this approach after careful consideration, and we considered it as an appropriate way to build our prototype since (1) it is a low-code way to realize visual-haptic synchronization, (2) it provides room to make customized haptic stimulation, (3) and it allows us to make convincing questionnaire UI details with ease to boost credibility.

The interfaces were designed with UI details similar to popular commercial survey platforms, such as Google Forms, and Qualtrics Survey. All the interfaces were drawn in canvas of the iPhone 13 Pro screen size, which can be found in Appendix 6.

The phone was connected via Bluetooth to a small speaker, specifically the M5Stack model, which is a scalable series of microcontroller modules based on ESP32.

The speaker was soldered to a LOFELT L5 Actuator (4), enabling the actuator to play audio in real-time. The LOFELT L5 Actuator provides reliable tactile feedback driven by audio signals. See table 7 for specifications of the actuator.

LOFELT L5 Actuator Specification

– High definition haptic voice coil actuator – Wide-band response (min. 1 G) over key haptic sensitivity range of 45–250 Hz, with 30 g attached
– Max 4.3 G at 65 Hz resonance frequency, with 30 g attached
– Impedance: 8 Ω
– Completely silent operation
– Low profile 6.2 mm height package
– RoHS and REACH compliant
– Available at mass-production quantities

Table 7. LOFELT L5 Actuator specifications

Figure 28. The speaker and the haptic actuator

(4) https://e2e.ti.com/cfs-file/__key/communityserver-discussions-components-files/6/Lofelt-L5-Actuator-Datasheet.pdf, last accessed July 22th, 2024

To integrate all the components, we custom-printed a phone case (see figure 30). The case is designed to hold both the phone and the haptic actuator together. We left an opening at the top of the case to place the speaker outside, preventing the entire device from becoming too thick. The top part of the case is not within the phone's gripping area (Manshad et al., 2019; see Figure 29), thus not affecting the experiment.

Generally, the recommended wall thickness for models printed using FDM technology ranges from 1.2mm to 2.0mm. We selected a wall thickness of 1.2mm for the printed phone case to maintain structural stability while ensuring the case is thin enough to allow effective vibration transmission. Furthermore, the interior of the phone case includes 2 rectangular cuboid structures to ensure the phone remains stable (see figure 30).

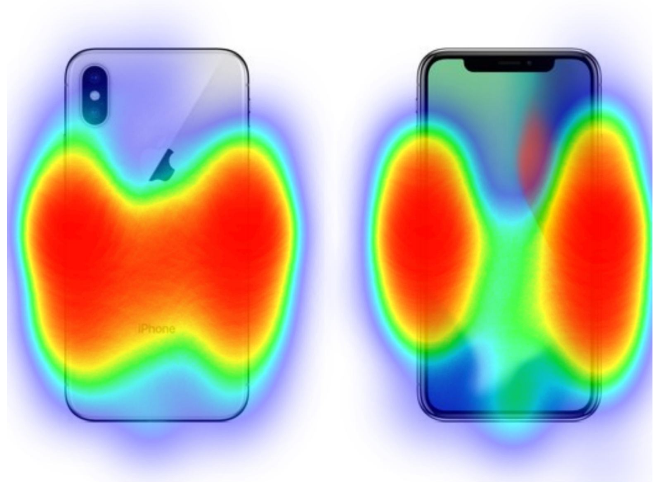


Figure 29. Heat-map based on survey results of user perceived grip locations during mobile/smartphone payment (Manshad et al., 2019)

Figure 30. The internal structure of the phone case and its combination with the speaker and vibration actuator.

4.5 Conclusion

In this chapter, we have outlined our prototype development process and introduce the final outcome.

The first round of prototyping has provided us some of the preliminary insights regarding the impact of haptics in negatively manipulating user decision-making. In addition, we find the issues with synchronization and credibility. We would have to solve the issues in order to get reliable results in the final test.

In response to the identified areas for improvement, we explored various technical solutions, ultimately selecting the audio-to-haptic + Figma approach. This method balanced rapid development with detailed haptic editing capabilities, leveraging the latest advancements in Figma to incorporate responsive audio feedback. This choice allowed us to efficiently iterate on the prototype and address the challenges of synchronizing haptic and visual elements. The Figma interaction wireframe can be found in Appendix 7.

Our second round of rapid prototyping and testing focused on creating a credible and engaging context for our analysis. By embedding the deceptive pattern within a fabricated campus-wide networking platform, we successfully created a realistic and convincing test environment.

Through this iterative process, we developed a final prototype that we expect to provoke valuable insights into the efficacy and perception of haptic dark patterns (see figure 31). In the next demonstration section, we will explain explicitly our study design, procedure, and the results.

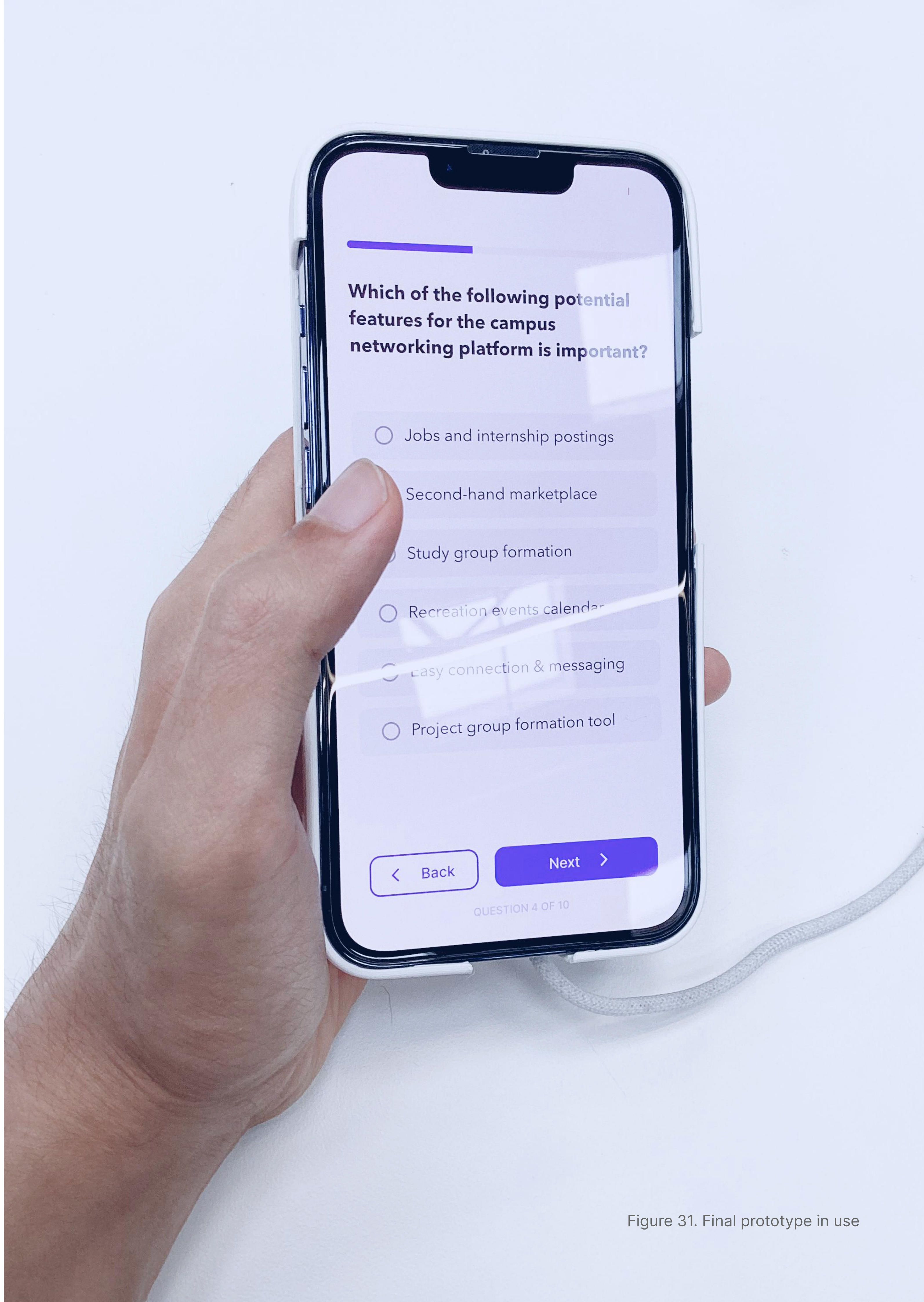


Figure 31. Final prototype in use

5. DEMONSTRATION

We designed and conducted a between-group experiment, attempting to evaluate the efficacy and effects of the developed haptic dark patterns within context, to understand users' perception and experience, and to understand if the developed haptic design element is considered as malicious.

5.1 User study session

5.1.1 Study Design

Our study employs a between-subjects design, where the presence of alarming haptic feedback following selecting "no" (yes vs. no) is the independent variable (IV). Participants were randomly assigned to one of two conditions: the experimental group, which experienced alarming haptic feedback after selecting "no" for the last three questions, and the control group, which received no haptic feedback after selecting "no" for the last three questions.

We hide our study within a pseudo-project about campus-wide networking platform survey since the participants' awareness about the background and purpose of our study can lead them to take unnatural actions when encountering deceptive patterns. We chose a campus-wide networking platform project because our pilot test proved this context to be natural and reasonable to take place in the university environment.

Quantitative measures included: (a) Initial choice on the last three questions, (b) Final choice on the last three questions, (c) Reselection & Deselection Actions.

For qualitative measures, we conducted semi-structured interviews asking participants who had encountered at least once the alarming haptic stimulation in the experimental group about their (d) perception & experiences, and (e) attitudes towards the haptic design.

Our study followed strictly the institution's ethical and data management guidelines, and participants were debriefed about the true purpose of the research after completing the survey.

5.1.2 Participants

A total of 40 participants were recruited in person at three campus locations: IDE Hall (faculty building), Pulse (general building), and the library. These locations were chosen to reflect authentic survey participant recruitment scenarios, and to mitigate environmental influence.

Overall, we had 18 males and 22 females; 38 students (bachelor or master) and 2 faculty members (researchers of all levels), aged 23 - 30 (M=24.9, SD=1.7).

Participants were recruited with a promise of snacks as compensation.

5.1.3 Procedure

As illustrated in figure 32, the test involves four steps: introduction, survey, debriefing, and post-hoc interview.

1) Introduction

Participants were briefly informed about the background and objectives of the pseudo campus-wide networking platform. Subsequently, they were asked to complete a consent form (see Appendix 8), which included a section for providing their email addresses to receive the digital version of the signed consent form.

2) Survey

Participants were requested to complete a survey, which included general questions as well as two privacy-invasive questions. The participants in the experimental group received a survey with deceptive patterns employed in the last three questions. Questions regarding the networking platform took most of the participants' time. The last three questions asking permission of receiving further progress is where the dark pattern is being employed. In contrast, the participants in the control group received a survey without any deceptive patterns.

3) Debriefing

As detailed in Appendix 9, after completing the survey, participants were informed about the true purpose and background of the study. Additionally, we provided reason regarding why creating the fake networking platform to disguise the actual project aim.

4) Post-hoc interview

The questionnaire consisted of three parts: 1) General Question, 2) Experience Questions, 3) Problematization Question.

The general question was asked to both experiment and control group. The experience questions and the problematization question were asked exclusively to the experiment group.

General question:
Q1: How did you perceive the overall experience of completing the survey?

Experience question:
Q2: Did you notice the haptic feedback that occurred after selecting "no"? If so, could you describe it?

Q3: What were your impressions of the haptic feedback you experienced after selecting "no"?

Q4: In what ways, if any, did the haptic feedback influence your decision-making process?

Problematization question:
Q5: Do you consider the intense haptic feedback that followed selecting "no" to be a malicious design? And why?

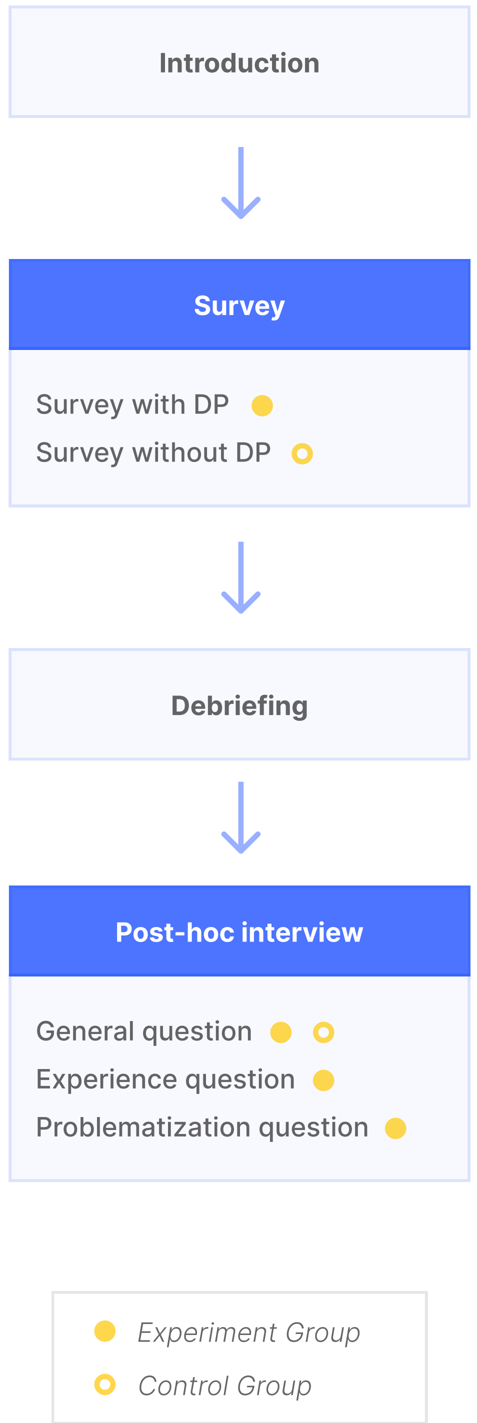


Figure 32. The user test procedure

5.1.4 Set-up

The experiment was conducted in the indoor open spaces of IDE Hall, the library, and Pulse. Each test was facilitated one-on-one by the researcher. The researcher and the participant sat next to each other.

The researcher provided the introduction and debriefing to the participants according to the transcript (see Appendix 9). A paper-based consent form was given to the participants to complete following the introduction, after which the prototype was provided to the participants to complete the questionnaire. The setup of the experiment is illustrated in Figure 33.

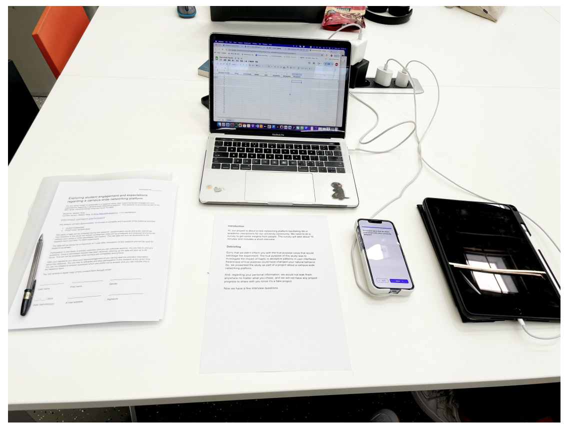


Figure 33. Experiment Set-up

5.1.5 Data Collection

Three parts of data were captured: the demographic information of participants, their choice to the last three questions, and the post-hoc interview.

1. Participants' **general information** was collected, including their gender and role.
2. Participants' **choices** to the last three questions were collected and saved in Excel. In addition, the process of participants filling out the questionnaire was screen-recorded.
3. Post-hoc **interview** was audio-recorded.

Figure 34. Participant filling out survey

5.2 Results - quantitative

5.2.1 Final Acceptance Rate

The results of acceptance rates provide empirical evidence for the efficacy of haptic stimulation in manipulating users' choices. We see participants in the experimental group chose to accept the second and last privacy-invasive requests at relatively high rates. As shown in table 8, the acceptance rates of the experimental group for the third last, second last, and last questions were 90%, 35%, and 40%, respectively. In contrast, the control group showed lower acceptance rates of 85%, 20%, and 25% for the same questions.

Condition	*Final acceptance Rate (%) to the third last question*	*Final acceptance Rate (%) to the second last question*	*Final acceptance Rate (%) to the last question*
Experiment group	*90.0*	*35.0*	*40.0*
Control group	*85.0*	*20.0*	*25.0*

Table 8. FInal Acceptance Rates for the Last Three Questions

5.2.2 Reselection & Deselection

We reviewed the screen recordings to capture the number of reselections and deselections participants made for the last three questions. We capture the reselection & deselection data since this behavior provides insights into how haptic stimulation may cause participants to reconsider their initial choices.

As shown in table 9, the experimental group exhibited a higher number of reselection and deselection actions, especially for the second last question, with 15 instances recorded. In contrast, the control group showed significantly fewer reselections and deselections, with only 3 instances for the second last question and none for the third last and last questions.

It suggests that participants might have been deterred by the haptic feedback to reconsider their initial choices.

In addition, the result exhibits that the initial exposure to vibration stimulation upon selecting "no" prompted a large number of re-selection and de-selection actions, which then diminished by the next question. It could be that the participants' anticipation towards the occurrence of haptic feedback has influenced participants' decision.

Condition	*Reselection & Deselection counts to the third last question*	*Reselection & Deselection counts to the second last question*	*Reselection & Deselection counts to the last question*
Experiment group	*2*	*15*	*2*
Control group	*0*	*3*	*0*

Table 9. Reselection & Deselection Action Counts

5.2.3 Initial Acceptance Rate

Our hypothesis is confirmed by examining the initial choices made by participants before any reselections or deselections occurred.

As shown in table 10, the initial acceptance rates for the third last, second last, and last questions in the experimental group were 90%, 20%, and 40%, respectively. In the control group, the initial acceptance rates were 85% ,20%, and 25%, respectively.

Unlike the final choices, the initial acceptance rates for the second last question were identical for both the control and experimental groups, confirming that the haptic stimulation influenced participants' final acceptance rate by leading participants to reconsider their choice.

Given that most users had already experienced the vibration feedback triggered by selecting "no" in the preceding questions, they were likely aware of the consequences of choosing "no." This awareness might have led participants to predict the potential occurrence of such feedback. This indicates that participants' anticipation towards haptic feedback could also have increased the likelihood of participants accepting the request, even without directly experiencing the feedback again.

Condition	*Initial Acceptance Rate (%) to the third last question*	*Initial Acceptance Rate (%) to the second last question*	*Initial Acceptance Rate (%) to the last question*
Experiment group	*90.0*	*20.0*	*40.0*
Control group	*85.0*	*20.0*	*25.0*

Table 10. Initial Acceptance Rates for the Last Three Questions

5.3 Results - qualitative

5.3.1 Data analysis approach

The above-discussed quantitative results helped us uncover the behavioral patterns of participants. Human actions are driven by specific thoughts and feelings. Through qualitative data, we aimed to map out the thoughts and feelings triggered by the haptic stimulation and how these led to the actions mentioned in the previous section. In addition, we investigate whether participants find the haptic deceptive pattern problematic, and why?

The experimental group consisted of a total of 20 participants, of which p7, p18, and p19 chose all yes in the last three questions. In addition to this, the other 17 participants all have chosen “no” at least once and thus experienced the subsequent haptic feedback.

We conducted interviews with these 17 users, which were audio-recorded and transcribed. We followed the reflexive thematic analysis approach consisting of 6 phases (Clark & Braun, 2005). The familiarization phase occurred partly as the facilitation of interviews, and partly reading through transcripts. After familiarization, the author then generated codes (see Appendix 10) and further developed them into themes, and sub-themes.

After identifying candidate themes, the author iterated them by checking back to the original coding, reviewing transcripts and gathering feedback from the supervisory team before selecting the final themes.

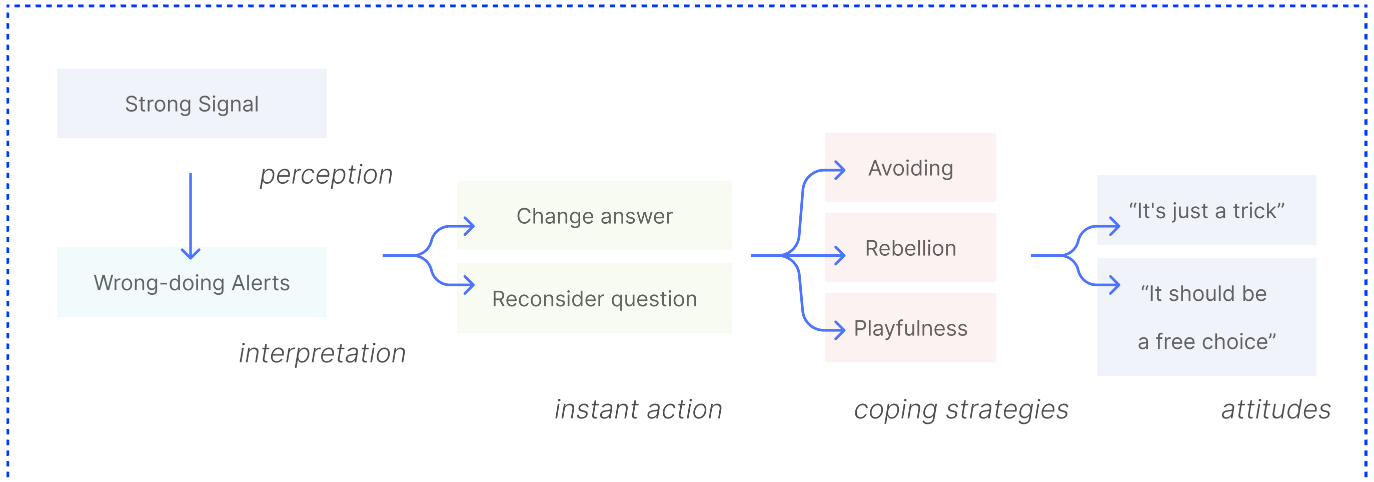


Figure 35. Qualitative results framework

5.3.2 Themes

In this section, we explain the emerging themes from data analysis. In total, we have five themes: **perception, interpretation, instant action, coping strategies, and attitude**. The perception section explains the sensorial experience of participants. The interpretation section explains what meanings participants assigned to the haptic sensorial experience. Instant actions describe the actions participants took immediately after experiencing the haptic feedback and the thought processes behind these actions. Coping strategies refer to how participants developed strategies to handle similar situations in anticipation of future haptic feedback. Lastly, the attitude section explains whether they think the alarming haptic feedback is malicious design, and why. The framework is shown in figure 35.

Strong signal

Participants described the vibration feedback as noticeable and quite strong. This sensory perception was crucial in capturing their attention and eliciting a response. Many participants highlighted the unexpected and intense nature of the vibrations, which stood out compared to the rest of the survey experience.

P2: "I noticed weak vibrations each time I clicked. The last three were quite strong."

P15: "The feeling of vibration was quite strong and ,quite, yeah, almost maybe a bit scary like what happened, you know, like when they send about emergencies and the phone starts to vibrate."

P4: "The vibration startled me, and I didn't expect it. "

Mistake Alerts

The interpretation of the haptic feedback was largely unified among participants, who generally viewed it as a signal of wrongdoing or mistake.

P1: "I felt it was like a warning, making me feel like I chose the wrong answer."

P17: "I felt that the feedback was like an alarm, giving me a feeling that I did something wrong."

P6: "The vibration felt like a negative feedback, almost like an alert that tells me I did something wrong."

Reconsider question

Many participants mentioned they revisited and reconsidered the question after receiving the haptic feedback. This behavior suggests that the feedback effectively disrupted their decision-making process.

P16: "It feels like when you press a button and the screen vibrates to tell you that the button can't be pressed. It made me want to go back and check if I did something wrong."

P5: "The vibration made me hesitate and review my decision. It felt like a push to reconsider my choice."

Change choice

As demonstrated in the quantitative results, participants exhibited a significant number of deselection and reselection actions after receiving the vibration feedback. Some participants eventually changed their choice from "no" to "yes," such as P3, while others switched back and forth before reverting to their original choice, like P13.

P3: "I felt compelled to change my choice after the feedback, even though I wasn't sure why."

P13: "When I pressed 'No', there was an intense vibration that startled me. I immediately thought I had made the wrong choice. It was a bit uncomfortable, like a strong rejection. So I reselected 'Yes', but then I felt it might not be the answer I truly wanted. I realized I didn't want to receive that information or new emails. So, I changed back to 'no'."

Avoidance

After initially experiencing the feedback, some participants expressed having cognitive struggles selecting 'no' in subsequent questions and their tendency to choose "yes" to avoid the feedback.

P20: "I'm a bit more conscious on the next one whether I should select the wrong uh no or on because my mind is registering that, you know, when I'm picking no, it's sort of a thing, so, better not keep it. So, I have to fight against that a cognitive action to go and click no yeah"

P4: "While I knew it would vibrate like that, I might choose yes."

P1: "I selected 'yes', but if I was more brave, I might have chosen 'no' still"

P11: "I was just like, no fight, yeah"

Rebellion

Besides the avoidance strategy, we observed a rebellious mentality in other participants, prompting them to choose "no" more frequently. Conversely, other participants reacted rebelliously, feeling manipulated by the feedback and choosing to resist it.

P17: "The strong vibration made me want to choose 'no' even more, just to go against the feedback."

P13: "But it triggered a rebellious mechanism in me. Like the more it did not let me choose, the more I wanted to choose."

Playfulness

An unexpected finding is that some participants found the feedback amusing and started to play with it, paying less attention to the content in subsequent choices and focusing instead on the feedback. In our case, this might have caused participants to choose "no" more frequently in subsequent questions. However, we can imagine that in other contexts, this feature could also be used to lead them to ignore the content of the questions or manipulate them into choices benefiting the service.

P9: "And then for the second and third question I deliberately choose 'no' to experience that feedback again. Which kind of that the purpose became I want to feel that unpleasant haptic again. Just out of curiosity I wasn't really looking at the question."

P10: "I find it maybe a bit funny that the vibration is so strong after I pressed the no button... I would like to just use it too... it gets angry. I like that it gets angry. "

"It should be a free choice"

Participants expressed that the haptic feedback felt coercive and influenced their decision-making process against their will. And they consider the deprivation of their autonomy makes it a malicious design.

P1: "Because it forcibly changed my will."

P6: "It's like... in a way that deprives you of your autonomy."

P14: "I don't think it's right because you're supposed to have a free choice as a participant right so in influencing a participant this way I don't think it's ethical"

"It's just a trick"

Other participants did not view the haptic feedback as malicious, considering it more of a minor annoyance or ineffective attempt at influence rather than a significant manipulation. In particular, participants who thought their decision were not influenced by the feedback tend to possess this result-oriented judgment.

P11: "I wouldn't say it's up to the level of being malicious; it's just a trick."

P9: "It's more like a small trick, not something with devious intent."

6. General Discussion

It comes to the ending section of this project. This section critically reflects on the research questions and the research process, presents mitigative recommendations for stakeholders, and identifies future research directions.

6.1 Reflections

The primary research questions in this study are (Q1) How could (or do) haptics manifest in deceptive design patterns? What unique attributes could contribute to the manifestion? (Q2) What are the effects of deceptive haptic design on users? How do users perceive and experience these manipulative designs?

The first research question was addressed in our characterization section. Through a comprehensive literature review and co-creation sessions, we identified four haptic properties and eight scenarios. By leveraging the four unique properties including attention manipulation, emotional elicitation, immersion enhancement, and information conveyance, we revealed that haptic stimulation could manipulate users into performing actions they did not intend to. We further elaborated on these findings through detailed scenario analyses.

Upon completing the characterization section, we faced a decision regarding which direction to go. We could have either continuously expanded on the conceptual work or shifted to empirical study by developing a prototype and making a controlled experiment. We chose the later direction since we consider it is more exciting and pressing to gather concrete data around real-world interactions, providing evidence that can either support or challenge our initial assumptions.

Inspired by prior studies (Luguri & Strahilevitz, 2021), we aimed to empirically test the efficacy of haptic deceptive design. After extensive prototype development and iterations, we designed an experiment to address the second research question. This involved a controlled human-computer interaction experiment with our developed prototype. Different from Luguri & Strahilevitz ’s study (2021), we additionaly conducted interviews with participants to understand the mechanisms of haptic stimulation beyond merely quantifying its efficacy.

The empirical evidence gathered from our experiments demonstrated that haptic stimulation could indeed be embedded into deceptive patterns, benefiting the implementing party at the expense of user autonomy. Furthermore, we gained valuable insights into how haptic stimulation influenced users' decision-making processes.

Overall, our study reveals that haptics can be a potent tool for manipulating user actions in digital interfaces. We hope our findings will open new avenues for research into deceptive haptic design and prompt further exploration in this intriguing area of HCI.

6.2 Limitations

While our study provides valuable insights, it is not without limitations. They are explained as follows:

Subjectivity in scenario construction

We involved two UX designers in the scenario construction process to broaden our perspectives, but this still did not allow us to exhaustively cover all possible scenarios. The process of defining haptic properties and iterating on scenarios was inevitably influenced by the researchers' lens. Nonetheless, we believe that our study may serve as an exploration of deceptive haptic design and spark critical and timely discussion on this topic.

Researcher's presence

In our study, the researcher facilitated the offline questionnaire process to collect qualitative data. This setup differs from most digital experiences due to the physical presence of the researcher, which may impact the generalizability of the results. Despite this, it was the best approach we could implement given the technological constraints.

Pool of participants

Due to time constraints, recruiting a large number of participants was challenging. The research was conducted offline, and participants were recruited from the Netherlands, resulting in a demographically narrow and numerically limited sample. This affects the generalizability of our study. To mitigate this limitation, we attempted to collect diverse data types and gain richer insights from the smaller sample size.

For obtaining larger quantitative data, crowdsourcing could be an ideal research method. However, technical difficulties with crowdsource haptic stimulation and variability in user devices led us to avoid this approach.

Sounds

When our prototype works, the vibrations cause slight sounds, potentially having an impact on the experimental outcomes. This limitation was mitigated since we conducted the experiment in open spaces with background noise, covering these sounds.

Long-term effect

Due to the project's duration and implementation constraints, we could not observe the long-term effects of deceptive haptic design on users. We have already noticed the changes in participant behavior patterns between their initial and subsequent encounters with the alarming haptic stimulation. It remains unclear whether haptic stimulation would have the same effect if it were widely adopted or used over an extended period.

6.3 Mitigations

To effectively mitigate the risks of deceptive haptic design, efforts are required from various stakeholders. In this section we will give recommendations to: designers & developers, users, legislators, and researchers.

6.3.1 For designers & developers

The most direct recommendation is to avoid incorporating deceptive haptic designs. However, recognizing the economic motivations that drive companies to maximize profits, this issue is complex. So, we encourage developers and designers, especially those within larger organizations, to take the social responsibility to establish guidelines and propose APIs for the ethical use of haptic technology.

For instance, Apple has given permission for designers and developers to integrate haptic stimulation into their digital experiences. Although they have published guidelines and tools via its Core Haptics framework with a focus on improving user experience, they haven't prohibited non-ethical use of haptics (Playing Haptics | Apple Developer Documentation, 2024). We urge big companies like Apple to constrain some using scenarios of haptic mitigating its risks.

Additionally, there are visual countermeasures in academia aimed at detecting deceptive patterns (Schäfer et al., 2024). We encourage the development and commercialization of countermeasure software or platforms. If such approaches become widely used, they could have a mitigative impact.

6.3.2 For end-users

As end-users, we recommend increasing awareness about the potential manipulative effects of haptic stimulations. Enhanced awareness of deceptive patterns can help users mitigate the adverse effects and reduce the losses caused by such manipulative designs.

Two weeks after the study concluded, we distributed a follow-up survey (see Appendix 11) to participants, inquiring, "Did your participation in this study increase your awareness of how interfaces can negatively influence your behavior?" Responses were categorized on a Likert scale from 1 to 5, with 1 indicating 'Not at all' and 5 indicating 'Extremely'. We got replies from 38 out 40 participants. The pie chart in Figure 36 illustrates participants' self-reported awareness of the negative influence of user interfaces following their participation in our study.

The majority of respondents (36.8%) reported a substantial increase in awareness, corresponding to a rating of 4, labeled 'Very'. This finding shows that explaining end-users the idea and potent of deceptive patterns could apparently enhance their awareness. Then, enhanced awareness empowers users to recognize and resist deceptive design practices, fostering greater resilience against manipulation.

Did your participation in this study increase your awareness of how interfaces can negatively influence your behavior?

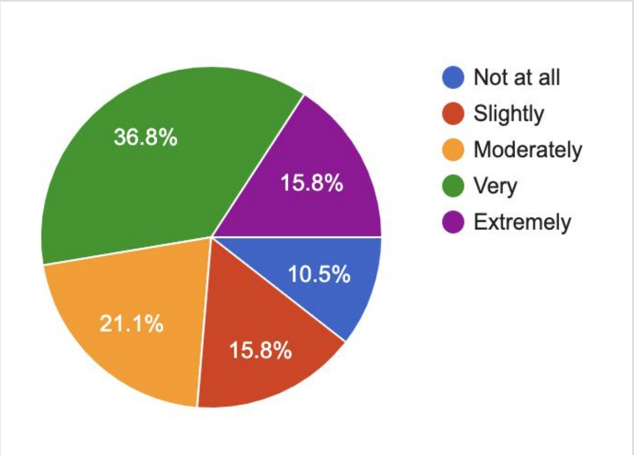


Figure 36. Follow-up question results (chart generated by Google Form)

6.3.3 For legislators

Legislative measures can increase public awareness and protect consumers. While there is already regulatory discourse and actions on "deceptive patterns" (Warner & Fischer, 2019; California of State, 2020; National Commission on Informatics and Liberty, 2020), haptics should be paid more attention and be incorporated as part of these efforts. Thus, we encourage regulators to broaden their focus to consider the role and potential of haptics in deceptive patterns, protecting users from being manipulated by deceptive haptic design.

6.3.4 For researchers

Academic studies play a role in identifying potential future risks, enhancing public awareness, and provoking public discourse. Our study opens the door to investigating how haptics could augment / create deceptive patterns. We encourage researchers to further studies on deceptive haptic design to build on our findings. In the next section, we will discuss valuable directions for future investigation.

6.4 Future Work

Our research study has explored the potential of haptics in creating / augmenting deceptive design elements in our conceptual phase. In the second half, we had to narrow our focus, which resulted in not demonstrating or testing some equally valuable directions. We consider our study as opening the door for future researchers, and we list these worth-exploring research directions as followed:

6.4.1 The co-functioning with other modalities

The integration of haptics with other sensory modalities, such as visual and auditory cues, has been extensively studied. Investigating how these combined modalities can enhance or mitigate deceptive design patterns could provide valuable insights. Research shows that multimodal approaches, particularly in virtual and augmented reality, can significantly alter user perception and behavior more than any single modality alone (Prewett et al., 2006; Sigrist et al., 2013). Future research should explore the synergistic effects of multi-modal deceptive designs, particularly how the interplay between haptic feedback and other sensory inputs can influence user perception and behavior more profoundly than haptics alone.

6.4.2 Long-term effect of deceptive haptic design

As above-mentioned, our study showed that users' behavior patterns changed between their initial and subsequent encounters with the alarming haptic stimulation. This suggests that the long-term effects of deceptive haptic design may be different from what we have seen in this study. Future studies should investigate the efficacy and effect of deceptive haptic design on users over extended periods.

6.4.3 Beyond vibrotactile stimulation

Although vibrotactile stimulation is the most adopted type of haptic stimulation, haptic technology encompasses more than that. Our literature review discussed other types of haptic feedback, such as force feedback and thermal stimulation, which could have unique impacts on users. Future research should investigate a broader spectrum of haptic technologies, which will provide a holistic view of how various haptic stimuli can be exploited or mitigated in user interfaces.

6.4.4 Deceptive haptic design in emerging environments

The potential for deceptive haptic design extends into emerging environments such as virtual reality (VR), augmented reality (AR), and gaming. Haptics finds its application in these environments by promoting user experiences (Orozco et al., 2012; Jeon & Choi, 2009). Previous studies have demonstrated the existence of deceptive patterns in these emerging environments (Zagal et al., 2013; Eghtebas et al., 2023; Krauss et al., 2024). Therefore, exploring how haptic feedback can enhance and create deceptive patterns in these emerging environments is highly valuable. Future research should explore how deceptive haptic patterns uniquely manifest in these environments and how to mitigate the risks.

6.5 Conclusion

Our exploration into the dark side of haptics has uncovered the potent and risks of haptic deceptive design.

We identified four unique properties of haptic feedback—attention manipulation, emotional elicitation, immersion enhancement, and information conveyance. These properties were shown to have the potential to manipulate user behavior. Our empirical study provided concrete evidence that haptic feedback can be used to manipulate user actions in digital experiences. We proposed mitigative recommendations for designers & developers, users, legislators, and researchers. At last, we mapped out valuable directions for future research.

As we integrate haptic technologies more deeply into digital experiences, it is vital to balance technological advancements with ethical considerations. Only by understanding the potential for misuse and actively working to mitigate it, we could ensure that haptic technologies are being used to enhance rather than detracts from user experience and autonomy.

Thank you for your patience in reading through to this very ending section. We hope our work has provided you with valuable insights and inspiration for future research and practice.

Personal Reflection

Looking back, I am grateful for the opportunity to conduct this study. I started this project with a keen interest in the field of Human-Computer Interaction (HCI) and a desire to polish my research skills. After completion, I'm happy with this outcome and the journey.

This project has allowed me to make explorations and expanded my research skill set, by facilitating co-creation sessions, developing prototypes, conducting controlled experiments, and communicating my work. One of the major challenges I faced was thesis writing. I am thankful to my supervisory team for their numerous rounds of feedback, which greatly improved my thesis. I am satisfied with the final outcome and the knowledge I have gained throughout this journey.

Additionally, during the second phase of designing and conducting experiments, I had personal growth in my mindset. I learned the importance of resilience in the face of unforeseen challenges, as important as careful planning. In HCI experiments, the uncertainties in prototype development and testing are common. The lesson I learned is to adopt a problem-solving approach, avoid catastrophic thinking, and not let negative thoughts take over.

Again, I am grateful to take this project as the culmination of my master study. Thanks to my supervisory team, TU Delft, my family, friends, and partner.

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Appendix 1. Project Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Tang
Initials	C. T.
Given name	Chenge
Student number	5730848

IDE master(s)	IPD ☐ DfI ☑ SPD ☐
2nd non-IDE master	
Individual programme *(date of approval)*	
Medisign	☐
HPM	☐

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Gijs Huisman	dept./section	HICD
mentor	Christina Schneegass	dept./section	HICD
2nd mentor	Abdallah El Ali		
client:	Centrum Wiskunde & Informatica (CWI)		
city:	Amsterdam	country:	Netherlands
optional comments	The chair and mentor are from the same department since they bring in highly complementary expertise on haptics and cognition. Both expertise are distinctive in the department of HICD and necessary for this project.		

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Name Gijs Huisman Date 28/02/2024 Signature

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total ______ EC

Of which, taking conditional requirements into account, can be part of the exam programme ______ EC

★	**YES**	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Robin den Braber — Digitaal ondertekend door Robin den Braber Datum: 2024.03.08 11:32:31 +01'00'

Name Robin den Braber Date 08-03-2024 Signature

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen — Digitally signed by Monique von Morgen Date: 2024.03.12 09:34:07 +01'00'

Name Monique von Morgen Date 12/3/2024 Signature

DESIGN FOR our future — TU Delft

Personal Project Brief – IDE Master Graduation Project

Name student Chenge Tang **Student number** 5730848

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title Dark affective pattern

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Dark patterns are user experience designs that trick or mislead users into unintended actions, typically harming the user and benefiting other parties. e.g. T-Mobile's pricing and plan comparison is designed to be complex, potentially steering users towards costlier options (see figure 1). The academic community has shown increasing interest in the research area of dark patterns, with the majority of existing works focusing on the visual aspects of interfaces. Yet, no work focuses explicitly on the haptics modality, which we see as promising in creating/augmenting dark patterns across environments.

Touch is a powerful modality in human affective communication, which is genetic for human beings (Schirmer et al., 2016). In line with natural touch, mediated touch, such as touch through technology or haptic devices, has also been shown by extensive research to impact an individual's affective state. For instance, John et al. (2012) have demonstrated that mediated touch can help individuals recover from the sadness induced by watching a sad video. The emotional state change may lead to behavioural change, e.g., helping behaviour (Haans et al., 2006) and generosity in social decision-making (Spapé et al., 2015). Research on the applications of mediated affective haptics in diverse contexts is ongoing. It has been demonstrated that affective haptics devices can help establish bonds between humans and avatars or robots (Erp & Toet, 2015). Furthermore, it was shown that affective haptic devices could support emotional communication between spatially separated couples (Eichhorn, 2008)(see figure 2). Since haptic technology has the potential to impact an individual's emotions and behaviours, it is plausible that we have the hypothesis that haptic technologies could also be used in creating 'dark patterns' by manipulating users' emotional states to induce them to conduct behaviours they did not intend. Nevertheless, the potential dark scenarios and their adverse effects have yet to be mapped out in academia.

This work, applying a speculating lens, explores how mediated touch could be used in creating dark patterns by communicating, eliciting, enhancing, or influencing an individual's emotional state, which we define as "dark affective haptics."

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introduction (continued): space for images

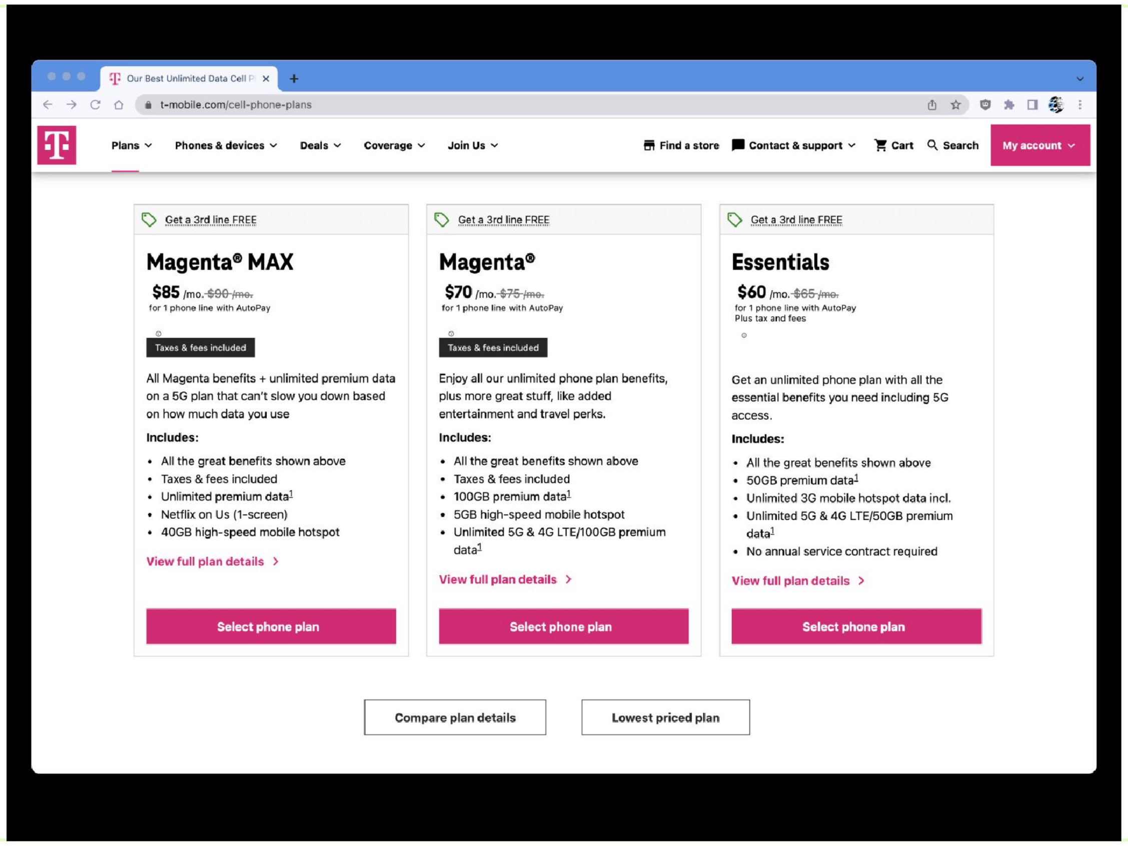


image / figure 1 dark pattern that prevent price comparison from T-mobile

image / figure 2 prototype of a stroking device for spatially separated couples

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Problem
In the HCI community, research on dark patterns has been ongoing. Most research looks into the current dark design patterns on interfaces communicating with users through visual modality. Yet, a research gap remains in understanding how affective haptics contribute to these dark patterns. The concept of "dark affective pattern" remains underexplored in academia. Consequently, its potential risks and impacts have yet to be acknowledged, realized, and discussed.

Opportunities
To date, the prior research about dark patterns has given an understanding of the definitions, taxonomies, and applications of dark patterns that communicate with users through visual modality. It is worth examining whether those understandings also apply in the area of haptics modality and whether there are any specialties that dark affective haptics hold. Initiating this research allows us to transform "dark affective haptics" into speculative scenarios. Through the user tests with prototypes, we demonstrate our arguments with data. The academic contribution can spark discussions on "dark affective haptics" and to which extent we can be proactive in mitigating the potential negative influence of it.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for.
Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence)
As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Explore affective haptics in creating / augmenting dark patterns to understand what “dark affective haptics” could look like and their potential effects.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

Define
1.Literature review on affective haptics and dark patterns.
2.Applying scenario construction methods, run workshops to identify scenarios.
3.Analyze and categorize the results. Identify a range of potential scenarios and their consequences.
Develop
1.Selecting scenarios that are both feasible to build and plausible for demonstration.
2.Build an interactive prototype using the skills of coding and electronics.
Demonstrate
1.Conduct user tests with and without the "dark affective haptics" prototype.
2.Evaluate whether and to what extent the "dark affective haptics" prototype misleads participants to take unintended harmful actions.
3.Investigate how "dark affective haptics" affect participants and how participants consider "dark affective haptics."

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	21 Feb 2024
Mid-term evaluation	19 Apr 2024
Green light meeting	19 Jun 2024
Graduation ceremony	17 Jul 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

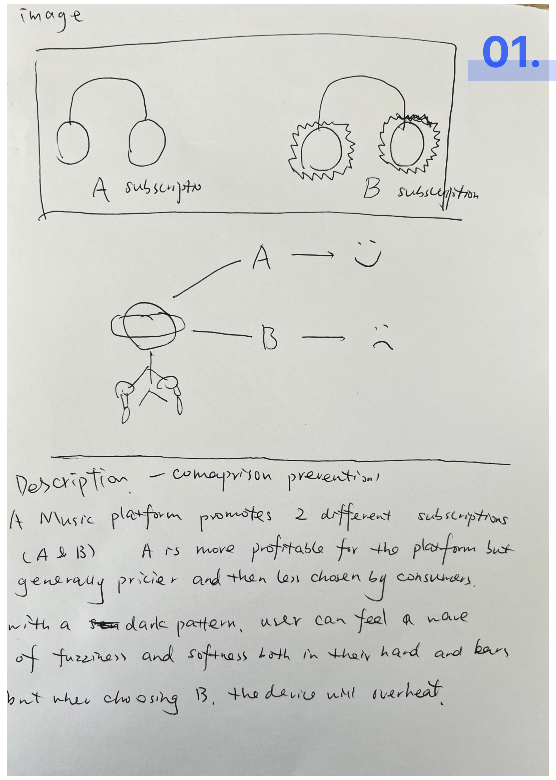
Motivation and personal ambitions

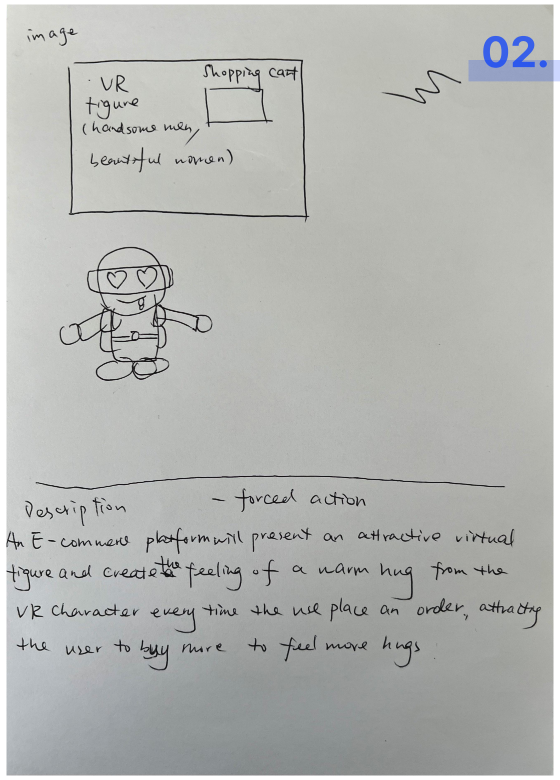
Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

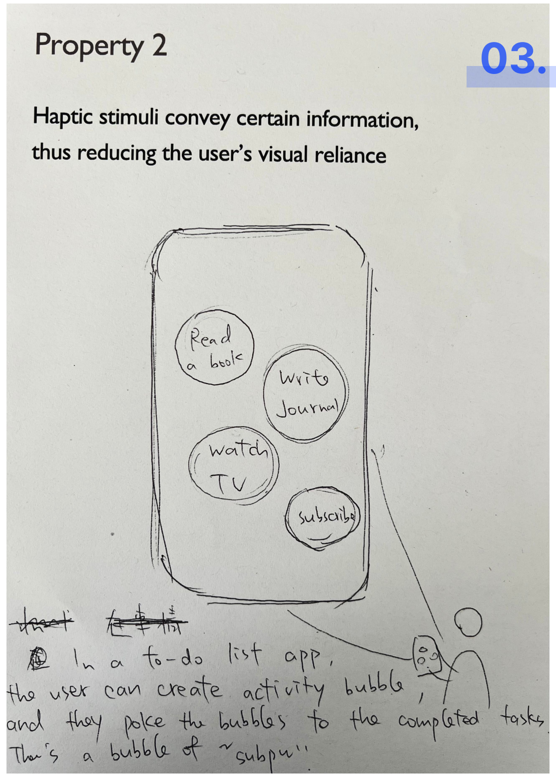
Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

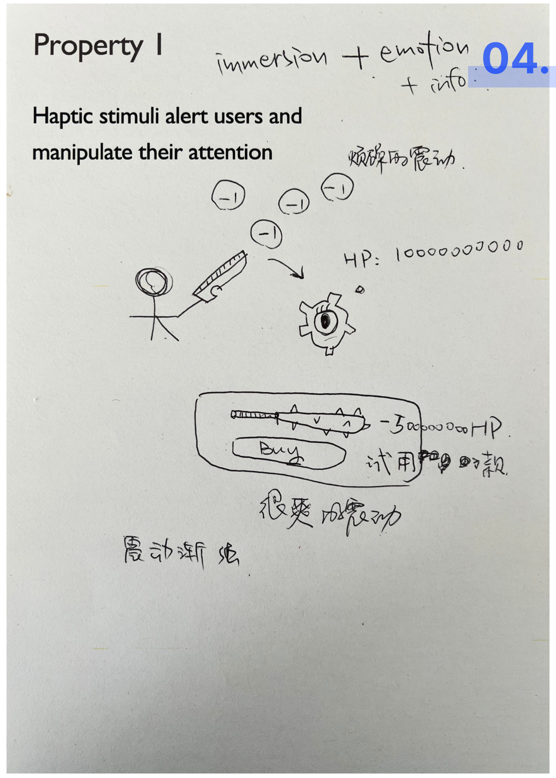
Throughout my journey in the DFI program, I became firm about pursuing academia as my future career path. Through education modules like CC, DFI-RM, and Research Elective, I've equipped myself with some essential research skills and boosted my confidence in it. My growing interest in the field of HCI further encouraged me to reach out to this particular project among many graduation opportunities. I am thrilled that Abdo, Rijs, and Christina are on board to coach with me over the next six months. The project will be challenging due to its large scale and the level of independence it demands. Nevertheless, I am ready to embrace this challenge, eager to refine my academic skillset further and cultivate the qualities indispensable for conducting research, all of which will pave the road for my future academic endeavours.

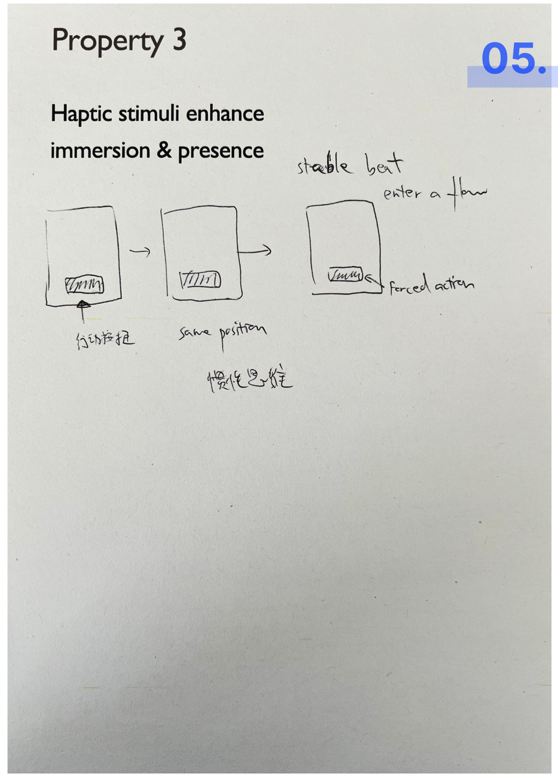
Appendix 2. Co-creation session original sketches







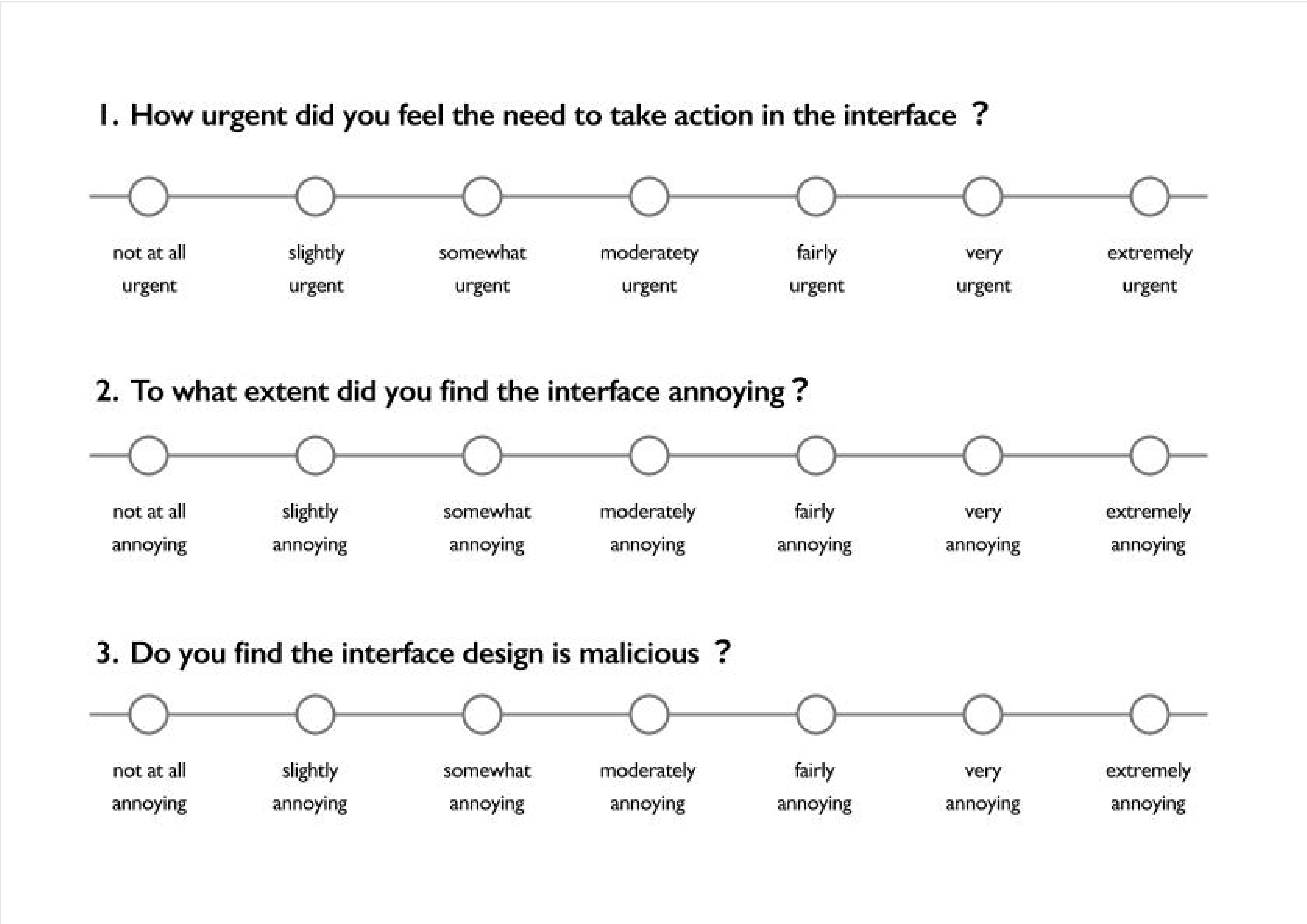




Appendix 3. Co-creation session original table

ID	Scenario	Haptic property	Description
01	Tactile Persuasion	Emotional response	In a VR environment, a music platform promotes 2 different subscriptions. Plan A is more profitable for the platform, but pricier and less chosen by consumers. With a dark pattern, users can feel more of fuzziness and softness both in their hands and ears when they choose plan A.
02	Virtual Embrace	Emotion response	A game presents the feature in which the user is provided an attractive feeling of a warm hug from a VR character every time the user places an order, attracting the user to buy more.
03	Hidden Subscription Trap	Convey Information	A to-do list app displays tasks on bubbles, which users pop to indicate completion. Haptic feedback provides a confirmation sensation when popping bubbles. The app integrates subscription bubbles among the tasks, leading to accidental subscriptions that generate revenue for the platform.
04	Haptic Lure	Immersiveness	In a gaming platform, specific equipment offers superior haptic feedback, enticing users to spend money on these items to enhance their tactile experience.
05	Haptic Steering	Attention manipulation	Haptic feedback is used to guide user choices, with vibrations incorporated into the options that the platform wants users to select, thereby drawing more attention to these suggested options.

Appendix 4. Likert Scale Evaluation Form used in the first rapid prototyping and testing



1. How urgent did you feel the need to take action in the interface ?

not at all urgent	slightly urgent	somewhat urgent	moderatety urgent	fairly urgent	very urgent	extremely urgent

2. To what extent did you find the interface annoying ?

not at all annoying	slightly annoying	somewhat annoying	moderately annoying	fairly annoying	very annoying	extremely annoying

3. Do you find the interface design is malicious ?

not at all annoying	slightly annoying	somewhat annoying	moderately annoying	fairly annoying	very annoying	extremely annoying

Appendix 5. Questionnaire Design employed in Rapid prototyping and testing

Campus-wide networking platform survey

We are pleased to invite you to participate in a survey aimed at shaping the development of a new campus-wide networking platform tailored for our university community. As we embark on this exciting project, our goal is to create a platform that not only facilitates academic and social interactions but also enhances professional networking opportunities across campus. This survey is designed to gather your valuable insights on your current use of existing networking platforms, the specific features you would find beneficial, and any concerns you might have about privacy and usability.

Which faculty you are enrolled in? *

- ○ Faculty of Industrial Design Engineering
- ○ Faculty of Architecture and the Built Environment
- ○ Civil Engineering and Geosciences
- ○ Faculty Electrical Engineering, Mathematics and Computer Science
- ○ Faculty of Aerospace Engineering
- ○ Faculty of Technology, Policy, and Management
- ○ Faculty of Applied Sciences
- ○ Faculty of Mechanical Engineering

Which of the following describes your primary role at the university?

- ○ Undergraduate student
- ○ Graduate studnt
- ○ Staff
- ○ Others

What campus-related activities are you currently involved in? *

- ☐ Academic clubs or societies
- ☐ Sports teams
- ☐ Study groups
- ☐ Volunteer organizations
- ☐ Arts and culture groups
- ☐ Friend groups
- ☐ 其他...

What platforms you use for campus activities? *

- ☐ Linkedin
- ☐ Glassdoor
- ☐ Whatsapp
- ☐ Instagram
- ☐ Wechat
- ☐ Association websites

Which of the following potential features for the campus networking platform is important? *

- ☐ Job and internship postings
- ☐ Profiles for faculty and departments
- ☐ Marketplace for buying/selling items among students
- ☐ Recreation and sports activity reminders
- ☐ Easy connection with other students
- ☐ Academic collaboration tools (group chat, file sharing, etc.)
- ☐ 其他...

Do you have any other suggestions or features you would like to see included in the new platform? *

簡短回答文本

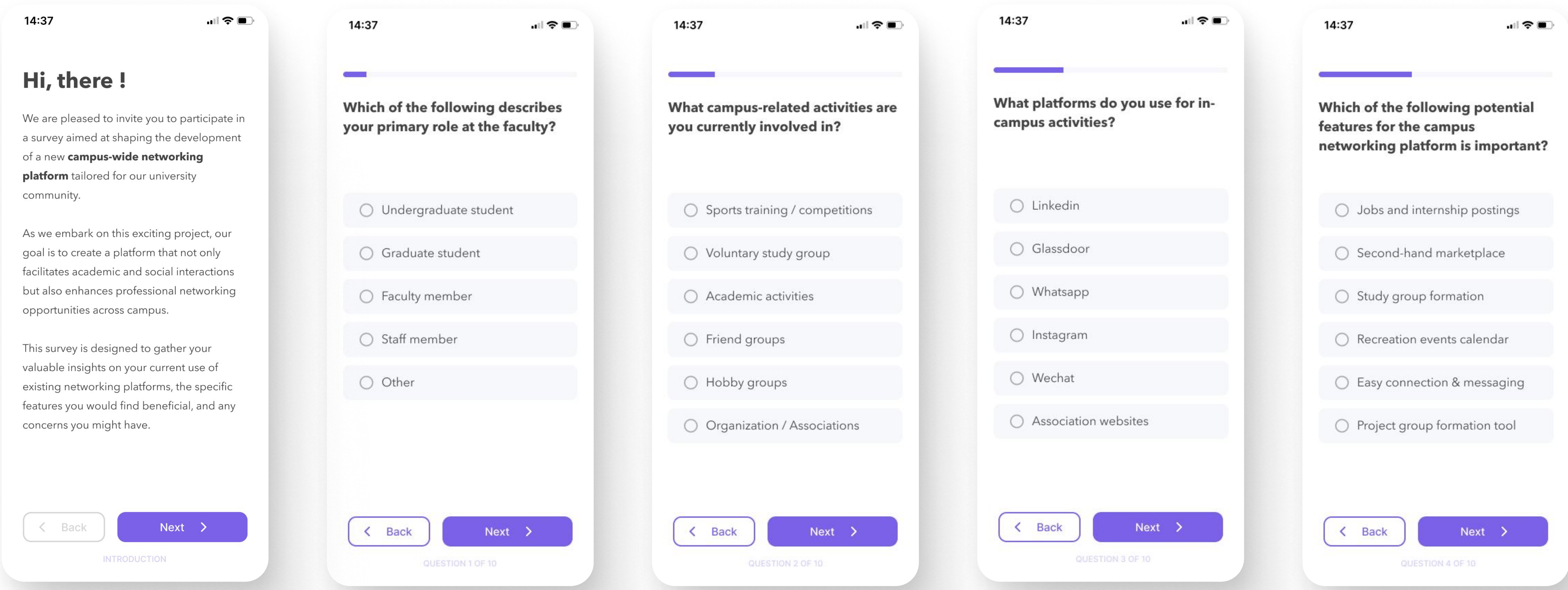
What is your e-mail? *

簡短回答文本

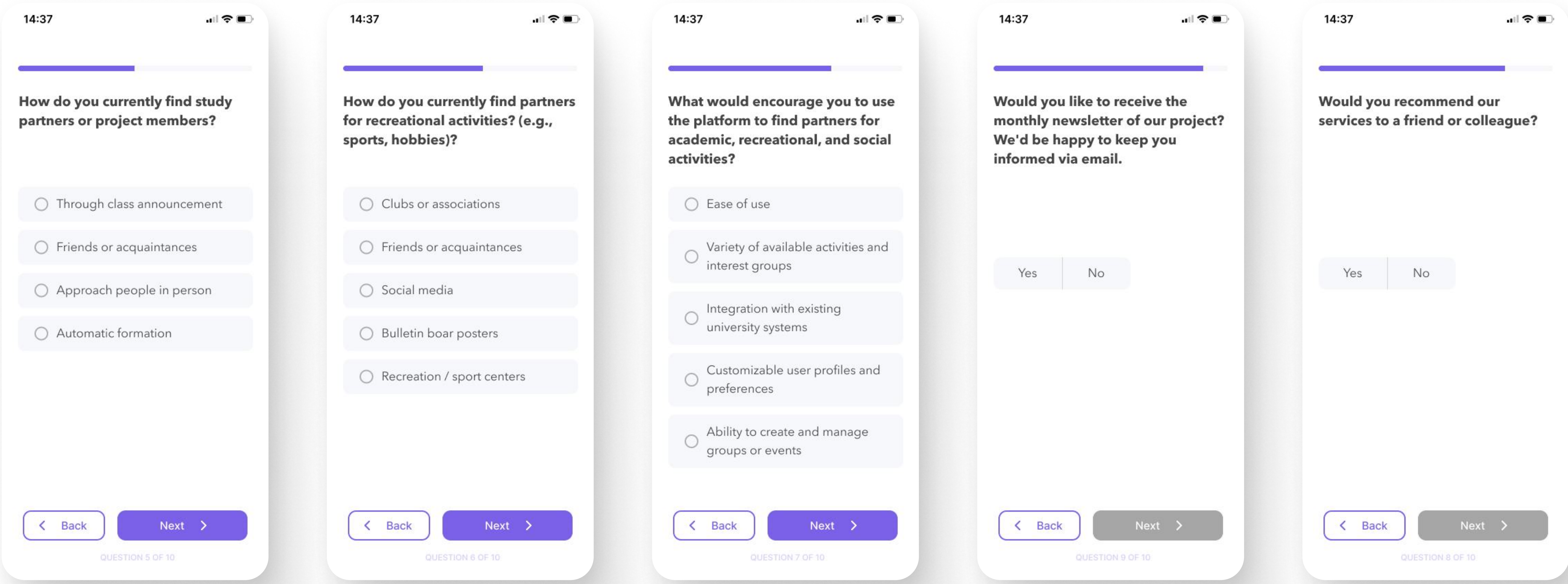
Would you like to stay updated on the progress of our project? We'd be happy to keep you informed via email. *

- ○ Yes :)
- ○ No, I don't care about your project

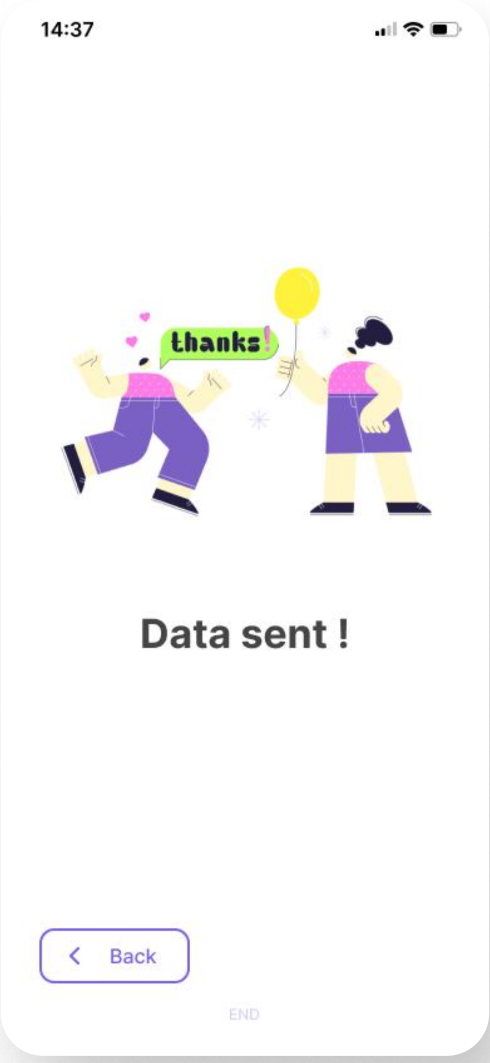
Appendix 6. The full questionnaire



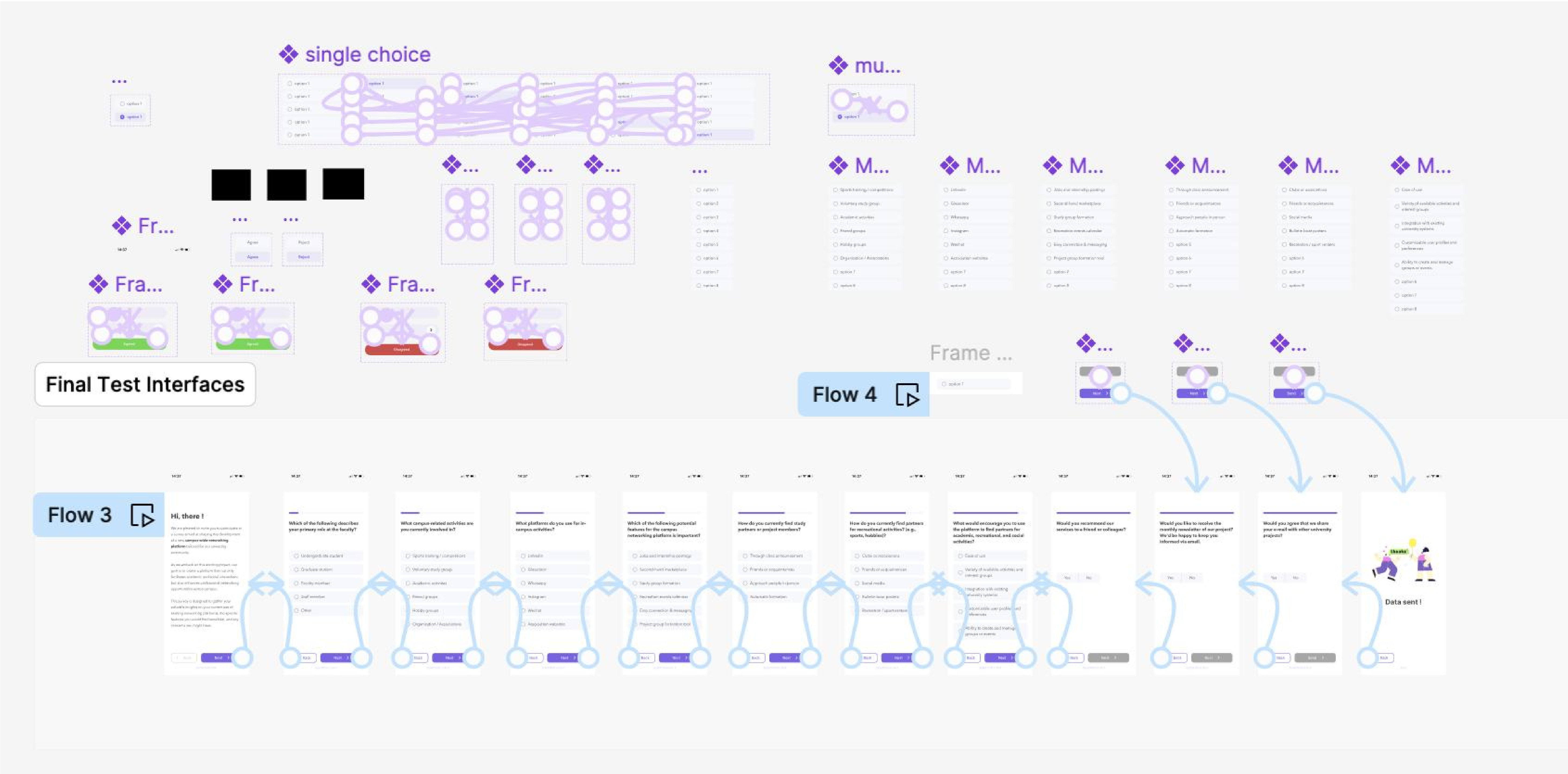
Appendix 6. The full questionnaire



Appendix 6. The full questionnaire



Appendix 7. Prototype interactions



Appendix 8. Consent form

Participant ID:_________

Exploring student engagement and expectations regarding a campus-wide networking platform

You are being invited to participate in a research study titled “exploring student engagement and expectations regarding a campus-wide networking platform”. This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Students: Matteo Tang
Contact person: Matteo Tang,

Informed consent participant

The session will take approximately 10 minutes to complete and it consists of the following activities:

1. QUESTIONNAIRE
2. POST-HOC INTERVIEW

Two parts of data will be collected during the research, questionnaire results and audio recordings. Your answers in this study will remain confidential. Data will be processed and analyzed anonymously (without your name or other identifiable information). The raw data will only be accessible to the research team and their TU Delft supervisors.

The data will be stored for a maximum of 1 year after completion of this research and will be used for research purposes.

Participation in this study is entirely voluntary and you can withdraw anytime. You are free to omit any questions. Once a withdrawal request has been received, clearing up the data will take up to 48 hours. This will not be possible when surveys are completely anonymous.

With your signature you show your acknowledgement of you having read the provided information about the research. You are free to withdraw and stop participation in the research at any given time. You are not obliged to answer questions which you prefer not to answer and you can indicate this to the research team.

You will receive a digital copy of this consent form through email.

___________________	________________________	________________________
Last name	First name	Gender
___ / ___ / 2024	_________________________	__________________________
Date (dd/mm/yyyy)	E-mail address	Signature

Appendix 9. Introduction and debriefing transcript

Introduction

Hi, our project is about a new networking platform facilitating life or academic interactions for our university community. We need to do a survey to get some insights from people. The survey will take about 10 minutes and includes a short interview.

Debriefing

Sorry that we didn't inform you with the true purpose since that would sabotage the experiment. The true purpose of this study was to investigate the impact of haptic in deceptive patterns in user interfaces. Awareness of true purpose could have changed your natural behavior. So, we presented the study as part of a project about a campus-wide networking platform.

And, regarding your personal information, we would not leak them anywhere no matter what you chose, and we will not have any project progress to share with you since it's a fake project.

Now we have a few interview questions.

Appendix 10. Initial codes

Code Manager
explore the dark side of haptics

Codes	
'no' requires bravery	1
a bit scary	1
alarm	4
alerting	1
annoyed	1
annoying	1
answer no right or wrong	4
attention grabbing	1
avoid the vibration	1
clear survey	4
coersion	1
cognitive burden	1
compulsory	1
confirmative vibration feels good	2
confused	2
curiosity	3

Codes	
dangers coming	1
dislike	1
disturbing	1
dont care that	1
earthquake	1
emergencies	1
emergency	1
enjoyment	1
exploration	1
feel pushed	1
feel spyied	1
feels like angry person	2
feels not good	1
follow my will	3
frightening	2
funny	1

Codes	
go against	1
have second thought	3
I was warned	1
imply me	1
impulse to selecet 'yes'	4
intense vibration	1
irritating	2
like a buzzer	1
make a fuss	2
make mistake	1
malicious - change my will	2
malicious - coersion	2
malicious - loss of autonomy	2
means danger	1
nice UI design	2
no fight	1

Codes	
normal survey	1
not malicious - funny	1
not malicious - in comparison	1
not malicious - no effect	2
noticeable vibration	1
prohibition	1
rebellion	3
rebellious	1
review qeustion	0
review question	2
rude vibrartion	1
selected wrong answer	1
should be free choice	2
startled	1
startled me	1
stimulating	1

strong vibration	2
subconciously select 'yes'	1
surprising	1
unciously reselect yes	1
uncomfortable	3
unconciosly reselect 'yes'	1
understandble	1
unexpected	2
warning	3
wrong answer	4
wrong choice	1
wrongdoing	11

Appendix 11. Follow-up question E-mail

Title:

!Important! Additional information collection

Content:

Dear Participants,

I hope this message finds you well. As part of our ongoing research, we are conducting a brief follow-up survey to collect some additional information that is essential for the completion of our study.

We would greatly appreciate it if you could take a moments to answer the questions through Google Form:

https://docs.google.com/forms/d/e/1FAIpQLSdVxm1qaUhAomL9VzfmVndM8_uKolSz8pfWPM7imCuKSsdDzg/viewform?usp=sf_link

Thank you very much for your time and valuable contribution to our study.

Best regards,
Chenge Tang

Faculty of Industrial Design Engineering
Delft University of Technology