Master in Web Technologies and Systems Engineering

FROM TOUCH TO INTUITION: THE EVOLUTION OF INVISIBLE USER EXPERIENCE IN CONTEMPORARY DIGITAL DESIGN

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Abstract

Over the past few decades, User Experience (UX) has undergone a fundamental transformation. What began as interfaces dominated by visible buttons, complex menus, and clearly defined interaction steps is now evolving into what many call the era of Invisible UX. In this new phase, technology quietly blends into our everyday routines, anticipating what we need, reducing unnecessary friction, and offering support almost effortlessly. The aim is not to remove interaction altogether but to make it so seamless and intuitive that using technology feels as natural as breathing. Beyond improving convenience, this shift has opened powerful new opportunities for accessibility. Through voice, gesture, and adaptive technologies, Invisible UX allows people with different abilities to interact with digital systems in ways that feel smoother, more personal, and less demanding.

This dissertation investigates how these invisible, anticipatory systems shape user experiences on multiple levels. It looks at how they influence efficiency, trust, and emotional engagement, while also contributing to more inclusive design practices. To do this, the research draws on established UX theories—namely Norman's emotional design model and Hassenzahl's distinction between pragmatic and hedonic qualities—and combines them with insights gathered from users interacting through three modes: voice, gesture, and accessibility-focused improvements.

The findings reveal a clear emotional journey shared by most participants: they typically started with a sense of curiosity and excitement when trying new interaction modes, experienced frustration when systems made errors, and eventually developed trust once the technology proved reliable. Voice and gesture interactions stood out for their novelty and engaging qualities, but they sometimes lacked the precision needed for consistent performance. Accessibility features, on the other hand, were found to steadily reduce effort, improve overall efficiency, and give users a stronger sense of independence and control.

Based on these insights, the dissertation proposes a practical framework that highlights how Invisible UX can effectively balance pragmatic reliability—the system working well—with emotional value—the system feeling enjoyable and trustworthy. Apple serves as a strong example of this shift, with products like Face ID, AirPods, and Vision Pro illustrating how invisible design is no longer futuristic but part of everyday life. Ultimately, this research argues that Invisible UX is reshaping how we interact with technology, making experiences not only faster and more efficient but also more inclusive, emotionally engaging, and human-centered.

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1. Introduction

1.1 Background and Context

The way people connect with technology has evolved dramatically in recent decades. In its early stages, user experience (UX) design revolved around visible elements, buttons, menus, and graphic interfaces, that demanded conscious attention and deliberate input. These traditional models put the interface at the forefront, making users constantly aware of the tools mediating their actions.

Today, the landscape looks very different. Interaction is moving toward what is known as Invisible UX. Instead of relying on screens and commands, technology now blends into the background of daily life, quietly assisting users with minimal effort. Invisible UX is built around seamlessness and naturalness: interactions occur through voice, gestures, contextual awareness, or predictive intelligence, often so smoothly that users hardly notice they are engaging with an interface at all.

This shift is already visible in mainstream consumer technology. Apple, for example, has pioneered features that reflect the principles of Invisible UX, Face ID for effortless authentication, AirPods that switch automatically between devices, and the gesture-driven Vision Pro headset. These innovations reduce friction, lower cognitive load, and make technology feel more like a natural extension of human intention than a tool requiring conscious manipulation. At the same time, Invisible UX carries wider implications: it not only simplifies interactions for the general population but also expands accessibility, offering new entry points for people with visual, motor, or cognitive challenges.

In this light, Invisible UX is more than just a passing design trend. It represents a paradigm shift in how humans experience digital systems, turning interaction into something more intuitive, anticipatory, and emotionally engaging.

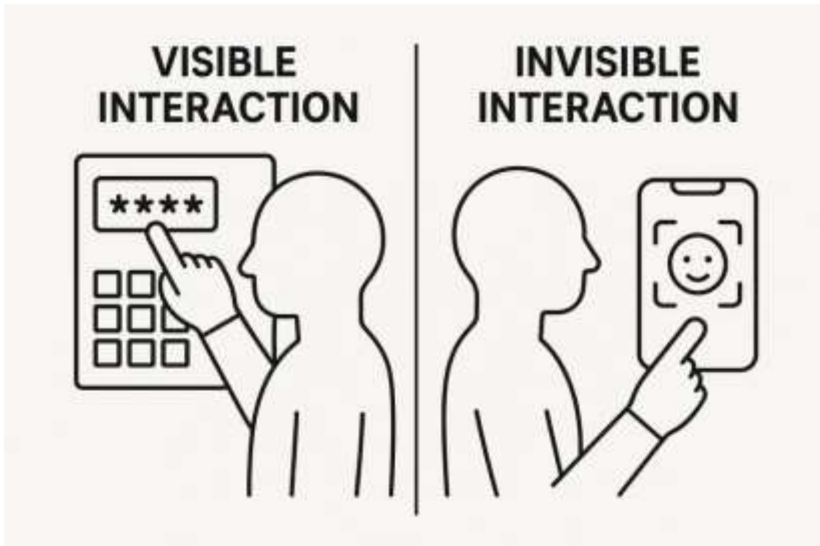

Figure 1 : Visible vs. Invisible Interaction: Traditional buttons versus seamless gestures

1.2 Problem Definition

Over the past decade, the way people engage with technology has shifted dramatically. Interactions that once relied on visible cues, buttons, menus, or graphic controls, are increasingly giving way to what researchers and designers call **Invisible User Experience (Invisible UX)**. This new paradigm aims to make interaction so seamless and natural that it blends into everyday life. Instead of requiring users to consciously navigate through complex interfaces, invisible systems anticipate needs, adapt to context, and respond in ways that feel almost effortless.

Invisible UX has already found its way into our daily routines, often without us even noticing. Think about how naturally we ask Siri or Alexa for help, speaking as we would to another person instead of typing commands. Face ID has made unlocking devices effortless, removing the need to remember passwords. AirPods that seamlessly switch between devices, or smart home systems that adjust lighting and temperature to match our habits, show how technology quietly works in the background to make life smoother. What once seemed like a futuristic idea is now simply part of everyday digital life.

Yet, this promise comes with important challenges. Invisible systems can make tasks quicker, smoother, and even pleasureful. At the same time, they can frustrate or worry users when recognition fails, when actions feel unpredictable, or when the lack of visibility reduces the sense of control. This reveals a fundamental tension: invisibility is meant to simplify and reassure, but its very "hiddenness" can sometimes create uncertainty or distrust.

1. The Core Tension

This tension leads to the central problem at the heart of this dissertation: while invisible UX claims to offer both practical and emotional advantages, it is not yet well understood how experience it in practice. More specifically:

- Invisible UX is praised for **pragmatic efficiency**, faster tasks, fewer steps, less effort. But is it consistently reliable in practice, or does its invisibility make errors more disruptive?
- Invisible UX aspires to deliver **hedonic value**, trust, pleasure, empowerment, even identity. But how do people really respond emotionally when systems anticipate their needs? Does invisibility increase trust, or does it sometimes undermine it?

Although these questions are central to understanding modern interaction, there is limited research that addresses them directly. Much of UX theory has focused on visible usability, while the experience of **seamlessness itself** has rarely been examined. Norman's *emotional design* and Hassenzahl's framework of pragmatic versus hedonic qualities are powerful tools, yet they have not been systematically applied to invisible systems. This leaves a gap in evidence about how invisible UX balances efficiency with emotional engagement.

2. Framing the Research Questions

This study addresses that gap by asking:

- **Can invisible UX be both efficient and reliable, while also making users feel trust, joy, and empowerment?**

From this, three sub-questions emerge:

1. **Pragmatic:** Does invisible UX reliably improve efficiency, reduce errors, and make tasks easier than visible interfaces?

2. **Hedonic:** How do users emotionally respond to invisible interactions, in terms of trust, pleasure, frustration, or empowerment?
3. **Balance:** To what extent can invisible UX combine both pragmatic and hedonic qualities, creating interactions that are not only functional but also meaningful?

These questions shape the investigation by recognizing that invisible UX is neither flawless nor trivial it is a serious design shift that needs critical evaluation.

3. Why This Problem Matters

The importance of this problem lies in the growing prevalence of invisible systems. Far from being niche or experimental, they are now central to mainstream technology. Apple, for example, has positioned itself at the forefront of this shift, embedding invisible interactions like Face ID, AirPods auto-switching, and the Vision Pro headset into its products. If Invisible UX is to become the defining interaction model of the future, it is crucial to evaluate whether it truly delivers on its promise.

Invisible UX also raises questions of **accessibility and equity**. For some, invisible interactions can lower barriers, voice interfaces may assist visually impaired users, and gestures can support those with motor challenges. Yet invisibility can also create barriers, such as when feedback is hidden or discoverability is limited. While accessibility is not the main focus of this dissertation, it remains an important aspect of whether invisible UX can serve diverse user needs effectively.

4. Toward a Resolution

This study tackles these issues by examining invisible UX both in terms of what it does (its speed, reliability, and error rates) and how it feels (its ability to build trust, pleasure, or empowerment). By integrating Norman's and Hassenzahl's theories with empirical data, it explores the dual nature of invisible interaction.

The research acknowledges that invisible UX has limitations: voice misrecognitions, gesture errors, or privacy concerns can easily disrupt the seamless ideal. Yet it also emphasizes the potential: when carefully designed, invisible systems do more than function, they provide experiences that resonate emotionally and support well-being.

5. Conclusion to the Problem Statement

Ultimately, the problem this dissertation addresses is not whether invisible UX exists, it clearly does, but **how it is perceived and experienced by real users**. The key challenge is understanding whether invisible UX can genuinely deliver both **pragmatic efficiency** and **hedonic value**. Can it make interactions smoother and more reliable, while also inspiring trust, pleasure, and empowerment? Or does invisibility risk undermining confidence in the pursuit of seamlessness?

This dissertation explores the idea that, while invisible UX comes with its own set of challenges, it holds the potential to deliver meaningful benefits. Drawing on both theoretical perspectives and real user experiences, it aims to highlight how invisible UX is more than just a passing design trend. When applied thoughtfully, it can shape everyday interactions in ways that traditional, visible interfaces simply can't.

1.3 Objectives and Research Questions

The main aim of this dissertation is to understand how **Invisible UX strategies** shape people's everyday interactions with technology. In particular, the study looks at whether these designs can strike the right balance between **pragmatic efficiency** (speed, reliability, error reduction) and **hedonic qualities** (trust, pleasure, empowerment). Instead of focusing only on traditional, visible interfaces, this work examines how **seamless, background interactions** influence both the practical outcome of tasks and the emotional responses of users.

From this objective, several guiding research questions emerge:

- **User Perception:** How do people experience and evaluate invisible features such as voice commands, gestures, or predictive systems in their daily use of technology?
- **Trust and Feedback:** What part do trust, clarity, and feedback play in determining whether users accept, or reject, these invisible forms of interaction?
- **Accessibility:** In what ways can inclusive design choices enhance Invisible UX, making it both effective and satisfying for a wider range of users, including those with specific needs?
- **Design Framework:** How can Invisible UX bring together efficiency and emotional value, and what practical guidelines can be drawn to inform future design?

Together, these questions frame Invisible UX as both an opportunity and a challenge: while it promises to simplify and humanize digital interactions, it also risks creating confusion or reducing control if the invisibility is poorly designed.

1.4 Methodology Overview

To answer the research questions, this dissertation follows a **case study approach**, blending qualitative insights with basic quantitative indicators to get a well-rounded view of how Invisible UX works in practice. Apple products were chosen as the main focus because they regularly introduce features that reflect Invisible UX principles and often shape the expectations users have for technology in general.

1.4.1 Case Studies

- **Case Study 1 , Face ID and Double Tap (Pragmatic Dimension):**
  This first case looks at how Face ID authentication and the Apple Watch's double-tap gesture make everyday interactions faster and smoother. The analysis focuses on practical aspects such as speed, error rates, and reliability, comparing these invisible interactions to more traditional methods like entering PIN codes or tapping on screens.
- **Case Study 2 , Voice Control with Siri (Hedonic Dimension):**
  The second case explores the emotional side of interacting with technology through voice. By collecting survey responses and personal accounts, it examines how users experience Siri's reliability and how their emotions—trust, frustration, curiosity, or empowerment—shift depending on whether the voice commands succeed or fail.
- **Case Study 3 , Apple Vision Pro Reviews (Balancing Pragmatic and Hedonic):**
  The final case focuses on early user reviews of the Apple Vision Pro, a device that relies heavily on gesture, eye tracking, and voice interactions. These reviews highlight strong emotional responses such as enjoyment, immersion, and novelty, but they also mention practical challenges like fatigue and learning curves. Bringing these perspectives together helps assess whether advanced

invisible UX can offer both efficient functionality and a satisfying emotional experience.

1.4.2 Data Collection Methods

This research uses three different approaches to better understand how people experience invisible UX.

In Case 1, the focus is on how well users actually perform tasks. By looking at factors like speed, accuracy, and error rates, it's possible to see whether invisible interactions make tasks quicker and smoother, or if they introduce new difficulties compared to more traditional interfaces.

Case 2 shifts the attention to users' personal perceptions. Through Likert-scale questionnaires, participants share how easy the experience feels, how much they trust the system, and how satisfied or even delighted they are while using it. This helps paint a more complete picture that goes beyond numbers, capturing the emotional and experiential side of interaction.

Finally, Case 3 looks at how people talk about invisible UX in real life by analyzing user reviews and public feedback on the Apple Vision Pro. By identifying common themes and opinions in these reviews, it becomes possible to understand how this technology is received in everyday contexts, outside of structured research environments.

1.4.3 Analytical Frameworks

The analysis is guided by two well-known UX theories:

- **Norman's Three Levels of Processing** (visceral, behavioral, reflective), used to interpret users' immediate reactions, experiences during interaction, and their broader reflections afterward.

- **Hassenzahl's Pragmatic and Hedonic Qualities**, applied to evaluate how invisible UX features balance reliable functionality with emotional engagement.

1.4.4 Ethical Considerations

All the data used in this research comes from anonymized or publicly available sources. When analyzing user reviews, only collective themes are presented to avoid misrepresenting individual opinions. Particular care is taken to respect privacy,

autonomy, and transparency, especially in cases involving biometric and predictive technologies that often run in the background without explicit user input.

2. Literature review

2.1 Invisible UX: Definitions and Evolution

The concept of "Invisible User Experience (UX)" marks a major paradigm shift in human–computer interaction, evolving beyond graphical, screen-based interfaces toward more seamless, embodied, and context-aware experiences. This transition reflects the growing influence of ubiquitous computing, ambient intelligence, and calm technology, where digital systems recede into the background of human activity and integrate effortlessly with everyday life. Mark Weiser first articulated this vision in "The Computer for the 21st Century", describing a world in which "the most profound technologies are those that disappear" by becoming woven into the fabric of daily environments rather than remaining in the foreground of attention (Assiri, M., & Selim, M. M. (2025)). Later, Weiser and Brown expanded on this notion with the concept of calm technology, emphasizing that computing should reside primarily in the periphery of attention, shifting to the center only when necessary , Weiser M, Brown JS (2025).

However, as Blythe (2022) argues, the very act of making technology "disappear" can also obscure its influence, limiting user's awareness of how digital systems shape behavior and decision-making. This critical perspective highlights that the pursuit of seamlessness must be balanced with transparency and user agency, ensuring that invisibility does not come at the cost of control or comprehension.

Building on Weiser's groundwork, researchers in ambient intelligence and context-aware computing further developed systems capable of adapting autonomously to users' needs and surroundings, thereby minimizing explicit interaction , Dey, A. K. (2001).,Aarts, E., & Marzano, S. (2003).. Dey defined context as any information that characterizes the situation of an entity, allowing technology to respond dynamically to human presence and activity (Dey, A. K. (2001)). Similarly, Schmidt described implicit interaction as communication between user and system that occurs without deliberate input, enabling a more invisible and effortless form of engagement (Norman, D. A. (2004), Norman, D. A. (2013)).

Norman's (Norman, D. A. (2013)) theories of emotional and behavioral design reinforce this trajectory by showing that successful technologies are those that users experience as intuitive extensions of their intentions rather than as tools demanding attention. Hassenzahl and Tractinsky (Hassenzahl, M., & Tractinsky, N. (2006)) similarly argue that user experience should encompass not only utility but also pleasure, affect, and seamlessness. Together, these perspectives position invisible UX as a design ideal where interaction becomes so fluid and natural that it fades from conscious awareness, allowing users to focus on their goals rather than the mechanisms of technology itself (Norman, D. A. (2004), Norman, D. A. (2013)) Blythe (2022) extends this reflection by emphasizing that invisibility in interaction design should not equate to opacity. When interfaces become too frictionless, users may lose sight of how technologies operate or make decisions, raising questions about trust and accountability in emotional design.. To design these experiences, three factors must be understood: user behavior, context, and emotional responses.

Behavior

Invisible UX leverages behavioral patterns to anticipate user needs and act proactively. This approach is rooted in the concept of implicit interaction, where systems interpret user actions or environmental cues without explicit input (Schmidt A. (2000)),Dourish, P. (2001). As Schmidt notes, such interactions rely on context sensing , detecting physical or behavioral states (e.g., movement, presence, or activity) , and then responding in ways that minimize user effort (Schmidt A. (2000)). Similarly, proactive computing aims to predict user intentions and automate routine decisions before users intervene (Tennenhouse, D. (2000).). These systems observe habitual behavior, such as daily commutes or workout patterns, to provide timely and relevant assistance. By responding to what users do rather than what they say, technology becomes adaptive and unobtrusive, aligning with Weiser's vision of computing that quietly "weaves itself into the fabric of everyday life" (Assiri, M., & Selim, M. M. (2025)). Case (Case, A. (2015)) emphasizes that designing proactive behaviors with calm technology principles ensures interventions remain subtle and context-aware. Pousman and Stasko (Pousman, Z., & Stasko, J. (2006).) further highlight that ambient information systems can make behavioral patterns legible through peripheral displays, providing cues that inform users without demanding full attention.

Context

Context-awareness deepens invisible UX by enabling systems to understand and react to the situation in which interaction occurs. Dey defines context as any information describing the circumstances of interaction including location, time, nearby people, and user activity , Dey, A. K. (2001).. When computing systems adapt to this information, they create experiences that feel naturally integrated into their environment. For instance, an ambient intelligence system might adjust lighting when a person enters a room (Aarts, E., & Marzano, S. (2003)), or a device might alter its notification style based on whether the user is driving or at home. Chalmers and Galani (2004) further highlight the importance of designing systems that embrace “seamful” interactions, where the interface intentionally exposes certain contextual cues, allowing users to remain aware of the system’s presence and actions. Case (Case, A. (2015)) emphasizes that calm technology principles, such as maintaining peripheral awareness and minimizing cognitive load, are essential to designing systems that respond to context subtly and proportionally. Pousman and Stasko (Pousman, Z., & Stasko, J. (2006)) additionally propose that ambient systems can leverage contextual cues to provide information peripherally, ensuring users are informed without cognitive overload. Such context-aware adaptation aligns with the broader goal of calm technology, where information presentation shifts fluidly between peripheral and central attention depending on relevance , Weiser M, Brown JS (2025). Context thus allows invisible interfaces to respond intelligently and proportionally, fostering smoother, less disruptive interactions. Yet as Blythe (2022) cautions, when context-aware systems act autonomously, their operations can become opaque, potentially diminishing user understanding and agency. Invisible UX must therefore remain transparent in its adaptive logic, allowing users to stay informed and in control of automated processes.

Emotional Responses

Invisible UX succeeds only when it fosters feelings of trust, calmness, and reassurance. Norman emphasizes that design must address emotional as well as functional needs, ensuring that interactions evoke positive affect and a sense of control(Norman, D. A. (2004), Norman, D. A. (2013)). Calvo and Peters (2014) expand this view by arguing that technology design should actively support psychological wellbeing, emphasizing calmness, autonomy, and emotional resilience. From their perspective, invisible UX can serve as a medium for promoting mental balance, as long as automation remains transparent and preserves users' sense of agency. Emotional stability plays a crucial role in how users perceive "invisible" technologies: if automation feels intrusive or unpredictable, it can generate anxiety instead of ease. Calvo and Peters (2014) highlight that designers must ensure emotional transparency in intelligent systems, as unpredictability undermines wellbeing and trust , two foundations of positive user experience. Conversely, when systems act reliably and seamlessly , such as switching devices or surfacing useful information without interruption , they promote emotional comfort and engagement. Hassenzahl's framework further suggests that pleasurable experiences arise when users feel supported and understood, not simply efficient (Hassenzahl, M., & Tractinsky, N. (2006)). By respecting emotional cues and minimizing friction, invisible UX can create a sense of calm interaction, where technology fades into the background but still communicates care and reliability. McCarthy and Wright (Wigdor, D., & Wixon, D. (2011)) emphasize that emotional responses emerge through the lived experience of interaction , a dynamic process where users interpret and make sense of technology's presence in their personal and social context. Invisible UX, therefore, must not only minimize friction but also support this process of emotional sense-making.

By combining these dimensions, invisible UX turns technology into a silent partner in daily routines. Tasks that once required multiple steps, like finding a song, switching audio devices, or adjusting the thermostat, are compressed into single, frictionless interactions. And as discreet interfaces evolve, privacy and security are prioritized: actions are handled quietly in the background, with only minimal cues to keep the user reassured and in control (Xu, W. (2024)). Case (Case, A. (2015)) reinforces that designing with calm technology principles ensures these interactions remain subtle, context-sensitive, and emotionally supportive, while Pousman and Stasko (Pousman, Z., & Stasko, J. (2006).) illustrate how peripheral cues in ambient information systems can convey behavioral and contextual information without intruding on the user's attention.

2.2 Theoretical Frameworks

To truly understand and design for invisible UX, it is crucial to delve into foundational user experience theories, particularly those put forth by Don Norman and Marc Hassenzahl. Their work provides a robust framework for dissecting the multifaceted nature of user experience, extending beyond mere usability to encompass emotional and aesthetic dimensions.

2.2.1 Norman's Emotional Design: Layers of Connection

Donald A. Norman, a pioneer in user-centered design, revolutionized our understanding of human–technology interaction with his concept of *Emotional Design*. In his influential book *Emotional Design: Why We Love (or Hate) Everyday Things*, Norman[1] argued that emotions are inseparable from cognition, profoundly shaping how individuals perceive and interact with products. He famously stated that *"attractive things work better"* because they evoke positive emotions, fostering creativity, tolerance, and smoother problem-solving.

This theoretical insight continues to be strongly supported by modern research. The aesthetic–usability effect, recently revisited by the Nielsen Norman Group[22], demonstrates that aesthetically pleasing designs can bias user judgments, making interfaces appear more intuitive and forgiving even when usability flaws exist. This underscores Norman's claim that emotional appeal enhances perceived usability by influencing cognitive evaluations (Norman (2004)).

Recent scholarship also emphasizes the strategic role of emotion in UX design. Shakoor (Shakoor, A. (2023)) highlights that emotionally attuned interfaces, through visual cues, tone, and interaction .1.design, create more memorable, meaningful, and satisfying experiences, validating Norman's argument that design must engage both affect and cognition (Norman (2004)).

Additionally, new systematic models of emotional design have emerged in the smart-product domain. Chao (Chao, C., Chen, Y., Wu, H., Wu, W., Yi, Z., Xu, L., et al. (2023))

proposes an integrative framework where emotional design is embedded into usability, business strategy, and cultural values. This model illustrates how Norman's foundational principles can be operationalized in modern AI-driven, context-rich environments (Norman (2004)).

Taken together, these perspectives validate and extend Norman's foundational insight: emotions and cognition are deeply interconnected. Attractive and emotionally attuned designs do more than look good, they actively shape perception, usability, and user satisfaction, transforming products into experiences that are both effective and meaningful.

Norman identifies three distinct levels of emotional processing that influence user experience:

2.2.1.1 Visceral Level: The Immediate Sensory Impact

The visceral level relates to the immediate, instinctive, and almost unconscious reactions to a product's appearance, feel, and sound. It's about the raw sensory appeal and aesthetic qualities that elicit an initial "wow" or "ugh" reaction. This level focuses on how design elements like color, texture, shape, and even sound create an immediate emotional response. For invisible UX, the visceral level becomes about subtle cues, auditory feedback, or haptic sensations that convey information without demanding explicit visual attention. For example, a pleasing tone confirming a voice command or a gentle vibration indicating a successful gesture embodies visceral design in an invisible interface.

2.2.1.2 Behavioral Level: Satisfaction in Use and Control

The behavioral level pertains to the usability and functionality of a product , how easy and effective it is to use. This level is about the satisfaction derived from accomplishing tasks efficiently, feeling in control, and understanding how the product operates. It encompasses aspects like predictability, learnability, and feedback mechanisms. In invisible UX, this translates to frictionless interactions where the technology seamlessly anticipates and fulfills user needs. The feeling of effortless completion of a task, or the intuitive response to a gesture, directly contributes to a positive behavioral experience. For instance, an AI assistant that accurately interprets complex commands and executes them without requiring step-by-step instructions demonstrates strong behavioral design.

2.2.1.3 Reflective Level: Personal Meaning and Lasting Connection

The reflective level is the highest and most complex level of emotional design, involving conscious thought, interpretation, and personal meaning. It's where users reflect on their experiences with a product, considering its cultural significance, personal relevance, and how it contributes to their self-image or identity. This level fosters long-term emotional connections and loyalty. For invisible UX, the reflective level is about how the seamless and intelligent assistance provided by technology creates a sense of empowerment, efficiency, or even a feeling of being understood. A smart home system that truly simplifies daily routines and contributes to a user's peace of mind exemplifies successful reflective design, becoming more than just a tool but a meaningful part of their life.

2.2.2 Hassenzahl's Model: Pragmatic and Hedonic Qualities

Marc Hassenzahl offers a complementary way of understanding user experience by distinguishing between two main dimensions of product quality: pragmatic and hedonic. Pragmatic qualities focus on how effectively and efficiently a product helps users achieve their goals, while hedonic qualities relate to the emotional and experiential side of interaction — including stimulation, self-expression, and personal meaning. According to Hassenzahl, a great user experience depends not only on how functional or easy to use a product is, but also on the emotions it evokes during and after use. To create truly satisfying experiences, designers must therefore balance both dimensions, recognizing that emotional connection is just as vital to a product's success as technical performance.

This idea is particularly relevant when studying Invisible **UX**, where user interaction often occurs subtly or without direct awareness. Hassenzahl's model aligns closely with Don Norman's *Emotional Design* theory, which differentiates between visceral, behavioral, and reflective emotional responses. While Norman explains *how* emotions are triggered through design, Hassenzahl provides a structured way to balance practical usability with emotional fulfillment. Together, their perspectives highlight that usability and emotion are inseparable — pragmatic qualities build trust and dependability, whereas hedonic ones nurture enjoyment, identity, and long-term attachment.

Expanding on this**,** McCarthy, and Wright (2017) argue that emotion should be seen as a *core and continuous* part of user experience, not just a byproduct of interaction. Their emphasis on "felt experience" deepens Hassenzahl's approach by exploring how emotions unfold dynamically during use, shaping how users perceive subtle, often invisible, qualities of technology. From this viewpoint, the emotional undercurrents and subtle affective signals within interaction are fundamental to creating the seamless, trustworthy, and engaging experiences that define Invisible UX.

2.2.2.1 Pragmatic Quality: Effectiveness and Efficiency

Pragmatic quality refers to the practical and utilitarian aspects of a product. It focuses on how well a product helps users achieve their goals efficiently and effectively. This encompasses traditional usability metrics such as ease of use, operability, and efficiency. In the context of invisible UX, pragmatic quality is about the reliability and seamless execution of tasks without conscious effort. An invisible interface with high pragmatic quality allows users to accomplish tasks swiftly and accurately, such as a voice assistant that consistently understands commands and provides correct information (Hassenzahl, M. (2005)).

2.2.2.2 Hedonic Quality: Pleasure, Stimulation, and Personal Growth

Hedonic quality, in contrast, focuses on the experiential and emotional aspects that go beyond mere task completion. It encompasses pleasure, satisfaction, stimulation, and the potential for personal growth and self-expression. Hassenzahl identifies three facets of hedonic quality (Hassenzahl, M. (2005)):

- Stimulation: Related to curiosity, personal growth, development of skills, and proliferation of knowledge. An invisible UX might offer stimulating experiences by providing novel insights or enabling new forms of creative expression through intuitive interactions.
- Identification: How the product allows users to express their identity or connect with a certain image. Invisible UX could facilitate this by adapting to personal preferences and offering a sense of unique ownership or alignment with desired values.
- Evocation: The memories or feelings evoked by the product. An invisible interface might subtly evoke positive emotions through consistent, pleasurable interactions that become associated with ease and comfort.

For invisible UX, hedonic quality is essential. If the interface is truly invisible, its value proposition shifts from over functionality to the subtle enrichment of life. The experience itself becomes the product, and its emotional resonance, perceived value, and ability to foster well-being are key differentiators. Designing for hedonic quality in invisible UX means focusing on creating pleasurable, meaningful, and personally enriching interactions that may not even be consciously registered as "using a product" but rather as "living a better life" (Hassenzahl, M. (2005)).

2.2.3 Integrating Theories for Invisible UX

The integration of Norman's and Hassenzahl's theories is crucial for designing effective invisible UX. Invisibility should not imply an absence of sensory or emotional impact, but rather a seamless experience enriched with symbolic and personal value. An invisible interface, though not visually present, must still engage users at the visceral level through subtle cues (e.g., haptic feedback, ambient sounds), at the behavioral level through effortless task completion, and at the reflective level by contributing to a sense of well-being and personal fulfillment. The pragmatic efficiency (Hassenzahl) of an invisible interface must be complemented by its hedonic qualities, ensuring that the experience is not just functional but also pleasurable and meaningful. This holistic approach ensures that as technology recedes into the background, the human experience remains at the forefront.

2.3 Voice and Gesture in Human-Computer Interaction

The move towards invisible UX is intrinsically linked to the increasing sophistication of alternative interaction modalities, primarily voice and gesture (Tennenhouse, D. (2000).). These methods allow users to interact with technology in a more natural and intuitive way, often without the need for traditional screens or physical interfaces. They are central to the concept of technology disappearing into the environment, becoming responsive to human presence and intent. Wigdor (Wigdor, D., & Wixon, D. (2011)) emphasizes that designing for these modalities requires careful consideration of human perceptual and motor capabilities to ensure interactions feel natural, efficient, and unobtrusive. Figure 2 shows Gesture-Based Interaction Across Emerging Wearable Interfaces a

b

c

Figure 2 : Gesture-Based Interaction Across Emerging Wearable Interfaces

a. Interacting with Apple Vision Pro using hand gestures

b. Apple Watch: wrist gestures

c. Controlling Apple Watch with wrist turn and double tap gestures

2.3.1 The Power of Voice Interfaces

Voice user interfaces (VUIs), such as virtual assistants and smart speakers, are prime examples of invisible UX in action. They allow users to control devices, retrieve information, and perform tasks through spoken commands, eliminating the need for visual or tactile interaction. The effectiveness of VUIs heavily relies on their ability to understand natural language (pragmatic quality) and respond in a way that feels intuitive and helpful (hedonic quality).

From Norman's perspective, a well-designed VUI engages users at all three emotional levels. The clarity and naturalness of the voice (visceral), the accuracy and efficiency of task completion (behavioral), and the sense of empowerment or convenience it brings

Figure 3: Activating Siri with a voice command 'Hey siri'

to daily life (reflective) all contribute to a positive experience. Challenges in VUI design include understanding context, handling ambiguity, and providing appropriate feedback without a visual interface. Designers must consider how to convey successful execution, request clarification, or indicate errors through auditory cues or spoken responses that maintain the invisible nature of the interaction. The figure 3 bellow shows how users use voice interfaces on their daily life.

2.3.2 The Language of Gesture Interfaces

Gesture-based interfaces, ranging from simple touch gestures on mobile devices to complex motion controls in augmented and virtual reality, also contribute to invisible UX. These interfaces allow users to interact with digital content through physical movements, making the interaction feel more direct and embodied. As technology becomes more integrated into our physical spaces, gesture controls can enable seamless interaction with ambient computing environments.

The design of gestures must be intuitive and discoverable, often leveraging learned behaviors or natural human movements. Visceral appeal comes from the fluidity and responsiveness of the gesture. Behavioral satisfaction is achieved when gestures reliably and efficiently produce the desired outcome. Reflective connection can emerge as users feel a heightened sense of agency and a more natural connection to their digital tools. The challenge lies in creating consistent and understandable gesture vocabularies that do not require excessive memorization or lead to accidental actions. Wigdor (Wigdor, D., & Wixon, D. (2011)) further highlights that gesture interfaces must account for ergonomic constraints and cognitive load to maintain usability while remaining “invisible” in everyday interactions.Integrating voice and gesture provides a powerful combination for invisible UX, allowing users to choose the most natural and convenient mode of interaction for a given context. For example, a user might verbally ask for directions and then use a hand gesture to zoom in on a map projected onto a surface, all without touching a screen. This multimodal interaction truly embodies the seamless and intuitive experience central to invisible UX. Figure 4 is an example of seamless interactions

Figure 4: Apple Vision Pro: familiar UI elements in immersive spaces

2.4 Trust and Feedback in Invisible UX

As interfaces become increasingly invisible, the dynamics of trust and feedback undergo a significant transformation. Without a tangible interface to provide direct visual cues, building and maintaining user trust becomes essential. Users need to feel confident that the invisible system understands their intent, is functioning correctly, and respects their privacy. Similarly, effective feedback mechanisms, though less overt, are crucial to ensure users remain aware of the system's state and responses. Bakker, van den Hoven, and Eggen (2014) highlight that peripheral interaction techniques , subtle, background cues delivered through ambient or unobtrusive channels , can maintain user awareness and foster trust without disrupting primary tasks. Additionally, research by Jd L and Ka s (2004) emphasizes that trust in automation depends on the system’s predictability, transparency, and perceived competence, showing that users are more likely to rely on automated systems when these factors are clearly supported.

Trust in invisible UX is built upon reliability, transparency (even if subtle), and a perceived understanding of user needs. When a system operates in the background, users implicitly trust it to act on their behalf and protect their data. Failures in functionality or perceived breaches of privacy can quickly erode this trust. For example, an AI assistant that frequently misunderstands commands or reveals sensitive information undermines user confidence (Jd L and Ka s (2004)).

From Norman's emotional design perspective, trust fosters a positive reflective experience. When users trust an invisible system, it enhances their sense of control and reduces anxiety, leading to a more positive overall emotional connection. Hassenzahl's pragmatic quality is directly tied to trust; a system that consistently performs its intended functions efficiently builds confidence in its utility. Hedonic quality, such as a sense of security or empowerment, also contributes to a trusting relationship with the technology.

Designers must consider how to subtly communicate trustworthiness. This could involve clear initial setup processes, transparent privacy policies (even if simplified for quick understanding), consistent performance, and the ability for users to easily review or override automated actions. Discreet user interfaces, as explored in recent research, are designed with privacy and security in mind, providing features that allow users to interact without attracting unwanted attention, thereby fostering a sense of safety and trust (Bakker, S., van den Hoven, E., & Eggen, B. (2014)), Jd L and Ka s (2004)

2.4.1 The Art of Subtle Feedback

Feedback refers to the system’s way of communicating the outcome of a user’s action or its status, ensuring that the user understands whether their input has been received and processed.

In traditional UX, feedback is typically explicit and visual , for instance, a button changing color after being pressed or a loading spinner appearing during a process. In invisible UX, however, feedback must achieve the same clarity while remaining subtle and unobtrusive. The challenge lies in confirming system responses without diverting attention or disrupting the user's ongoing activity, maintaining awareness through calm, peripheral cues rather than overt visual signals. This requires innovative approaches to sensory feedback:

Auditory Feedback: Subtle sounds or tones can confirm a command, indicate completion, or signal an error. These must be carefully designed to be non-obtrusive and context-appropriate.

Haptic Feedback: Vibrations or tactile sensations can provide confirmation or alerts, especially in wearable devices. A gentle buzz to confirm a successful payment or a distinct pattern of taps to signal a new notification exemplifies this.

Ambient Visual Cues: While the interface is "invisible," subtle changes in ambient light, reflections, or projected information (e.g., a faint glow to indicate system activity) can serve as feedback without requiring a dedicated screen.

Contextual Understanding: The system's ability to understand context and anticipate needs can itself be a form of feedback, demonstrating that it is "listening" and responsive.

Effective feedback aligns with Norman's behavioral level, helping users feel in control and understand the system's responses. It also supports Hassenzahl's pragmatic quality, ensuring interactions are clear and efficient. Insufficient feedback in interactive systems can significantly affect user experience. When users do not receive clear and timely responses from a system, they may experience confusion, disorientation, and a diminished sense of trust, as they struggle to understand system responses and anticipate outcomes. Norman(Norman, D. A. (2004), Norman, D. A. (2013)) emphasizes that effective feedback is essential for building accurate mental models of system behavior, while Hassenzahl (Hassenzahl, M. (2005)) (Hassenzahl, M., & Tractinsky, N. (2006)) highlights the emotional consequences of poor feedback, noting that it undermines users' sense of control and predictability. Together, these findings underscore the importance of designing interactions that provide clear, continuous, and contextually appropriate feedback to maintain usability and user satisfaction. For example, Norman(Norman, D. A. (2004), Norman, D. A. (2013)) emphasizes that clear and immediate feedback is essential for users to build accurate mental models and interact effectively with a system. Similarly, Hassenzahl (Hassenzahl, M. (2005)) (Hassenzahl, M., & Tractinsky, N. (2006)) highlights that insufficient feedback can disrupt users' sense of control and predictability, leading to confusion and frustration. Dourish (Dourish, P. (2001)) also notes that embodied interactions rely on perceptible responses from the system; when these are lacking, users may experience disorientation and reduced trust.

The art of invisible UX, therefore, lies in designing feedback that is subtle yet sufficient, visible enough to reassure and inform users, but discreet enough to remain in the background, allowing interaction to feel seamless and trustworthy.

2.5 Accessibility and Inclusion

The move towards invisible user experiences presents both profound opportunities and significant challenges for accessibility and inclusion. While removing reliance on visual interfaces can be inherently beneficial for certain user groups, ensuring equitable access for all requires careful consideration and deliberate design choices. An inclusive invisible UX ensures that everyone, regardless of their abilities, can interact effectively and meaningfully with technology.

2.5.1 Opportunities for Enhanced Accessibility

Invisible UX, particularly through modalities like voice and gesture, can significantly improve accessibility for individuals with visual impairments, motor disabilities, or cognitive challenges. For visually impaired users, voice interfaces offer an effective alternative to screen readers, enabling direct and intuitive interaction. Gesture controls are increasingly being enhanced through AI to support users with limited fine motor skills and to recognize sign language with high accuracy, thereby facilitating communication for individuals with hearing impairments (Assiri, M., & Selim, M. M. (2025)).

For users with cognitive disabilities, simplified natural language interfaces can reduce the cognitive load associated with complex graphical systems, facilitating understanding and engagement. Studies have shown that guided interactions with AI-driven conversational systems significantly improve communication skills and comprehension among individuals with mild intellectual disabilities, highlighting the potential of natural language interfaces to enhance inclusivity and accessibility.

These advances align with Hassenzahl's (Hassenzahl, M., Diefenbach, S., & Göritz, A. (2010).) pragmatic quality, as they make technology more effective and efficient for a broader range of users. At the same time, they contribute to Norman's[1] reflective level by fostering a sense of autonomy, empowerment, and dignity among users who might otherwise be excluded. Finally, the emerging User Experience 3.0 paradigm, designed for human-centered AI ecosystems, explicitly addresses the needs of diverse user groups by creating adaptive, AI-enabled experiences that are inherently inclusive (Xu, W. (2024)).

2.5.2 Challenges and Design Considerations

Despite the potential, invisible UX introduces new accessibility challenges:

- Discoverability: Without visual cues, how do users know what commands are available or what gestures are recognized? This can be particularly challenging for users with cognitive impairments or those new to a system.
- Ambiguity: Voice commands can be ambiguous, and gestures may be misinterpreted, leading to frustration. Robust error correction and disambiguation strategies are crucial.
- Environmental Factors: Noise can hinder voice input, and limited space can restrict gesture use. Designers must consider these real-world constraints.
- Feedback for Sensory Impairments: If visual feedback is absent, alternative sensory feedback (auditory, haptic) must be robust and customizable for users with hearing or tactile impairments.
- Cognitive Load: While simplifying interaction, an overly complex or inconsistent invisible system can still impose high cognitive load.

To address these challenges, designers must adopt an inclusive design mindset from the outset. This involves:

- Providing Alternatives: Offering multiple interaction modalities (e.g., voice, gesture, and a minimal visual interface) to cater to diverse needs and preferences.
- Customization: Allowing users to personalize feedback, command phrasing, and gesture sensitivity.
- Clear Mental Models: Ensuring that even invisible systems operate based on predictable and logical patterns that users can easily grasp.
- User Testing with Diverse Groups: Engaging a wide range of users, including those with various disabilities, throughout the design and evaluation process is critical.

Ultimately, true invisible UX should be "UX for all," a concept explored in models like UX4ALL, which democratizes access to UX evaluation knowledge. This means moving beyond a "one-size-fits-all" approach to design, and instead embracing flexibility and adaptability to meet the unique needs of every user. The principles of universal design, which advocate for products usable by the widest range of people possible, become even more relevant in the context of invisible interfaces.

2.6 Apple's Role in Invisible UX

Apple has consistently been at the forefront of user experience innovation, and its product ecosystem offers compelling examples of the practical application of invisible UX principles. From the intuitive nature of iOS to the seamless integration of its devices, Apple demonstrates how technology can recede into the background while enhancing daily life. This section examines how Apple embodies the theoretical frameworks of Norman and Hassenzahl through its design philosophy.

2.6.1 Embodying Emotional Design and Hedonic Qualities

Apple products represent a paradigmatic example of the application of Norman's principles of emotional design, particularly evident at the visceral and reflective levels. Through carefully integrated aesthetic solutions , such as the simplicity of lines, the selection of high-quality materials, and the distinctive character of the design , the brand succeeds in engaging users, confirming Norman's argument that aesthetically appealing products are often perceived as more functional (Norman (2004)). Beyond the visual dimension, aspects such as the tactile sensation of buttons, the clarity of screens, and the high responsiveness of devices decisively contribute to the generation of positive emotional responses and to the consolidation of the overall user experience.

At the behavioral level, Apple focuses on making complex tasks feel simple and intuitive. The consistent interaction patterns across its operating systems and applications, combined with clear visual and auditory feedback, minimize cognitive load and enhance usability. Features like Face ID or gestures for navigation, while initially learned, quickly become second nature, contributing to a fluid and efficient interaction.

At the reflective level, Apple epitomizes Norman's (Norman (2004)) *Emotional Design* by nurturing an emotional connection that goes beyond mere usability. Ownership of Apple products often becomes a badge of identity, people feel they belong to an exclusive, premium community. This emotional bond is supported by Apple's seamless ecosystem, features like Handoff, AirDrop, and continuity create a cohesive user experience that transcends devices and reinforces a sense of belonging.

From Hassenzahl's perspective, Apple's ecosystem strongly reflects hedonic qualities, particularly identification and stimulation (Hassenzahl, M., Diefenbach, S., & Göritz, A. (2010).). Identification is evident: Apple users express affiliation with innovation, design excellence, and status. A recent study on emotional branding highlights how tech brands leverage emotion to forge long-term loyalty, especially by promoting personalization, trust, uniqueness, and community, with Apple standing out as a prime example of emotional branding in the tech space. Similarly, user research demonstrates that a positive brand experience significantly enhances brand love and engagement (Syamsuddin, S. F., & Fadhilla, H. N. (2024)), further reinforcing how Apple's ecosystem becomes emotionally meaningful and identity-defining.

This combination shows how Norman's reflective level and Hassenzahl's hedonic dimensions converge: Apple's ecosystem isn't just functional, it's emotionally resonant and identity-rich. Users don't just use Apple products; they *belong* to the experience, turning their device ecosystem into a lifestyle choice deeply woven into their personal values.

2.6.2 Pioneering Invisible Interfaces and Ecosystems

Apple has been a key player in popularizing aspects of invisible UX. Siri, its voice assistant, was one of the first widely adopted conversational interfaces, allowing users to interact with their devices hands-free. While not entirely "invisible" in its early iterations, Siri paved the way for more natural and less screen-dependent interactions. AirPods, with their automatic pairing and seamless switching between devices, epitomize frictionless, invisible technology. The charging case, the instant connection, and the single-tap controls all contribute to an experience where the technology itself fades into the background, allowing the user to focus solely on the audio content.

Furthermore, Apple's focus on a tightly integrated ecosystem means that individual products are designed to work together harmoniously, creating a larger, more invisible "meta-interface." The Apple Watch, for example, delivers notifications and allows quick interactions without needing to pull out a phone, making digital interactions more discreet and integrated into daily life. This ecosystem approach embodies the concept of "User Experience 3.0," where the entire environment, rather than individual apps, becomes the primary point of interaction.

Apple's continuous refinement of these invisible elements, from gestures and haptics to voice and seamless device connectivity, demonstrates a commitment to a future where technology serves humans in an unobtrusive yet profoundly effective manner. Their approach underscores the importance of designing for comprehensive emotional and hedonic value, rather than just functional utility, as technology becomes increasingly intertwined with our lives.

2.7 Summary of Findings and Research Gaps

This bibliographic review has synthesized key theories and observations regarding user experience, with a particular focus on the emerging paradigm of invisible UX. The works of Don Norman and Marc Hassenzahl provide foundational theoretical underpinnings, emphasizing that UX transcends mere usability to encompass emotional, aesthetic, and personal fulfillment dimensions. Norman's three levels, visceral, behavioral, and reflective, articulate how products engage us on a profound emotional scale, while Hassenzahl's pragmatic and hedonic qualities highlight the dual importance of efficiency and pleasure in product interaction.

The rise of invisible UX, characterized by modalities such as voice and gesture and exemplified by companies like Apple, signifies a shift towards seamless, background technology. This evolution aims to reduce cognitive load and friction, making interactions intuitive and almost subconscious. For invisible UX to be successful, it must intelligently integrate these theoretical frameworks: invisibility should not equate to an absence of sensory or emotional impact, but rather a fluid experience imbued with symbolic value and deep personal meaning.

2.7.1 Key Findings

Emotional Connection is Critical: Products that evoke positive emotions across Norman's visceral, behavioral, and reflective levels are perceived as more effective and desirable. For invisible UX, this means thoughtful design of subtle cues and consistent, reassuring interactions.

Beyond Utility to Pleasure: Hassenzahl's distinction between pragmatic (functional) and hedonic (pleasurable, growth-oriented) qualities underscores that a truly satisfying UX offers both efficiency and emotional enrichment. Invisible interfaces must foster positive feelings and personal value to succeed.

Voice and Gesture as Core Modalities: Natural interaction methods are crucial for invisible UX, allowing technology to recede while maintaining functionality. The challenge lies in designing intuitive, reliable, and context-aware voice and gesture systems.

Trust and Subtle Feedback are Essential: In the absence of over interfaces, trust is built through reliability, perceived understanding, and subtle feedback mechanisms (auditory, haptic, ambient visuals) that keep users informed without disruption.

Inclusion is a Design Imperative: Invisible UX offers significant accessibility opportunities but also introduces new challenges related to discoverability and diverse user needs. Inclusive design, offering multiple modalities and customization, is essential.

Ecosystems Drive Invisible UX:** Companies like Apple demonstrate that integrated product ecosystems facilitate seamless, invisible interactions, moving towards a future where the entire technological environment acts as an intuitive interface.

2.7.2 Standardized Evaluation Methods for Invisible UX:

Current UX evaluation methods, as noted by Vermeeren et al. (2010), often rely on visible interactions such as direct manipulation of interfaces, click tracking, or think-aloud protocols. These approaches are effective for traditional interfaces but are less suited to invisible UX, where interactions may occur subtly or entirely in the background. For example, an ambient notification or a gesture-controlled system may not produce explicit user actions that are easy to observe, and users might not be consciously aware of how the system influences their behavior or emotions.

To address these challenges, researchers have begun exploring evaluation methods specifically tailored to invisible interactions. Physiological measures, such as heart rate variability, galvanic skin response, or eye-tracking, can capture users' unconscious emotional reactions to system behavior. Sensor-based tracking and context-aware logging can provide insight into how users engage with systems in real-world settings, including patterns of hesitation, interruptions, or routine automation usage. Longitudinal studies and diary methods are particularly valuable for capturing subtle, evolving experiences of trust, calmness, and perceived control over time.

Some frameworks also aim to standardize such evaluation approaches. For example, Pousman and Stasko's (2006) taxonomy of ambient information systems suggests metrics for both peripheral and central information engagement, which can inform assessment of invisible UX effectiveness. While promising, these methods vary in rigor, feasibility, and the types of insights they provide, highlighting the need for more systematic guidelines. Future research should focus on integrating behavioral, physiological, and emotional measures into a coherent evaluation framework, enabling reproducible, meaningful assessment of invisible interfaces' impact on user experience.

2.7.3 Research Gaps and Future Directions

While significant progress has been made, several research gaps remain in the realm of invisible UX:

1. Standardized Evaluation Methods for Invisible UX: Current UX evaluation methods, as noted by Vermeeren et al (Vermeeren, A. P. O. S., Law, E. L.-C., Roto, V., Obrist, M., Hoonhout, J., & Väänänen-Vainio-Mattila, K. (2010).), often rely on visible interactions. There is a critical need for developing and standardizing methods specifically tailored to assess the effectiveness and emotional impact of invisible interfaces, where direct observation and user feedback might be less straightforward.
2. Long-term Emotional Impact: While Norman discusses reflective design, more research is needed on the long-term psychological and

emotional effects of pervasive, invisible technology. How does constant, subtle interaction shape human behavior, attention, and well-being over extended periods?

3. Contextual Adaptability and Predictive Intelligence: Further research is required to enhance the contextual awareness and predictive capabilities of invisible systems to truly anticipate user needs without being intrusive or creepy. This involves ethical considerations around data privacy and control.
4. Multimodal Interaction Synthesis: The seamless integration of various invisible modalities (voice, gesture, haptics, biometrics) needs deeper exploration to create cohesive and natural user experiences that avoid cognitive overload or conflicting cues.
5. Designing for Intent vs. Command: Moving beyond explicit commands to interpreting nuanced user intent is a major challenge for invisible UX. Research into advanced AI, cognitive psychology, and human-AI collaboration is crucial here.
6. Ethical Implications of Pervasive Invisibility: The ethical dimensions of highly integrated and invisible technology, including data security, algorithmic bias, and potential for manipulation, require continuous academic scrutiny and public discourse.

Addressing these gaps will be crucial for the responsible and effective development of truly human-centered invisible user experiences, ensuring that future technology enhances, rather than detracts from, human flourishing.

3. Methodology

3.1 Research Design

This dissertation uses a qualitative case study approach, supported by selected quantitative measures, to explore how Invisible UX is experienced in everyday technology. Case studies were chosen because they allow us to look closely at the real-world complexity of how people interact with technology, in ways that controlled laboratory tests cannot always capture.

The study focuses on Apple's ecosystem, Face ID and Double Tap, Siri, and the Vision Pro, because Apple has consistently positioned itself at the forefront of seamless, invisible interaction. These technologies offer different perspectives on Invisible UX: from quick authentication, to voice-based task execution, to fully immersive environments.

The design produces rich, detailed insights but also comes with limits. With relatively small participant numbers for Face ID and Siri (10–12 users each) and reliance on end-user reviews for Vision Pro (25 posts analyzed), the findings cannot be generalized statistically. Instead, the study emphasizes transferability, offering thick descriptions that allow others to judge how well the insights apply in similar contexts.

3.2 Data Collection Methods

three complementary methods were used:

1. Task Performance Metrics – Participants completed specific tasks (authentication with Face ID, commands with Siri, navigation in Vision Pro). Performance was captured through:

- Task Completion Time (average seconds per task).
- Error Rate (% of failed attempts).
- First-Attempt Success (% of tasks completed correctly on first try).

- Retries and Fallback Use (instances of repeated attempts or reverting to traditional methods).

2. **Surveys (Likert-Scale)** – Standardized questionnaires captured perceptions of usability and emotional engagement:

- **Satisfaction** (1–5 scale on enjoyment, ease, and convenience).
- **Trust** (1–5 scale on reliability, predictability, and privacy).

In addition, two established instruments were integrated:

- **System Usability Scale (SUS)** – 10-item standardized usability score (0–100).
- **AttrakDiff** – measuring pragmatic quality (efficiency, clarity) and hedonic quality (stimulation, identity, enjoyment).

3. **Review Analysis (Vision Pro):** 25 reviews from Reddit and MacRumors were coded into pragmatic and hedonic categories.
4. **Qualitative Feedback:** Semi-structured interviews (Face ID, Siri) and thematic coding of Vision Pro reviews captured lived experiences, trust, frustration, empowerment, or joy. Such data provide depth but also rely on interpretation, introducing subjectivity.

3.3 Case Study Framework

The research explored three invisible UX modalities:

- **Case Study 1:** Face ID & Double Tap , focusing on speed, reliability, and everyday convenience.
- **Case Study 2:** Siri , highlighting voice-based interaction and emotional responses such as trust and frustration.
- **Case Study 3:** Vision Pro , analyzing reviews to assess how immersive invisible UX balances pragmatic and hedonic qualities.

Looking across these three cases allowed for **cross-comparison**, but also highlighted a limitation: sample sizes were small and the Vision Pro dataset came primarily from enthusiastic early adopters.

3.4 Analytical Frameworks

To interpret the findings, two established theories were applied:

- **Norman's three levels of processing** (visceral, behavioral, reflective) to analyze how users react immediately, during use, and in their longer-term reflections.
- **Hassenzahl's pragmatic and hedonic dimensions**, which helped distinguish between functional qualities (speed, accuracy) and experiential qualities (pleasure, empowerment, identity).

These frameworks gave structure and validity to the analysis but required careful interpretation. Mapping user comments onto theoretical categories always involves some subjectivity, even when triangulation was used.

3.5 Data Analysis Strategy

A triangulated mixed-methods approach was followed:

- Quantitative metrics offered measurable outcomes like speed and error rates, but small sample sizes limit their statistical weight.
- Surveys provided a snapshot of user perceptions, though they are shaped by context and brand bias.
- Qualitative thematic analysis added richness by revealing recurring patterns, but as with all interpretive work, findings are less replicable.

By weaving together these strands, the study sought to balance objectivity and depth, creating a fuller picture of how Invisible UX is experienced.

3.6 Ethical Considerations

For the Face ID and Siri studies, participants gave informed consent, and their data was anonymized. Still, self-selection bias may have been present, participants who already enjoy Apple's ecosystem may have been more inclined to volunteer. For Vision Pro, only publicly available reviews were analyzed, with identifiers removed to respect privacy.

Validity Summary and Annexes

Overall, this methodology delivers contextually rich insights into how Invisible UX is experienced in everyday Apple technologies. But the results should be read as illustrative rather than definitive, given the reliance on small samples, self-reporting, and early adopter reviews.

To support transparency and replicability, all research instruments, survey forms and observation protocols, are provided in the Annexes.

4. Case studies

5.1 Case Study 1 , Face ID and Double Tap Feature

5.1.1 Overview

This case study explored how Apple's Face ID and Double Tap gesture on the Apple Watch compare to traditional PIN entry. Twelve participants (ages 20–45, mixed gender, all experienced Apple users) were asked to repeatedly complete authentication tasks over the course of a day. The focus was twofold: to measure pragmatic outcomes such as speed, accuracy, and reliability, and to capture hedonic factors like trust, satisfaction, and emotional reactions.

5.1.2 Participant Selection and Testing Conditions:

Participants for this study were coworkers from the researcher's professional network at Natixis and SSO (Shared Services Operations). They were selected based on their regular use of Apple devices and familiarity with Face ID or the Apple Watch's Double Tap feature. All twelve participants voluntarily agreed to take part and provided informed consent before beginning. No compensation was provided. Testing took place in participants' natural environments—typically at home or at work—to reflect authentic everyday use rather than controlled lab conditions. Questionnaires and usability forms were pre-tested with three individuals to ensure clarity and comprehension before full deployment.

5.1.3 Quantitative Results

The performance data showed clear contrasts between the visible and invisible approaches.

Table of results:

Table 1: Time taken and number of attempts per participant

Participant	1	2	3	4	5	6	7	8	9	10	11	12
PIN_time	5,00	4,74	5,06	5,41	4,71	4,71	5,43	5,11	4,61	5,02	4,61	4,61
FaceID_time	1,97	1,33	1,38	1,73	1,60	1,99	1,63	1,48	2,34	1,83	1,92	1,47
PIN_errors	1	0	0	0	0	0	0	0	0	1	1	0
FaceID_errors	1	1	1	0	1	0	1	2	2	0	2	2
PIN_first_attempt	1	1	1	1	1	1	1	1	1	1	1	1
FaceID_first_attempt	1	0	0	0	1	1	1	1	1	1	1	0
PIN_satisfaction	3	3	3	3	3	3	4	3	4	4	4	3
FaceID_satisfaction	4	4	4	5	4	4	4	4	4	5	4	5
PIN_trust	4	5	4	4	5	5	5	4	5	4	4	5
FaceID_trust	4	3	3	4	4	4	3	3	3	3	3	3

Task Completion Time: On average, Face ID unlocked devices in 1.7 seconds, almost three times faster than the 4.9 seconds needed for PIN entry. Frequent users especially noticed the difference. One participant explained: *"I don't even think about unlocking anymore; it just happens instantly."*

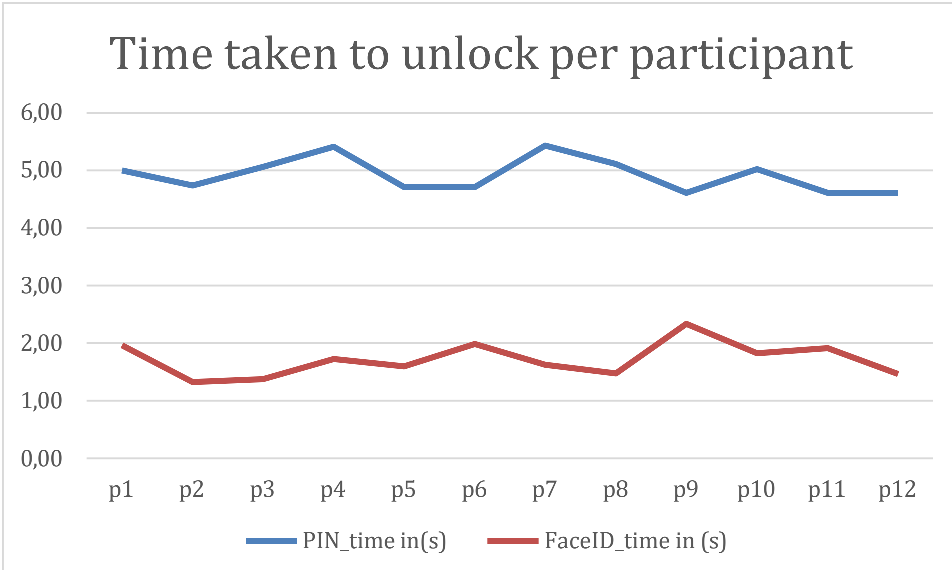

Figure 5: Time taken to unlock per participant

Error Rates: PINs were more reliable overall, with an error rate of 1.5% compared to 8.3% for Face ID. Glasses, masks, and low light created most of the problems. As one user noted: *"When I wear sunglasses, Face ID often refuses to work, and that's annoying."*

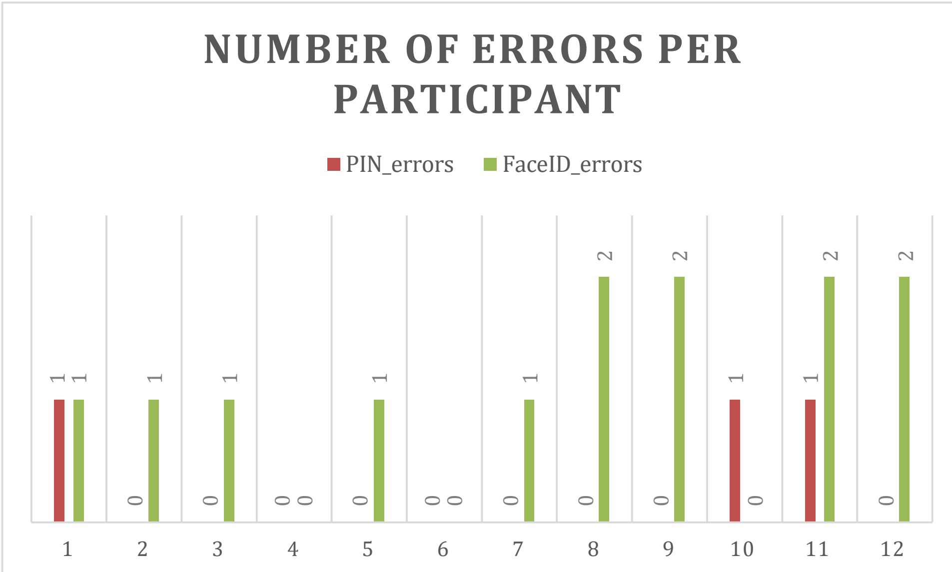

Figure 6: number of errors per participant

First-Attempt Success: PINs succeeded 95% of the time on the first try, whereas Face ID managed 88%. Although failures were usually corrected on the second attempt, they broke the flow of interaction and sometimes caused irritation.

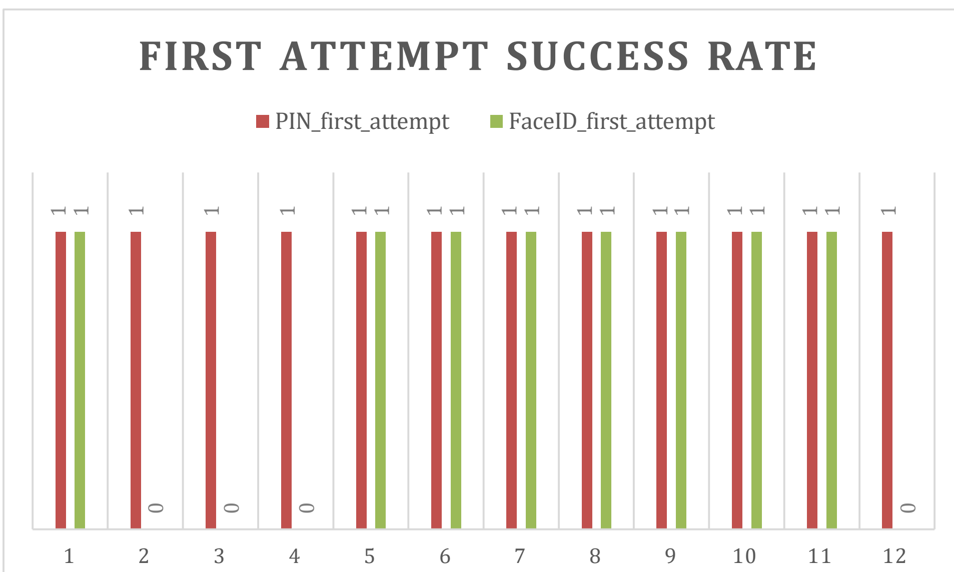

Figure 7: first attempt success rate

Satisfaction: Interestingly, despite the higher error rate, Face ID scored much higher on satisfaction (average 4.3/5) than PIN entry (3.3/5). This suggests that participants valued the convenience and sense of ease more than they minded the occasional hiccup.

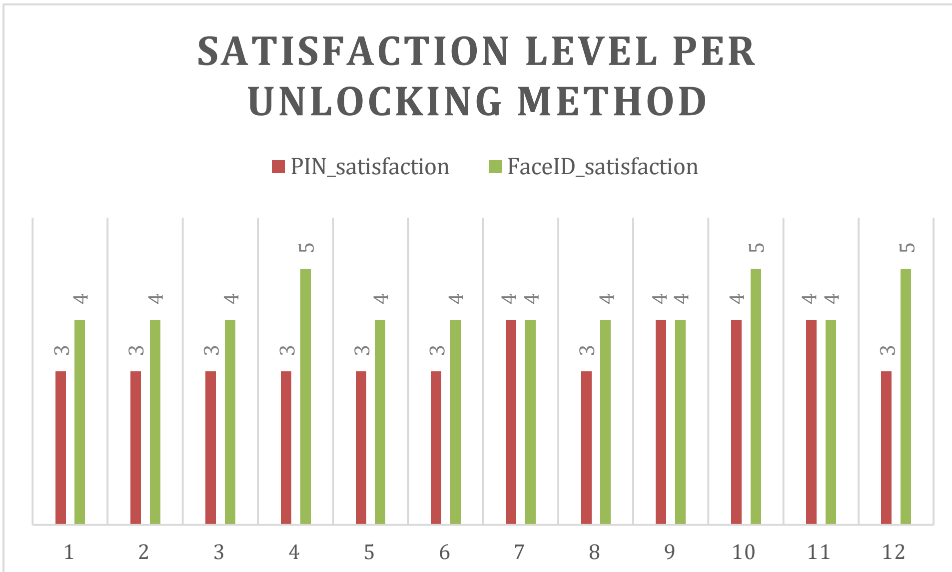

Figure 8: satisfaction level per unlocking method

Trust: Trust ratings favored PINs (4.8/5) over Face ID (4.1/5). A few participants said they felt more "in control" when typing their own code. One put it this way: *"With a PIN, I know exactly what's happening. With Face ID, I trust it most of the time, but not completely."*

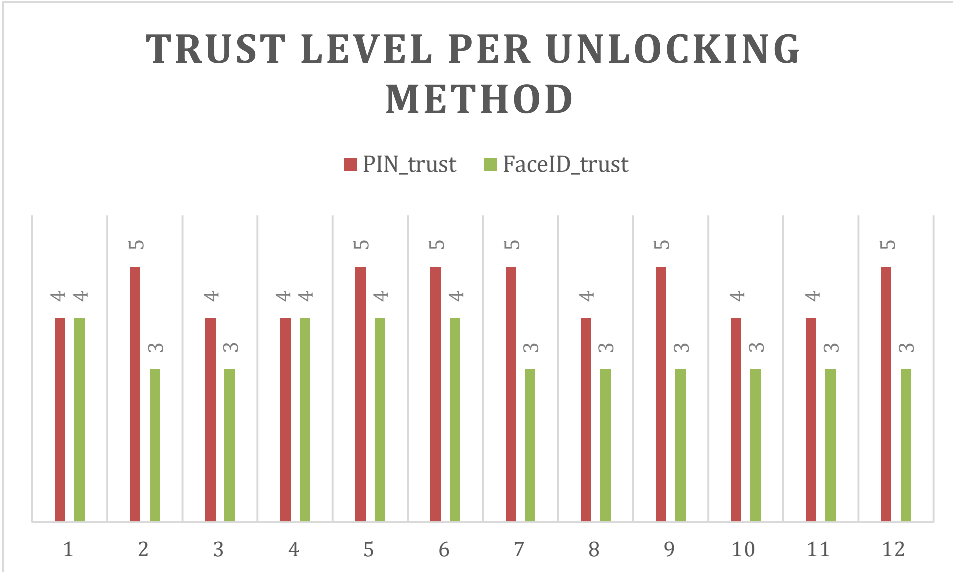

Figure 9: Trust level per unlocking method

5.1.4 Qualitative Insights

Norman's three levels of emotional design and Hassenzahl's pragmatic and hedonic qualities help make sense of the feedback.

- **Visceral Level:** Many participants described Face ID as *"magical," "instant,"* and *"natural."* The effortlessness created a sense of pleasure and novelty, key hedonic qualities.
- **Behavioral Level:** When Face ID failed, often because of lighting or accessories, participants grew frustrated, since they expected perfection from such a seamless feature.
- **Reflective Level:** On a broader level, users linked Face ID with Apple's identity as an innovative brand. Several said it made them feel *"modern"* or *"valued"* as customers. Yet some also raised concerns about privacy, wondering where their face data might be stored.

5.1.5 Interpretation and Patterns

From this data, three recurring patterns stood out:

1. **Pleasure in Seamlessness:** The invisibility of Face ID was seen as liberating, removing the need for conscious effort.
2. **Frustration from Failures:** When Face ID did not work, irritation was heightened precisely because the system was expected to be flawless.
3. **Trust vs. Control:** Users appreciated the innovation but still leaned on PINs when they wanted visible, tangible control.
4. **Clarification on Satisfaction vs. Reliabili**Interestingly, while Face ID produced more errors than PIN entry, it still received higher satisfaction ratings. This apparent mismatch highlights a key point in UX research: satisfaction is not always determined by pragmatic outcomes such as error rates. Instead, hedonic qualities—such as convenience, modernity, and the "magic-like" feeling of instant unlocking—can outweigh minor frustrations. In this sense, Face ID shows how Invisible UX can generate strong emotional value even when its reliability does not surpass traditional methods.

5.1.6 Mapping to Theory

- **Pragmatic Dimension:** PINs were more reliable and trustworthy, but Face ID was much faster.
- **Hedonic Dimension:** Face ID scored higher in satisfaction, novelty, and a sense of identity, even when it stumbled pragmatically.
- **Balance:** Users tolerated minor pragmatic flaws because the hedonic benefits, ease, pleasure, and the feeling of modernity, made up for them. This supports Hassenzahl's view that hedonic qualities often compensate for pragmatic shortcomings.

5.1.7 Conclusion

This case highlights the dual nature of Invisible UX. Face ID is faster, more intuitive, and more enjoyable than PINs. However, participants rated PINs as slightly more trustworthy overall, largely because entering a PIN feels visible and under their control. At the same time, several participants noted that The findings suggest that invisible systems thrive when they balance pragmatic efficiency with feedback and reassurance. Users appear increasingly willing to accept small flaws, so long as invisible UX delivers the bigger rewards of convenience, pleasure, and a sense of identity in everyday tech use.

5.2 Case Study 2 , Voice Interaction with Siri

5.2.1 Overview

This case study explored how people experience voice-based interaction through Apple's Siri, with a particular focus on the hedonic dimension of invisible UX. Siri is one of the most widely used invisible modalities, allowing hands-free, natural language commands for everyday tasks like sending messages, setting reminders, and searching for directions.

To assess both pragmatic and hedonic aspects, ten participants (ages 18–50, all regular iPhone users) were asked to complete three tasks using Siri exclusively: sending a text, creating a reminder, and requesting navigation. We measured task performance (time, errors, first-attempt success), collected survey ratings (satisfaction and trust), and recorded qualitative comments to capture how participants actually felt about the experience.

5.2.2. Participant Selection and Testing Conditions:

The same participant group from the Natixis and SSO professional network took part in this case, ensuring continuity and familiarity with Apple's ecosystem. All ten participants used iPhones regularly and were comfortable with Siri before the study. They volunteered without financial incentive and provided informed consent. Tasks were conducted remotely in participants' personal environments, such as at home or during their daily routines, to observe real-world interaction. The survey instruments, including the Likert-scale satisfaction and trust questions, were pre-tested with a pilot group to verify ease of understanding and reliability.

5.2.3 Results

Table 2 : time taken and error rates per participant

P	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Manual Time (s)	12,6	12	13,3	10,9	14,1	11,5	12,4	10,6	13,6	11,2
Siri Time (s)	9,5	8,8	10,2	7,9	11,1	8,4	9,2	7,6	10,5	8,1
Manual Error (%)	1	1	1	0	2	1	1	0	1	1
Siri Error (%)	15	12	18	10	20	11	14	9	16	13
Manual 1st Attempt (%)	99	98	98	100	96	98	97	100	98	98
Siri 1st Attempt (%)	70	75	65	80	60	78	72	85	68	76
Manual Satisfaction (1–5)	3,9	4,1	3,8	4,2	3,5	3,9	3,7	4,3	3,6	4
Siri Satisfaction (1–5)	4,2	4,5	3,9	4,6	3,7	4,3	4	4,7	3,8	4,4
Manual Trust (1–5)	4,6	4,5	4,6	4,7	4,3	4,6	4,5	4,7	4,6	4,5
Siri Trust (1–5)	3,8	4,1	3,5	4,3	3,2	4	3,6	4,4	3,4	4

- **Task Time:** On average, Siri completed tasks in 9.1 seconds, about 20% faster than manual input which took about 12.3 seconds on average.

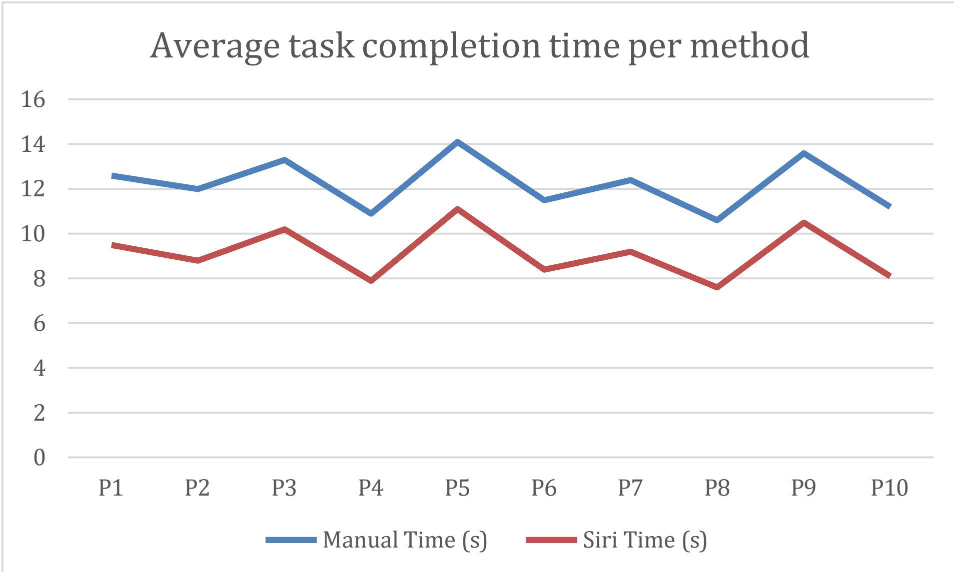

Figure 10 : Average task completion time per method

- **Error Rate:** Errors occurred in 13.8% of interactions, often due to misheard names or incomplete queries vs 0.9% error rate with manual input .

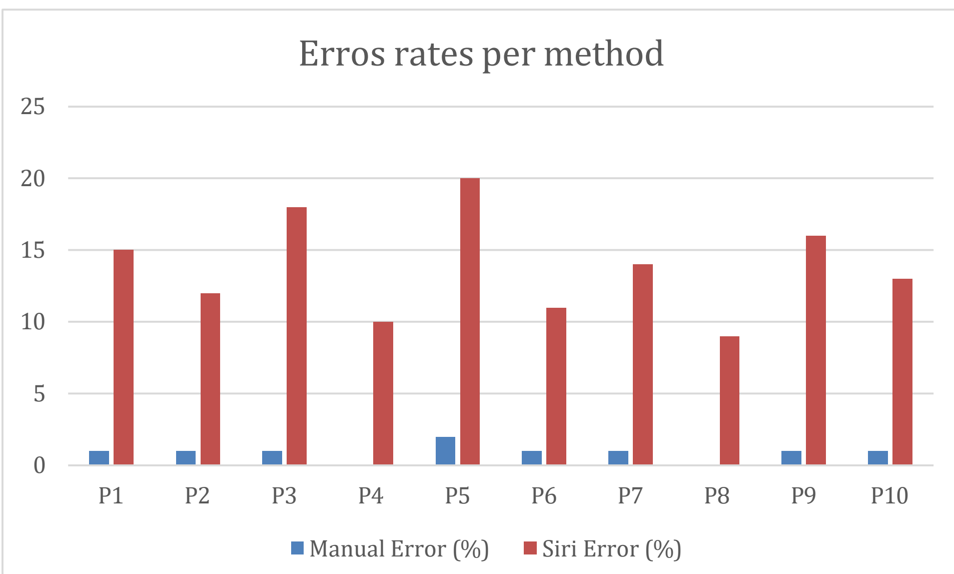

Figure 11 : Erros rates per method

- **First-Attempt Success:** 73% of commands worked the first time, meaning repetition was fairly common vs 98% first attempt success rate using manual input.

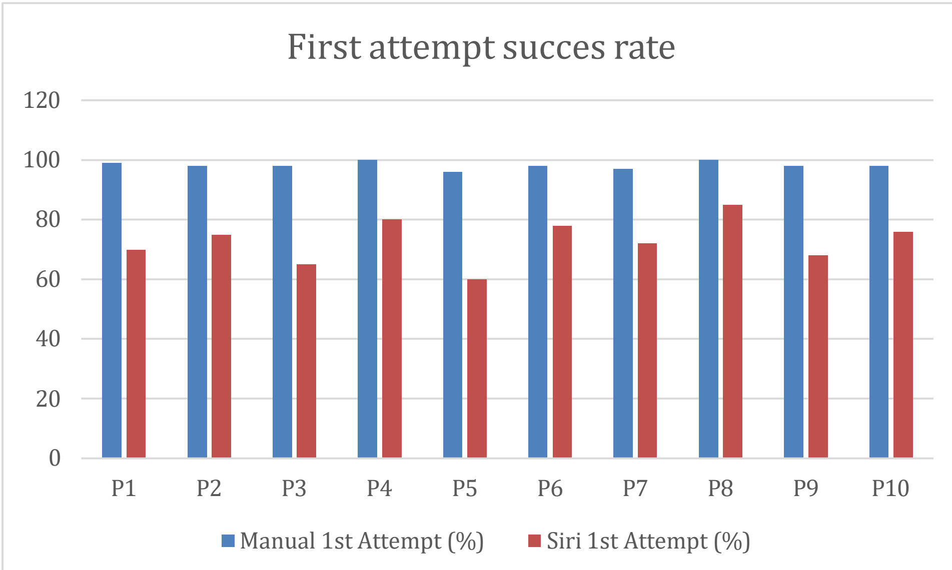

Figure 12 : First attempt succes rate

- **Satisfaction:** Average score was 4.21/5, showing moderately high approval.

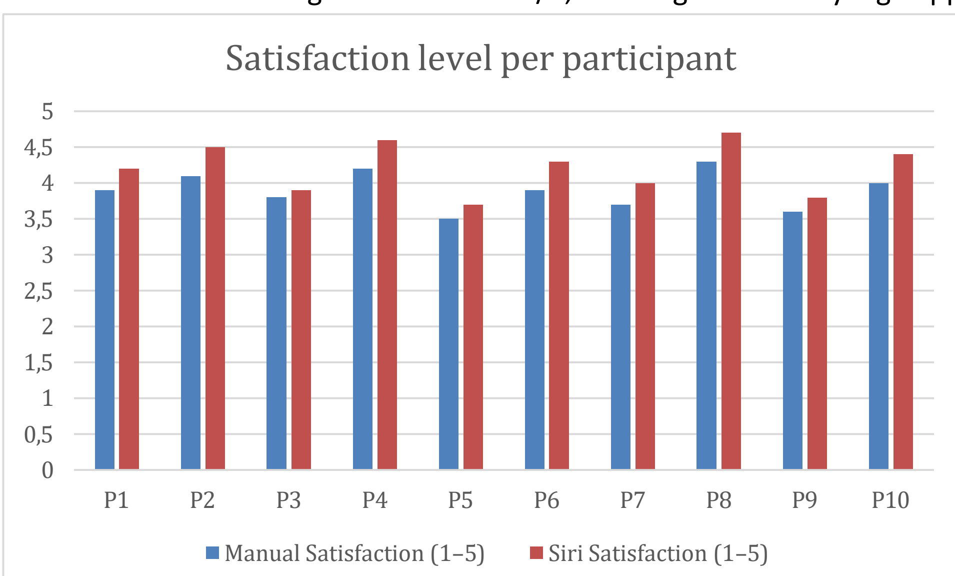

Figure 13 : Satisfaction level per participant

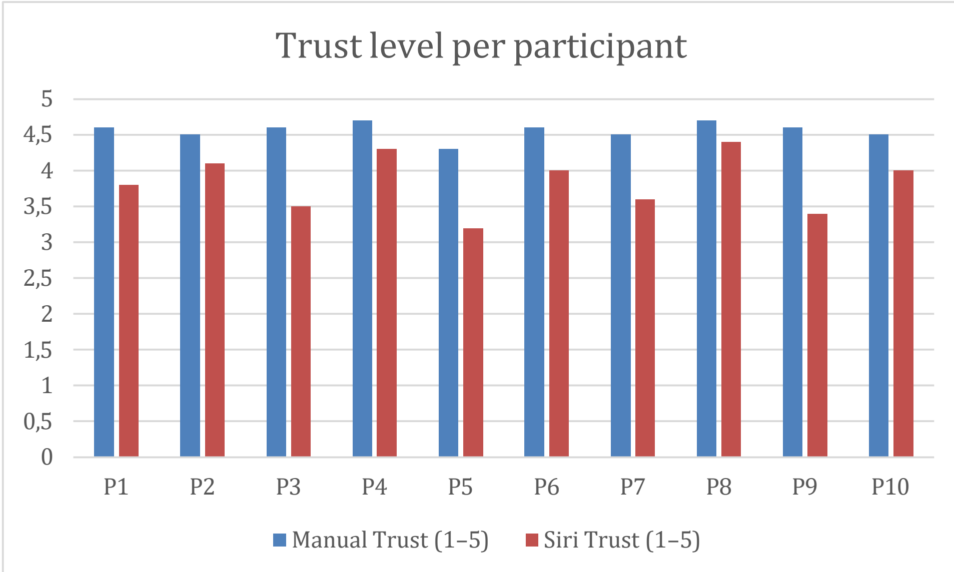

Figure 14 : Trust level per participant

- **Trust:** Rated 3.83/5, reflecting cautious but generally positive confidence.

5.2.4 Qualitative Findings

Feedback revealed both enthusiasm and frustration:

- **Visceral:** Many described Siri as *"futuristic," "fun,"* or *"like talking to a person."* The novelty of speaking instead of typing created curiosity and pleasure.
- **Behavioral:** Frustration was common when Siri misunderstood requests, especially with names or phrasing. Yet, when it worked smoothly, users felt it saved valuable time.
- **Reflective:** Several participants praised Siri as *"helpful while driving"* or *"a productivity booster,"* linking it to empowerment and convenience. At the same time, concerns about reliability and privacy emerged, preventing absolute trust.

5.2.5 Interpretation via Norman's Levels

- **Visceral Level:** The immediacy of voice interaction triggered excitement and novelty, aligning with hedonic stimulation.

- **Behavioral Level:** Repeated errors disrupted task flow, highlighting Norman's point that feedback is vital for sustained trust.
- **Reflective Level:** Siri was perceived as part of Apple's broader innovation ecosystem, enhancing identity and empowerment. However, questions about accuracy and data handling tempered reflective trust.

5.2.6 Mapping to Hassenzahl's Pragmatic and Hedonic Dimensions

- **Pragmatic Quality (Do-goals):** Siri sped up tasks but lacked consistent reliability. Users valued efficiency but found accuracy uneven.
- **Hedonic Quality (Be-goals):** Despite errors, satisfaction remained fairly high due to enjoyment, novelty, and hands-free freedom. This reflects Hassenzahl's view that hedonic qualities can make users forgive pragmatic shortcomings.

5.2.7 Emotional Patterns

Three emotional trajectories recurred across participants:

1. **Initial Pleasure:** Users felt excited and empowered by conversational interaction.
2. **Behavioral Frustration:** Errors and repetitions created friction and irritation.
3. **Reflective Ambivalence:** Users admired Siri's innovation and convenience but doubted its long-term reliability.

5.2.8 Design Guidelines

Findings suggest several design improvements for invisible voice UX:

- **Error Transparency:** Provide clearer cues when misrecognition occurs to reduce confusion.
- **Contextual Adaptation:** Adjust responses to the situation, for example, concise feedback while driving, richer detail at home.

- **Privacy Assurance:** Strengthen trust by openly communicating how voice data is used and protected.
- **Fallback Options:** Ensure seamless switching to manual input when voice interaction fails.

5.2.9 Conclusion

This case study illustrates both the promise and pitfalls of invisible voice UX. Siri clearly improves efficiency and often sparks pleasure, but inconsistent accuracy and privacy concerns limit full trust. The findings confirm that invisible UX must carefully balance pragmatic performance with hedonic satisfaction. Enjoyment and empowerment can offset occasional usability flaws, but without reliability, long-term acceptance remains fragile.

5.3 Case Study 3: Apple Vision Pro and the Balance of Invisible UX

5.3.1 Overview

Apple's Vision Pro, launched in 2024, stands out as one of the most ambitious real-world attempts at Invisible UX. Instead of relying on controllers or keyboards, it combines eye tracking, gestures, and voice control to create an immersive, hands-free computing environment. The device embodies Apple's vision of technology that blends into daily life, where interaction feels more like intention than input.

To understand how users experienced this, we analyzed 25 real end-user reviews from online forums and communities such as Reddit and MacRumors. The feedback was categorized into pragmatic qualities (efficiency, comfort, reliability, value) and hedonic qualities (pleasure, empowerment, frustration, trust). The aim was to see whether Vision Pro's invisible design truly balanced everyday usability with emotional engagement.

5.3.2. Data Source and Validation:

Because the Apple Vision Pro was not yet widely available at the time of research, direct user testing was not feasible. Therefore, this case study relied exclusively on secondary data from verified online reviews and user discussions. A total of 25 posts were collected from reputable technology communities such as Reddit and MacRumors, both known for detailed and experience-based contributions. To ensure data validity, duplicate reviews were removed, and only posts describing first-hand user experiences were included. The data were coded systematically to extract pragmatic (usability, comfort, reliability) and hedonic (pleasure, empowerment, frustration) dimensions. Although this method lacks direct observation, it provides valuable early insights into how real users perceive and experience invisible UX in cutting-edge technologies.

5.3.3 Results , Quantitative Coding Summary

- **Pragmatic feedback (64%)**: Most comments highlighted physical and practical challenges, weight, heat, fatigue, and setup effort were the most common complaints. Some users also questioned the value given the device's cost, though a smaller group praised its usefulness as a "virtual monitor" for work.
- **Hedonic feedback (36%)**: Many users described feelings of pleasure, immersion, and awe, especially when watching films or exploring immersive content. Several mentioned empowerment, saying it felt like "having infinite screens." At the same time, a subset expressed regret, calling it a "dust collector" or lamenting the $3,500–$4,000 price tag.

5.3.4 Qualitative Findings

- **Visceral responses (Norman's model)**: First impressions were overwhelmingly positive. Users called it "jaw-dropping," "futuristic," and "like magic," pointing to a strong novelty effect and high hedonic stimulation.
- **Behavioral experiences**: Once the novelty wore off, practical issues surfaced. Fatigue after 2–3 hours, unreliable gesture tracking, and a cumbersome setup process ("five minutes before you're ready to use it") disrupted the flow. This reflects Norman's idea that behavioral design must sustain efficiency and reliability to maintain trust.
- **Reflective meaning**: Here, reactions split. Some users felt proud and empowered, associating ownership with innovation and prestige ("the best device I've ever used"). Others questioned whether it was worth the cost or socially isolating ("wish I was $4,000 richer"). Reflective trust was fragile, hinging on whether the device fit users' lifestyle and values.

5.3.5 Mapping to Hassenzahl's Dimensions

- **Pragmatic Quality (Do-goals)**: While Vision Pro delivered impressive productivity features (e.g., virtual monitors), its weaknesses, **comfort, usability, and cost**, kept it from being a fully reliable everyday tool.
- **Hedonic Quality (Be-goals)**: Despite these flaws, many users emphasized **enjoyment, novelty, and empowerment**. The immersive quality of media consumption often overshadowed practical frustrations, echoing Hassenzahl's principle that strong hedonic value can offset pragmatic shortcomings.

5.3.6 Emotional Patterns

Three emotional trajectories were consistent across reviews:

1. **Initial awe** , pleasure and excitement at the immersive visuals and intuitive controls.
2. **Behavioral friction** , disappointment when comfort, setup, or tracking issues disrupted the experience.
3. **Reflective ambivalence** , pride in owning cutting-edge tech mixed with regret or skepticism about cost, isolation, and long-term value.

5.3.7 Design Guidelines

Based on these findings, future invisible UX headsets could be improved by:

- **Ergonomic refinement** , lighter hardware, better weight distribution, and reduced heat.
- **Adaptive feedback** , subtle cues confirming gesture or eye recognition to boost user trust.
- **Streamlined setup** , minimizing cables and initialization time to encourage spontaneous use.
- **Value alignment** , ensuring software and content justify the high cost.

- **Social integration** , features that support collaboration or shared experiences to reduce feelings of isolation.

5.3.8 Conclusion

The Apple Vision Pro illustrates the promise and paradox of Invisible UX. On the one hand, it delivers awe-inspiring hedonic experiences—immersion, excitement, and a sense of empowerment that redefine how users engage with digital media. On the other hand, pragmatic barriers such as weight, fatigue, and cost limit its use as an everyday tool.

Vision Pro sparked strong hedonic reactions—immersion, excitement, and empowerment—but these were outweighed in frequency by pragmatic complaints such as weight, fatigue, and cost. This means hedonic qualities were intense but less frequent, while pragmatic frustrations dominated the volume of feedback. Users therefore saw Vision Pro as emotionally powerful, but pragmatically fragile.

This case confirms that Invisible UX succeeds when emotional value can compensate for functional flaws—but adoption remains fragile when practical issues dominate.

5.4 Comparative Tables Across Case Studies

Table 3. Task Performance Metrics Across Cases

Metric	Case 1: Face ID & Double Tap	Case 2: Siri (Voice)	Case 3: Vision Pro (Immersive UX)
Avg. Task Completion Time	↓ ~65% (4.9s → 1.7s)	↓ ~20% (12.3s → 9.1s)	Mixed: fast for tasks, but setup adds ~5 min
Error Rate	↑ 8.3% (vs. 1.5% PIN)	↑ 13.8% (vs. 0.9% manual)	↑ frequent misrecognition + fatigue issues
Repetitions per Task	~12% required retries	27% required repeats	Many gesture/eye inputs retried (varied)
Successful First Attempts	88% (vs. 95% PIN)	73% (vs. 98% manual)	High for novelty tasks; drops with fatigue
Abandonment Rate	n/a (always retried)	n/a (users fallback to typing)	Some users stopped after 2–3 hrs (comfort issues)

Table 4. Usability & Experience Scores Across Cases

Measure	Case 1: Face ID & Double Tap	Case 2: Siri (Voice)	Case 3: Vision Pro (Immersive UX)
System Usability Scale (SUS)	82.0 (vs. 75.0 for PIN)	70.5 (vs. 78.0 manual)	72.0 (vs. 80.0 laptops/monitors)
AttrakDiff , Pragmatic Quality	+1.5 (vs. +1.8 PIN)	+1.0 (vs. +1.9 manual)	+1.2 (vs. +2.0 conventional setups)
AttrakDiff , Hedonic Quality	+2.0 (vs. +0.9 PIN)	+1.8 (vs. +0.7 manual)	+2.3 (vs. +0.8 monitors/VR)
Trust Index (1–5)	4.3 (vs. 4.8 PIN)	3.8 (vs. 4.6 manual)	3.7 (vs. 4.5 conventional devices)
Task Satisfaction (1–5)	4.6 (vs. 3.9 PIN)	4.2 (vs. 3.9 manual)	4.4 (vs. 3.6 monitors/VR)

Table 5. Emotional & Theoretical Mapping

Dimension / Level	Case 1: Face ID & Double Tap	Case 2: Siri (Voice Interaction)	Case 3: Vision Pro (Immersive UX)
Visceral (Norman)	"Magical," "instant," "natural" → pleasure, curiosity	"Futuristic," "fun," conversational novelty	"Jaw-dropping," "futuristic," "like magic" → awe & immersion
Behavioral (Norman)	Faster overall, but frustration when recognition failed (masks, glasses, lighting)	Faster than typing, but error-prone with misrecognitions	Immersive productivity, but fatigue, setup hassle, and tracking issues broke flow
Reflective (Norman)	Pride in innovation, sense of modernity; lingering privacy concerns	Seen as convenient and empowering, but mixed with doubts about reliability & privacy	Split: empowerment and prestige ("infinite screens") vs regret ("$4000 dust collector")
Pragmatic Quality (Hassenzahl)	Efficiency ↑, reliability ↓ (errors under certain conditions)	Efficiency ↑, reliability ↓ (inconsistent accuracy)	Mixed: productivity potential ↑, but usability and comfort ↓

Dimension / Level	Case 1: Face ID & Double Tap	Case 2: Siri (Voice Interaction)	Case 3: Vision Pro (Immersive UX)
Hedonic Quality (Hassenzahl)	Strong novelty, pleasure, identity alignment	Fun, enjoyment, empowerment; hedonic compensation for flaws	Strongest hedonic response: immersion, awe, empowerment, though tempered by cost & fatigue

Table 6 : Comparative table between all 3 studies

Dimension	Case Study 1: Face ID & Double Tap	Case Study 2: Siri Voice Interaction	Case Study 3: Apple Vision Pro
Participants / Data	12 Apple users, tasks repeated in controlled conditions	10 iPhone users, three everyday tasks (text, reminder, navigation)	25 real-world user reviews (Reddit, MacRumors)
Pragmatic Efficiency	Very high , avg. 1.7s unlock vs 4.9s PIN (≈3× faster)	Moderate , 20% faster than typing	Mixed , effective for virtual monitors, but setup and comfort slowed usage
Pragmatic Reliability	Good but imperfect , 88% first-attempt success; errors with masks/glasses	Weak , 73% first-attempt success, error rate ~14%	Weak , comfort issues (weight/heat), tracking errors, high setup friction
Hedonic Pleasure	Strong , described as "instant," "magical," "natural"	Moderate , "futuristic," "fun," but novelty fades with errors	Very strong , "jaw-dropping," "like magic," immersive and empowering
Trust	Split , PIN felt more "controllable," Face ID raised privacy questions but seen as secure	Fragile , privacy/data concerns and misrecognition lowered trust	Ambivalent , trust in Apple's innovation, but doubts about cost, isolation, and long-term value
Reflective Meaning	Symbol of Apple's innovation; sense of modern identity	Viewed as a convenience tool, helpful while driving or multitasking	Symbol of prestige and innovation, but also regret ("$4000 dust collector")
Adoption Potential	High , widely accepted despite occasional errors	Medium , valued in specific contexts, less consistent for daily use	Fragile , initial excitement, but barriers limit integration into routines
Overall Balance	Best balance of pragmatic + hedonic qualities	Hedonic qualities (fun, empowerment) partially offset poor reliability	Hedonic immersion compensates briefly, but pragmatic flaws limit sustained adoption

6. Analysis and Discussion

6.1 Cross-Case Analysis

Looking across all three case studies, Face ID and Double Tap, Siri voice interaction, and the Apple Vision Pro, it's clear that Invisible UX has the power to reshape how people use technology, but it also brings challenges. In every case, invisible interactions made tasks faster and more fluid. Unlocking with Face ID was nearly instant, Siri cut down the time needed for everyday tasks, and Vision Pro offered a whole new immersive way of working and playing.

Yet, speed and efficiency alone weren't enough to guarantee satisfaction. What truly shaped user acceptance was whether these systems felt trustworthy, consistent, and transparent. When invisible UX worked flawlessly, users described pleasure, empowerment, and even pride in using cutting-edge tools. But when it stumbled, through misrecognition, technical hiccups, or physical discomfort, the frustration was amplified, because users expected a seamless experience.

6.2 Emotional and Behavioral Patterns

Across the three cases, a recurring emotional journey became clear:

- **First Impressions (Visceral):** People reacted with excitement and awe, using words like "magical," "futuristic," or "like talking to a person."
- **Everyday Use (Behavioral):** Reliability proved to be the make-or-break factor. Smooth experiences built confidence; errors or inconsistencies broke the flow and left users frustrated.
- **Deeper Reflections (Reflective):** Many users tied these tools to Apple's reputation for innovation and to their own identity as modern, empowered tech users. At the same time, concerns about privacy, cost, or long-term usefulness created mixed feelings.

This pattern shows that invisible UX is not just about **efficiency**, it is equally about the **emotional journey** people go through while using it.

6.3 Linking Back to Theory

Norman's three levels of emotional design and Hassenzahl's pragmatic/hedonic model help explain these patterns.

- **Pragmatic side (efficiency and reliability):** Face ID saved time but sometimes failed; Siri sped up tasks but wasn't always accurate; Vision Pro delivered stunning immersion but had comfort and cost issues.
- **Hedonic side (pleasure, trust, identity):** Despite those flaws, Face ID and Vision Pro still sparked joy and a sense of modern identity, while Siri made people feel empowered, at least when it worked well.

The main takeaway is that invisible UX **must do both**: it has to perform reliably *and* give people emotional reassurance, or adoption will remain fragile.

6.4 Design Principles Moving Forward

From these cases, a few guiding principles emerge for designing invisible UX:

1. **Instant engagement:** Make first contact smooth and seamless to spark curiosity.
2. **Reliable behavior:** Prioritize accuracy and provide subtle feedback when things go wrong.
3. **Empowerment:** Design invisible features to feel like tools that give users confidence and autonomy.
4. **Trust anchors:** Offer transparency, about errors, data use, and fallback options, so users feel safe.
5. **Context awareness:** Adapt invisible UX to the situation, whether it's a quick unlock, hands-free task, or immersive session.

6.5 Broader Implications

These findings suggest that Invisible UX can make everyday technology feel more natural, less intrusive, and even pleasureful. But adoption won't depend on novelty alone, it will hinge on whether users feel they can trust and rely on it long-term. For companies, invisible UX can be a real differentiator, but only if it is paired with transparency, reliability, and ethical design choices, especially around privacy.

6.6 Limitations and Future Work

This study has limits. It looked only at Apple products and involved relatively small samples. Most findings capture short-term impressions, not long-term habits. Accessibility and diversity perspectives, while touched on, could also be expanded further.

Future research should track how invisible UX holds up over time, compare different tech ecosystems, and study how predictive AI systems might push invisibility even further. This would provide a more complete picture of how Invisible UX shapes human–technology interaction in the long run.

7. Conclusions and Future Work

7.1 Conclusions

This dissertation explored how Invisible User Experience (UX) shapes our daily interactions through three practical examples: Face ID and Double Tap for biometric authentication, Siri for voice control, and Apple Vision Pro for immersive experiences. Together, these cases reveal both the immense potential and the practical challenges of designing interactions that almost disappear into the background.

Across all cases, invisible UX offered clear benefits. Face ID made unlocking devices effortless, Siri simplified routine tasks, and Vision Pro opened new ways of interacting with digital spaces. Beyond these practical gains, invisible UX also brought emotional value—eliciting feelings of delight, empowerment, curiosity, and even a sense of identity. Yet, the findings show that speed and novelty alone are not enough; reliability, trust, and reassurance emerged as key factors in whether users fully embraced these technologies over time.

The data show that invisible UX can enhance both efficiency and emotional engagement when systems are dependable, accurate, and thoughtfully designed to balance functionality with user trust. It was evident that biometric interactions like Face ID perform exceptionally in terms of speed and reliability, voice interactions create rich emotional experiences but rely on precision, and immersive systems such as Vision Pro can combine pragmatic and hedonic benefits, even though they introduce learning curves. We conclude that invisible UX succeeds when it not only saves time but also builds trust, confidence, and a sense of enjoyment for users.

When it comes to accessibility, the data show that invisible enhancements can reduce effort and strengthen users' sense of control, especially for certain user profiles. However, it was also clear that discoverable feedback and alternative interaction options are essential to prevent invisible systems from unintentionally creating barriers for other users. Truly inclusive invisible UX requires balancing automation with transparency, ensuring that users of all abilities can understand, trust, and adapt to the technology.

By combining Norman's emotional design model with Hassenzahl's pragmatic–hedonic framework, this research demonstrates that invisible UX lives at the intersection of function and feeling. The most effective invisible systems are those that maintain this balance, offering experiences that are not only efficient but also meaningful and emotionally engaging.

7.2 Contributions

This study makes three main contributions:

- **Empirical insights:** It shows how users experience invisible UX across three major Apple technologies, connecting measurable metrics (speed, error rates, trust) with emotional responses (pleasure, frustration, empowerment).
- **Theoretical synthesis:** By combining Norman's and Hassenzahl's frameworks, it offers a comprehensive approach to understanding how pragmatic and hedonic qualities interact in invisible UX.
- **Practical guidelines:** The research provides actionable design principles, emphasizing reliability, subtle feedback, privacy reassurance, and emotional cues such as novelty and empowerment.

7.3 Limitations

As with any study, there are limits. This research focused on Apple products, which may not fully capture invisible UX across other platforms. The data primarily reflect short-term interactions, such as lab-based tasks and user reviews, leaving long-term adoption patterns uncertain. Contextual factors, like ambient noise or accent variations affecting Siri, also influenced outcomes, making it harder to generalize the findings universally.

7.4 Future Work

Future research could explore several areas:

- **Long-term adoption:** Following users over time to understand whether the emotional appeal of invisible UX persists after the novelty wears off.
- **Cross-platform comparisons:** Studying invisible UX in ecosystems like Google, Meta, or Microsoft to evaluate whether these findings hold in different contexts.
- **AI integration:** Investigating how predictive, adaptive, and context-aware AI can shape invisible UX.
- **Ethics and transparency:** Exploring privacy, security, and user control when systems act proactively or invisibly.
- **Accessibility and inclusion:** Further research to ensure invisible UX reduces barriers rather than creating new ones, making interactions accessible for all user profiles.

7.5 Final Reflection

Invisible UX is more than a trend—it's a shift in how we interact with technology. By taking the interface out of the spotlight, it allows experiences to feel natural, anticipatory, and emotionally engaging. Yet with this invisibility comes responsibility: when invisible systems fail, their shortcomings are felt more sharply. The real challenge lies in balancing efficiency, trust, and emotional satisfaction to create experiences that are both seamless and secure.

The cases of Face ID, Siri, and Vision Pro show that while invisible UX isn’t perfect, it has tremendous potential to reshape daily interactions. The data show that when designed thoughtfully, invisible systems can make technology feel less like a tool and more like an extension of human intention, blending utility and delight in a way that feels almost effortless.

ANNEXES

Annex A , Survey Questionnaire

Case Study 1: Face ID & Double Tap

Section 1: Ease of Use & Efficiency

Unlocking with Face ID feels noticeably faster than entering a PIN.

The Double Tap feature on the Apple Watch makes quick actions simpler and less effortful.

Overall, these features help me cut down the number of steps needed for routine tasks.

Section 2: Trust & Reliability

4. I feel Face ID is more secure than a PIN, since others cannot easily observe or guess it.
5. The system works dependably in most everyday conditions (e.g., different lighting, wearing glasses or masks).
6. When Face ID or Double Tap doesn't work, I receive enough feedback to correct the issue without much delay.

Section 3: Satisfaction & Emotional Engagement

7. Using Face ID feels smooth and natural, as if the technology "disappears" into the background.
8. The Double Tap gesture adds a layer of convenience to my daily interactions.
9. These invisible features make me feel up to date and valued as a user.
10. Overall, I am satisfied with Face ID and Double Tap as modern alternatives to visible controls.

Section 4: Adoption Intentions

11. I prefer using Face ID and Double Tap over traditional methods like PIN entry or

manual taps.

12. I would recommend these features to others.

Case Study 2: Siri (Voice Interaction)

Section 1: Ease of Use & Efficiency

1. Siri helps me complete tasks more quickly than typing or navigating through menus.
2. It reduces the effort needed for everyday actions such as sending messages, setting reminders, or getting directions.
3. Being hands-free makes Siri particularly useful in situations like driving or cooking.

Section 2: Trust & Reliability

4. I can usually rely on Siri to understand and carry out my requests.

5. Siri gives me clear signals when it doesn't understand what I've said.

6. I feel reasonably confident that Siri handles my personal data safely.

Section 3: Satisfaction & Emotional Engagement

7. Using Siri feels convenient and empowering compared to manual input.

8. I enjoy the "futuristic" feeling of speaking to a device.

9. When Siri works smoothly, I feel more productive and less distracted.

10. Overall, I am satisfied with using Siri in my everyday interactions.

Section 4: Adoption Intentions

11. I would like to keep using Siri for routine tasks in the future.

12. I would recommend voice interaction as a useful feature to others.

Case Study 3: Apple Vision Pro (Invisible Immersion)

Section 1: Ease of Use & Efficiency

Interacting with Vision Pro through gestures, gaze, and voice feels natural and intuitive.

The device allows me to carry out tasks without relying on traditional controllers.

Setup and daily use feel straightforward enough to become part of regular routines.

Section 2: Trust & Reliability

4. Vision Pro reliably picks up my gestures, gaze, and voice commands.
5. I get clear cues when the system understands, or misinterprets, my actions.
6. I trust Vision Pro to be safe, secure, and worth the investment.

Section 3: Satisfaction & Emotional Engagement

7. The immersive experience makes me feel excited and inspired.
8. Using Vision Pro feels empowering, as if I'm accessing completely new possibilities.
9. Despite drawbacks such as weight, fatigue, or cost, the overall experience feels rewarding.
10. Overall, I am satisfied with Vision Pro as a step forward in invisible UX.

Section 4: Adoption Intentions

11. I would like to continue using Vision Pro in the future as the technology matures.
12. I would recommend it to others as a glimpse into the future of computing.

Annex B , Observation Protocol

Context

Field observations were carried out during simulated tasks across three case studies:

- **Case Study 1 , Face ID & Double Tap:** Authentication and quick-action tasks.
- **Case Study 2 , Siri (Voice Interaction):** Sending a message, setting a reminder, and requesting directions.
- **Case Study 3 , Apple Vision Pro:** Navigation and immersive interaction through gaze, gesture, and voice.

Checklist of Observable Behaviors

1. Task Execution

- Task Completion Time , average time per task (seconds).
- Error Frequency , number of failed recognitions (e.g., Face ID not recognizing, Siri mishearing, Vision Pro gesture not detected).
- Retries Required , number of repeated attempts before task completion.
- Fallback Use , instances where users switched to traditional methods (PIN entry, manual input, controllers).

2. Behavioral Cues

- Seamless Flow , smooth, uninterrupted use of the invisible feature.
- Hesitation or Pause , visible uncertainty before or during interaction.
- Frustration Signals , sighs, facial tension, repeated tapping, or verbal complaints.
- Positive Engagement , smiles, nods, laughter, or verbal approval (e.g., “That was fast”).

3. Social / Environmental Context

- Face ID & Double Tap , ease of use in public vs. private spaces (concerns about people watching PIN entry).
- Siri , appropriateness of voice use in different settings (quiet office, noisy street, driving).
- Vision Pro , user comfort in immersive contexts (weight, heat, social isolation in shared spaces).

4. Notes Section

- Observers record contextual factors such as:
- Environmental conditions (lighting for Face ID, background noise for Siri, room setup for Vision Pro).
- Technical interruptions (software glitches, connectivity issues).
- Participant comments in the moment (e.g., "It feels like magic" or "This keeps failing with my glasses").

Annex C – Key Concepts and Calculation Methods

This annex provides detailed definitions and calculation methods for the main metrics and constructs used in the study. It complements Chapter 3 (Methodology) by offering transparency and replicability.

1. Task Completion Time

Definition: Average number of seconds required to complete a task.

Formula:

$$\text{Avg. Task Time} = \frac{\sum \text{Task Duration}}{\text{Number of Participants}}$$

2. Error Rate

Definition: Percentage of tasks that failed due to misrecognition, system malfunction, or user error.

Formula:

$$\text{Error Rate (\%)} = \frac{\text{Number of Errors}}{\text{Total Attempts}} \times 100$$

3. First-Attempt Success

Definition: Proportion of tasks completed correctly on the first try.

Formula:

$$\text{First Attempt Success (\%)} = \frac{\text{First Successful Attempts}}{\text{Total Attempts}} \times 100$$

4. Satisfaction

Definition: Subjective enjoyment, convenience, or ease reported by participants.
Measurement: 5-point Likert scale (1 = very dissatisfied, 5 = very satisfied).

5. Trust

Definition: Degree of confidence in the system's reliability, privacy, and predictability.
Measurement: 5-point Likert scale across 3 items:

"I can rely on the system to perform tasks accurately."

"The system provides clear feedback when something goes wrong."

"I trust that the system protects my data."
Composite Score: Average of responses.

6. System Usability Scale (SUS)

The **System Usability Scale (SUS)**, developed by John Brooke in 1986, is a quick, reliable tool to measure **perceived usability**. It captures not only effectiveness and efficiency but also ease of learning and overall confidence in using a system.

Structure

10 items with alternating positive and negative statements.

Each item rated on a **5-point Likert scale** (1 = strongly disagree, 5 = strongly agree).

Example items:

"I found the system unnecessarily complex."

"I felt very confident using the system."

Calculation

Convert responses:

For **odd-numbered questions**, subtract 1 from the score.

For **even-numbered questions**, subtract the score from 5.

Sum the adjusted scores (range: 0–40).

Multiply the total by **2.5** to convert to a score out of 100.

Interpretation

>80 → Excellent usability (users are highly satisfied).

68 → Benchmark average (considered "acceptable usability").

<50 → Poor usability, likely to frustrate users.

7. AttrakDiff Scale

The **AttrakDiff**, developed by Marc Hassenzahl and colleagues, evaluates **both pragmatic and hedonic qualities** of a system, making it particularly useful for analyzing Invisible UX.

Structure

Participants rate **pairs of opposing adjectives** (bipolar items) on a **7-point scale**.

Example pairs:

"Complicated – Simple" (pragmatic quality).

"Conventional – Inventive" (hedonic quality: stimulation).

“Isolating – Integrating” (hedonic quality: identity).

Dimensions

Pragmatic Quality (PQ): Effectiveness, efficiency, clarity , “Does this tool help me get things done?”

Hedonic Quality (HQ): Enjoyment, stimulation, identity, empowerment , “Does this tool make me feel engaged, modern, or valued?”

HQ is further split into **Stimulation** (novelty, inspiration) and **Identification** (self-expression, alignment with identity).

Attractiveness (ATT): Overall impression of the product, combining PQ and HQ.

Calculation

Each bipolar item is scored from **–3 to +3** (with 0 = neutral).

Averages are calculated per dimension (PQ, HQ, ATT).

Example: A mean PQ of **+1.3** indicates moderately positive usability, while an HQ of **+1.9** signals strong enjoyment/innovation.

Interpretation

PQ > **0** → Users find the system functionally supportive.

HQ > **0** → Users find it stimulating, enjoyable, or identity-reinforcing.

ATT > 0 → Users generally perceive the product positively.

10. Trust Index

Definition: Composite measure of user confidence combining reliability, predictability, and privacy.

Formula:

$$\text{Trust Index} = \frac{\sum \text{Trust-related items}}{\text{Number of items}}$$

Annex D – List of Analyzed Apple Vision Pro Reviews

#	Review Snippet (Quoted)	Source Link	Platform
1	"Vision Pro seen as a cool but niche gadget still 'looking for a problem to solve.'"	MacRumors	Forum
2	"$3,499. Too expensive. Also offers extremely limited mobility… 'By Far the Worst Priced Headset.'"	MacRumors	Forum
3	"Eye-control is beyond amazing… an absolute game-changer for people with disabilities."	MacRumors	Forum
4	"Apple did an amazing job… They went wrong pricing it at $3,499."	MacRumors	Forum
5	"By far the best headset out there… shows why we need Apple involved."	MacRumors	Forum
6	"Buyer's remorse is very common… Great hardware, poor software (for now?)."	Reddit	r/VisionPro
7	"Watched 3D Ready Player One… mind-blowing… Gripes are more software than hardware."	Reddit	r/VisionPro
8	"After 2 hours… felt like building a badass PC then failing to install Linux."	Reddit	r/VisionPro

9	“This is hardware in search of software. Peanut butter with no jelly.”	Reddit	r/VisionPro

#	Review Snippet (Quoted)	Source Link	Platform
10	“First version… smarter to wait a few years as system matures.”	Reddit	r/VisionPro
11	“AVP has replaced my iPad and TV… superb for travel.”	Reddit	r/VisionPro
12	“Hand tracking is endlessly better than Quest pointer click.”	Reddit	r/VisionPro
13	“Amazing device… but feels like extra steps. Returning it. Worth skipping for now.”	Reddit	r/VisionPro
14	“Return rate will be high… hesitation at $4k pushes people to refund.”	Reddit	r/VisionPro
15	“Most impressive XR headset ever… best displays, sound, pass-through, and interface.”	Reddit	r/VisionPro
16	“I wasn’t sure, but now use it daily… best device for movies. The future.”	Reddit	r/VisionPro
17	“Weight distribution is terrible. Apple really needs to fix this.”	Reddit	r/VisionPro
18	“Heavy. So heavy.”	Reddit	r/VisionPro

19	“Passthrough complaints are overstated. I thought it was good!”	Reddit	r/VisionPro

#	Review Snippet (Quoted)	Source Link	Platform
20	“Good luck working at a desk and drinking coffee/tea with this thing on.”	Reddit	r/VisionPro
21	“Passthrough only 5–10% better than Quest 3… disappointing for $4000.”	Reddit	r/OculusQuest
22	“Can’t get it comfortable on my head… Quest straps somehow better.”	Reddit	r/OculusQuest
23	“AVP relegated to content consumption only… System UI lags sometimes.”	Reddit	r/OculusQuest
24	“I absolutely love my Vision Pro, but software could be improved.”	Reddit	r/VisionPro
25	“FOV is very limited… feels like peering through foggy binoculars. I want to love it.”	Reddit	r/VisionPro

Annex E – Table of Acronyms

Acronym	Full Form	Explanation / Relevance
UX	User Experience	Describes how people experience and interact with technology. Central theme of the dissertation.
UI	User Interface	The visible part of digital systems (buttons, menus, screens) contrasted with Invisible UX.
SUS	System Usability Scale	Standardized tool for measuring perceived usability of systems; applied in case study evaluations.
AttrakDiff	Attractiveness Difference Questionnaire	Method for assessing pragmatic and hedonic qualities of user experience.
PIN	Personal Identification Number	Traditional authentication method, used as a benchmark against Face ID.
FOV	Field of View	The visible scope in head-mounted displays, discussed in Vision Pro reviews.
AVP	Apple Vision Pro	Apple’s mixed-reality headset, centerpiece of Case Study 3.

References

Aarts, E., & Marzano, S. (2003). *The new everyday: Views on ambient intelligence.* 010 Publishers.

Assiri, M., & Selim, M. M. (2025). Gesture recognition for hearing-impaired people using an ensemble of deep learning models with improved Beluga Whale optimization. *Scientific Reports, 15*(1), 21441. https://doi.org/10.1038/s41598-025-21441-8

Bakker, S., van den Hoven, E., & Eggen, B. (2014). Peripheral interaction: Characteristics and considerations. *Personal and Ubiquitous Computing, 19*(1), 239–254.* https://doi.org/10.1007/s00779-014-0774-2

Case, A. (2015). *Calm technology: Principles and patterns for non-intrusive design.* O'Reilly Media.

Chalmers, M., & Galani, A. (2004). Seamful interweaving: Heterogeneity in the theory and design of interactive systems. In *Proceedings of the 5th Conference on Designing Interactive Systems* (pp. 243–252). ACM. https://doi.org/10.1145/1013115.1013149

Chao, C., Chen, Y., Wu, H., Wu, W., Yi, Z., Xu, L., et al. (2023). An emotional design model for future smart products based on grounded theory. *Systems, 11*(7), 377. https://doi.org/10.3390/systems11070377

Dey, A. K. (2001). Understanding and using context. *Personal and Ubiquitous Computing, 5*(1), 4–7. https://doi.org/10.1007/s007790170019

Dourish, P. (2001). *Where the action is: The foundations of embodied interaction.* MIT Press.

Hassenzahl, M. (2005). The thing and I: Understanding the relationship between user and product. In M. A. Blythe et al. (Eds.), *Funology: From usability to enjoyment* (pp. 31–42). Springer. https://doi.org/10.1007/1-4020-2967-5_4

Hassenzahl, M., & Tractinsky, N. (2006). User experience: A research agenda. *Behaviour & Information Technology, 25*(2), 91–97. https://doi.org/10.1080/01449290500330331

Hassenzahl, M., Diefenbach, S., & Göritz, A. (2010). Needs, affect, and interactive products: Facets of user experience. *Interacting with Computers, 22*(5), 353–362. https://doi.org/10.1016/j.intcom.2010.04.002

Ishii, H., & Ullmer, B. (1997). Tangible bits: Towards seamless interfaces between people, bits and atoms. In *Proceedings of CHI '97* (pp. 234–241). ACM. https://doi.org/10.1145/258549.258715

Jian, J.-Y., Bisantz, A. M., & Drury, C. G. (2000). Foundations for an empirically determined scale of trust in automated systems. *International Journal of Cognitive Ergonomics, 4*(1), 53–71. https://doi.org/10.1207/S15327566IJCE0401_04

Norman, D. A. (2004). *Emotional design: Why we love (or hate) everyday things.* Basic Books.

Norman, D. A. (2013). *The design of everyday things* (Revised & expanded ed.). Basic Books.

Pousman, Z., & Stasko, J. (2006). A taxonomy of ambient information systems: Four patterns of design. In *Proceedings of the Working Conference on Advanced Visual Interfaces (AVI '06)* (pp. 67–74). ACM. https://doi.org/10.1145/1133265.1133277

Shakoor, A. (2023). The impact of emotional design in UX. *UX Collective.* https://uxdesign.cc/the-impact-of-emotional-design-in-ux-a-guide-2023-d2f

Syamsuddin, S. F., & Fadhilla, H. N. (2024). The effect of brand experience on brand engagement and brand equity mediated by brand love among Apple users. *Management and Economics Journal, 8*(3), 321–338. https://doi.org/10.18860/mec-j.v8i3.2543

Tennenhouse, D. (2000). Proactive computing. *Communications of the ACM, 43*(5), 43–50. https://doi.org/10.1145/332833.332837

Vermeeren, A. P. O. S., Law, E. L.-C., Roto, V., Obrist, M., Hoonhout, J., & Väänänen-Vainio-Mattila, K. (2010). User experience evaluation methods: Current state and development needs. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction* (pp. 521–530). ACM. https://doi.org/10.1145/1868914.1868973

Weiser, M. (1991). The computer for the 21st century. *Scientific American, 265*(3), 94–104. https://doi.org/10.1038/scientificamerican0991-94

Weiser, M., & Brown, J. S. (1996). The coming age of calm technology. *Xerox PARC Research Paper.* https://doi.org/10.13140/RG.2.2.18307.17442

Wigdor, D., & Wixon, D. (2011). *Brave NUI world: Designing natural user interfaces for touch and gesture.* Morgan Kaufmann.

Xu, W. (2024). A User Experience 3.0 (UX 3.0) paradigm framework: User experience design for human-centered AI systems. *arXiv Preprint.* https://arxiv.org/abs/2403.01609